Department of Energy

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SEP 1 8 2019

Mr. Brian Begley
Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Boulevard, 2nd Floor
Frankfort, Kentucky 40601

PPPO-02-5575312-19B

Ms. Julie Corkran
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Ms. Corkran:

TRANSMITTAL OF THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY WORK PLAN FOR THE C-400 COMPLEX OPERABLE UNIT AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/LX/07-2433&D2)

References:

1. Letter from J. Corkran to T. Duncan, "RE: EPA Comments: Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, (DOE/LX/07-2433&D1), Primary Document, transmittal dated November 19, 2018 (PPP0-02-5267944-19) [*sic*]," dated May 22, 2019
2. Letter from A. Webb to T. Duncan, "RE: Submittal of Comments to the Remedial Investigation / Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant (DOE/LX/07-2433&D1), Paducah Site, Paducah, McCracken County, Kentucky, #KY8-890-008-982," dated May 10, 2019
3. Letter from T. Duncan to B. Begley and J. Corkran, "Schedule Extension for Submittal of the D2 Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-2433&D1)," (PPPO-02-5682156-19), dated July 17, 2019

Please find enclosed the *Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2433&D2 (RI/FS Work Plan). This version of the RI/FS Work Plan incorporates Kentucky Department for Environmental Protection (KDEP) and U.S. Environmental Protection

Agency (EPA) comments received on May 10, 2019, and May 22, 2019, respectively; reflects changes from discussions held among the U.S. Department of Energy, KDEP, and EPA during comment resolution meetings; and includes the *Paducah Gaseous Diffusion Plant C-400 Basement Slab and Subsurface Structures Data Summary Report*, DOE/LX/07-2442&D1 (Data Summary Report), which is included as Appendix D of the RI/FS Work Plan. In addition, the RI/FS Work Plan has been revised to incorporate recent Federal Facility Agreement (FFA) parties agreements, as documented in the *Memorandum of Agreement for Resolution of Formal Disputes on EPA Conditional Concurrence on the Removal Notification for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2420&D2 *and the Engineering Evaluation / Cost Analysis for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2425&D2) [*sic*], and the *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Annual Revision—Fiscal Year 2018 and FY 2019*, DOE/LX/07-2418&D2/R2. Also enclosed are a redline version of the RI/FS Work Plan that reflects changes from the D1 RI/FS Work Plan, EPA and KDEP Comment Response Summaries, and a Certification Page. In accordance with Section XX.G of the Paducah FFA, EPA and KDEP have a 30-day review and comment period.

If you have any questions or require additional information, please contact David Dollins at (270) 441-6819.

Sincerely,

Tracey Duncan
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosures:

1. Certification Page
2. RI/FS Work Plan for the C-400 Complex Operable Unit, DOE/LX/07-2433&D2 – Clean
3. RI/FS Work Plan for the C-400 Complex Operable Unit, DOE/LX/07-2433&D2 – Redline
4. Comment Response Summary – EPA
5. Comment Response Summary – KDEP

Administrative Record File—ARF400OUREMEDIAL

Administrative Record File—ARF400OUREMEDIAL

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CERTIFICATION

Document Identification: ***Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2433&D2, dated September 2019**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Four Rivers Nuclear Partnership, LLC

[signature] 9/18/19

Myrna E. Redfield, Program Manager
Four Rivers Nuclear Partnership, LLC

Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

U.S. Department of Energy

Jennifer Woodard 9/18/19

Jennifer Woodard, Paducah Site Lead
Portsmouth/Paducah Project Office
U.S. Department of Energy

Date Signed

DOE/LX/07-2433&D2
Primary Document

Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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DOE/LX/07-2433&D2
Primary Document

Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—September 2019

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Four Rivers Nuclear Partnership, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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CONTENTS

FIGURES

TABLES

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ACO	Administrative Order by Consent
AL	action level
ANSI	American National Standards Institute
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AT123D	Analytical Transient 1-,2-,3-Dimensional
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
CAAS	criticality accident alarm system
CAS	Chemical Abstracts Service
CCF	central control facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CHFA	Cabinet for Health and Family Services
COC	contaminant of concern
COE	U.S. Army Corps of Engineers
COPC	chemical or radionuclide of potential concern
COPEC	chemical or radionuclide of potential ecological concern
CRP	community relations plan
CRQL	contract-required quantitation limit
CRZ	contamination reduction zone
CSM	conceptual site model
CTR	contract technical representative
CVAA	cold vapor atomic absorption
DAF	dilution attenuation factor
DMIP	data management implementation plan
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DPT	direct push technology
DOT	U.S. Department of Transportation
DQI	data quality indicator
DQO	data quality objective
DyeLIF	Dye-enhanced laser induced fluorescence
ECD	electron capture detector
EDD	electronic data deliverable
ELCR	excess lifetime cancer risk
EMS	environmental management system
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERH	electrical resistance heating
EZ	exclusion zone
FFA	Federal Facility Agreement
FID	flame ionization detector
FIDLER	field instrument for detection of low energy radiation
FRNP	Four Rivers Nuclear Partnership, LLC

FS	feasibility study
FY	fiscal year
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GIS	geographic information system
HSA	hollow stem auger
HASP	health and safety plan
HAZWOPER	Hazardous Waste Site Operations and Emergency Response
HI	hazard index
HSS&Q	health, safety, security, and quality
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
HSWA	Hazardous and Solid Waste Amendments
HU	hydrogeologic unit
ICP	inductively coupled plasma
ID	identification
IDW	investigation-derived waste
IH	industrial hygiene
IS	industrial safety
ISMS	integrated safety management system
JHA	job hazard analysis
KDEP	Kentucky Department for Environmental Protection
KDWM	Kentucky Division of Waste Management
KPDES	Kentucky Pollutant Discharge Elimination System
KYRHB	Kentucky Radiation Health Branch
LCS	laboratory spike blanks
LDR	land disposal restriction
LLW	low-level waste
LOTO	lockout/tagout
MCL	maximum contaminant level
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	method detection limit
MEPAS	Multimedia Environmental Pollutant Assessment System
MIP	membrane interface probe
MOA	memorandum of agreement
MODFLOW	modeling program
MPC	measurement performance criteria
MS	matrix spikes
MSD	matrix spike duplicate
MW	monitoring well
N/A	not applicable
NAL	no action level
nb	indicates no toxicological benchmark available
NCS	Nuclear Criticality Safety
NDIRD	nondispersive infrared detector
NE	land use scenario not of concern
NEPA	National Environmental Policy Act
NSDD	North-South Diversion Ditch
NWS	National Weather Service
OREIS	Oak Ridge Environmental Information System

OSHA	U.S. Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PA	public address
PAAA	Price-Anderson Act Amendment
PAH	polycyclic aromatic hydrocarbon
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEL	permissible exposure limit
PEMS	Paducah Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PID	photoionization detector
PM	project manager
POC	pathway of concern
PPE	personal protective equipment
PPPO	Portsmouth/Paducah Project Office
PQL	practical quantitation limit
PRG	preliminary remediation goal
PSS	plant shift superintendent
PTW	principal threat waste
PWMC	project waste management coordinator
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RAD	radiation
RADCON	radiation control
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
RCW	recirculating cooling water
RDSI	remedial design support investigation
RESRAD	Residual Radioactive Materials
RfD	reference dose
RFD	request for disposal
RGA	Regional Gravel Aquifer
RGO	remedial goal option
RI	remedial investigation
RMD	Risk Methods Document
RME	reasonable maximum exposure
ROD	record of decision
ROM	rough order of magnitude
RPD	relative percent difference
RTL	ready-to-load
RWP	radiological work permit
S&A	sampling and analytical
SADA	Spatial Analysis and Decision Assistance
SAP	sampling and analysis plan
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
SOW	statement of work
SPH	six-phase heating
SQL	sample quantitation limit
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SZ	support zone
TBD	to be determined
TCLP	toxicity characteristic leaching procedure
TLV	threshold limit value
TOC	total organic carbon
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
UCL	upper confidence limit
UCRS	Upper Continental Recharge System
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USEC	United States Enrichment Corporation
VI	vapor intrusion
VISL	Vapor Intrusion Screening Level
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area group or grouping
WICL	waste item container log
WKWMA	West Kentucky Wildlife Management Area
WMC	waste management coordinator
WMP	waste management plan

EXECUTIVE SUMMARY

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

In August 2017, the *Memorandum of Agreement on the C-400 Complex under the Federal Facility Agreement for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (MOA) was signed by DOE, EPA, and KDEP (DOE 2017a). The MOA included the following:

- Resequenced the approved Fiscal Year (FY) 2015 Site Management Plan (SMP)[1] milestones;

- Established the C-400 Complex Operable Unit (OU) and the requirement to conduct a remedial investigation/feasibility study (RI/FS) to support remedy selection for a final remedial action; and

- Required integration of the Phase IIb Interim Action source area into the Final Action for the C-400 Complex with a remedial action start date of 2023 (first quarter of FY 2024). [NOTE: the approved FY 2018 and FY 2019 SMP (DOE 2019a) includes a revised remedial action start date of third quarter FY 2024 that supercedes the date listed above from the 2017 MOA.]

The C-400 Complex (C-400 Cleaning Building and area bounded by adjacent streets) contains numerous solid waste management units (SWMUs) and contaminated environmental media/debris (e.g., groundwater, soils, and concrete slabs) and is the primary source of off-site trichloroethene (TCE) groundwater contamination at the Paducah Site (Figure ES.1). The C-400 Complex OU is intended to characterize fully the nature and extent of contamination and take the necessary actions to address all environmental contamination in order to achieve a final remedial action for the entire C-400 Complex. The C-400 Complex final remedial action will address all sources of contamination within the defined footprint of the C-400 Complex including, but not limited to, principal threat waste (PTW) [e.g., TCE dense nonaqueous-phase liquid (DNAPL) and high concentration TCE contamination]. The following are included in the C-400 Complex final remedial action.

- Conduct a combined RI/FS for the C-400 Complex area that includes an investigation of all remaining building structure(s) (e.g., slab and subsurface structures) and releases of any hazardous substances to soils and/or groundwater associated with the C-400 Cleaning Building and C-400 Complex area operations (including, but not limited to, TCE DNAPL and high concentration areas considered PTW).

- RI/FS characterization to define the full nature and extent of all contamination within the C-400 Complex from the surface down through the Regional Gravel Aquifer and to include the upper McNairy Formation.

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[1] Last approved SMP at the time of the MOA (DOE 2015).

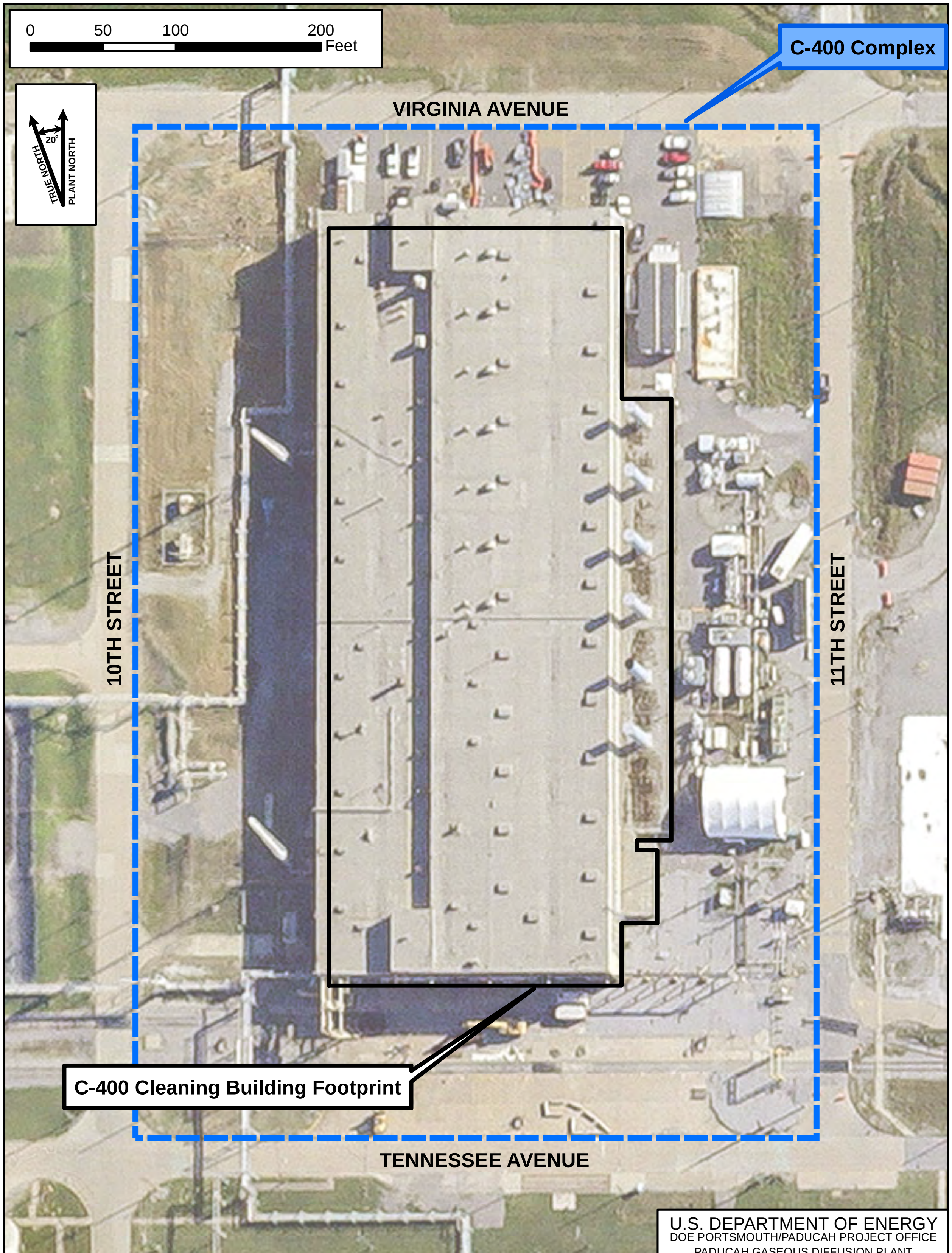

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Figure ES.1. C-400 Complex

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- Remedy selection [proposed plan and Record of Decision (ROD)] to document a final remedial action(s) for all source areas and related contaminants of concern (COCs) requiring remediation for the entire C-400 Complex.

- Post-ROD documents (e.g., remedial design report, remedial action work plan) and implementation of a final remedial action(s) as specified in the ROD.

An RI/FS Scoping Document entitled *Scoping Document for the C-400 Complex Remedial Investigation/Feasibility Study at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2424&D1, was developed in compliance with CERCLA, the FFA, and agreements included in the MOA (DOE 2018a). Information in the RI/FS Scoping Document was used in a series of project scoping meetings with EPA and KDEP. The purposes of the scoping meetings were to support a meaningful exchange of information/expectations; develop a general consensus on the scope; ensure that EPA and KDEP had the opportunity to provide input into designing the RI/FS; and, specifically, to facilitate development of this RI/FS Work Plan, thereby accelerating the review, comment, and approval process of the work plan. During the scoping process, progress was made in defining sample locations; clarifying concepts and identifying data needs; exchanging ideas on investigation methods; and identifying and resolving concerns/issues related to the RI/FS Work Plan development. Comments (verbal or written) and action items received on the C-400 RI/FS Scoping Document and/or scoping meetings have been considered and incorporated into the development of this C-400 Complex RI/FS Work Plan, as appropriate.

This C-400 Complex RI/FS Work Plan describes how the RI and FS will be implemented, summarizes data availability and data needs, identifies how data needs will be addressed, and provides details on the process that will be used to develop and evaluate remedial alternatives for the C-400 Complex based on the results of the investigation. In addition, this C-400 Complex RI/FS Work Plan includes Appendix A, ARARs; Appendix B, Historical Data; Appendix C, Gamma Walkover Survey Plan for C-400 Complex Sectors; and Appendix D contains the *Paducah Gaseous Diffusion Plant C-400 Basement Slab and Subsurface Structures Data Summary Report*.

The goals for the C-400 Complex RI/FS are consistent with those established in the FFA; the Paducah SMP; and the C-400 MOA negotiated among DOE, EPA, and KDEP (DOE 2019a; DOE 2017a). As discussed during the scoping process, the following are the goals for the C-400 Complex RI/FS.

- Goal 1: Characterize Nature of Source Zone(s)—Characterize the nature of contaminant source materials using existing data and by collecting additional data, as necessary.

- Goal 2: Define Extent of Source and Contamination in Soil and Remaining Structures in the OU Area—Define the nature, extent (vertical and lateral), and magnitude of contamination in soils and perform a multimedia evaluation (e.g., groundwater, concrete) to ensure that all exposure pathways for the OU area are assessed adequately to support cleanup decisions.

- Goal 3: Evaluate Surface and Subsurface Transport Mechanisms and Pathways—Assess existing data and collect additional data, as necessary, to analyze contaminant transport mechanisms and support development of an RI/FS.

- Goal 4: Complete a Risk Assessment for the C-400 Complex—Conduct a screening risk evaluation of the combined newly generated data and historical data to complement the previously performed Baseline Human Health Risk Assessment (DOE 1999a) and conduct a screening-level ecological risk assessment (Steps 1 and 2) (DOE 2019b).

- Goal 5: Identify, Develop, and Evaluate Remedial Alternatives—Use historical and newly collected data to identify, develop, and evaluate final action alternatives that will reduce risk to human health and the environment and meet the remedial action objectives identified.

Cleanup progress at the Paducah Site has been made possible, in part, by the active and informed participation by site stakeholders, including regulators, workers, elected officials, and other members of the public. Public participation and information exchange are key components of the CERCLA process, and this RI/FS Work Plan describes the process and timing for formal and informal stakeholder participation in the C-400 Complex remedial alternatives selection analysis.

1. INTRODUCTION

1.1 BACKGROUND

The Paducah Site is located within the Jackson Purchase region of western Kentucky. The Paducah Site, located approximately 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River in the western part of McCracken County, is an inactive uranium enrichment facility owned by the U.S. Department of Energy (DOE) (Figure 1.1).

In July 1988, off-site groundwater contamination was detected in groundwater wells north of the Paducah Site. In August 1988, DOE and U.S. Environmental Protection Agency (EPA) Region 4 entered into an Administrative Order by Consent (ACO) under Section 104 and 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Kentucky provided regulatory review of the CERCLA ACO documents, but was not a signatory on the agreement.

PGDP (CERCLIS# KY8-890-008-982) was placed on the National Priorities List on May 31, 1994. In accordance with Section 120 of CERCLA, DOE entered into a Federal Facility Agreement (FFA) with EPA and the Kentucky Department for Environmental Protection (KDEP) on February 13, 1998 (EPA 1998). The FFA established one set of consistent requirements for achieving comprehensive site remediation in accordance with the Resource Conservation and Recovery Act (RCRA) and CERCLA, including community relations and other stakeholder involvement. As established by the FFA, DOE is the lead agency for remedial actions, and EPA and KDEP have regulatory oversight responsibilities.

Source units and areas of contamination (AOCs) at the Paducah Site have been combined into operable units (OUs) for investigation and evaluation of remedial alternatives. Each OU is designed to remediate contaminated media associated with the Paducah Site (DOE 2019a). These OUs include the C-400 Complex OU (C-400 Complex), which includes the C-400 Cleaning Building and the immediate area around it. The C-400 Complex is located inside the fenced security area near the center of the industrial section of the Paducah Site. The C-400 Complex is between 10th and 11th Streets to the west and east, respectively, and between Virginia and Tennessee Avenues to the north and south, respectively (Figure 1.2).

1.2 C-400 COMPLEX FINAL REMEDIAL ACTION SCOPE

The C-400 Complex contains numerous solid waste management units (SWMUs) and contaminated environmental media/debris (e.g., groundwater, soils, and concrete slabs) and is the primary source of off-site trichloroethene (TCE) groundwater contamination at the Paducah Site. The highest levels of technetium-99 (Tc-99), as measured in RGA monitoring wells (MWs), occur around the C-400 Complex, which is consistent with historical releases at the C-400 Building. The C-400 Complex final remedial action is intended to evaluate fully and take the necessary actions to achieve a final remedial action for the entire C-400 Complex area, as shown in Figure 1.2. The C-400 Complex final remedial action will address all sources of contamination within the defined footprint of the C-400 Complex, including, but not limited to, principal threat waste (PTW) [e.g., TCE dense nonaqueous-phase liquid (DNAPL) and high concentration TCE contamination]. The following are included in the C-400 Complex final remedial action.

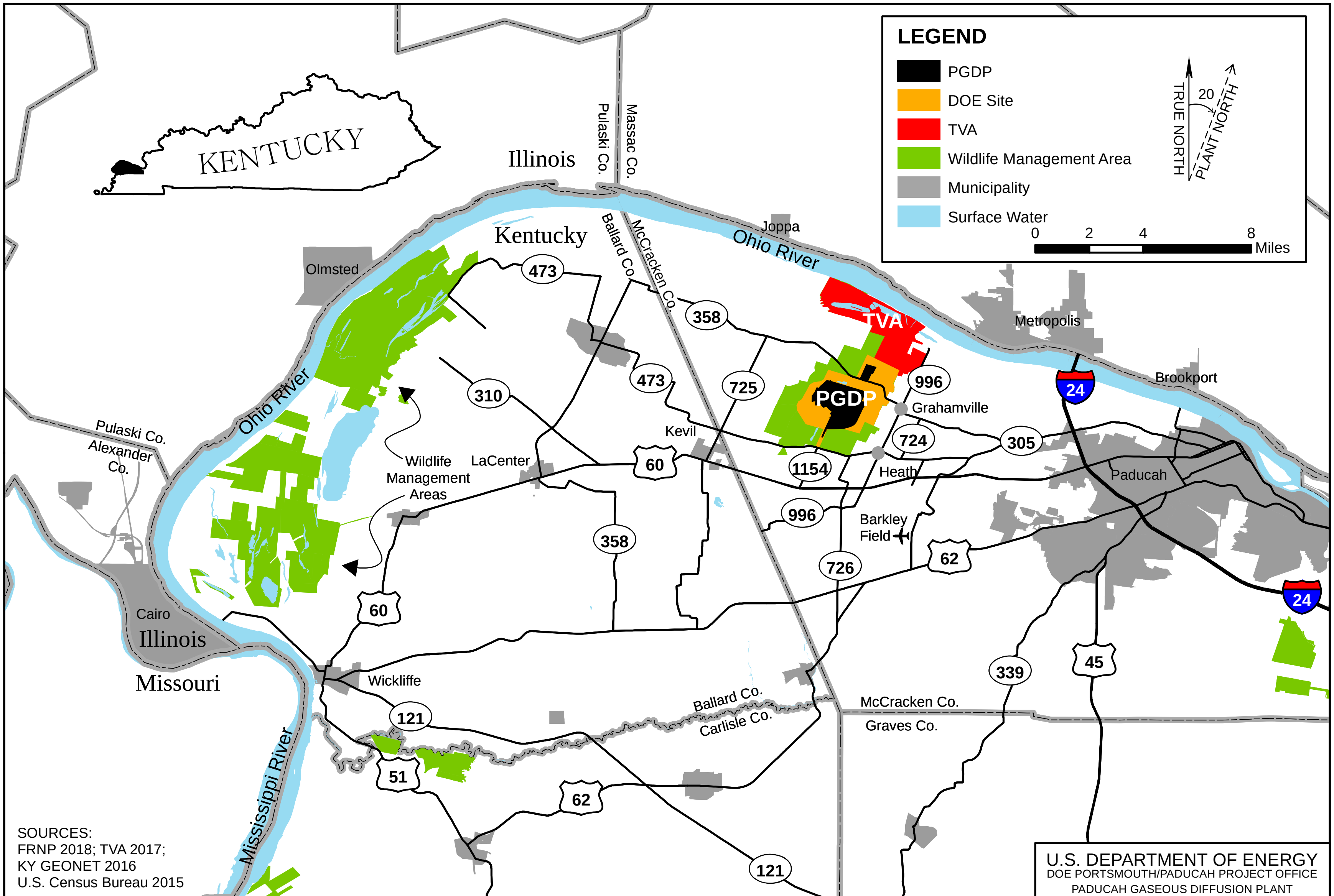

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Figure 1.1. Paducah Site Vicinity Map

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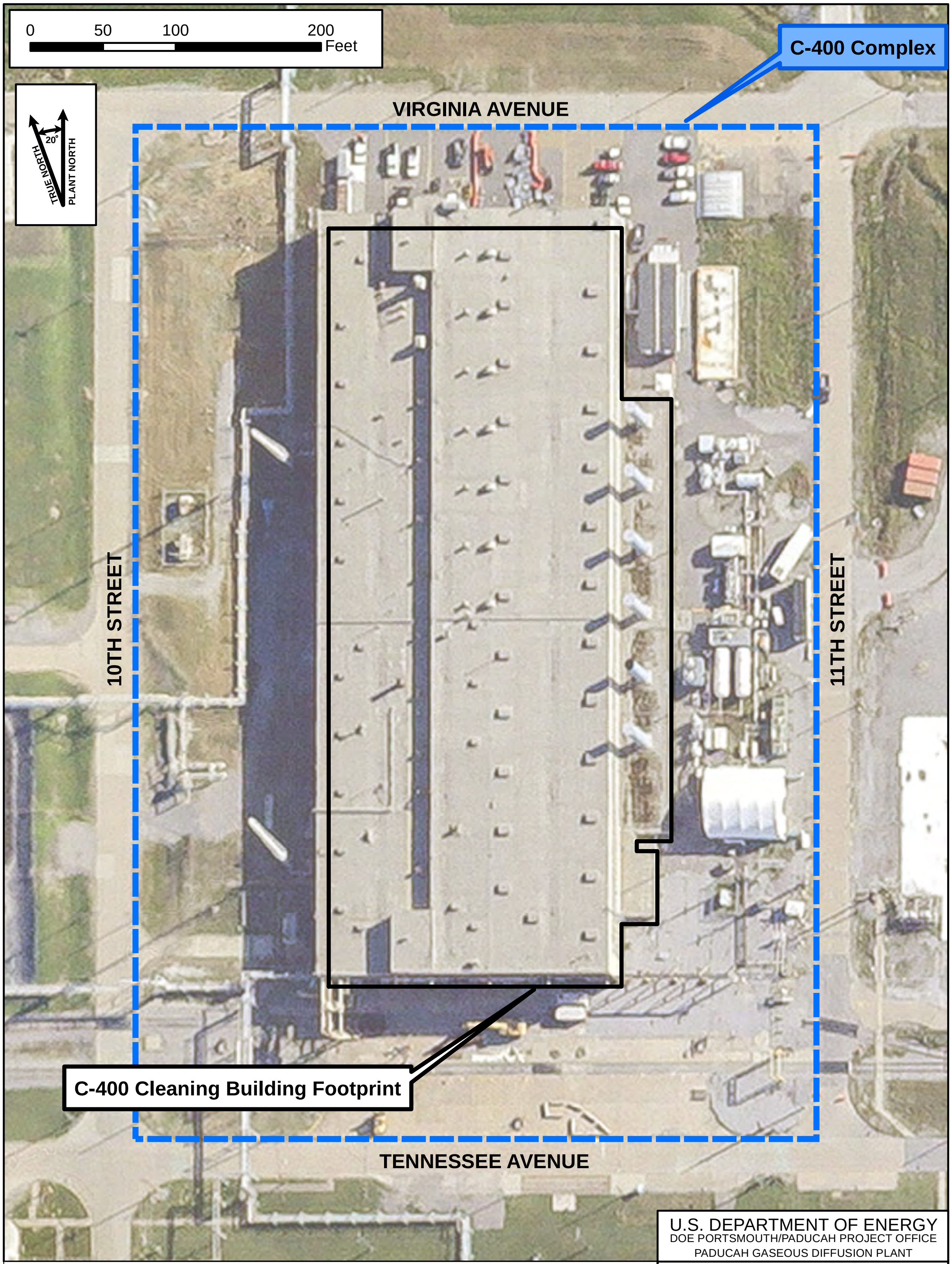

Figure 1.2. C-400 Complex Area

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- Conduct a combined remedial investigation (RI)/feasibility study (FS) for the C-400 Complex area that includes an investigation of all remaining building structure(s) (e.g., slab and subsurface structures) and releases of any hazardous substances to soils and/or groundwater associated with the C-400 Cleaning Building and C-400 Complex area operations (including, but not limited to, TCE DNAPL and high concentration areas considered PTW).

- RI/FS characterization to define the full nature and extent of all contamination within the C-400 Complex from the surface down through the Regional Gravel Aquifer (RGA) and to include the upper McNairy Formation.

- Remedy selection [proposed plan and Record of Decision (ROD)] to document a final remedial action(s) for all source areas and related contaminants of concern (COCs) requiring remediation for the entire C-400 Complex.

- Post-ROD documents (e.g., remedial design report, remedial action work plan) and implementation of a final remedial action(s) as specified in the ROD.

1.3 PROJECT OBJECTIVES AND GOALS

The goals for the C-400 Complex RI/FS are consistent with those established in the FFA; the Paducah Site Management Plan (SMP); and the C-400 Memorandum of Agreement (MOA) negotiated among DOE, EPA, and KDEP (DOE 2019a; DOE 2017a). As discussed during the scoping process, the following are the goals for the C-400 Complex RI/FS.

Goal 1: Characterize Nature of Source Zone(s)—Characterize the nature of contaminant source materials using existing data and by collecting additional data, as necessary.

Goal 2: Define Extent of Source and Contamination in Soil and Remaining Structures in the OU Area—Define the nature, extent (vertical and lateral), and magnitude of contamination in soils and perform a multimedia evaluation (e.g., groundwater, concrete) to ensure that all exposure pathways for the OU area are assessed adequately to support cleanup decisions.

Goal 3: Evaluate Surface and Subsurface Transport Mechanisms and Pathways—Assess existing data and collect additional data, as necessary, to analyze contaminant transport mechanisms and support development of an RI/FS.

Goal 4: Complete a Risk Assessment for the C-400 Complex—Conduct a screening risk evaluation of the combined newly generated data and historical data to complement the previously performed Baseline Human Health Risk Assessment (DOE 1999a) and conduct a screening-level ecological risk assessment (SERA) (Steps 1 and 2) (DOE 2019b).

Goal 5: Identify, Develop, and Evaluate Remedial Alternatives—Use historical and newly collected data to identify, develop, and evaluate final action alternatives that will reduce risk to human health and the environment and meet the remedial action objectives (RAOs) identified.

1.4 PROJECT DATA QUALITY OBJECTIVES

The Data Quality Objective (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 [*Guidance on Systematic Planning Using the Data Quality Objectives Process* EPA QA/G-4 (EPA 2006)]. The steps outlined in the DQO process have been used to develop the RI/FS Work Plan. These steps formulate a set of criteria that will achieve the desired control of uncertainty, allowing the decisions to be made with acceptable confidence.

The first step in the DQO process is to identify the problem to be resolved. It is possible that contaminants originating from the SWMUs/areas of concern have been released to the environment. The following is the overall problem statement developed for the DQO process.

> Hazardous substances that historically have been present and/or migrated from the C-400 Complex and its SWMUs have been released to surrounding environmental media. These substances, in turn, have infiltrated into groundwater and been transported through subsurface pathways. The nature and extent of contamination have been defined adequately for some SWMUs, and areas and risk assessments have been prepared. For other SWMUs and areas, the nature and extent of contamination have not been defined adequately to assess whether potential contaminants pose unacceptable risks to human health and the environment at the C-400 Complex and at downgradient exposure points. Data gaps must be identified so that a comprehensive RI/FS report can be prepared for the C-400 Complex.

The following seven steps in the process were completed in accordance with the referenced guidance and are listed in Figure 1.3 (EPA 2006). In order to facilitate discussions, the seven steps of the DQO process were initiated, in accordance with the referenced EPA guidance (EPA 2006), and a set of decision rules and questions to be answered are provided in Table 1.1 to complete the DQO process. As part of the process, meetings among DOE, EPA, and KDEP were held to review and discuss the scoping of the project. Table 1.1 includes the goals and outlines the decision rules, evaluation methods, and data needs that will support evaluation of alternatives for selection of the final remedial action(s).

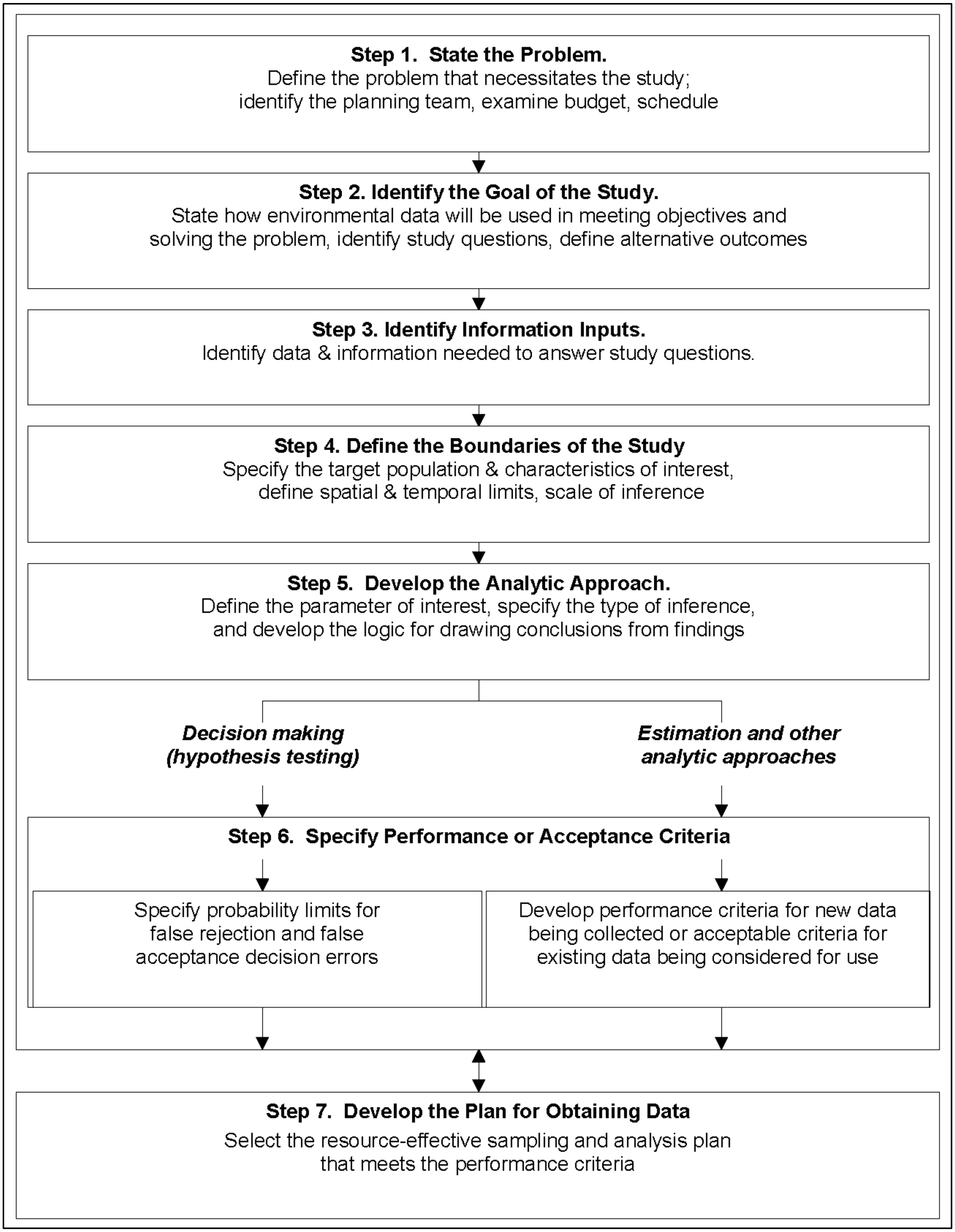

Figure 1.3. DQO Process Chart (EPA 2006)

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS

GOAL 1: CHARACTERIZE NATURE OF SOURCE ZONE(S)

Decisions and questions
1-1: What are the suspected contaminants?
1-2: What are the plant processes/activities that could have contributed to the contamination? When and over what duration did releases occur?
1-3: Are there hazardous substances present in the remaining building infrastructure at the time of the RI/FS?
1-4: What are the chemical concentrations and radionuclide activities at the source(s)?
1-5: What are the chemical and physical properties of associated material (e.g., groundwater, soil, concrete) at the source areas?

Decision rule	**Evaluation method**	**Data needs**
D1a: If an analyte is found at a concentration greater than its background concentration, then identify the analyte as a contaminant. Use this information to identify nature and extent of the source area(s) for the contaminant.	<u>Screening</u> Quantitative comparisons by medium between detected concentrations of analytes and background concentrations	Proposed characterization levels Analytical levels Characterization data Background concentrations [2]

[2] Background concentrations to be used for the evaluation will be taken from the version of the Risk Methods Document that is current at the time of the data evaluation and were taken from the *Background Levels of Selected Radionuclides and Metals in Soil and Geologic Media at the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1586&D2 (DOE 1997), and *Background Concentrations of Naturally Occurring Inorganic Chemicals and Selected Radionuclides in the Regional Gravel Aquifer and McNairy Formation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky in Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, Volume 5, DOE/OR/07-1857&D1 (DOE 2000).

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

GOAL 2: DEFINE EXTENT OF SOURCE AND CONTAMINATION IN SOIL AND REMAINING STRUCTURES IN THE OU AREA

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 chemical concentrations or radionuclide activity gradients?
2-4: What is the vertical and lateral extent of contamination?
2-5: What is the extent of contamination to integrator units (i.e., groundwater, surface water)?
2-6: What is the area and volume of the source zone(s)?
2-7: Where is the source?

Decision rule	Evaluation method	Data needs
D2a: Determine if isolated contamination exists or if contamination is general across the OU; if isolated contamination exists, determine its extent. Use this information to determine where remedial alternative is required and where no further action is necessary.	Quantitative comparisons by medium between detected concentrations of analytes in the source zone and background concentrations and preliminary remediation goals (PRGs) Quantitative comparison by medium between detected concentrations of analytes and ecological receptor benchmarks Quantitative comparison by medium between analyte concentrations and any applicable or relevant and appropriate requirements (ARARs)[3] Quantitative comparison by medium between modeled analyte concentrations at downgradient exposure points and any ARARs	Historical data Proposed characterization levels Analytical levels Characterization data Background concentrations and PRGs Current and expected land-use patterns

[3] A discussion of ARARs for the C-400 Complex is presented in Appendix A.

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

Decision rule	Evaluation method	Data needs
D2b: If secondary[4] sources are found, **and** if the concentration of analytes within the secondary source is found to result in a cumulative ELCR greater than 1×10^{-6} or a cumulative HI greater than 1 through contact with contaminated media and/or debris (as applicable) at the unit, **and** if the concentrations of analytes are greater than those expected to occur naturally in the environment, then evaluate remedial alternatives that will mitigate risk; otherwise do not consider secondary sources when making remedial decisions for the unit.	<u>Screening</u> Quantitative comparisons by medium between detected concentrations of analytes and background concentrations and PRGs Quantitative comparison by medium between detected concentrations of analytes and ecological receptor benchmark Conduct a screening risk evaluation of the combined newly generated data and historical data to complement the previously performed Baseline Human Health Risk Assessment (BHHRA) (DOE 1999a) and conduct a Screening-Level Ecological Risk Assessment (SERA) (Steps 1 and 2) (DOE 2019b)	Results of previous investigations, reports, and treatability studies to target sampling locations and analytical requirements Analytical limits for identification of secondary sources Subsurface characterization information including stratigraphy Current and expected land-use patterns (industrial)

[4] As discussed during the scoping process and as previously used at the Paducah Site, secondary sources are those sources of contamination that were not expected based upon historical information and/or previous site investigations or characterization efforts. Secondary source information is detectable through analysis of characterization data where chemicals or radionuclides of potential concern (COPCs) exist in sufficient quantities, in addition to the indicator chemicals that were expected.

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

GOAL 3: EVALUATE SURFACE AND SUBSURFACE TRANSPORT MECHANISMS AND PATHWAYS

Decisions and questions
3-1: Are and how are the contaminants migrating from the source?
3-2: What is the direction of contaminant transport in groundwater?
3-3: What are the effects of building construction, underground utilities, previous remedial actions, treatability studies, and plant operations on migration pathways including ditches?
3-4: What is the role of the Upper Continental Recharge System (UCRS), RGA, and McNairy Formation in contaminant release and transport?
3-5: What are the physical, chemical, and hydrogeological 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 sources are found, **and** if these contaminants are found to be migrating from the source zone or from secondary sources at concentrations that result in a cumulative ELCR greater than 1×10^{-6} or a cumulative HI greater than 1 through contaminated media and/or debris (as applicable) at downgradient points of exposure, **and** the concentrations of analytes are greater than those expected to occur naturally in the environment, then evaluate remedial alternatives that will mitigate risk (see D3b).	<u>Screening</u> Quantitative comparisons by medium between modeled contaminant concentrations and background concentrations and PRGs	Results of analyses performed under D1a and D2a Procedures and methods for human health and ecological risk assessment Current and expected land-use patterns Results of models [e.g., Multimedia Environmental Pollutant Assessment System (MEPAS), Residual Radioactive Materials (RESRAD), Seasonal Soil Compartment Model (SESOIL)] that can predict future soil contaminant concentrations at exposure points Modeling parameters including chemical parameters, mineralogy, reduction-oxidation potential, porosity, hydraulic conductivity, and stratigraphy Potentiometric surfaces (groundwater flow direction) Video borescope of drain lines Information regarding upgradient contamination impacting C-400 Complex

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

Decision rule	Evaluation method	Data needs
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating from the source zone or from the secondary source at concentrations that exceed any chemical-specific ARARs, then evaluate remedial alternatives that will bring migratory concentrations into compliance with any chemical-specific ARARs (see D3a).	Quantitative comparison by medium between modeled analyte concentrations at downgradient exposure points and any chemical-specific ARARs Evaluate if ARAR waiver or other alternative standards are appropriate	Results of analyses performed under D1b List of ARARs Current and expected land-use patterns Results of models (e.g., MEPAS, RESRAD, SESOIL) that can predict future soil contaminant concentrations at exposure points (Geochemical equilibrium will be addressed in the RI/FS report) Modeling parameters including chemical parameters, mineralogy, reduction-oxidation potential, porosity, hydraulic conductivity, and stratigraphy

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

GOAL 4: COMPLETE A RISK ASSESSMENT FOR THE C-400 COMPLEX

Decisions and questions
4-1: Where have contaminants been detected?
4-2: Are isolated AOCs present or is contamination general?
4-3: What are the contaminants of concern (COCs) that define the contamination?
4-4: What are the characterization levels?
4-5: Are SWMUs within the C-400 Complex RI/FS similar enough to be addressed in the same manner?

Decision rule	Evaluation method	Data needs
D4a: If the concentration of analytes found could result in a cumulative ELCR greater than 1×10^{-6} or a cumulative HI greater than 1 through contact with contaminated media and/or debris (as applicable), or exceeds a chemical-specific ARAR, then evaluate remedial alternatives or otherwise pursue a "no further action" decision (see D4b).	Screening Quantitative comparisons by medium between detected concentrations of analytes, background concentrations and PRGs	Results of previous investigations, reports, and treatability studies to target sampling locations and analytical requirements, including the identification of suspected contaminants
	Quantitative comparison by medium between detected concentrations of analytes and ecological receptor benchmarks	Sampling data from each medium (e.g., groundwater, soil, concrete), including extent of source zone
	Conduct a screening risk evaluation of the combined newly generated data and historical data to complement the previously performed BHHRA (DOE 1999a) and a SERA (Steps 1 and 2) (DOE 2019b)	Site use and activity history
		Procedures and methods for human health risk assessment and SERA
		Procedures and methods for performing comparisons
		Current and expected land-use patterns (industrial)
		Potential ARARs

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

Decision rule	Evaluation method	Data needs
D4b: 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 any chemical-specific ARARs, **and** if the concentrations of these contaminants could result in risks greater than those defined in D4a or concentrations greater than any chemical-specific ARARs, then evaluate remedial alternatives that will mitigate potential future risk and/or obtain compliance with the impacted chemical-specific ARARs.	Quantitative comparison by medium between analyte concentrations and any ARARs Evaluate if ARAR waiver or other alternative standards are appropriate	Results of previous investigations, reports, and treatability studies to target sampling locations and analytical requirements Sampling data from each medium (e.g., groundwater, soil, concrete) Site use and activity history Potential 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 C-400 Complex RI/FS (Continued)

GOAL 5: IDENTIFY, DEVELOP, AND EVALUATE REMEDIAL ALTERNATIVES
Decisions and questions What is the nature and extent of contamination? What are stakeholder's perceptions of potential remedial alternatives? What are the principal threats? What media are contaminated to unacceptable levels? What contaminant groups are present driving the unacceptable risk? What are the preliminary RAOs? What is unacceptable risk? What are the PRGs? What are the general remedial alternatives/what are the remedial technology types? What is the schedule of remedial action? What are the possible remedial technologies applicable for this unit? Are potential remedial technologies incompatible? Are cultural and infrastructure impediments present? What are the potential remedial process option(s) to be used/what are the potential representative remedial technologies to be assessed? What are the physical, chemical, and hydrogeological properties of media to be remediated? What treatability studies would be required? What is the area/volume of affected media? Are potential remedial process options innovative or proven? Are potential remedial process options applicable to multiple contaminant families? What would be the impact of a potential remedial process option on and by other sources? What would the impact of potential remedial process options on the integrator units (e.g., groundwater)? Are there geologic limitations to potential remedial process options? Are potential remedial process options acceptable to the community and state? Are potential remedial process options reversible?

Table 1.1. Decision Rules, Evaluation Methods, and Data Needs for C-400 Complex RI/FS (Continued)

Decision rule	Evaluation method	Data needs
D5a: If Decision D2a, D2b, D3a, D3b, D4a, or D4b indicates that remedial alternatives are needed, then evaluate remedial alternatives 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 any 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 any ARARs Evaluation of existing risk management procedures or activities currently being conducted at the site	Data listed for D1a, D1b, 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 characteristics, grain size, cation exchange, chemical oxygen demand, pH, hydraulic conductivity, microbial community, natural oxidant demand, and moisture content of soils Potential ARARs

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2. PROJECT ORGANIZATION AND MANAGEMENT PLAN

This section presents the project organization for this C-400 Complex RI/FS. The topics addressed in this chapter include project organization, project coordination, project tasks and implementation plan, project schedule, and RI/FS Work Plan activities.

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 C-400 Complex RI/FS. The responsibilities of key personnel are described in the following paragraphs.

2.1.1 DOE Project Manager

The DOE Project Manager (PM) will provide technical and management oversight for DOE for the C-400 Complex RI/FS. This individual also will be the primary interface between EPA, KDEP and the DOE Prime Contractor.

2.1.2 DOE FFA Manager

The DOE FFA Manager oversees implementation and compliance with the terms of the FFA and has overall FFA responsibility for DOE. This individual will serve as the primary interface among EPA, KDEP, and the DOE Prime Contractor FFA Managers. This individual also will interface with the DOE Project Manager, DOE Prime Contractor personnel, and the regulators for FFA activities related to the C-400 Complex OU, as appropriate.

2.1.3 DOE Prime Contractor Environmental Services Director

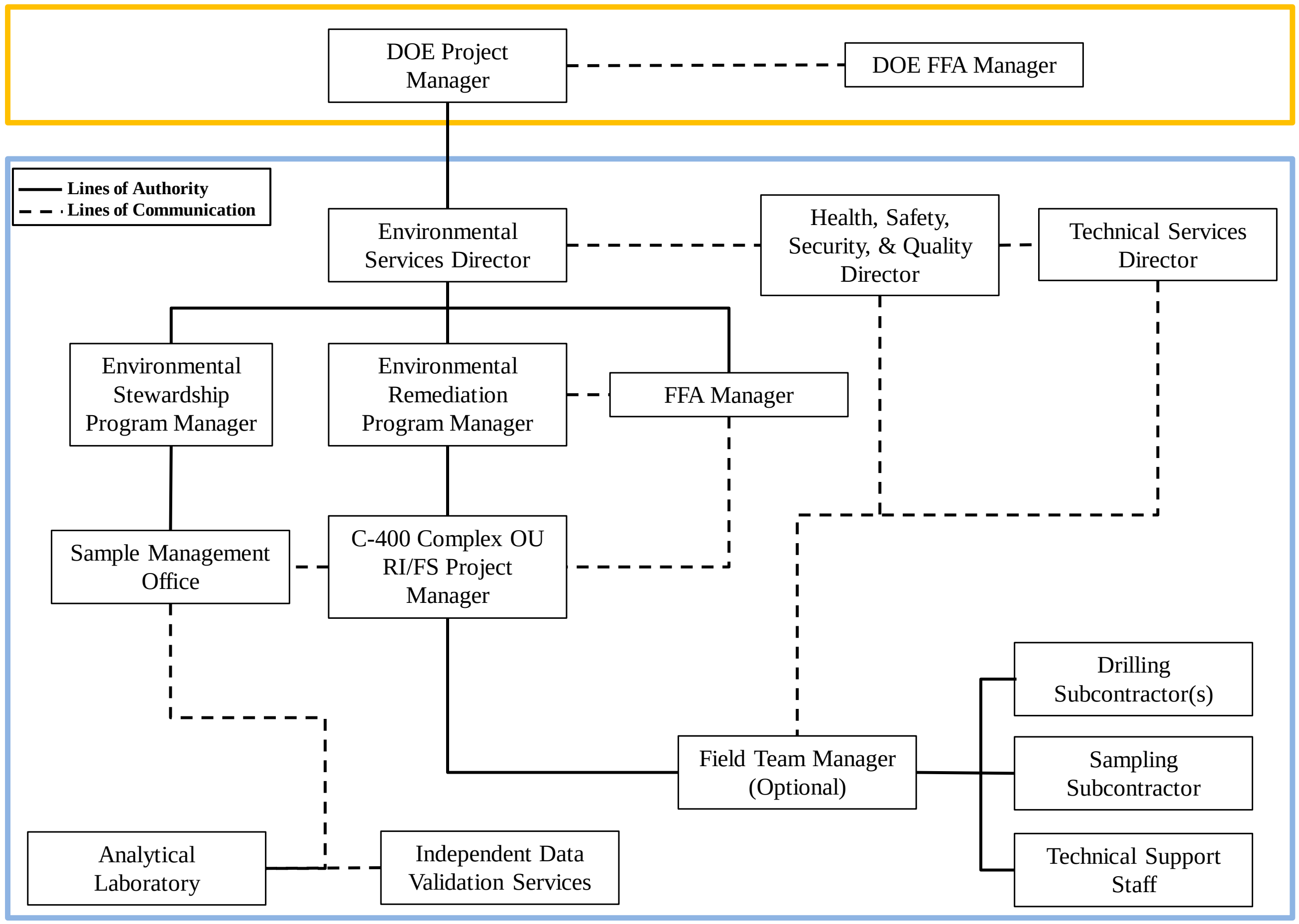
The DOE Prime Environmental Services Director will have overall programmatic responsibility for the Contractor for the technical, financial, and scheduling of matters related to the C-400 Complex RI/FS. This individual will interface with DOE and the regulators, as appropriate.

2.1.4 DOE Prime Contractor Health, Safety, Security, and Quality Director

The DOE Prime Contractor Health, Safety, Security, and Quality (HSS&Q) Director will have overall HSS&Q program responsibility for the Contractor. The HSS&Q Director will provide support/resources to the Environmental Service Director and/or the C-400 RI/FS Field Team, as necessary. This individual will interface with DOE and the regulators, as appropriate.

2.1.5 DOE Prime Contractor Technical Services Director

The DOE Prime Contractor Technical Services Director will have overall programmatic responsibility for the Contractor for engineering, work controls, waste management, etc., related to the C-400 Complex RI/FS. This individual will interface with DOE and the regulators, as appropriate. The Technical Services Director will provide support/resources to the Environmental Service Director and/or the C-400 RI/FS Field Team, as necessary. This individual will interface with DOE and the regulators, as appropriate.



Note: DOE personnel are in Orange Box, and DOE Prime Contractor personnel are in Blue Box.

Figure 2.1. C-400 Complex RI/FS Organizational Chart

2.1.6 DOE Prime Contractor Federal Facility Agreement Manager

The DOE Prime Contractor FFA Manager will have overall FFA responsibility for the Contractor. This individual reports to the Environmental Services Director. This individual will coordinate with the DOE Federal Facility Manager and also will interface with the C-400 Complex OU RI/FS Project Manager, DOE, and the regulators, as appropriate.

2.1.7 DOE Prime Contractor Environmental Remediation Program Manager

The DOE Prime Contractor Environmental Remediation Program Manager will have overall programmatic responsibility for the Contractor related to the environmental remediation projects across the site. This individual reports to the Environmental Services Director. This individual will interface with C-400 Complex OU RI/FS Project Manager, DOE, and the regulators, as appropriate.

2.1.8 DOE Prime Contractor Environmental Stewardship Manager

The DOE Prime Contractor Environmental Stewardship Manager will have overall environmental stewardship responsibility (e.g., environmental compliance) for the Contractor. This individual reports to the Environmental Services Director. This individual will interface with the C-400 Complex OU RI/FS Project Manager, DOE, and the regulators, as appropriate.

2.1.9 DOE Prime Contractor C-400 Complex OU RI/FS Project Manager

The DOE Prime Contractor C-400 Complex OU RI/FS PM will have overall responsibility for implementing the investigation and conducting field activities. This individual also will serve as the RI/FS technical lead and the principal point of contact for preparation of the RI/FS report. The C-400 Complex RI/FS PM will track the project budget and schedules and will delegate specific responsibilities to project team members. This individual reports to the Environmental Remediation Program Manager. This individual will interface with DOE, and the regulators, as appropriate.

2.1.10 DOE Prime Field Team Manager

The DOE Prime Contractor Field Team Manager/Frontline Supervisor provides technical oversight and coordination for all field team activities during the investigation. The Field Team Manager/ Frontline Supervisor also acts as the primary contact for coordination of subcontractor field efforts and coordinates scheduling of support services from other groups such as Industrial Safety (IS)/Industrial Hygiene (IH) personnel, Waste Management personnel, Radiological Control personnel, Protective Services, Fire Services, and Infrastructure Management Contractor. This individual reports to the C-400 Complex OU RI/FS Project Manager. This individual will interface with the C-400 Complex OU RI/FS Project Manager, DOE, and the regulators, as appropriate.

2.1.11 DOE Prime Contractor RI/FS Technical Support

Throughout implementation of the RI/FS, a number of technical areas may support the project. Technical support areas that may provide support include, but are not limited to, the following.

- IS/IH Support
- Waste Management
- Quality Assurance (QA) Specialist
- Radiological Control
- Geologic Support

- Engineering
- Laborers and Operators
- Risk Assessor

2.2 PROJECT COORDINATION

Coordination and liaison between the DOE Prime Contractor and Subcontractor personnel will occur at various levels and among personnel appropriate to each level. DOE, regulatory agencies, and the DOE Prime Contractor will communicate via telephone, e-mail, and face-to-face meetings, as appropriate. Deviations from the work plan will be communicated upward through the chain of command to the regulatory agencies using communication tools commensurate with the issue.

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 this RI/FS project, as described below.

(1) The first step in this process was initial scoping of the RI/FS project internally and with EPA and KDEP. During this process, existing information was evaluated to develop a common understanding of operational history and existing nature and extent of contamination. In turn, the existing knowledge and project DQOs were used to design a sampling strategy to address defined data needs.

(2) The next step was preparation of this C-400 Complex RI/FS Work Plan. The sector sampling approaches developed from scoping meetings and information/evaluations as a result of scoping meeting discussions were used to develop this work plan.

(3) Implementation of this C-400 Complex RI/FS Work Plan will begin with procurement of subcontract services, such as drilling and sample support.

(4) Fieldwork will consist of several discrete activities, as outlined in this work plan, including drilling, sampling, sample handling, decontamination, waste management, and documentation. In addition, HSS&Q coordination will occur concurrently with the other activities. As discussed in Section 9, upon FFA approval of the RI/FS Work Plan and likely prior to drilling activities, initial field activities may include the Gamma Walkover Surveys (Appendix C); collection of 5-point grid composite soil samples (Section 9.1.2.1); and/or maintenance/redevelopment of existing MWs around the C-400 complex (based on the results of the MW assessment discussed in Section 9.1.2.4), as applicable.

(5) Field and laboratory data will be obtained, reduced, validated, verified, assessed, and summarized as required. 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 and contract screening. 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 Paducah Oak Ridge Environmental Information System (OREIS) and archived for future use.

(6) Technical exchange meetings will be conducted among personnel from EPA, KDEP, DOE, and the DOE Prime Contractor to evaluate the existing and newly collected data and to determine future actions.

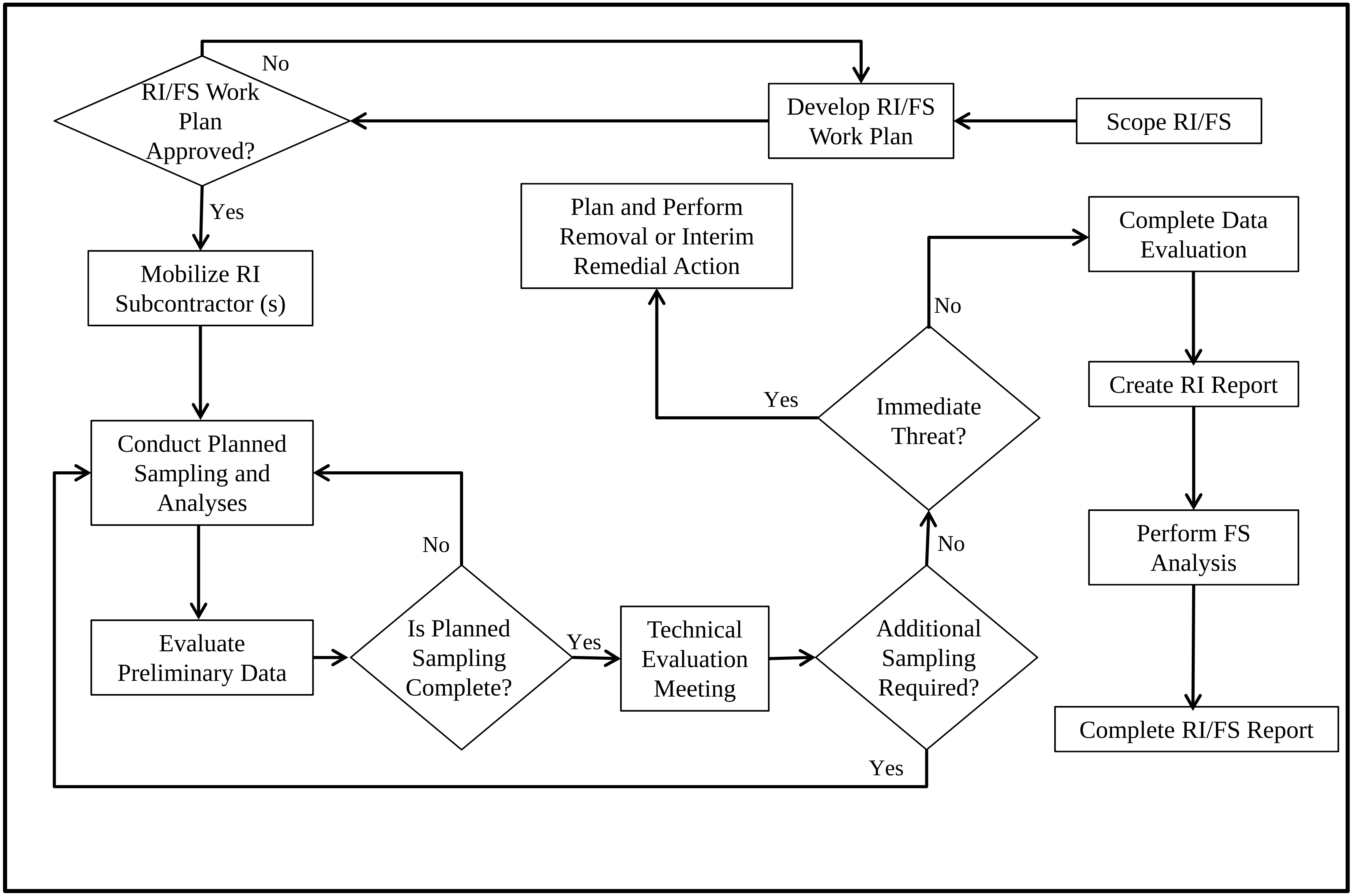


Figure 2.2. C-400 Complex OU RI/FS Process Flowchart Showing Major Activities and Decision Points

(7) Non-field-related tasks also may be performed during the RI/FS and include coordination of community relations during the project, preparation of a risk screening evaluation, implementation of the QA program, and evaluation of remedial technologies.

(8) The C-400 Complex RI/FS Report will be prepared and issued after samples and data have been processed and evaluated. Early removal and/or remedial actions will be considered and implemented, if appropriate, along with preparation of the necessary remedial decision documentation.

(9) Project management, tracking, and reporting will be conducted concurrently with all activities.

2.4 PROJECT SCHEDULE

Table 2.1 provides a schedule of the activities proposed for the C-400 Complex RI/FS Work Plan implementation. This schedule is an estimate for planning and is included here for informational purposes only and is not intended to establish enforceable schedules or milestones. Per the C-400 MOA, the C-400 dates are based on streamlined assumptions (no extensions and no disputes). Dates may be adjusted pursuant to the FFA, based on extensions or disputes. Enforceable milestones are contained in Appendix C of the Paducah FFA and Appendix 5 of the Paducah SMP as amended (DOE 2019a).

Table 2.1. C-400 Complex Final Remedial Action Schedule of Activities

Activities	Planning Schedule (fiscal year)
D1 RI/FS Work Plan	11/28/2018
RI/FS Field Start	2/15/2020
D1 RI/FS Report	1st Quarter 2022
D1 Proposed Plan	3rd Quarter 2022
D1 ROD	2nd Quarter 2023
D1 Remedial Design Work Plan	2nd Quarter 2023
D1 Remedial Design Report (90% RDR)	2nd Quarter 2024
D1 Remedial Action Work Plan	2nd Quarter 2024
C-400 Remedial Field Start	3rd Quarter 2024
D1 Remedial Action Completion Report	2nd Quarter 2031

2.5 RI/FS WORK PLAN ACTIVITIES

2.5.1 Field Preparation Activities

Prior to performing work on the site, personnel shall be required to read, or be briefed, on the DOE Prime Contractor's Worker Safety and Health Program, this HASP, applicable job hazard analyses (JHAs), the work package, and other applicable work control and project-related documents. This shall be documented on acknowledgement forms, briefing sheets, or as required reading. Visitors also will be oriented to the applicable plans and potential hazards that they may encounter. The Frontline Supervisor will ensure that field planning meetings and appropriate review(s) occur before fieldwork 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 performing the fieldwork associated with the project.

2.5.2 Field Investigation

Activities to be conducted during the field investigation include mobilization, implementation of HSS&Q procedures, drilling, sampling, and waste management. In addition, pre-built and as-built civil surveying activities will be performed to provide horizontal and vertical references for the locations being characterized.

2.5.3 Data and Analytical Activities

Activities concerning performance of data and analytical assessments are discussed in Chapters 5 and 6. Additionally, the following RI/FS Work Plan chapters support the data and analytical assessments to be conducted during this RI/FS:

- Quality Assurance Project Plan (QAPP)—Chapter 11
- Data Management Implementation Plan (DMIP)—Chapter 12

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3. REGULATORY SETTING

The sections that follow provide a condensed version of the regulatory framework for the Paducah Site. The summary in this chapter is intended to provide readers with general knowledge of the facility and the regulatory protocol that guides environmental management activities at the Paducah Site. Detailed descriptions can be found in the *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Annual Revision—FY 2018 and FY 2019* (DOE 2019a), as amended.

3.1 ADMINISTRATIVE ORDER BY CONSENT

EPA and DOE entered into the ACO effective November 1988, after discovery of contamination in residential wells north of PGDP. Kentucky provided regulatory review of the CERCLA ACO documents, but was not a signatory on the agreement. The ACO is a legally binding agreement for the participating parties that initiated the investigation into the nature and extent of the contamination impacting 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) (Phase I and Phase II) was completed in 1992 under the guidelines of the ACO (CH2M HILL 1992). The requirements of the ACO were superseded by the execution of the FFA (EPA 1998).

3.2 ENVIRONMENTAL PROGRAMS

Environmental sampling at the Paducah Site is a multimedia (air, water, soil, sediment, direct radiation, and biota) program of chemical, radiological, ecological, 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 environmental activities, SWMUs and areas of concern, both on and off the Paducah Site, have been identified. Characterization and/or remediation of these sites is continuing pursuant to CERCLA, and the Hazardous and Solid Waste Amendments (HSWA) corrective action conditions of RCRA Permit. RCRA and CERCLA requirements are coordinated by DOE, EPA, and KDEP through the FFA.

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 the Paducah Site are contained in Paducah's Hazardous Waste Management Facility Permit (KY8-890-008-982, initially issued July 1991). This permit originally was issued by both 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 was authorized in 1996 for the corrective action provisions of HSWA. The RCRA permit contains regulatory provisions for treatment, storage, and disposal units, as well as for provisions requiring corrective action for SWMUs.

3.4 CERCLA/NATIONAL PRIORITIES LIST

PGDP was placed on the National Priorities List on May 31, 1994. In accordance with Section 120 of CERCLA, DOE entered into an FFA with EPA and KDEP in 1998. The FFA established one set of consistent requirements for achieving comprehensive site remediation in accordance with RCRA and CERCLA, including stakeholder involvement.

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 (DOE 1994). 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 socioeconomic impacts, to the extent practicable.

3.6 INVESTIGATIVE OVERVIEW

This RI/FS Work Plan defines the sampling necessary to obtain sufficient data to complete the risk assessment and the FS for the C-400 Complex. Areas included in the C-400 Complex have undergone previous environmental investigations and remedial actions. The strategy for this work plan is to conduct a combined RI/FS for the C-400 Complex area that includes an investigation of all remaining building structure(s) (e.g., slab and subsurface structures) and releases of any hazardous substances to soils and groundwater associated with the C-400 Cleaning Building and C-400 Complex area operations (including, but not limited to, TCE DNAPL and high concentration areas considered PTW) (DOE 2017a). RI/FS characterization is to define the full nature and extent of all contamination within the C-400 Complex from the surface down through the RGA and to include the upper McNairy Formation.

4. ENVIRONMENTAL SETTING AND SITE CHARACTERIZATION

The Paducah Site consists of an inactive diffusion cascade system and associated support facilities. The enrichment process required extensive support facilities, and included a steam plant, four major electrical switchyards, four sets of cooling towers, a building for chemical cleaning and decontamination (C-400 Cleaning Building), a water treatment plant, and maintenance and laboratory facilities.

Source units and AOCs at the Paducah Site have been combined into OUs for evaluation of remedial alternatives. Each OU is designed to remediate contaminated media associated with the Paducah Site. These OUs include the C-400 Complex consisting of the C-400 Cleaning Building and the surrounding block. The C-400 Complex is located inside the fenced security area, near the center of the industrial section of the Paducah Site. The C-400 Complex is bounded by 10th and 11th Streets to the west and east, respectively, and by Virginia and Tennessee Avenues to the north and south, respectively (Figure 1.2).

4.1 LOCATION

The Paducah Site is located approximately 10 miles west of Paducah, Kentucky, 3.5 miles south of the Ohio River in the western part of McCracken County (Figure 1.1). The plant is located on a 3,556 acre DOE-owned site. Approximately 628 acres of the Paducah Site are within a fenced security area, approximately 809 acres are located outside the security fence, 133 acres are in acquired easements, and the remaining 1,986 acres are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA). Bordering the Paducah Site to the northeast, between the plant and the Ohio River, is a Tennessee Valley Authority (TVA) reservation on which the Shawnee Fossil Plant is located (Figure 4.1). This figure represents both the current land use and the 229 Boundary revision, per *Federal Register*, Notices, Vol.83, No. 213, dated November 2, 2018. In subsequent figures that delineate the 229 boundary, the boundary will be referred to as the "fenced security area."

The topographic features at the site include nearly level to gently sloping dissected plains and the flood plain of the Ohio River. The elevations of the stream valleys in the dissected plains are up to 30 ft lower than the adjoining uplands.

Local elevations range from 290 ft above mean sea level (amsl) along the Ohio River to 450 ft amsl southwest of the Paducah Site. Generally, the topography in the Paducah Site area slopes toward the Ohio River at an approximate gradient of 27 ft per mile (CH2M HILL 1992). Ground surface elevations vary from 360 to 390 ft amsl within the fenced security area and 340 to 420 ft amsl within the greater Paducah Site.

4.2 DEMOGRAPHY AND LAND USE

The Paducah Site is surrounded by WKWMA and sparsely populated agricultural lands. The closest communities to the plant are Heath, Grahamville, and Kevil, all of which are located within 3 miles of the Paducah Site boundaries. Metropolis, Illinois, is located 5 miles to the northeast, Paducah, Kentucky, is located approximately 10 miles to the east, and Cape Girardeau, Missouri, is located approximately 40 miles to the northwest.

Historically, the economy of Western Kentucky has been based on agriculture, although there has been increased industrial development in recent years. The Paducah Site employs approximately 1,270 people,

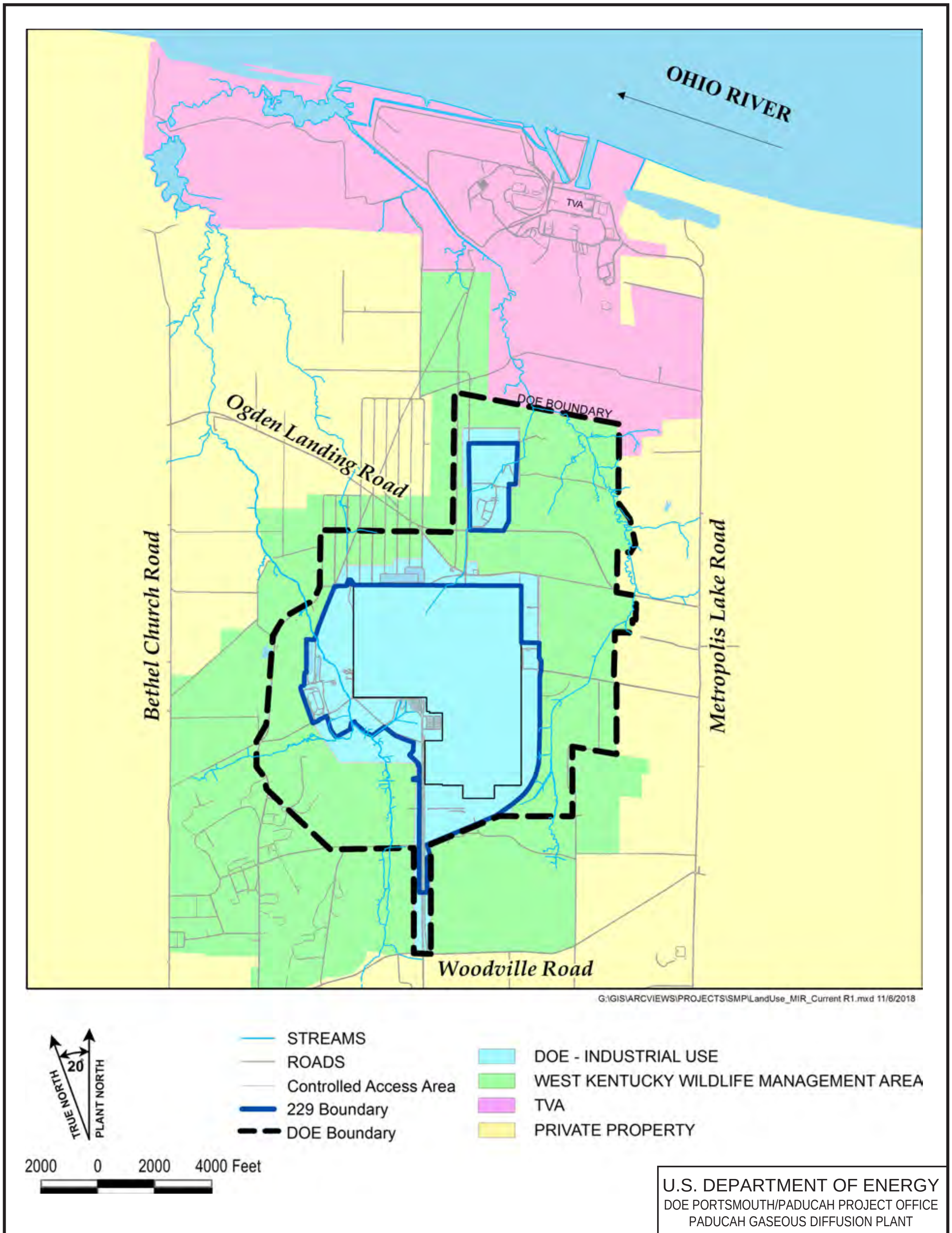

Figure 4.1. Current Land Use at the Paducah Site

while the TVA Shawnee Fossil Plant employs an additional 275 people. The total population within the counties that lie within a 50 mile radius of the Paducah Site is approximately 731,500; and approximately 87,750 people live within the three counties that contain the 10-mile radius of the plant (Massac County, Illinois, and Ballard and McCracken Counties, Kentucky) (DOC 2018). The estimated population of Paducah, Kentucky, is approximately 25,000. The population of McCracken County is estimated to be approximately 65,375 (DOC 2018).

In addition to the residential population surrounding the plant, WKWMA draws thousands of visitors each year for recreational purposes. WKWMA is used by visitors, primarily for hunting and fishing, but other activities include horseback riding, dog trials, hiking, and bird watching.

4.3 GENERAL HISTORY

PGDP is an inactive uranium enrichment facility owned by DOE. Construction of PGDP began in 1951 and operations initiated in 1952. From 1953 until 1977, most of the uranium hexafluoride (UF_6) used by PGDP was produced from feedstock in the feed plant (C-410 Building), which was designed to process both natural uranium and uranium from reactor tails. The reactor tails included uranium that had been returned for re-enrichment from the plutonium production reactors at the DOE Hanford and Savannah River plants. As a result of nuclear reactions in the plutonium production reactors, the reactor tails contained Tc-99 and are believed to be the sole source of Tc-99 released to the environment at PGDP. Beginning in 1977, PGDP was supplied with UF_6 feedstock from commercial vendors, such as Honeywell in Metropolis, Illinois, and from foreign sources.

C-400: In June 1986, a routine construction excavation along the 11th Street storm sewer revealed TCE soil contamination. The cause of the contamination was determined to be a leak in a drain line from the C-400 Cleaning Building’s basement sump to the storm sewer. The amount of TCE released is unknown. The area of contamination became known as the C-400 Trichloroethylene Leak Site and was given the designation of SWMU 11. SWMU 11 and the C-400 area have been the subjects of several investigations since then.

PGDP-related groundwater contaminants were found in groundwater wells north of the Paducah Site in August 1988. DOE conducted a Phase I and Phase II CERCLA SI, beginning in 1989 and concluding in 1992, for the following reasons: (1) to evaluate the nature and extent of off-site contamination originating at PGDP and (2) to evaluate on-site source of contamination and to develop sufficient characterization data for supporting an assessment of remedial alternatives. The investigations found that various hazardous, nonhazardous, and radioactive wastes resulting from ongoing operations had been generated and disposed of at PGDP. The SIs determined that TCE and Tc-99 in groundwater and uranium and polychlorinated biphenyls (PCBs) in surface water and sediment were the four primary environmental COCs at the facility (CH2M HILL 1991; CH2M HILL 1992). Since the plant’s construction, TCE had been used as a cleaning solvent. PGDP discontinued use of TCE as a degreaser on July 1, 1993.

The Phase I and Phase II CERCLA SIs included the C-400 area within its scope, with the installation of soil borings and groundwater MWs (CH2M HILL 1991; CH2M HILL 1992). These investigations confirmed that TCE contamination at the southeast corner of C-400 extended from the surface to the base of the RGA at approximately 92 ft below ground surface (bgs). A subsequent Groundwater Monitoring Phase IV Investigation demonstrated that the C-400 area was a potential major source for the Northwest Plume (DOE 1995a).

The Waste Area Grouping (WAG) 6 RI, as well as other investigations and studies, characterized the nature and extent of contamination around the C-400 Cleaning Building (DOE 1999a). Analytical results from the WAG 6 RI indicate that the primary site-related volatile organic compounds (VOCs) in the subsurface soil and groundwater in the C-400 Cleaning Building area are TCE and its breakdown products [*trans*-1,2-dichloroethene (DCE), *cis*-1,2-DCE, and vinyl chloride] and 1,1-DCE. The WAG 6 RI concluded that there are zones of dense nonaqueous-phase liquid (DNAPL) TCE in the UCRS and RGA adjacent to and potentially beneath the C-400 Cleaning Building. Data from the WAG 6 RI, as well as other investigations and studies, indicate that DNAPL zones in the southeast area of the C-400 Cleaning Building area account for the majority of the known mass of DNAPL at PGDP. As part of the WAG 6 RI, UCRS soil was characterized and shown to be a residual source of DNAPL.

A treatability study conducted in 2003 was a test of full-scale deployment of electrical resistance heating (ERH) technology in the area adjacent to the southeast corner of the C-400 Cleaning Building. This study included the installation and operation of one six-phase heating (SPH) treatment array and a vapor recovery system. The SPH treatability study began on February 14, 2003, and was discontinued on September 6, 2003. The primary objective was to demonstrate implementability of the ERH technology in unsaturated and saturated soils of the UCRS and in the groundwater of the underlying RGA (DOE 2001a). Comparison of pretreatment and post treatment sample results was used to measure treatment efficacy. Approximately 1,900 gal of TCE was removed from the subsurface. The SPH treatability study achieved a 98% reduction of TCE concentrations in UCRS soils and a 99.1% reduction of TCE concentration in RGA groundwater, which met the removal efficiency criteria. The residual contaminant levels averaged 2,493 µg/kg, with a maximum of 49,200 µg/kg in soil, and averaged 6,394 µg/L, with a maximum of 10,100 µg/L in groundwater, within the RGA and inside the treatment zone (DOE 2004a).

DOE conducted a Remedial Design Support Investigation (RDSI) in 2006 with the purpose of improving the ERH design by determining the subsurface soil conditions and the presence and relative concentration of VOCs in the UCRS, the RGA, and the RGA/Upper McNairy interface. This RDSI used membrane interface probe (MIP) technology to define the extent of source zones of TCE (DOE 2005a). During the RDSI, 18 MIP borings were completed through the UCRS to a depth of approximately 55 ft bgs, and 33 MIP borings were completed to the base of the RGA at an approximate depth of 100 ft bgs. The RDSI Characterization Plan optimized location and depth of the MIP borings to complement the characterization data from the WAG 6 RI. These data characterized the three-dimensional aspects of the TCE DNAPL source zones and demonstrated that the residual TCE distribution was consistent with the conceptual model from the WAG 6 RI. Moreover, the data showed that the vertical extent of the DNAPL did not extend downward (beyond 1 ft) into the McNairy Formation below the primary RGA DNAPL pool at the base of the RGA.

The *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (ROD) selected ERH as the remedy to address VOC source mass in the UCRS and the RGA in treatment areas immediately adjacent to the C-400 Cleaning Building (DOE 2005b). ERH was implemented in two phases, Phase I (beginning December 2008) and Phase II (beginning September 2012). The Phase I ERH system consisted of a network of in ground electrodes and vapor extraction wells distributed throughout the east and southwest zones of contamination in a three-phase heating pattern. The east and southwest areas were selected for Phase I because they were the smallest of the source areas near the C-400 Cleaning Building and had contaminants primarily in the UCRS. Phase II was to follow Phase I to treat the southeast area, which was expected to contain a larger amount of source contamination in both the UCRS and the RGA. Figure 4.2 illustrates the locations of the interim remedial action with respect to the C-400 Cleaning Building. For informational purposes, Figure 4.2 also shows the area in which a steam treatability study was performed.

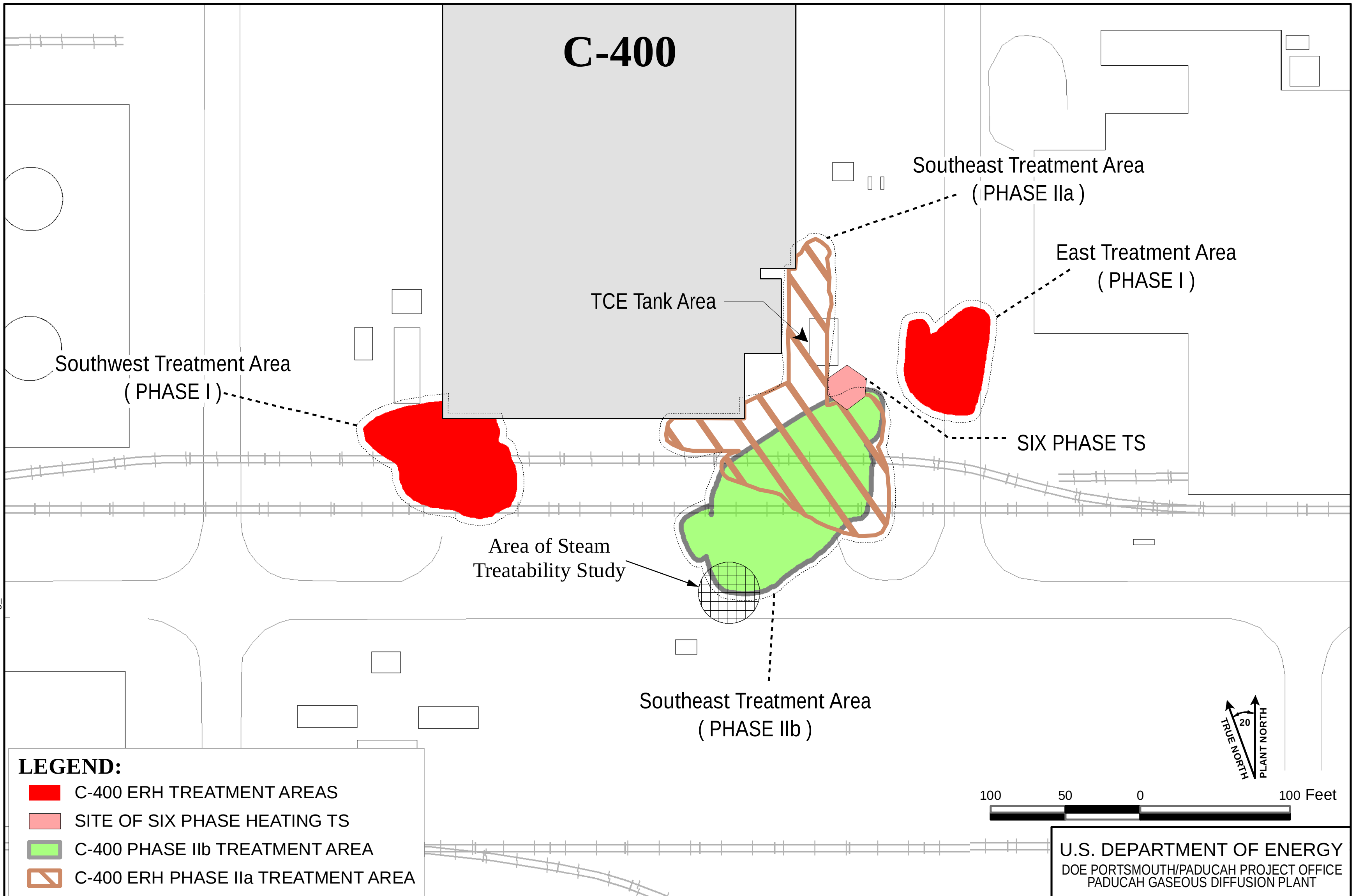

Figure 4.2. C-400 Cleaning Building Interim Remedial Actions

Phase I operations were completed in December 2010. Approximately 535 gal of VOCs (primarily TCE) was removed. Phase I ERH reduced soil TCE concentrations by 95% in the East Treatment Area and by 99% in the Southwest Treatment Area. The residual contaminant levels averaged 29 µg/kg, with a maximum of 315 µg/kg, in the East Treatment Area and averaged 15 µg/kg, with a maximum of 228 µg/kg, in the Southwest Treatment Area.

An important objective of Phase I was to evaluate the heating performance of the base ERH design through the RGA down to the McNairy Formation interface in the Southwest Treatment Area. During Phase I, temperature goals were not attained in the lower RGA in the Southwest Treatment Area, particularly below 70 ft bgs (refer to the Phase I Technical Performance Report) (DOE 2011a).

In 2011, an additional RDSI was completed. Soil and groundwater samples were collected from the Phase II Southeast Treatment Area to provide data for reevaluation of the TCE mass estimate. Two goals of the investigation were as follows:

1. Development of predictive relationships of previous and proposed MIP responses to current TCE concentrations, and

2. Assessment of the TCE DNAPL mass and volume within the C-400 Phase II treatment area.

Additional information regarding the predictive relationships and initial mass volume estimate approaches is included in the C-400 Cleaning Building Remedial Design Report, Appendix A (DOE 2012a).

Because of the inability of ERH to reach target temperatures in the lower RGA during the Phase I remedy, the FFA parties agreed to divide Phase II into Phase IIa (using ERH to address the UCRS and upper RGA to a depth of 60 ft bgs) and Phase IIb (using a technology to be decided to address the lower RGA). Phase IIb has been incorporated into the C-400 Complex OU. Phase IIa operations were completed in fall of 2014 and consisted of the implementation of ERH in the UCRS and upper RGA in the Southeast Treatment Area. Phase IIa operations removed approximately 1,137 gal of VOCs (primarily TCE). The median of TCE concentration reductions in collocated preoperational versus post operational soil samples of Phase IIa was 99.8%. The residual contaminant levels averaged 200 µg/kg, with a maximum of 10,000 µg/kg in the Phase IIa treatment area.

4.4 REGIONAL GEOLOGIC SETTING

The Paducah Site is located in the Jackson Purchase region of western Kentucky, which represents the northern most extent of the Mississippi Embayment portion of the Coastal Plain Province. The stratigraphic sequence in the region consists of Cretaceous [144 to 65 million years ago (mya)]; Tertiary (65 to 1.8 mya); and Quaternary (1.8 mya to today) sediments unconformably overlying Paleozoic (543 to 248 mya) bedrock (Paleozoic strata younger than Mississippian are not present at the site).

PGDP is situated near the New Madrid Seismic Zone, which is a seismically active region. Geophysical investigations of the Paducah Site identify the south extension of high-angle, northeast-trending faulting in the bedrock beneath the Paducah Site that likely is associated with the Fluorspar Area Fault Complex of southern Illinois. Inferred age of faulting is consistent with age of faulting in southern Illinois. The Barnes Creek Fault Zone of southern Illinois (approximately 7.5 miles northeast of PGDP), if extended sufficiently southward below the Mississippi Embayment, most likely would pass under or near PGDP (on the east side). Another southern Illinois fault zone that could pass below or near PGDP (possibly on the west side) is the Massac Creek Structure of the Hobbs Creek Fault Zone (approximately 8 miles northeast of PGDP).

Two recent, major seismic field studies have been conducted at the Paducah Site. These area field investigations are at the site of a potential CERCLA waste disposal facility called Site 3A (DOE 2004b) and a field investigation in support of the expansion of the current C-746-U Solid Waste Landfill (KRCEE 2006). Site 3A is located immediately south of the PGDP security-fenced area (DOE 2004b), and the C-746-U Landfill is located l mile north of the PGDP security-fenced area (KRCEE 2006). These field studies identified subsurface faulting, exhibiting both normal and reverse displacement from the carbonate bedrock extending upward and into the Continental Deposits, in both locations. Specifically, the Site 3A investigation identified a series of faults beneath Site 3A (DOE 2004b). For most of the faults beneath Site 3A, relative movement along the main fault plane is normal, with the downthrown side to the east. These normal faults, along with their associated splays, either form a series of narrow horst and graben features or divide the local sediments into a series of rotated blocks. Several of the faults extend through the Porters Creek Clay and into the materials underlying the surficial loess. Three of these faults extend to within approximately 20 ft of the ground surface. Age dating analysis of soil core samples at these locations determined that the latest faulting was pre-Holocene age at both sites (DOE 2018b).

More recently, a review of results from seismic (shear wave) and electrical resistivity (dipole-dipole) experiments implied that the groundwater TCE plumes at PGDP are aligned with the general orientation of an underlying Paleozoic fault system (Almayahi and Woolery 2018). This implication is consistent with alignment of the Northwest Plume with a series of imaged grabens identified by Blits, Woolery, Macpherson, and Hampson in 2008.

4.5 GEOLOGY OF THE PADUCAH SITE

The Paducah Site, including the C-400 Complex, is underlain by a sequence of clay, silt, sand, and gravel layers deposited on limestone bedrock. The sediments above the limestone bedrock are grouped into three major stratigraphic units (loess, Continental Deposits, and McNairy Formation) and three major hydrogeologic units (UCRS, RGA, and McNairy Flow System) as shown in Figure 4.3.

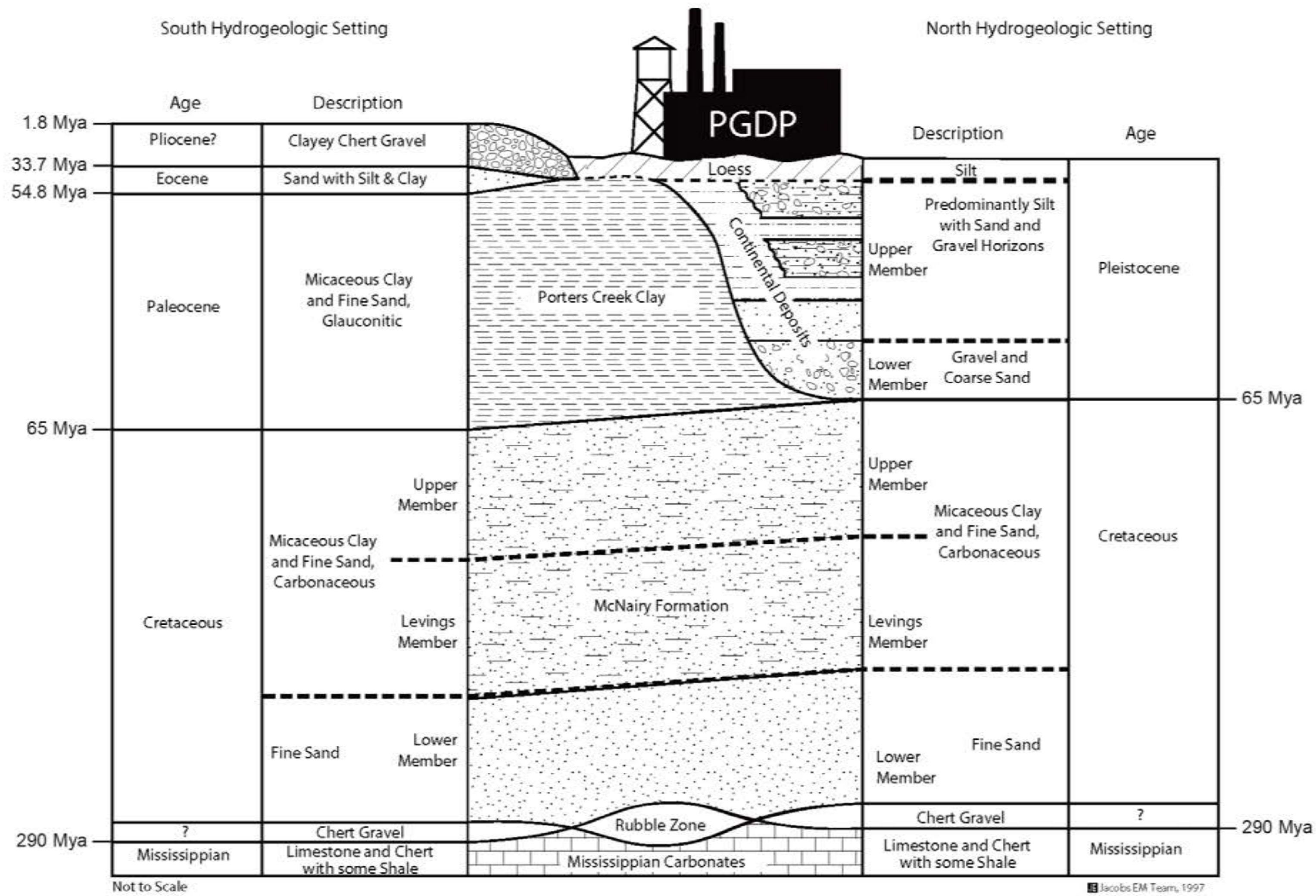

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Figure 4.3. Stratigraphy in the Vicinity of the Paducah Site

Across the Paducah Site, the upper-most stratigraphic unit consists primarily of wind-deposited, clayey silt, known as loess, extending from the surface to a depth of approximately 20 ft bgs. Fill material, when present, is included in this unit. Beneath the loess, the Upper Continental Deposits, a subunit of the Continental Deposits consisting of discontinuous sand and gravel layers within a sequence of silts and clays, extends to an average depth of 60 ft bgs. The Lower Continental Deposits, also a subunit of the Continental Deposits, is a highly permeable layer of gravelly sand or chert gravel, typically extending from approximately 60 to 90 ft bgs. Below the Continental Deposits is the McNairy Formation, a sequence of silts, clays, and fine sands that extends from approximately 90 to 350 ft bgs. These depths represent general conditions; depths vary at specific locations.

Groundwater flow through the loess and the Upper Continental Deposits is predominately downward into the Lower Continental Deposits. The groundwater flow system in the loess and the Upper Continental Deposits is called the UCRS. Sand and gravel lenses locally present in the top of the Upper Continental Deposits are separated from the underlying RGA by a 12- to 18-ft-thick silty or sandy clay aquitard, the deepest layer in the UCRS. This aquitard reduces the vertical flow of groundwater from the sand and gravel units of the UCRS to the gravels of the RGA.

The groundwater flow system primarily developed in the Lower Continental Deposits is called the RGA and constitutes the uppermost aquifer beneath the Paducah Site and the adjacent area to the north. The RGA consists of a basal sand member of the Upper Continental Deposits and the thick sand and gravel member of the Lower Continental Deposits. The RGA potentiometric surface slopes to the north beneath the Paducah Site. In the area of the C-400 Complex, the depth of the RGA potentiometric surface is approximately 53 ft bgs (DOE 2004a). Groundwater flow in the Lower Continental Deposits is generally northward toward the Ohio River, although there is variability in groundwater flow as evidenced by the existence of multiple groundwater plumes.

Below the RGA is the McNairy Flow System, which corresponds to the McNairy Formation. The McNairy Formation consists of fine sands, silts, and clays of marine origin. High contrast of hydraulic conductivity between the conductive Lower Continental Deposits and relatively nonconductive McNairy Formation limits flow between the Lower Continental Deposits and the McNairy. A middle member of the McNairy Formation, the Levings Member, contains a higher proportion of silt and clay.

The depth of the shallow water table within the UCRS varies considerably across the Paducah Site. In the C-400 Complex, ground covers (i.e., asphalt and concrete) and engineered drainage (i.e., storm sewers and ditches) limit rainfall infiltration. In MW157, which monitors the water table depth directly at the south end of the C-400 Complex, the water table depth averages 31 ft (Chapter 9).

Subsequent subsections briefly discuss the formations represented in Figure 4.4 to detail Paducah Site geology.

4.5.1 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 undetermined. Where it occurs, the rubble zone ranges from approximately 5 to 20 ft in thickness.

SYSTEM	SERIES	FORMATION	THICKNESS IN FEET	DESCRIPTION	HYDROGEOLOGIC SYSTEMS
Quaternary	Pleistocene and Recent	Alluvium	0-40	Brown or gray sand and silty clay or clayey silt with streaks of sand	Upper Continental Recharge System (UCRS)
	Pleistocene	Loess		Brown or yellowish-brown to tan to gray unstratified silty clay	
	Pleistocene	Continental Deposits	3-121	Upper Continental Deposits (Clay Facies) Orange to yellowish brown to brown clayey silt, some very fine sand, trace of fine sand to gravel. Often micaceous.	
Tertiary	Pliocene(?)			Lower Continental Deposits (Gravel Facies) Reddish-Brown silty and sandy gravel, silt and clay.	Regional Gravel Aquifer
	Eocene	Eocene Sands (Undiff)	0-100	Red brown, or white fine to coarse grained sand. Beds of white to dark gray clay are distributed at random.	McNairy Flow System
				White to gray sandy clay, clay conglomerate and boulders, scattered clay lenses and lenses of coarse red sand. Black to dark gray lignitic clay, silt, or fine grained sand.	
	Paleocene	Porters Creek Clay	0-200	Dark gray, slightly to very micaceous clay. Fine grained clayey sand, commonly glauconitic in the upper part. Glauconitic sand and clay at the base. A Gravel layer ("Terrace Gravels") present atop the clay terrace, 2-8 feet thick	
Cretaceous		Clayton and McNairy Formations	200-300	Grayish white to dark micaceous clay, often silty, interbedded with light gray to yellowish brown very fine to medium grained sand. The upper part is mostly clay, the lower part is predominantly micaceous fine sand.	
		Tuscaloosa Formation	?	White, well rounded or broken chert gravel with clay.	
Mississippian		Mississippian Carbonates	500+	Dark gray limestone and interbedded chert, some shale.	

Adapted from:
Finch, W.I., 1967 Geological Map of part of the Joppa Quadrangle, McCracken County, Kentucky, U.S. Geological Survey GQ-652
Olive, W.W., 1966 Geological Map of part of the Heath Quadrangle, McCracken and Ballard Counties, Kentucky, U.S. Geological Survey GQ-561

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Figure 4.4. Lithostratigraphic Column of the Jackson Purchase Region

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4.5.2 Bedrock

Mississippian (354 to 323 mya) carbonates, consisting of a dark gray limestone with some interbedded chert and shale, underlie the entire Paducah Site at depths varying from 340 to 400 ft. The thickness of these carbonates is estimated to be greater than 500 ft.

4.5.3 McNairy Formation

The McNairy Formation consists of Upper Cretaceous sediments of gray to yellow to reddish-brown, very fine- to medium-grained sand interbedded with grayish-white to dark gray micaceous silt and clay. A basal sand member also is present beneath the Paducah Site. The total thickness of the McNairy Formation ranges from 200 to 300-ft thick.

4.5.4 Porters Creek Clay/Porters Creek Clay Terrace Slope

The Paleocene (65 to 54.8 mya) Porters Creek Clay occurs in the southern portions of the Paducah Site and consists of dark gray to black silt with varying amounts of clay and fine-grained micaceous, commonly glauconitic, sand. It can be as thick as 200 ft beneath the Paducah Site. The Porters Creek Clay subcrops along a buried terrace slope that extends east–west across the site. This subcrop is the northern limit of the Porters Creek Clay and the southern limit of the Pleistocene (1.8 mya to 11,000 years) Lower Continental Deposits under the Paducah Site.

4.5.5 Eocene Sands

Eocene (54.8 to 33.7 mya) sands occur above the Porters Creek Clay in the extreme southwestern part of the Paducah Site and do not underlie the C-400 Complex. This unit includes undifferentiated quartz sands and interbedded and interlensing silts and clays of the Claiborne Group and Wilcox Formation (Olive 1980). The Eocene sands thicken south of the Paducah Site. The Claiborne Group ranges up to 200-ft thick, and the Wilcox Formation may be up to 100-ft thick.

4.5.6 Continental Deposits

Continental sediments [Pliocene (?-age uncertain) (5.3 to 1.8 mya) to Pleistocene (1.8 mya to 11,000 years ago)] unconformably overlie the Cretaceous through Eocene strata throughout the area. These continental sediments were deposited on an irregular erosional surface consisting of several terraces and have a total thickness from near zero to about 120 ft. The thicker Continental Deposits sections represent Pleistocene valley fill sediments that comprise a fining-upward cycle. The continental sediments have been divided into the following two distinct facies:

(1) Lower Continental Deposits. The Lower Continental Deposits is a gravel facies consisting of chert, ranging from pebbles to cobbles, in a matrix of poorly sorted sand and silt. Gravels of the Lower Continental Deposits overlie three distinct terraces in the Paducah Site area.

- The upper terrace of the Lower Continental Deposits consists of Pliocene (?-age uncertain) gravel units, ranging in thickness from near 0 to 30 ft, occurring in the southern portion of the Paducah Site at elevations greater than 350 ft amsl. This gravel unit overlies the Eocene sands and Porters Creek Clay (where the Eocene sands are missing).

- Pliocene (?-age uncertain) gravels of the Lower Continental Deposits also occur on an intermediate terrace eroded into the Porters Creek Clay at an elevation of approximately 320 to

345 ft amsl in the southeastern and eastern portions of the Paducah Site. The thickness of this unit typically ranges from 15 to 20 ft.

The Lower Continental Deposits of the upper and intermediate terraces are referred to collectively as the Terrace Gravel.

- The third and most prominent of the Lower Continental Deposits members consists of a Pleistocene gravel deposit resting on an erosional surface at an elevation of approximately 280 ft amsl. This gravel underlies most of the plant area and the region to the north, but pinches out under the south side of the Paducah Site along the subcrop of the Porters Creek Clay. The Pleistocene member of the Lower Continental Deposits averages approximately 30 ft in thickness. Trends of greater thickness, as much as 50 ft, fill deeper scour channels.

(2) Upper Continental Deposits. The Upper Continental Deposits is a Pleistocene age, fine-grained facies that commonly overlies the Lower Continental Deposits. This unit ranges in thickness from 15 to 55 ft. The Upper Continental Deposits includes three general horizons beneath the Paducah Site: (1) an upper silt and sand interval, (2) an intermediate interval of common sand and gravel lenses (sand and gravel content generally diminishes northward), and (3) a lower silt, sand, and clay interval. The upper silt and sand interval consists of the Peoria Loess and Roxana Silt (KRCEE 2006). The Peoria Loess and Roxana Silt blanket the entire Paducah Site area and range from zero to about 43 ft in thickness.

4.5.7 Surficial Deposits/Soils

The surficial deposits found in the vicinity of the Paducah Site are Pleistocene loess and Holocene alluvium (11,000 years ago to present). Both units commonly consist of silt or clayey silt and range in color from yellowish-brown to brownish-gray or tan, making field differentiation difficult.

Loess deposition probably occurred in upland areas during all stages of the glaciation that extended into the Ohio and Mississippi River Valleys. The upland areas are located in the southern portion of the Paducah Site and are characterized by a gently northward sloping plain that is generally above 350 ft amsl. This area is underlain by loess soils, along with ridges with elevations above 380 ft amsl that are underlain by sand, clay, or silt.

The general soil map for Ballard and McCracken Counties delineates three soil associations within the vicinity of the Paducah Site: the Rosebloom-Wheeling-Dubbs association, the Grenada-Calloway association, and the Calloway-Henry association (USDA 1976). Inside the fenced area of the plant, the best description of the soil would be Urban, because many of the characteristics of these soil types have been changed due to construction and maintenance activities (USDA 2005).

4.5.8 C-400 Complex Area Geology

Soil boring SB59, located on the south end of C-400, provides a general geologic characterization of the C-400 Complex. The SB59 geologic stratigraphic sequence consists of the following (from top to bottom).

- Silt and sandy silt to a depth of 24.1 ft
- Sand and gravel units (2.0- to 4.6-ft thick), separated by fine sands and silts to a depth of 43.1 ft
- Silt to silty sand to a depth of 50.0 ft
- Very fine sand to a depth of 60.0 ft

- Sand and gravel to a depth of 95.6 ft
- Interbedded clay, sand, and silt to the total depth of the boring of 97.0 ft

The uppermost 24.1 ft of soils is disturbed soils and loess; the Upper Continental Deposits extends to 60.0-ft depth; and the Lower Continental Deposits extends to a depth of 95.6 ft, which is the contact with the underlying McNairy Formation.

Numerous additional soil borings define lateral trends of the geologic units in the C-400 area. With few exceptions, the geologic units are laterally extensive. Based on information from SB59, the gravel member of the Lower Continental Deposits, the RGA, consists of sand and gravel from 60 to 95.6 ft. In the C-400 area, the gravel member of the Lower Continental Deposits generally consists of poorly sorted chert-gravel with discontinuous thin lenses of fine sand. The erosional surface that is the top of the McNairy Formation has over 9 ft of relief under the south end of C-400 Building, with a structural low in the area south of C-400. The depth of the base of the Lower Continental Deposits/top of the McNairy Formation, therefore, is expected to be variable throughout the area of the C-400 Complex.

Several historical cross sections are incorporated herein for reference (from the WAG 6 report); the following illustrate representative lithologic profiles of the subsurface in the study area.

- Figure 4.5, cross section A-A', illustrates a southwest to northeast transect

- Figure 4.6, cross section B-B', illustrates a west to east transect in the southern section of the complex

- Figure 4.7, cross section C-C', illustrates a west to east transect that crosses the central portion of C-400 Building

- Figure 4.8, cross section D-D', illustrates a south to north transect situated west of C-400 Building

- Figure 4.9, cross section E-E', illustrates a northwest to southeast transect that crosses through C-400 Building

- Figure 4.10, cross section F-F', illustrates a south to north transect east of C-400 Building

4.6 HYDROGEOLOGY

The significant geologic units relative to shallow groundwater flow at the Paducah Site include the Terrace Gravel and Porters Creek Clay (south sector of the Paducah Site) and the Pleistocene Continental Deposits and McNairy Formation (underlying the Paducah Site and adjacent areas to the north). Figure 4.11 illustrates the water level elevations and geologic units of the shallow groundwater flow systems at the Paducah Site. Groundwater flow in the Pleistocene Continental Deposits is a primary pathway for transport of dissolved contamination from the Paducah Site. The following paragraphs provide the framework of the shallow groundwater flow system at the Paducah Site (adapted from DOE 1999a).

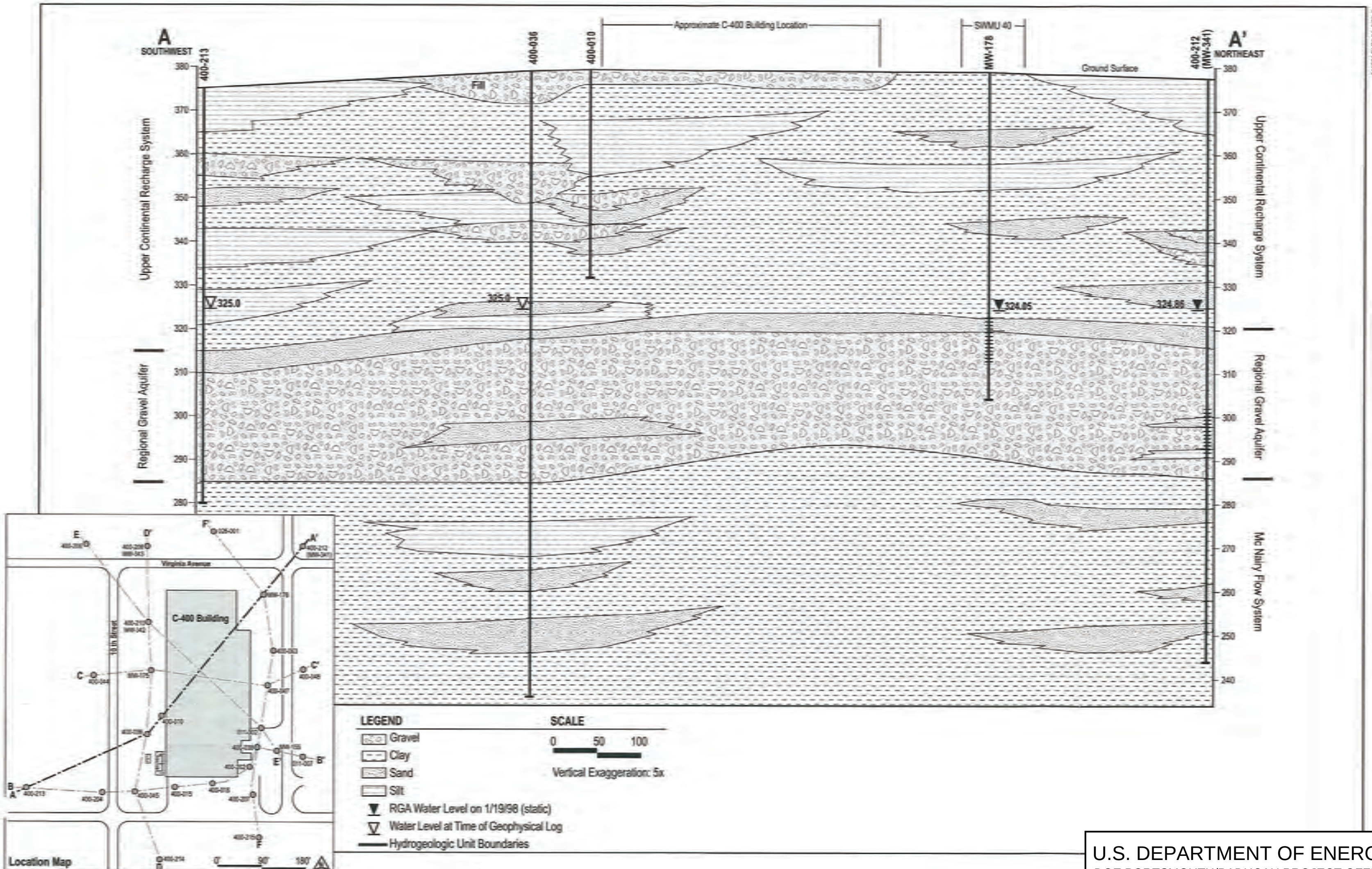

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Figure 4.5 Southwest-Northeast A-A' Cross-section Showing Stratigraphy at WAG 6 (DOE 1999a)

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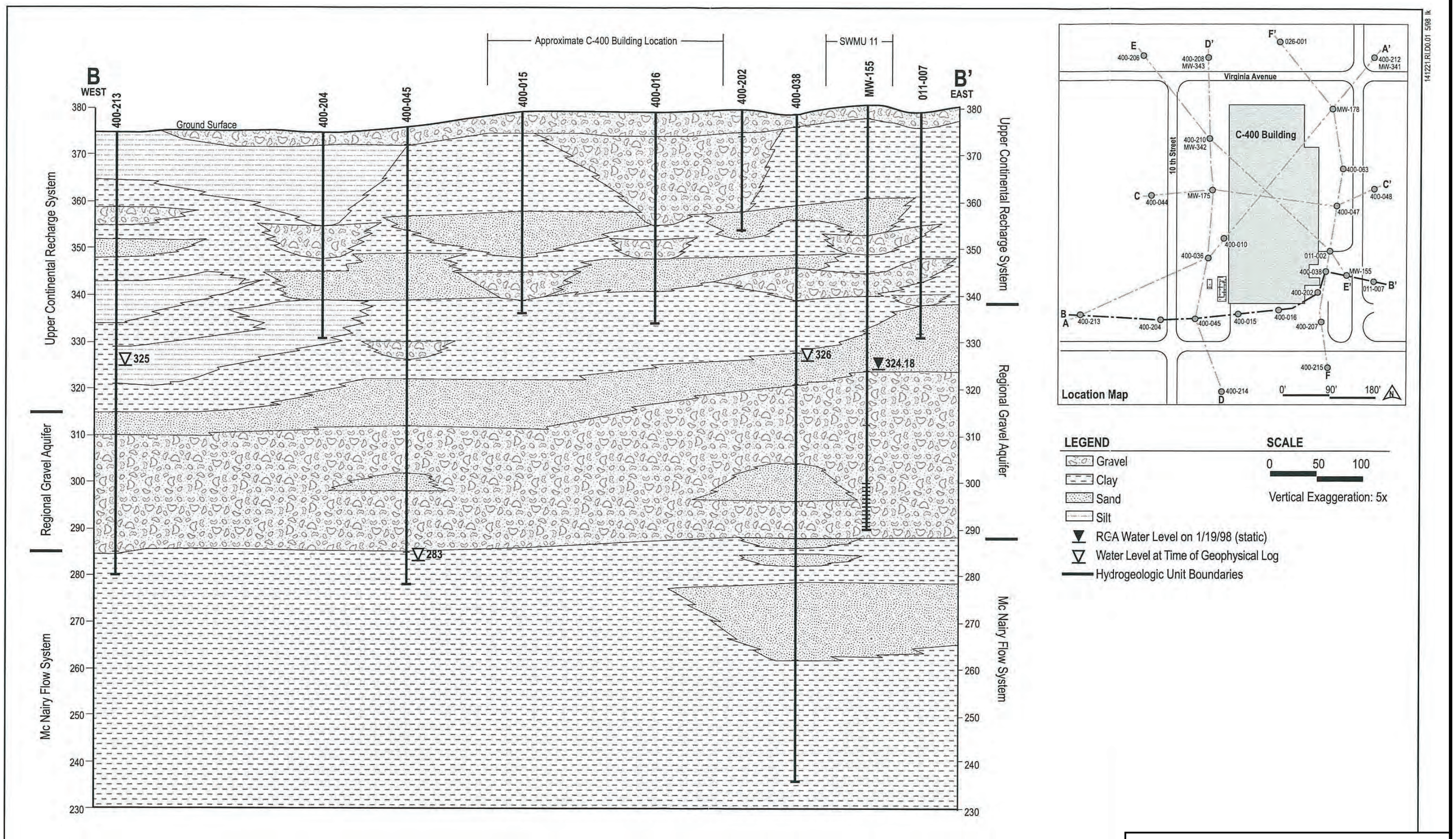

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Figure 4.6 East-West B-B' Cross-section Showing Stratigraphy at WAG 6 (DOE 1999a)

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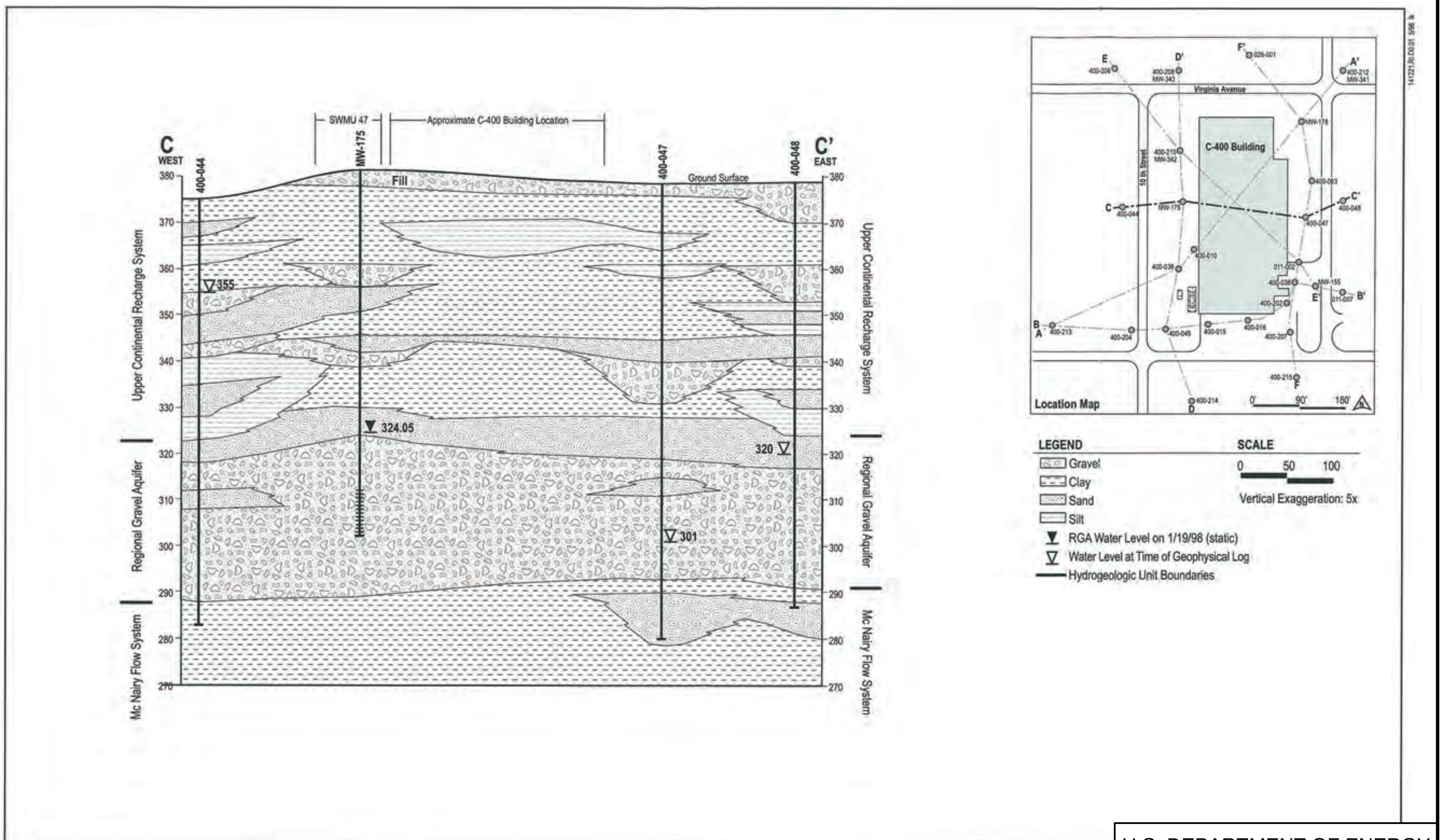

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Figure 4.7 East-West C-C' Cross-section Showing Stratigraphy at WAG 6 (DOE 1999a)

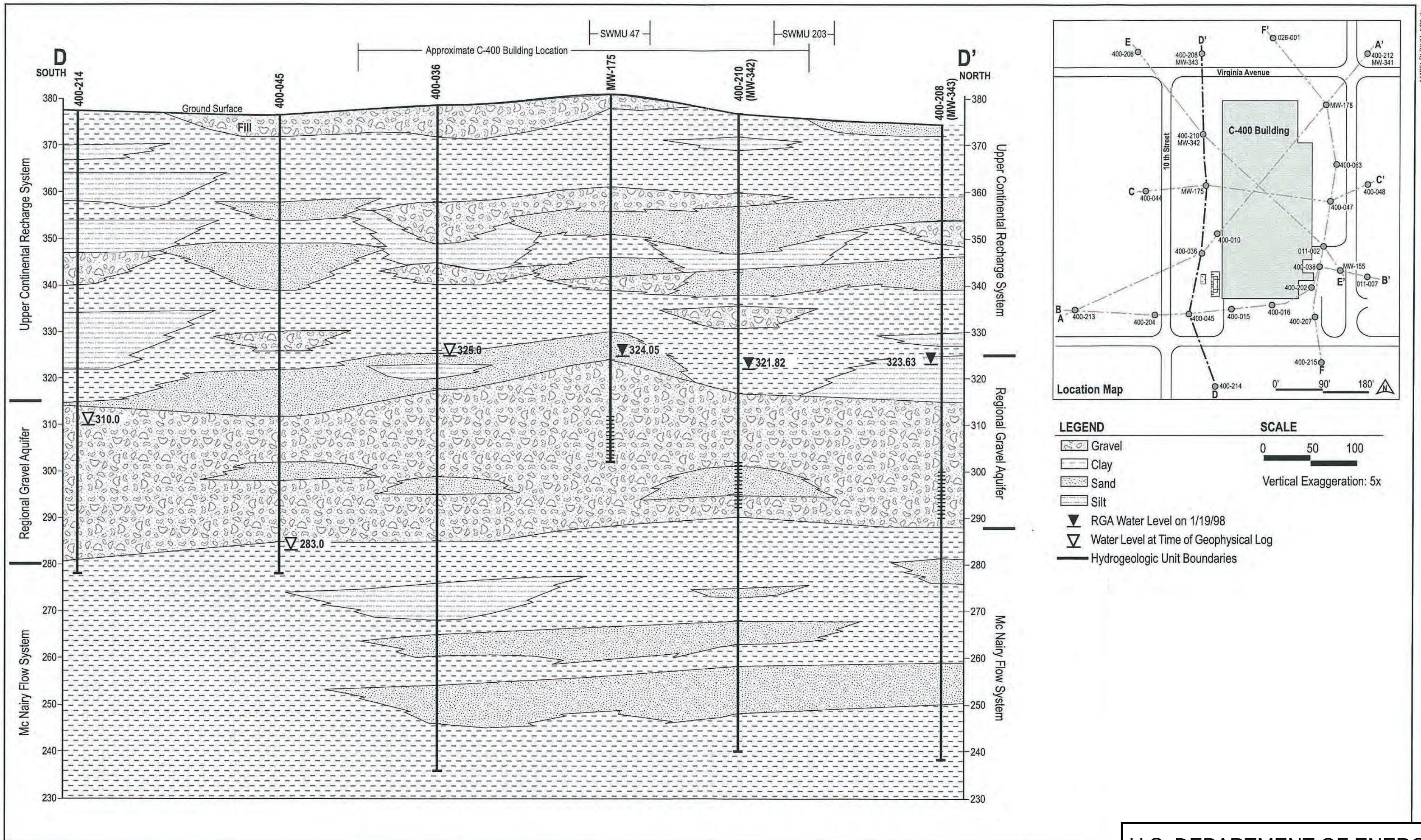

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Figure 4.8 North-South D-D' Cross-section Showing Stratigraphy at WAG 6 (DOE 1999a)

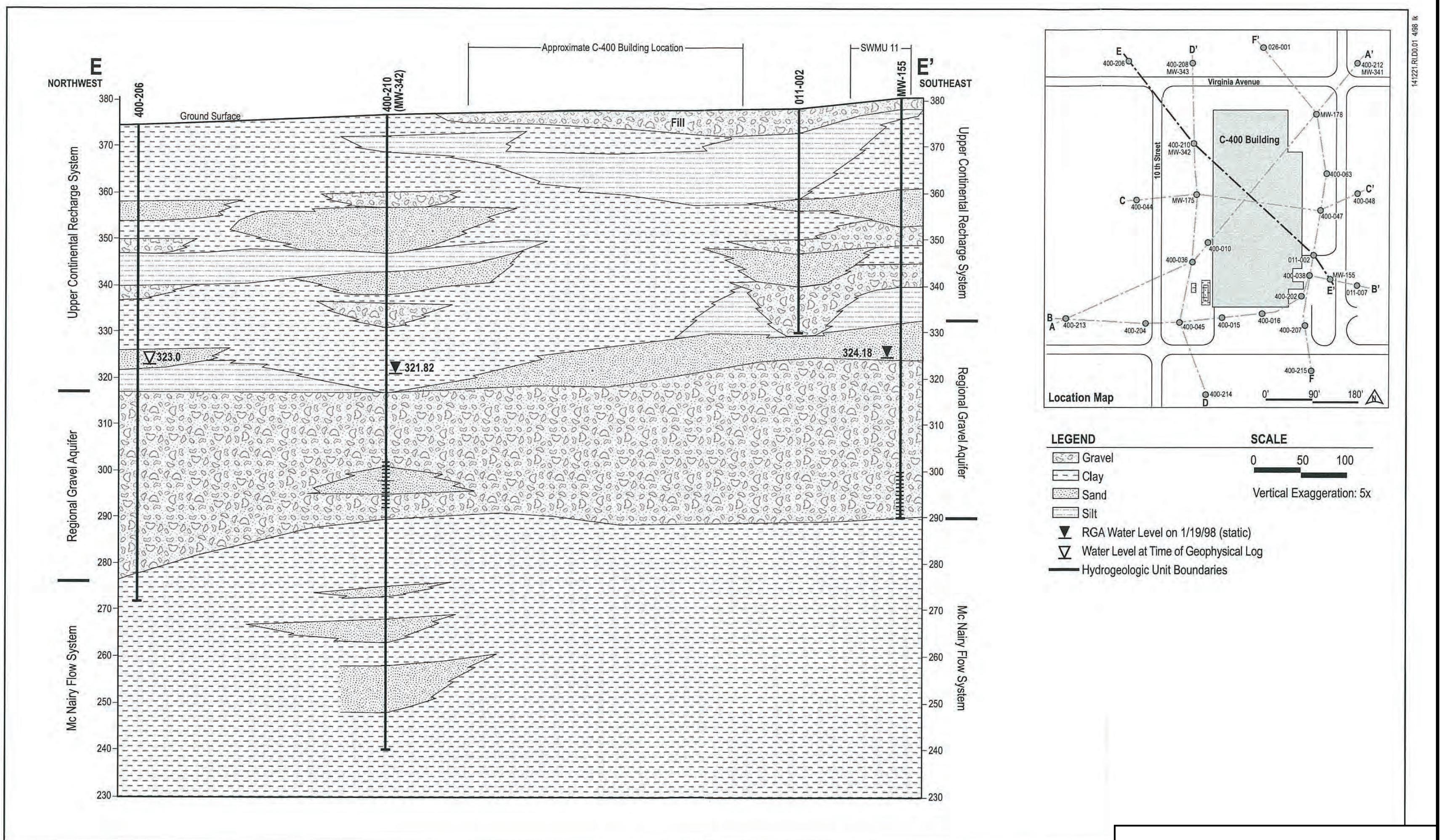

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Figure 4.9 Northwest-Southeast E-E' Cross-section Showing Stratigraphy at WAG 6 (DOE 1999a)

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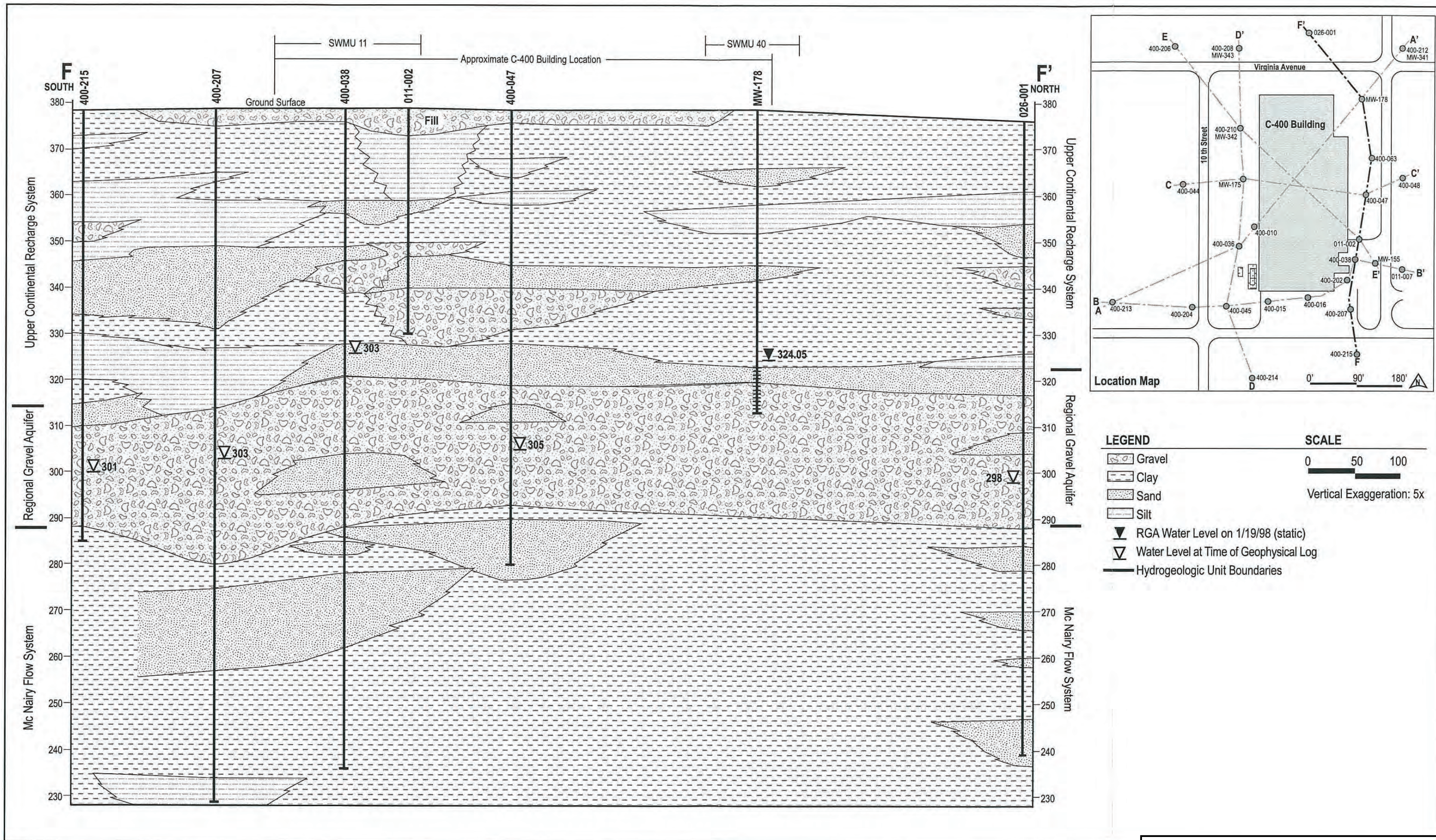

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Figure 4.10 North-South F-F' Cross-section Showing Stratigraphy at WAG 6 (DOE 1999a)

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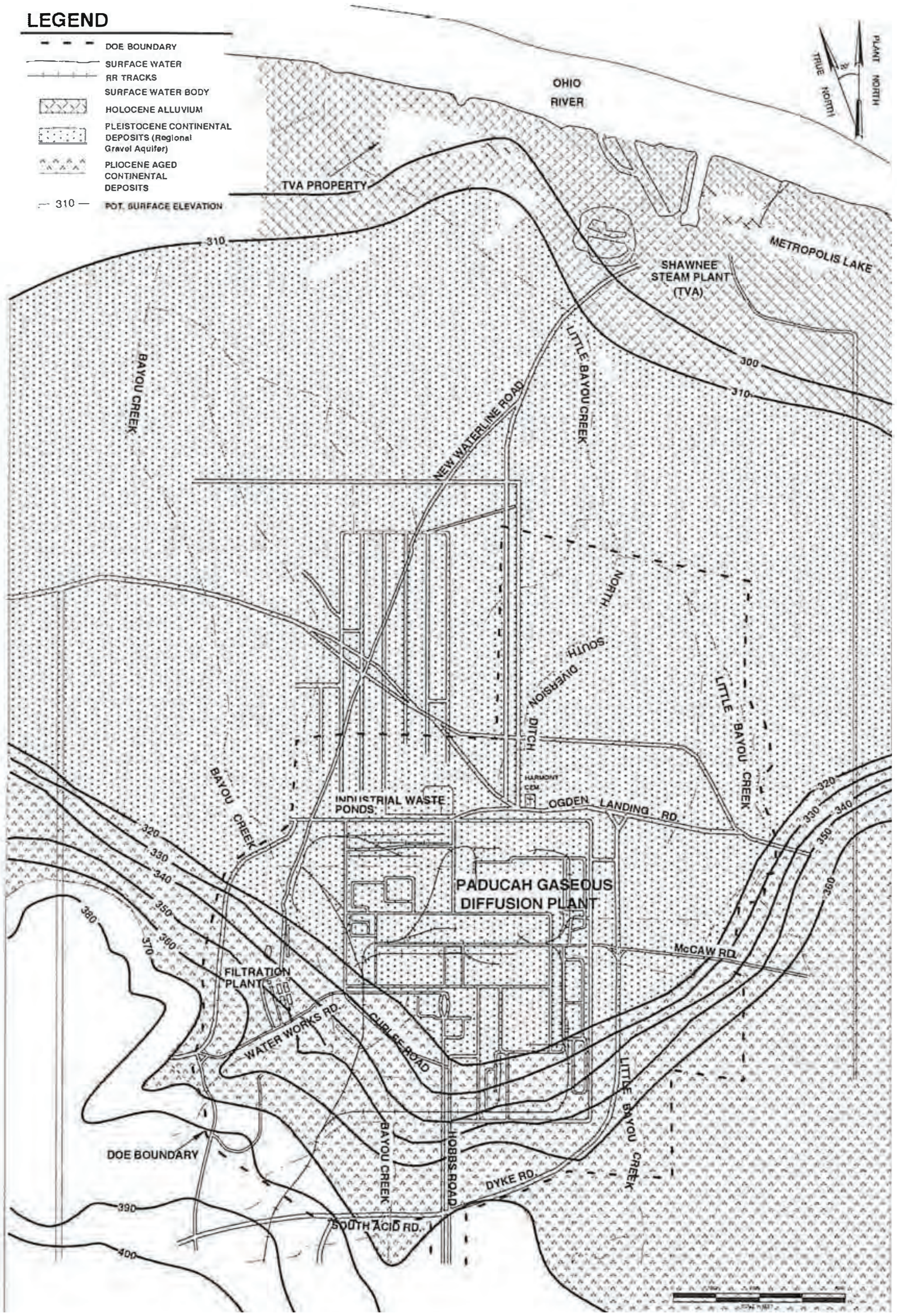

DOE 1999a

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Figure 4.11. Water Level Trends of the Shallow Groundwater Flow Systems in the Vicinity of the Paducah Site

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4.6.1 Terrace Gravel Flow System

The Porters Creek Clay with a vertical hydraulic conductivity of 1.5×10^{-4} to 1.4×10^{-1} ft/day is a confining unit to downward groundwater flow south of the Paducah Site (DOE 2004b). A shallow water table flow system is present in the Terrace Gravel, where it overlies the Porters Creek Clay south of the Paducah Site. Discharge from this water table flow system provides baseflow to Bayou Creek and underflow to the Pleistocene Continental Deposits to the east of the Paducah Site.

The elevation of the top of the Porters Creek Clay is an important control to the area's groundwater flow. A distinct groundwater divide (i.e., south of the Terrace Slope) is centered in hills located approximately 9,000 ft southwest of the C-400 Complex, where the Terrace Gravel and Eocene sands, with a lateral hydraulic conductivity as high as 5 ft/day (Maxim 1997), overlie a "high" on the top of the Porters Creek Clay (Olive 1966). In adjacent areas where the top of the Porters Creek Clay approaches land surface, as it does immediately south of the Paducah Site and near the subcrop of the Porters Creek Clay to the west of the security-fenced area, the majority of groundwater flow is forced to discharge into surface streams (gaining reaches) and little underflow occurs into the Pleistocene Continental Deposits. To the east of the Paducah Site, the Terrace Gravel overlies a lower terrace and a thick sequence of Terrace Gravel occurs adjacent to the Pleistocene Continental Deposits, allowing significant underflow from the Terrace Gravel. Surface drainages in this area typically are losing reaches. Figure 4.12 presents hydraulic potential contours for the Terrace Gravel flow system (DOE 1997). Where there is uncertainty due to limited MW data from the area depicted in Figure 4.12, the water table contours are based on stream elevations and water levels in abandoned gravel pits (USGS 1978).

4.6.2 Upper Continental Recharge System

The UCRS is the upper strata where infiltration of surface water occurs and where the water table is found north of the Porters Creek Clay Terrace slope. The infiltration rate for the Paducah Site area is approximately 6.6 inches/year. Groundwater flow is primarily downward in the Upper Continental Deposits; however, lateral flow may occur over short distances. A plot of elevation of water level versus midpoint of the MW screen for UCRS wells at the Paducah Site (Figure 4.13) demonstrates that steep vertical hydraulic gradients are characteristic of the UCRS (DOE 1997). Vertical hydraulic gradients generally range from 0.5 to 1 ft/ft, as measured in wells completed at different depths in the UCRS. The UCRS is composed predominately of silt and fine sand members with a large range of hydraulic conductivity. Overall, the depth-averaged UCRS hydraulic conductivity is approximately 0.001 ft/day (DOE 2017b).

Beneath the Paducah Site and adjacent land to the north, the water table is found within the UCRS. Water table elevations are best known in the immediate vicinity of the fenced security area and in the area of the C-746-S&T and C-746-U Landfills to the north. Within the west area of the fenced security area, the elevation of the water table is controlled by the bottom of drainage ditches and the water level in the bordering Bayou Creek. The water table is as shallow as 5 to 10 ft in some localities and less than 20-ft deep throughout the west plant area. Depth to the water table is much greater (as much as 40 ft) in the northeast plant area, where a storm sewer system is present to collect storm runoff. In the northeast plant area, the water table is believed to slope east toward bordering Little Bayou Creek.

At the currently operating C-746-U Landfill, trends and the elevation of the water table are controlled by water levels in the North-South Diversion Ditch (NSDD) on the south side of the landfill and by water levels in Little Bayou Creek on the east and north sides. The water table slopes northward toward Little Bayou Creek at depths of 20 to 40 ft.

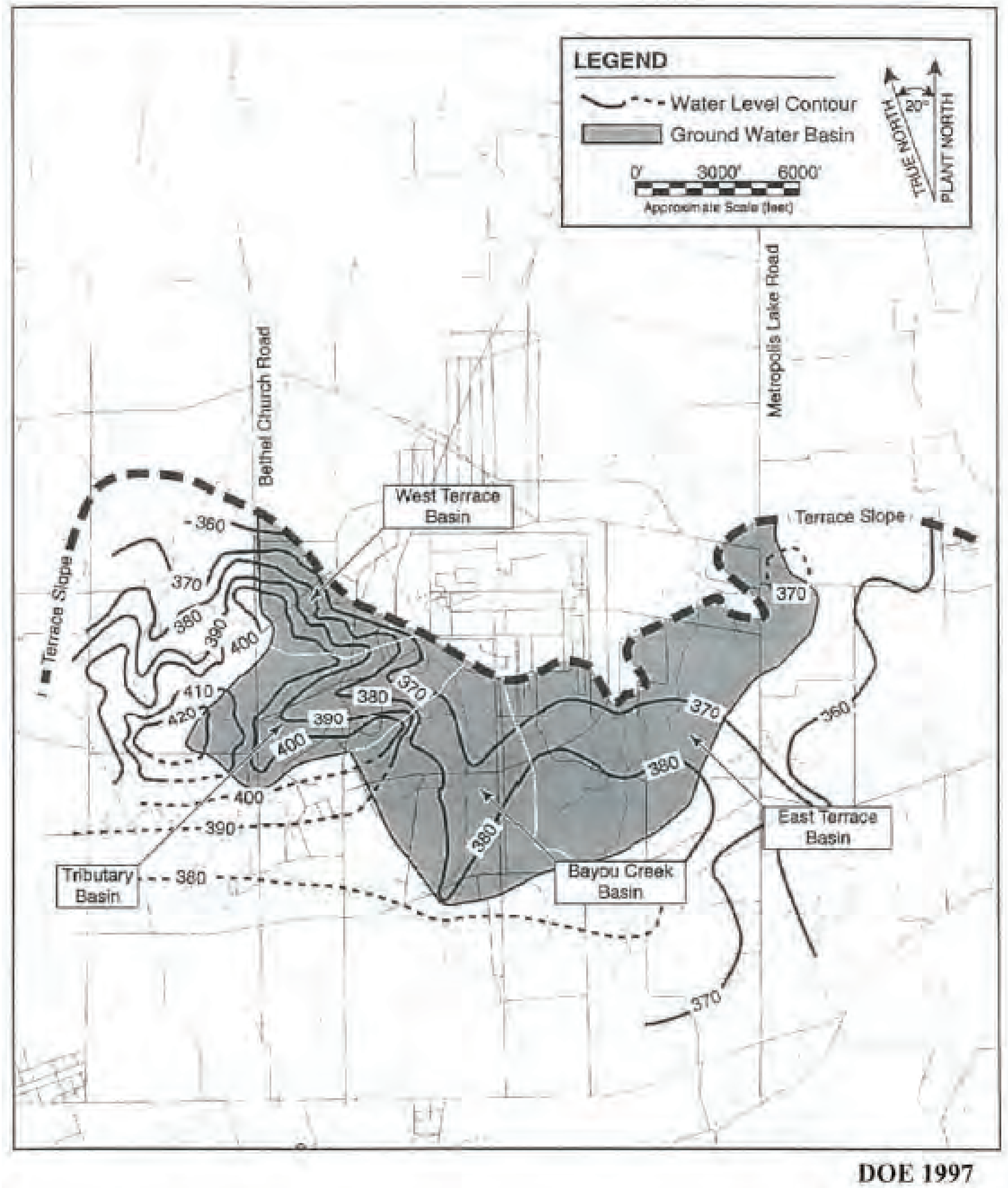

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Figure 4.12. Water Level in the Terrace Deposits South of the Paducah Site

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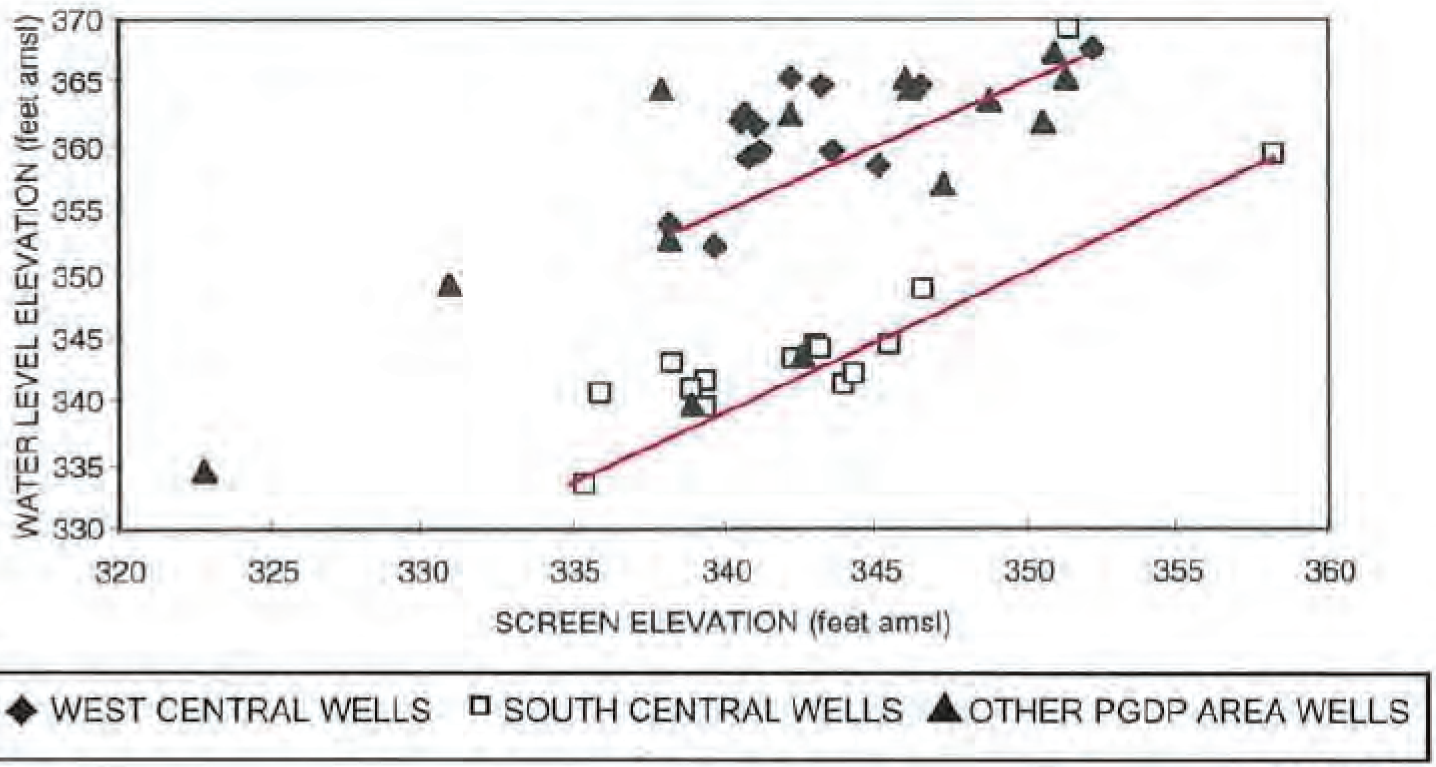

DOE 1997

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Figure 4.13. Plot of Water Level Versus Well Screen for Upper Continental Recharge System Wells

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These depths represent the expected range of water table elevations and depths associated with the UCRS. In general, the water table slopes away from areas of tributaries and higher land surface toward Bayou and Little Bayou Creeks. The depth to the water table is very shallow in the vicinity of tributaries and wetlands found on the highlands and in the vicinity of the creeks.

4.6.3 Regional Gravel Aquifer

Vertically infiltrating water from the UCRS primarily moves downward into a basal sand member of the Upper Continental Deposits and the Pleistocene gravel member of the Lower Continental Deposits and then laterally north toward the Ohio River. This lateral flow system is called the RGA. As documented in the Paducah Site groundwater flow model and based on site specific lithological data, the RGA is the shallow aquifer beneath the Paducah Site and contiguous lands to the north (DOE 2017b).

Hydraulic potential in the RGA declines toward the Ohio River, which controls the base level of the region's surface water and groundwater systems. The RGA potentiometric surface gradient beneath the Paducah Site is commonly 10^{-4} ft/ft, but increases by an order of magnitude near the Ohio River. Vertical gradients are not well documented, but small, vertical gradients measured at nested wells at the C-404 Burial Ground, for example, range from 0.001 to 0.01 ft/ft, but are not consistently upward or downward (dependent on season and location relative to areas of recharge).

The hydraulic conductivity of the RGA varies spatially. Pumping tests have documented the hydraulic conductivity of the RGA ranges from 53 ft/day to 5,700 ft/day (DOE 2017b). The overall flow in the RGA is northward to the Ohio River, but there are localized northeast and northwest flow regimes in response to anthropogenic recharge and anisotropy of the hydraulic conductivity. Ambient groundwater flow rates in the more permeable pathways of the RGA commonly range from 1 to 3 ft/day.

4.6.4 McNairy Flow System

Groundwater flow in the fine sands and silts of the McNairy Formation is called the McNairy Flow System. The overall McNairy groundwater flow direction in the area of the Paducah Site is northward to the Ohio River, similar to that of the RGA. Hydraulic potential is greater in the RGA than in the McNairy Flow System beneath the Paducah Site. Area MW clusters document an average downward vertical gradient of 0.03 ft/ft. Because the RGA has a steeper hydraulic potential slope toward the Ohio River than does the McNairy Flow System, the vertical gradient reverses nearer the Ohio River. The "hinge line," which is where the vertical hydraulic gradient between the RGA and McNairy Flow System changes from a downward vertical gradient to an upward vertical gradient, parallels the Ohio River near the northern DOE property boundary.

The contact between the Lower Continental Deposits and the McNairy Formation is a marked hydraulic properties boundary. Representative lateral and vertical hydraulic conductivities of the upper McNairy Formation in the area of the Paducah Site are approximately 0.02 ft/day and 0.0005 ft/day, respectively. Vertical infiltration of groundwater into the McNairy Formation beneath the Paducah Site is on the order of 0.1 inch per year. (Lateral flow in the McNairy Formation beneath PGDP is on the order of 0.03 inch per year.) As a result, little interchange occurs between the RGA and McNairy Flow System.

4.6.5 Hydrogeologic Settings

The ancestral Tennessee River channel is filled with thick sand and gravel deposits overlain by a sequence of silts and clays. Southward advance of the ancestral Tennessee River during the Pleistocene Epoch eroded away the Porters Creek Clay immediately beneath and north of the Paducah Site. The presence of the Porters Creek Clay south of the Paducah Site and the absence of the Porters Creek Clay beneath the Paducah Site and to the north define the two distinct hydrogeologic settings.

4.6.5.1 South Hydrogeologic Setting

South of the Paducah Site, significant groundwater flow is restricted to the sediments above the Porters Creek Clay. A shallow water table system is developed in the Pliocene (?) gravels and Eocene sands where they overlie the Porters Creek Clay. Groundwater flow in this shallow water table system discharges as baseflow to Bayou Creek and its tributaries and also can migrate across the buried terrace slope as underflow to the UCRS/RGA flow system.

4.6.5.2 North Hydrogeologic Setting

Beneath the Paducah Site and north, shallow groundwater flows downward through the silts and fine sands (i.e., UCRS) until it encounters the RGA sand and gravel deposit. Once in the RGA, groundwater flow is generally north, toward the Ohio River. Lateral flow in the RGA dominates this hydrologic regime, with comparatively little groundwater migrating downward into the underlying McNairy Formation. Lateral groundwater flow in the more permeable pathways of the RGA is approximately 1 to 3 ft/day.

4.6.6 Hydrogeologic Units

Five hydrogeologic units (HUs) are commonly used to discuss the shallow groundwater flow system beneath the Paducah Site and the contiguous lands to the north (Figure 4.14). In descending order, the HUs are as follows:

- HU1 (UCRS): Loess that covers most of the site.
- HU2 (UCRS): Discontinuous sand and gravel lenses in a clayey silt matrix.
- HU3 (UCRS): Relatively impermeable unit that acts as the upper semiconfining-to-confining layer for the RGA. The lithologic composition of HU3 is predominantly silt and fine sand.
- HU4 (RGA): Sand unit with a silt matrix that forms the top of the RGA, where present.
- HU5 (RGA): Sand and gravel, primary member of the RGA.

4.7 SURFACE WATER HYDROLOGY

The Paducah Site is situated in the western portion of the Ohio River basin, approximately 15 miles downstream of the confluence of the Ohio River with the Tennessee River and approximately 35 miles upstream of the confluence of the Ohio River with the Mississippi River. Locally, the Paducah Site is within the drainage areas of the Ohio River, Bayou Creek (also known as Big Bayou Creek), and Little Bayou Creek.

The Ohio River is located approximately 3.5 miles north of the Paducah Site. It is the most significant surface-water feature in the region, carrying over 25 billion gal/day of water through its banks. Several dams regulate flow in the Ohio River. The Ohio River stage near the Paducah Site is measured upstream at Paducah, Kentucky, and downstream at Olmsted, Illinois, by U.S. Geological Survey gauging stations.

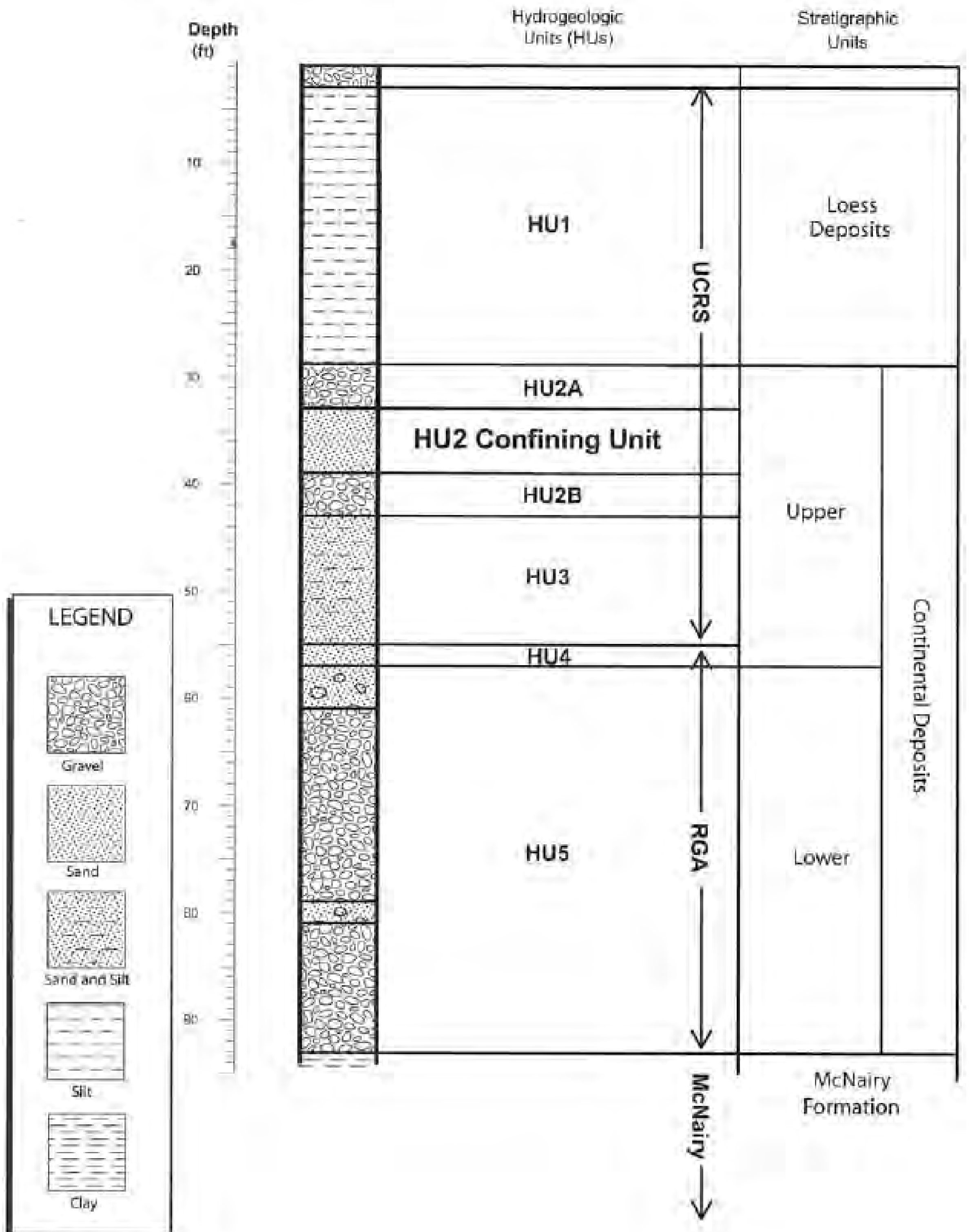

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Figure 4.14. Major Hydrogeologic Units beneath the Paducah Site

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River stage typically varies between 293 and 335 ft amsl near the Paducah Site over the course of a year. Water levels on the lower Ohio River generally are highest in late winter and early spring and lowest in late spring and early summer. The fenced security area of the Paducah Site is above the historical high water floodplain of the Ohio River (CH2M HILL 1991) and above the local 100-year flood elevation of the Ohio River (333 ft).

The fenced security area is situated on the divide between Little Bayou and Bayou Creeks (Figure 4.15). Surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Bayou Creek. Bayou Creek is a perennial stream on the western boundary of the plant that flows generally northward, from approximately 2.5 miles south of the plant site to the Ohio River along a 9 mile course. An 11,910 acre drainage basin supplies Bayou Creek. Little Bayou Creek becomes a perennial stream at the east outfalls of the Paducah Site. The Little Bayou Creek drainage originates within WKWMA and extends northward and joins Bayou Creek near the Ohio River along a 6.5 mile course within a 6,000 acre drainage basin. Drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential, agricultural, and commercial properties, including the Paducah Site and the TVA Shawnee Fossil Plant. The confluence of the two creeks is approximately 3 miles north of the plant site, just upstream of the location at which the combined flow of the creeks discharges into the Ohio River.

A network of ditches discharges effluent and surface water runoff from the Paducah Site to the creeks. Plant discharges are monitored at the Kentucky Pollutant Discharge Elimination System (KPDES) outfalls prior to discharge into the creeks. During the period of uranium enrichment operations at PGDP, most of the flow within Bayou and Little Bayou Creeks was from process effluents or surface water runoff from the Paducah Site.

Other surface water bodies in the vicinity of the Paducah Site include the following: Metropolis Lake, located east of the Shawnee Fossil Plant; several small ponds, clay and gravel pits, and settling basins scattered throughout the area; 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.

4.8 ECOLOGICAL SETTING

The following sections give a brief overview of the terrestrial and aquatic systems at the Paducah Site. 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 1994) and Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky, Volume V: Floodplain Investigation, Part A: Field Results of Survey (COE 1994). While threatened and endangered species likely are present at the Paducah Site, no species are known to be present at the C-400 Complex OU.

4.8.1 Terrestrial Systems

The terrestrial component of the Paducah Site 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 Paducah Site area include soybeans, corn, tobacco, and sorghum.

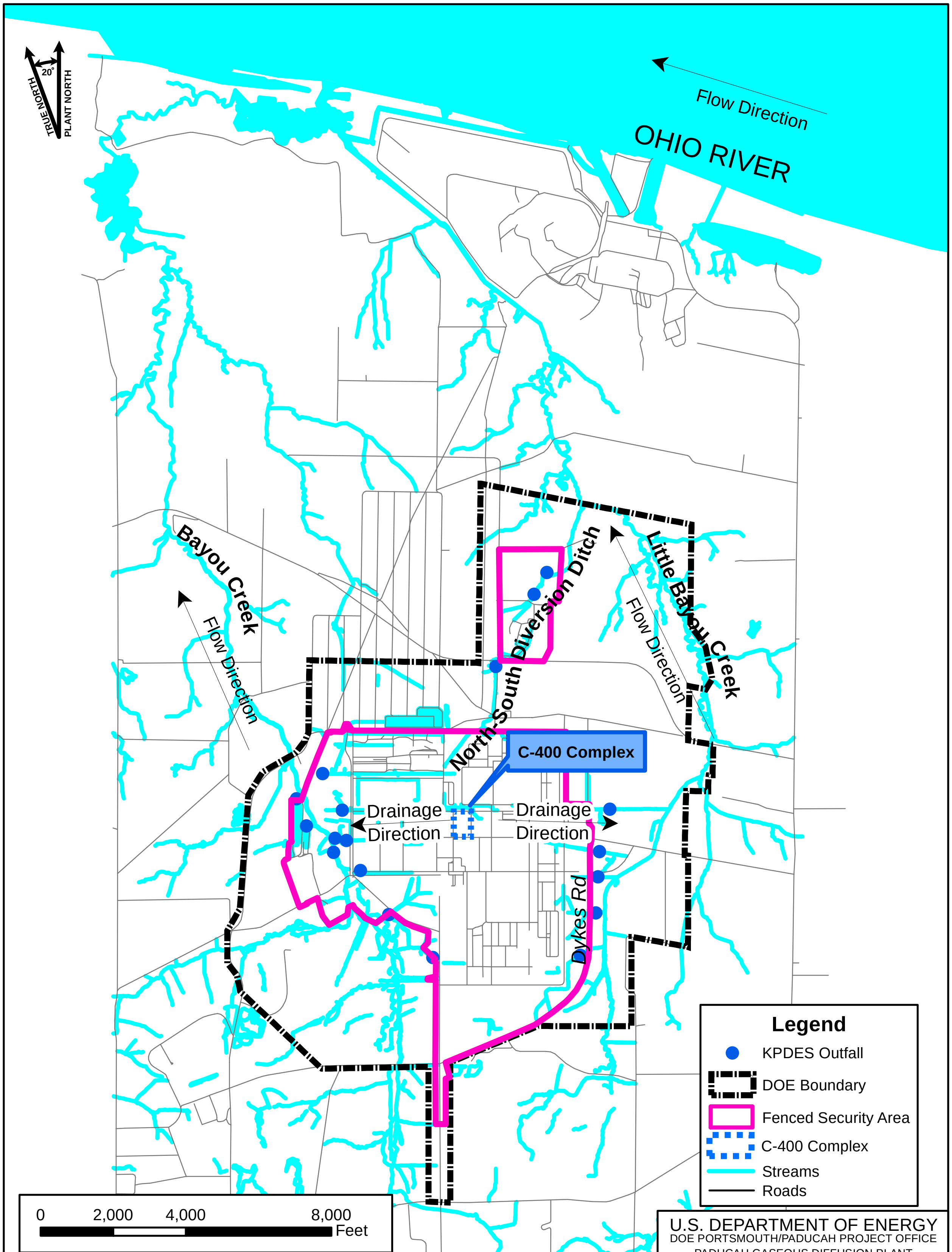

Figure 4.15. Surface Water Features in the Vicinity of the Paducah Site

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DOE periodically mows much of the grassland habitat adjacent to the plant. The Kentucky Department of Fish and Wildlife Resources manages a large percentage of the adjacent WKWMA to promote native prairie vegetation by burning, mowing, and various other techniques.

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 Paducah Site area consists of species indigenous to open grassland, thicket, and forest habitats. 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. Mist netting activities in the area have captured red bats, little brown bats, Indiana bats, northern long-eared bats, evening bats, and eastern pipistrelles (KSNPC 1991).

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

Examples of a few amphibians and reptiles present include the 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).

4.8.2 Aquatic Systems

The aquatic communities in and around the Paducah Site area that could be impacted by the Paducah Site plant discharges include two perennial streams [Bayou Creek (named in older 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. Algal and benthic macroinvertebrate and insect populations vary seasonally. Periphyton, benthic macroinvertebrates, and fishes found in Bayou and Little Bayou Creeks are described in *Final Report on Environmental Studies at the Paducah Gaseous Diffusion Plant Paducah, Kentucky, to Union Carbide Corporation* (Battelle 1978).

4.8.3 Wetlands and Floodplains

A study of the Paducah Site area by the U.S. Army Corps of Engineers (COE) groups the area wetlands 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. Wetlands inside the plant security fence are confined to portions of drainage ditches traversing the site (CDM 1994).

At the Paducah Site, the Ohio River, Bayou Creek, and Little Bayou Creek cause local area flooding during precipitation events. A floodplain analysis performed by the COE (1994) found that much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of the Ohio River and these creeks. In addition, the COE 1994 analysis determined that ditches within the plant area can contain the expected 100- and 500-year discharges. Wetlands and floodplains are not located in the vicinity of the C-400 Cleaning Building.

4.9 CLIMATOLOGY

The Paducah Site's climate is humid-continental. The term "humid" refers to the surplus of precipitation versus evapotranspiration that normally is experienced throughout the year. According to the National Weather Service for the period from 1981–2010, the average monthly precipitation is 4.09 inches, varying from an average of 2.76 inches in August (the monthly average low) to an average of 4.94 inches in May (the monthly average high). The total precipitation for 2017 was 46.41 inches, compared to the normal of 49.08 inches. The "continental" nature of the local climate refers to the dominating influence of the North American landmass. Continental climates typically experience large temperature changes between seasons. The mean annual temperature for the Paducah area for 2017 was 60.3°F. The average monthly temperature is 57.8°F, with the coldest month being January with an average temperature of 34.6°F and the warmest month being July with an average temperature of 78.9°F. https://www.weather.gov/pah/monthlynormals.

The prevailing wind speed is from the south-southwest at approximately 10 miles per hour. Historically, stronger winds are recorded when the winds are from the southwest.

4.10 CONCEPTUAL SITE MODEL

In general, the C-400 Cleaning Building rests on an approximate 16-inch concrete slab floor designed with four main pits and sumps and an east-side basement area that is 15 to 20 ft below grade. The east-side basement includes a plenum and fan room system to ventilate the building (Figure 4.16). Some of the concrete slab in the basement and pits were constructed with a base slab and an overlying finished slab of differing construction materials (e.g., multiple discreet concrete layers, acid brick lining). For example, in the north fan room, plenum room, and TCE degreaser basement, original construction of the basement included a primary concrete floor with a slightly graded finished slab of concrete above to direct and control drainage to floor drains. Also, the compressor disassembly pit was constructed of an acid-proof brick floor with concrete below. In areas where multiple construction materials (e.g., multiple discreet concrete layers, acid brick lining) are located, the RI will collect additional samples at each interface to support characterization of the slab.

During original construction of the C-400 Building, the building footprint was excavated to allow for the installation of basements and building footers and gravel backfill (ranging from approximately 8 to 12 ft under the building grade slab) was used as the base, potentially creating a permeable zone for contaminant migration. This gravel backfill is anticipated to exist beneath the building grade slab, including most pits and basement areas. In pits, basements, etc., the gravel thickness is anticipated to be less than 8 to 12 ft thick and not present under some basement areas (e.g., North Fan Basement). In addition, footing drains were placed around the building footers in order to keep the footings dry and the area around the footers stable. Roof drains also are connected to the storm sewer lines that traverse beneath the building slab in some areas. Leaking and/or discharge from lines that traverse beneath the building slab periodically could flush contaminants into the subsurface.

Cleaning (clothes laundry and machinery parts), disassembly, and testing of cascade components are the primary activities the building was designed to support. The building has also housed many other activities, including recovery of precious metals and treatment of radiological waste streams.

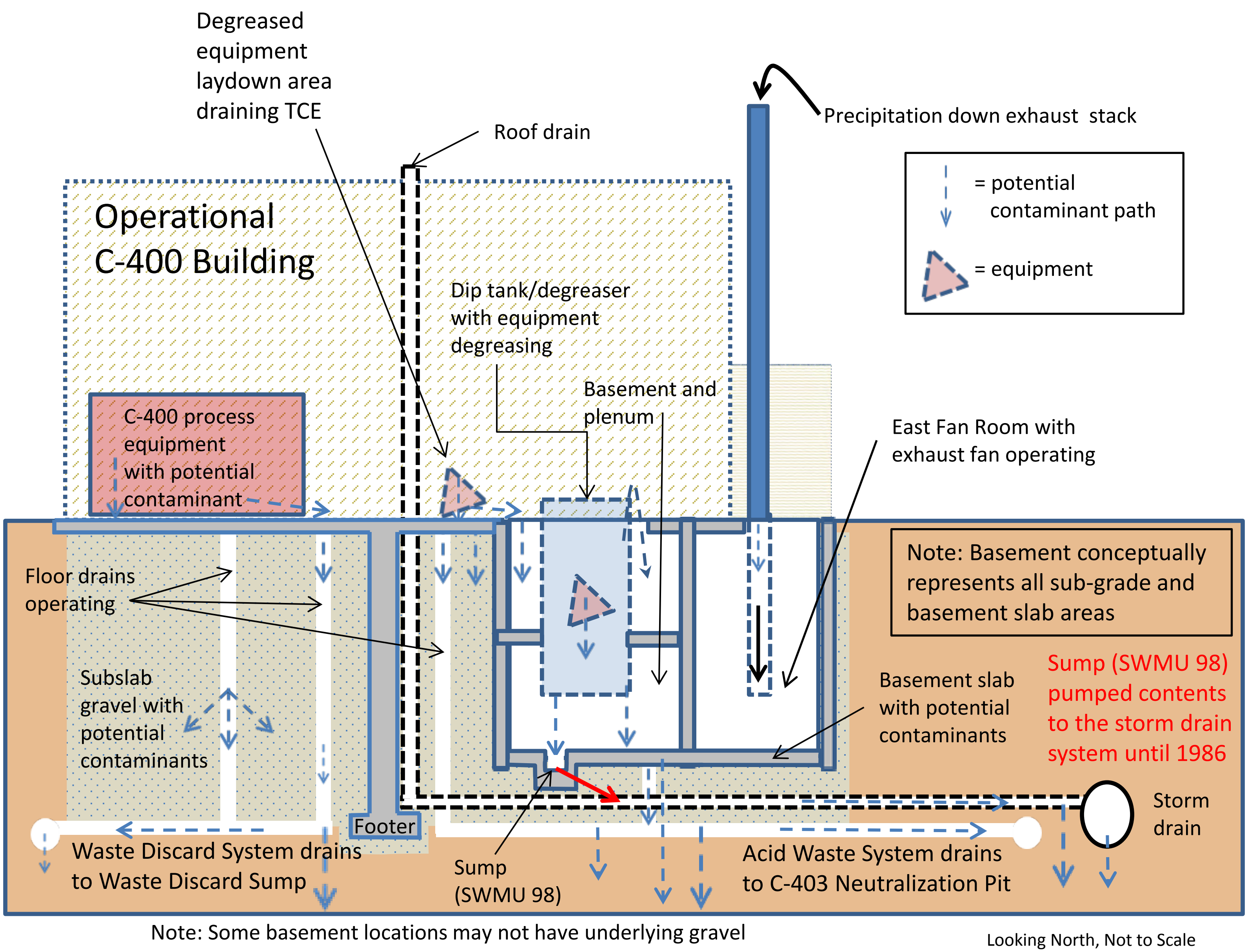

Figure 4.16. Historical C-400 Building Operational and Contaminant Release CSM

As indicated in the *C-400 Process and Structure Review*, the tank bottom of the TCE degreaser rusted out, and the resulting leakage of solvents and other contaminants flowed to a sump near the unit. From the sump, they were discharged to the storm-water drain system via pipe. A hole in the underside of this pipe may have allowed solutions within the pipe to escape to surrounding media. In approximately 1973, the sump pump became inoperable and was tagged out. When sufficient liquid backed up, the liquid crossed the floor to the drains beneath the cleaning tanks. These floor drains were connected to the C-403 Neutralization Pit. The sump pump and degreaser body were replaced in approximately 1978. The C-400 Spray Booth (which was used to clean large radiologically contaminated items) originally was built out of common steel, and the unit's base degraded over time. During replacement of the original booth, it was found that the floor beneath was gravel, not concrete, and that this material had eroded or had undergone severe settling. Dye trace tests were performed in 1995 on the safety equipment sink and dissolver drain. Observations of the local storm sewer, sanitary sewer, and discard waste systems did not indicate the presence of dye. The general consensus among those involved at the time of the dye trace tests was that the volume of water/dye was not sufficient to flush out clear water in the lines or did not exceed leakage within the lines, or existing blueprints were incorrect and solutions actually are conveyed in a manner presently not identified (DOE 1995b).

Potential contaminant source areas include a TCE off-loading pump station, spills, overfill from sumps, and releases from tanks or underground piping. Releases from these sources would directly impact soils below or adjacent to the source and/or sediments and surface water in nearby drainage ways. Continuing transport processes also may result in secondary releases that may impact larger areas or affect additional environmental media. Transport processes likely to be active at the site include vertical infiltration in soil, lateral and vertical migration in groundwater, soil erosion and surface runoff, volatilization, and mobilization of dust particles. Figure 4.17 illustrates the hydrogeologic setting for the conceptual site model (CSM).

4.10.1 Contaminant Sources, Release Mechanisms, and Migration Pathways

In accordance with historical process knowledge and the findings of sampling and analysis performed during the WAG 6 RI, several contaminant sources have been identified. Detections of chemicals in soil and groundwater confirm potential for media-specific chemical transport. The following migration pathways discussed below appear to be the most viable exposure routes.

- Contaminant migration through construction bedding (gravel) around building footers and/or below building concrete slabs, pits, and basements
- Leaching of contaminants through soil to groundwater
- Migration of groundwater to downgradient receptors
- Migration of vapors to on-site receptors

The C-400 Complex is the source of many types of potential contaminants, including VOCs, semivolatile organic compounds (SVOCs), metals, and radionuclides. Examples of contaminant sources, release mechanisms, and pathways for migration are illustrated in Figure 4.18. In this example, primary sources are related to the following processes:

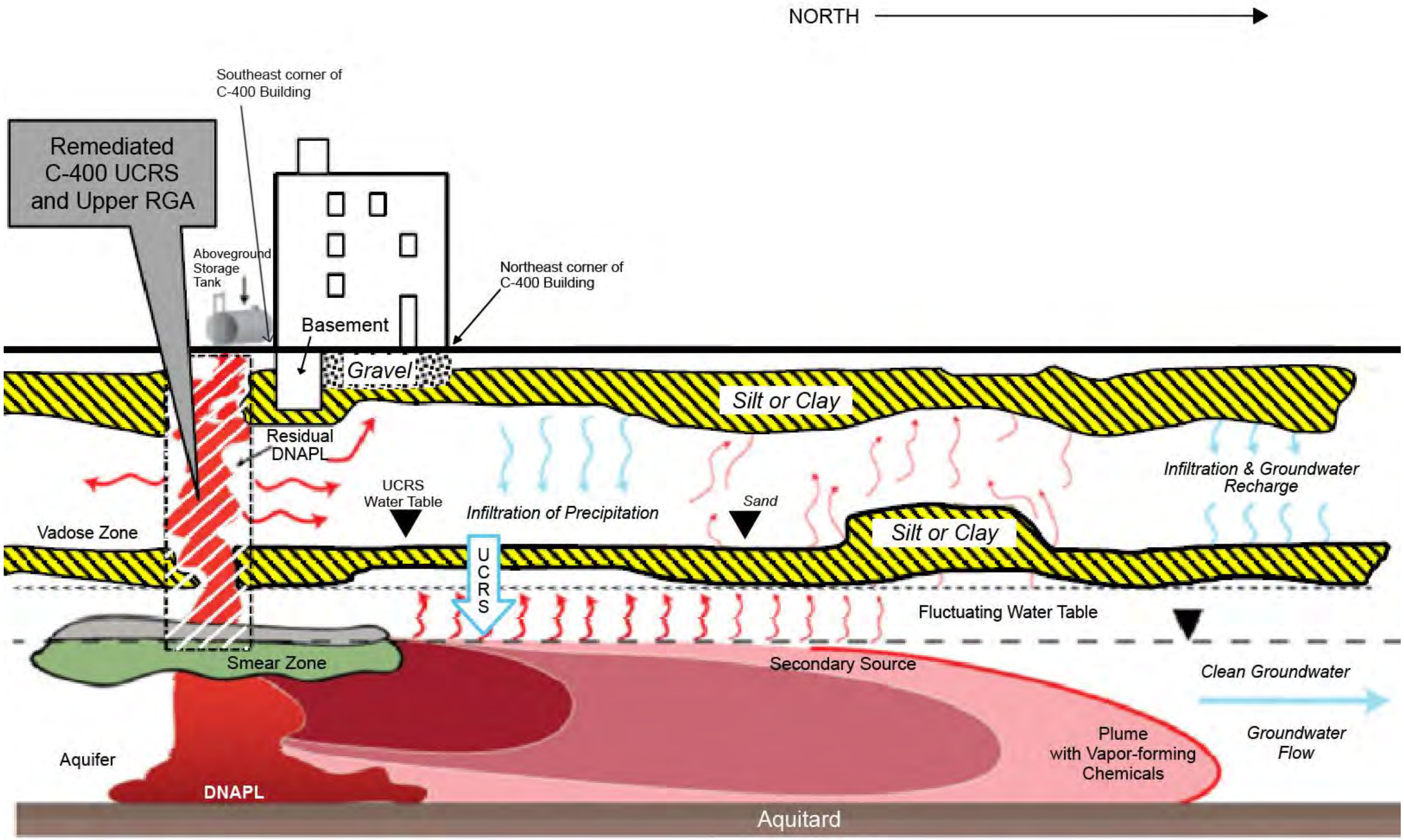

Figure 4.17. Hydrogeologic Setting for Conceptual Site Model

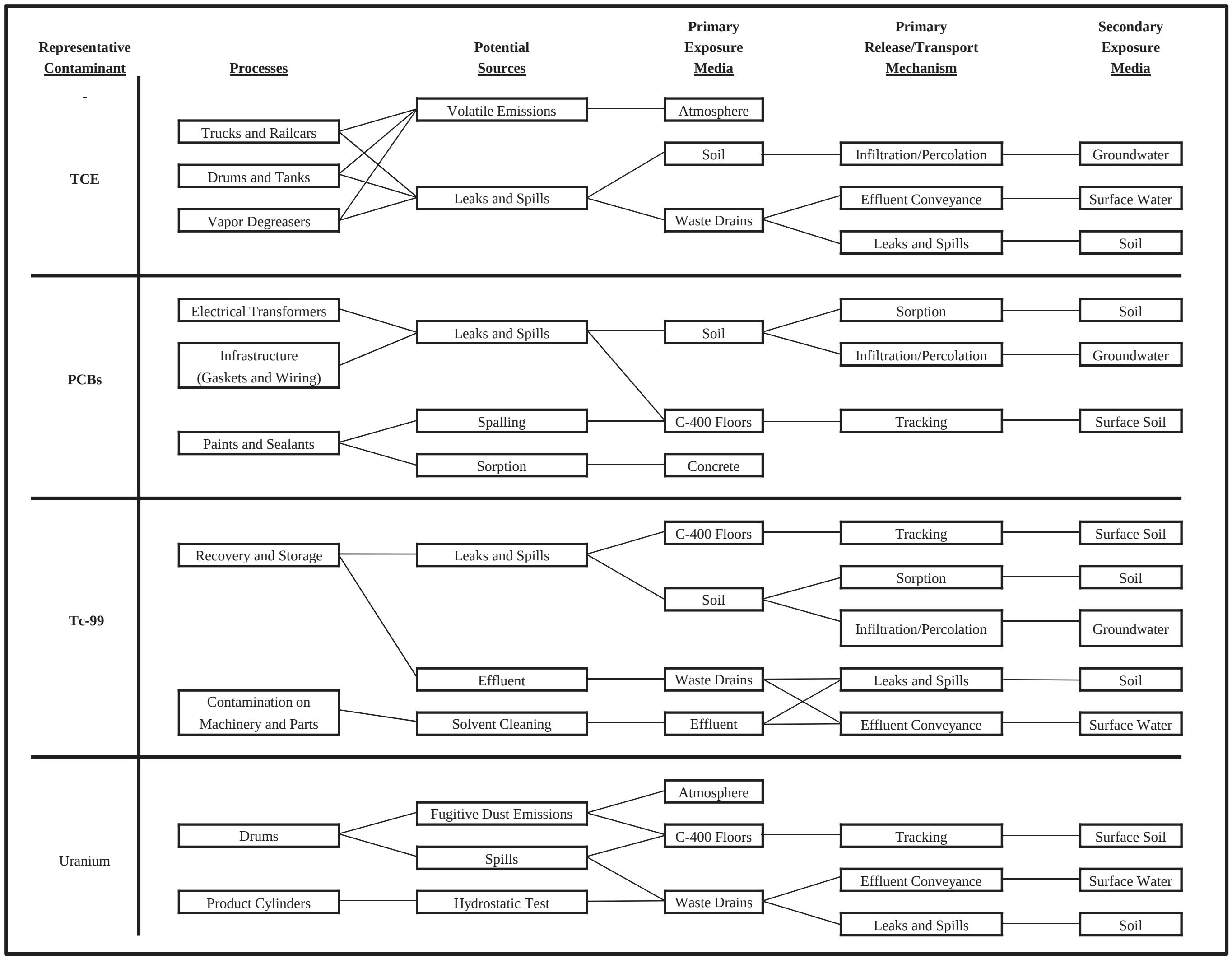

Figure 4.18. Pathway Network Diagram for Representative Contaminants

- TCE: truck and railroad delivery and pump and transfer system, storage tank systems, and vapor degreasers;

- PCBs: leaks of electrical transformers, leaks of gaskets and degradation of building wiring, and wall and floor coatings;

- Tc-99: radionuclide recovery and storage and spray booth and degreasing operations; and

- Uranium: pulverizing and screening of the diffusion process heels and hydrostatic testing of product cylinders.

Construction gravel of varying thicknesses (ranging from approximately 0-12 ft) was placed as base material under C-400 Complex building slabs, basements, and within pits. These subsurface gravel beds also housed an assortment of drain lines (e.g., discard waste, acid waste, sanitary sewer, and storm sewer systems) that potentially transported VOCs, SVOCs, metals, and radionuclides. Breaches in the building slab and or drain lines potentially allowed COPCs to enter into these gravel zones and disperse laterally and downward, eventually migrating to the soil interface below.

Extensive areas of soil surrounding the C-400 Cleaning Building have been impacted by releases of TCE and other contaminants into the shallow subsurface soil. Due to the DNAPL characteristics of TCE, the dominant dispersal pattern through the vadose soil to the top of the RGA is gravity-driven. Within the RGA, where spill volumes were sufficiently large, vertical DNAPL migration has penetrated to the base of the RGA. Lateral transport of dissolved-phase contaminants within the RGA follows groundwater flow paths established by the regional groundwater gradient. Releases of TCE at the C-400 Complex are the source for the downgradient, off-site Northwest Plume and may be related to the Northeast Plume.

Because large releases of TCE likely occurred and TCE is expected to have penetrated the thickness of the RGA as a DNAPL, TCE DNAPL likely pooled at the top of the McNairy Formation. Where TCE pools obtained enough height to overcome the interfacial tension between the RGA and McNairy Formation soils, TCE may have migrated to greater depths in the McNairy Formation. These migration depths could be significantly greater if faulting is present beneath C-400.

4.10.2 Migration Pathways

4.10.2.1 Soil to Groundwater Pathway—UCRS

Contaminants present in surface and subsurface soils may leach to the underlying aquifer. Several factors influence the dissolution of COPCs in soils and the rate of contaminant movement through soils. These include the physical/chemical properties of the contaminants [e.g., solubility, density, viscosity, distribution coefficient (K_d)] and the physical/chemical properties of the environment (e.g., rainfall, percolation rate, soil permeability, porosity, particle size, and amount of organic carbon). Contaminants migrate to groundwater through infiltration, leaching, and the movement of subsurface water within the capillary fringe.

Generally, the groundwater is relatively deep at the C-400 Complex, and many of the potential source areas have been present for a long time; therefore, leaching potential is indicated by the observed groundwater concentrations. The depth to the water table in many areas is approximately 50 ft, suggesting a long travel time from the surface to the water table. In areas beneath pavement or other low permeability zones, less infiltration would occur. Adjacent to paved areas, higher rates of recharge may occur as runoff increases infiltration in localized areas. It is obvious that vertical migration has occurred at a much higher rate than indicated by advection/leaching, primarily because of diffusion. Diffusion can increase the rate of contaminant migration significantly as the chemical moves to counteract concentration gradients, which are estimated to be quite significant at the C-400 Complex. It appears that the dominant driving force for chemical migration in the UCRS is diffusion.

Chemicals can attenuate in the vadose zone. Chemicals that strongly sorb to soils, including most polycyclic aromatic hydrocarbon (PAH) compounds, tend to remain in or near the point of release. The retardation factors for these constituents indicate that they would be expected to migrate much more slowly than water in some instances. In addition to their strong tendency to adsorb, these compounds biodegrade during the slow transport, limiting the impacted area. Other constituents such as VOCs tend to volatilize in the unsaturated zone, decreasing their persistence in that medium.

The cosolvent effect may apply where there are two types of organic contaminants present in the waste: one type that is hydrophobic and sparingly soluble, (e.g., PAHs and PCBs), and another type that may function as a cosolvent for the sparingly soluble contaminant or moderately to highly soluble in water (Huling 1989). In order for a substance to behave as a cosolvent, it must be miscible with water, even to a small degree. The cosolvent effect is such that the solubility of the hydrophobic compounds increases due to co-mixing with the organic cosolvent, particularly if the latter is fully miscible with water (e.g., ethanol or methanol) (Suresh et al. 1990; Li and Andren 1994). Nonspecific hydrophobic partitioning to solid phase materials also is understood to decline in the presence of an organic cosolvent.

The main cosolvency effect at the C-400 Complex is anticipated to be PCBs and/or PAHs in TCE. If DNAPL is present or if a small amount of DNAPL is captured in a sample, a “nugget effect” in the concentration levels of PAHs, PCBs, or other cosolved constituents may be observed in the analytical data—this would be evidenced by a higher than expected concentration of the cosolved constituent. Conversely, a higher than expected concentration of a constituent that could be cosolved may be the result of several factors, but could indicate that a small amount of DNAPL was captured in the sample. Cosolvency also may be evidenced during DNAPL remediation, where PCB or PAH concentrations in water and air may increase as the DNAPL is removed/remediated. Raoult’s Law can be used to predict this effect. Uncertainties due to the effects of cosolvency will need to be considered during the evaluation of remedial alternatives in the RI/FS Report.

4.10.2.2 Groundwater Migration—RGA

The COCs from the WAG 6 RI reported in RGA groundwater include arsenic, beryllium, iron, chromium, lead, manganese, thallium, silver, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, vinyl chloride, 1,1-DCE, 1,1,1-trichloroethane (TCA), 1,1,2-TCA, and several radionuclides. VOCs are the most widespread of the COCs. The highest concentrations of VOCs were reported in the southeast area of the C-400 Complex. DCE is formed from anaerobic biodegradation of TCE, TCA, or the DCE intermediates. It subsequently degrades to ethene and/or ethane. The current data indicate that anaerobic biodegradation (e.g., TCE to DCE) is not a major process in the hydrogeological/geochemical environment at the C-400 Complex.

Once in the groundwater, COCs generally move through the RGA via advection. COCs spread both horizontally and vertically due to the process of dispersion, while adsorption retards the movement of chemicals in groundwater. Dispersion generally causes chemicals to migrate from 10 to 20% farther than migration caused by advection alone. Adsorption, which retards the movement of chemicals, counteracts the advection and dispersion processes. Adsorption is generally described by a chemical’s K_d.

In accordance with the COCs identified in the WAG 6 RI**,** the most mobile constituents include the chlorinated VOCs. Other constituents, including PAHs and metals (such as lead and vanadium), are not readily transported in groundwater. Consistent with these properties, PAHs were not detected in the groundwater. The widespread occurrence of unfiltered metals in the WAG 6 RI groundwater samples, such as iron, is the result of highly turbid groundwater samples and is not a result of migration or site-related activities.

4.10.2.3 Groundwater Migration–McNairy

The following text summarizes the site data available for the Cretaceous McNairy Formation, relative to groundwater migration.

Stratigraphy Overview

The McNairy Formation includes an upper silt and sand member, a middle silt and clay member (known as the Levings Member), and a lower sand member at the Paducah Site. Laterally extensive, smaller scale, bedding has not been identified in the McNairy members in the proximity of the Paducah Site.

McNairy Upper Member: The upper member of the McNairy Formation primarily consists of interlensing, fine-grained, silt and sand. In the area of the Paducah Site, the Paleocene age Clayton Formation and upper member of the Cretaceous age McNairy Formation are indistinguishable based on soil textures and are referred to collectively as the McNairy upper member. Sand units comprise less than one-half of the thickness of the McNairy upper member at the Paducah Site. The top of the McNairy upper member underlies the Porters Creek Clay under the south portion of the Paducah Site at an elevation of approximately 240 ft amsl. The irregular erosional surface of the ancestral Tennessee River basin, at an approximate elevation of 250 to 280 ft amsl is the top of the McNairy upper member under the north portion of the Paducah Site.

McNairy Levings Member: A common interval of generally finer-grained clastic sediments exists beneath the Paducah Site and adjacent areas. The lithologic character and stratigraphic position is consistent with description of the Levings Member by Pryor and Ross (1962). In the area of the Paducah Site, the contact of the upper member and Levings Member appears relatively planar, at an approximate elevation of 215 to 220 ft amsl.

McNairy Lower Member: The lower member of the McNairy Formation predominately consists of well-sorted, fine sand with lesser silt and clay interbeds. As noted by regional studies (Moneymaker and Grant 1954; Pryor 1960; and Davis, Lambert, and Hansen, Jr. 1973), the McNairy Formation sands are characteristically fine-grained. Sands of the lower member are uniquely well-sorted. Beneath the industrial complex of the Paducah Site, the top of the McNairy lower member occurs at an approximate elevation of 110 to 130 ft amsl, and the base is at an approximate elevation of -5 to 90 ft amsl.

McNairy/RGA Interface

The low hydraulic conductivity of the fine-grained sediments of the McNairy Formation (interbedded fine sands, silts, and clays) sharply contrasts with the high hydraulic conductivity of the coarse grained sediments of the overlying RGA (gravelly sands and sandy gravels). This contrast of hydraulic conductivity within a low vertical, hydraulic gradient field,[5] results in a dominant lateral flow regime in the RGA with little vertical flow between the RGA and the McNairy Formation. Although the lower McNairy member is an aquifer capable of producing residential supplies, the upper McNairy Formation in the area of the Paducah Site functions as a lower aquitard to the RGA.

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[5] At the C-400 Complex, the vertical hydraulic gradient of both the RGA and McNairy Formation is approximately $\underline{+}1 \times 10^{-2}$ ft/ft.

McNairy Formation Data of the Paducah Site

Characterization of the McNairy Formation at the Paducah Site can be summarized utilizing three types of data: lithologic descriptions, aquifer properties, and groundwater elevations.

Lithologic Descriptions of the C-400 Area

While numerous Paducah Site investigations provide lithologic logs of the upper McNairy member, relatively few soil borings transect all (or most) of the McNairy Formation. Deep McNairy Formation lithology and geophysical logs include the following:

- The 2 deep Z-series locations, Z-9/Z-12 and Z-14/Z-16, on the north and west sides of the Paducah Site (ERCE 1990),
- The P4F8 soil boring of the Groundwater Monitoring Phase IV Investigation, located in the north central area of the industrial complex (DOE 1995a), and
- The DB01 soil boring from the siting investigation for a potential CERCLA waste disposal facility, located immediately south of the industrial complex (DOE 2004a).

The WAG 6 RI provides lithologic logs of the upper McNairy member in the C-400 area for 11 deeper soil borings, with total depths ranging from 104 to 147 ft. The predominant soil textures that are described range from clay to fine sand (DOE 1999a). No upper McNairy member lithologic units can be correlated across the C-400 area.

Hydrogeologic Properties

Several area investigations contribute measurements of aquifer properties of the McNairy Formation at the Paducah Site. Appendix B includes a figure that shows the historical McNairy Formation sample locations. Table 4.1 summarizes measurements of natural moisture content and specific gravity of McNairy Formation soil samples and the derived porosity for the samples. Direct measurements of McNairy Formation porosity as part of the WAG 6 RI, as summarized in Table 4.2, are similar to the area-wide results (DOE 1999a).

Four Paducah Site investigations have measured hydraulic conductivity of the McNairy Formation. The Phase I SI (CH2M HILL 1991) measured horizontal hydraulic conductivity with slug tests in three McNairy MWs. Results ranged from 2.88×10^{-5} to 1.84×10^{-4} cm/sec (Table 4.3) with a median value of 9.69×10^{-5} cm/sec. Tests for siting investigations of the Northwest Plume Capture System and the C-746-U Landfill measured vertical hydraulic conductivity with permeameters from 18 soil borings and 20 discrete sample depths (Table 4.4). Vertical hydraulic conductivity values ranged from 1.80×10^{-8} to 5×10^{-4} cm/sec with a median value of 3.67×10^{-7} cm/sec.

Table 4.1. Porosity of McNairy Formation Samples

Soil Boring ID	Sample Number	Depth (ft bgs)	Elevation (ft amsl)	Grain Size Description	Natural Moisture Content (%)	Specific Gravity (gm/cm^3)	Calculated Porosity (%)
S-7	27	135.0-137.5	244.8-247.3	SILT, sandy	42	2.65	65
Z-1	30	124.0-125.5	254.8-256.3	SAND, silty	23	2.56	43
Z-5	33	133.5-135.0	244.9-246.4	SAND, silty	30	2.56	52
Z-12	1	137.8-139.2	211.9-213.3	CLAY, silty	30	2.59	53
	4	197.8-199.2	151.9-153.3	CLAY, sandy	10	2.60	23
	7	257.8-258.9	92.2-93.3	SILT, sandy	19	2.62	38
	10	317.8-318.2	32.9-33.3	SAND, clayey	27	2.75	51
Z-14	31	123.5-125.0	246.5-248.0	CLAY, silty	27	2.70	49
Z-16	2	137.0-139.0	231.9-233.9	SAND, clayey	33	2.62	56
	5	167.7-169.2	201.7-203.2	CLAY, sandy	26	2.66	48
	6	177.7-179.2	191.7-193.2	SAND, silty	25	2.65	47
	8	197.7-199.2	171.7-173.2	CLAY, silty	24	2.63	46
	11	227.7-228.1	142.8-143.2	SAND, silty	27	2.67	50
	14	257.7-258.8	112.1-113.2	CLAY, silty	25	2.65	46
	17	287.7-288.2	82.7-83.2	SAND, silty	31	2.65	55
	19	307.7-308.2	62.7-63.2	SAND	28	2.66	51
						Average Porosity:	**48**

Table 4.2. Measurements of McNairy Formation Samples as Part of the WAG 6 RI

Soil Boring ID	Depth (ft bgs)	Elevation (ft amsl)	Percentage			Porosity (%)
			Clay	Silt	Sand	
026001SA120	127-130	246.0-249.0	1.9	5.0	93.1	41
400036SA110	109*	269.3	4.0	3.3	92.7	51
400036SA120	120*	258.3	27.5	15.3	57.2	52
400036SA140	141*	237.3	7.8	22.5	69.7	48
400038SA120	120-120.5*	258.4-258.9	54.0	37.7	8.3	45
400038SA140	141-143.5	235.4-237.9	27.8	58.6	13.6	32
400208SA140	126-128*	246.4-248.4	15.2	73.0	11.8	42
400210SA110	115.5-116*	261.4-261.9	16.0	33.8	50.2	56
400212SA100	117-119.5*	256.3-258.8	20.0	45.4	34.6	46
					Average Porosity:	**46**

*Depth of associated analytical sample.

Table 4.3. Slug Tests of McNairy Formation Monitoring Wells from the Phase I SI

Monitoring Well	Screen Interval		Lithologies of the Screen Interval	Hydraulic Conductivity (cm/sec)
	Depth (ft)	Elevation (ft amsl)		
MW120	155-170	214-229	CLAY, silty and SAND	1.84×10^{-4}
MW121	198-210	162-174	SILT and SAND, silty	2.88×10^{-5}
MW122	144-158	205-219	SAND, medium and CLAY, sandy	9.69×10^{-5}
			Average:	$\mathbf{1.03 \times 10^{-4}}$
			Median:	$\mathbf{9.69 \times 10^{-5}}$

Table 4.4. Permeameter Tests of McNairy Formation Samples outside C-400 Vicinity

Soil Boring ID	Depth (ft bgs)	Elevation (ft amsl)	Lithology	Hydraulic Conductivity (cm/sec)
GB-01D	86-88 #2	272.2-274.2	CLAY with sand interbeds	2.75×10^{-7}
	86-88#3			3.67×10^{-7}
GB-02D	88-90 #2	272.3-274.3	CLAY with silt interbeds	4.09×10^{-8}
	88 90 #3			7.25×10^{-8}
GB-03D	88-90 #2	271.9-273.9	CLAY with sand interbeds	4.66×10^{-6}
	88 90 #3			2.67×10^{-6}
GB-04D	83-85 #2	279.9-281.9	SAND, very fine	4.71×10^{-5}
	83-85 #3			4.12×10^{-6}
GB-05D	83-85 #2	278.4-280.4	CLAY, sandy	1.25×10^{-6}
	83-85 #3			2.05×10^{-6}
MW239	124-126	244.1-246.1	No description	2.10×10^{-7}
MW245	95-97	272.2-274.2	GRAVEL, sandy, silty	5.00×10^{-4}
MW247	118-120	247.0-249.0	No description	5.90×10^{-6}
MW248	98-100	268.5-270.5	No description	9.80×10^{-5}
MW250	95-97	270.8-272.8	SAND and CLAY, silty	1.20×10^{-7}
SB-28	114-116	253.9-255.9	SAND, fine above/CLAY below	4.10×10^{-6}
SB-29	114-116	253.8-255.8	CLAY with sand above/CLAY below	3.90×10^{-8}
SB-30	114-116	251.5-253.5	CLAY above/SAND and CLAY below	2.50×10^{-7}
SB-31	114-116	252.3-254.3	CLAY above/CLAY below	1.60×10^{-7}
SB-33	98-100	267.2-269.2	SAND and CLAY, interbedded	1.80×10^{-8}
	174-176	191.2-193.2	CLAY	1.30×10^{-7}
SB-36	118-120	246.3-248.3	No description	1.50×10^{-4}
SB-37	88-90	279.9-281.9	CLAY with little sand	4.80×10^{-7}
	114-116	253.9-255.9	CLAY	3.30×10^{-7}
SB-38	118-120	248.1-250.1	CLAY with sand	5.40×10^{-8}
			Average:	$\mathbf{3.29 \times 10^{-5}}$
			Median:	$\mathbf{3.67 \times 10^{-7}}$

The WAG 6 RI measured the vertical hydraulic conductivity of 9 McNairy Formation soil samples from the C-400 area (DOE 1999a). Values ranged from 8.2×10^{-8} to 1.09×10^{-3} cm/sec with a median of 1.33×10^{-5} cm/sec (Table 4.5).

Table 4.5. Permeameter Tests of McNairy Formation Samples from the C-400 Area

Soil Boring ID	Depth (ft bgs)	Elevation (ft amsl)	Lithology	Hydraulic Conductivity (cm/sec)
026001SA120	127-130	246.0-249.0	SAND	1.09×10^{-3}
400036SA110	109*	269.3	SAND, silty	3.62×10^{-4}
400036SA120	120*	258.3	SAND, clayey, silty	8.20×10^{-8}
400036SA140	141*	237.3	SAND, silty	2.11×10^{-6}
400038SA120	120-120.5*	258.4-258.9	CLAY, silty	4.73×10^{-6}
400038SA140	141-143.5	235.4-237.9	SILT, clayey	1.52×10^{-5}
400208SA140	126-128*	246.4-248.4	SILT, clayey	7.36×10^{-5}
400210SA110	115.5-116*	261.4-261.9	SAND, clayey, silty	1.33×10^{-5}
400212SA100	117-119.5*	256.3-258.8	SILT, clayey, sandy	1.32×10^{-6}
			Average:	$\mathbf{1.74 \times 10^{-4}}$
			Median:	$\mathbf{1.33 \times 10^{-5}}$

* Depth of associated analytical sample.

Water Level Measurements

The regional potentiometric surface of the McNairy groundwater flow system dips from an outcrop recharge area at Kentucky Lake westward and northward to the Ohio River (Davis, Lambert, and Hansen, Jr., 1973). Local groundwater flow in the McNairy Formation discharges to the Ohio River. Potentiometric trends of the RGA and the McNairy Formation are similar at the Paducah Site.

The Paducah Site has 7 McNairy MWs with an extensive record of water level measurements, including 54 synoptic water level measurements during the period 1996 through 2011. (Six of these McNairy wells have neighboring RGA wells with synoptic water level measurements.) These synoptic measurements constitute a robust data set for analysis that documents similar McNairy water level trends in all 7 MWs (Figure 4.19).

Three of the McNairy MWs (MW122, MW239, and MW247) are located in close vicinity of extraction wells. The remaining four McNairy wells (MW102, MW120, MW121, and MW133) are located distal to extraction wells and provide opportunity for assessment of the vertical and horizontal gradients in the McNairy Formation.

The measured vertical gradients (using the water level in the adjacent RGA well as the water level at the base of the RGA) range between -0.013 (at MW121) and +0.014 ft/ft (at MW133). Horizontal gradients measured between two upgradient McNairy wells (MW102 and MW120) and downgradient McNairy wells (MW121 and MW133) are 4.65×10^{-4} ft/ft (at N24°E)[6] and 4.2×10^{-4} ft/ft (at N21°E),[6] respectively, (based on the median of water elevations in each well and corrected to a reference screen midpoint elevation of 219 ft amsl) (Figure 4.20).

Groundwater Flow Rates

The product of hydraulic conductivity (*K*) and gradient (*i*) divided by porosity (*n*) determines the groundwater flow rate of the McNairy Formation. Using the median horizontal hydraulic conductivity based on slug test data (Table 4.3) and assuming maximum horizontal hydraulic gradient, the horizontal groundwater flow rate in the McNairy Formation beneath C-400 is calculated as follows.

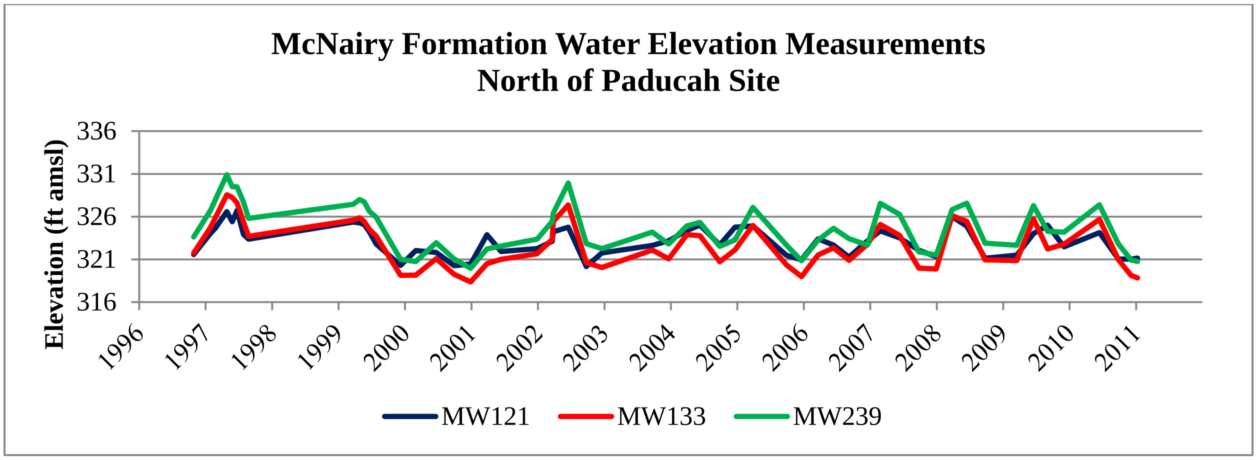
$$(K_{median} \text{ x } i)_{\text{horizontal}} \div n = (9.69 \times 10^{-5} \text{ cm/sec} \times 4.65 \text{ x } 10^{-4}) \div 0.46 = 9.80 \times 10^{-8} \text{ cm/sec} = 1.01 \times 10^{-1} \text{ ft/yr}$$

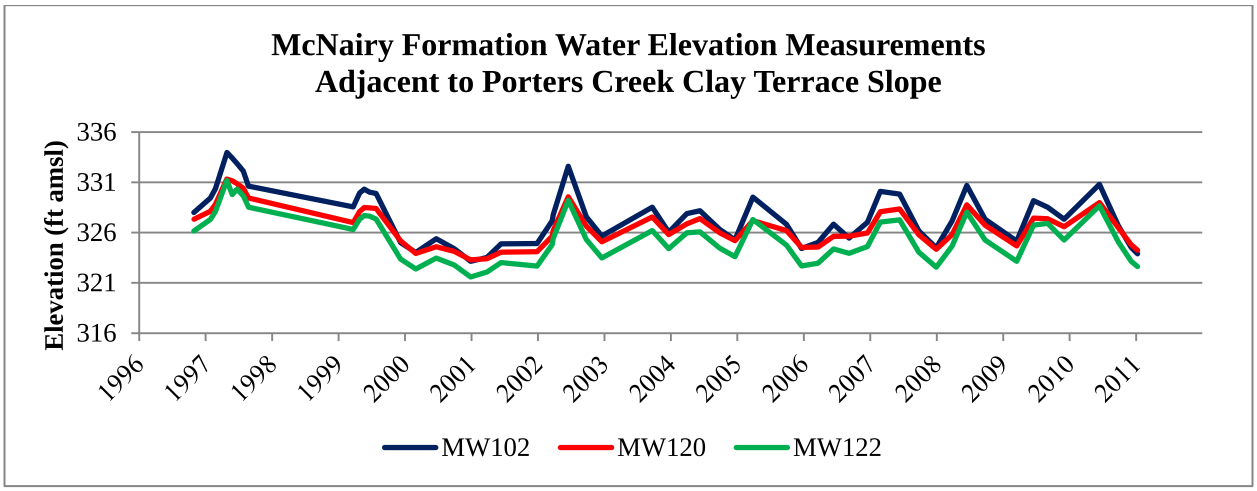
Using the median horizontal hydraulic conductivity based on permeameter test data (Table 4.5) and assuming the vertical gradient for the C-400 area is the same as MW121, the vertical groundwater flow rate in the McNairy Formation beneath C-400 is calculated as follows.

$$(K_{median} \text{ x } i)_{\text{vertical}} \div n = (1.33 \times 10^{-5} \text{ cm/sec} \times 1.3 \times 10^{-2}) \div 0.46 = 3.76 \times 10^{-7} \text{ cm/sec} = 3.89 \times 10^{-1} \text{ ft/yr}$$

Travel time for vertical advective flow across the 125-ft thickness of the Upper and Levings Members of the McNairy beneath C-400 is approximately 321 years.

[6] Bearings are relative to the Paducah Site coordinate system.





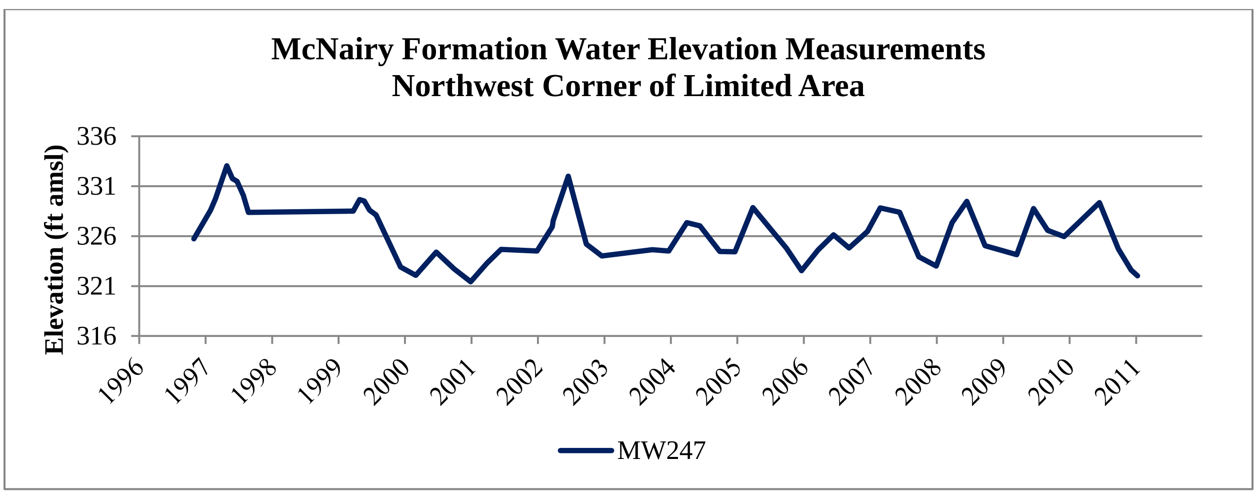


Figure 4.19. McNairy Formation Synoptic Water Elevation Measurements

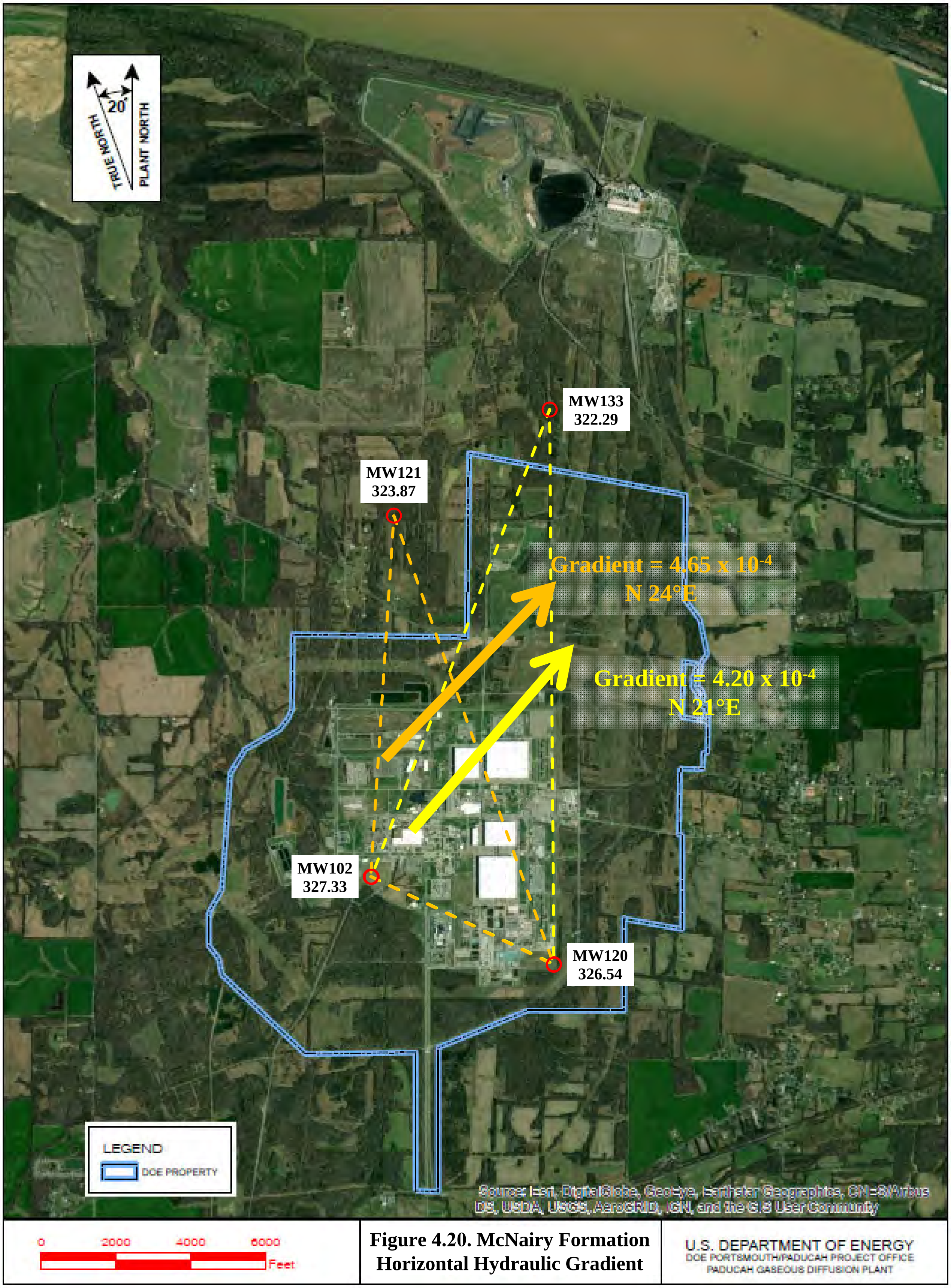


Figure 4.20. McNairy Formation Horizontal Hydraulic Gradient

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

Contaminant Migration

The rate of transport of dissolved contamination in the McNairy Formation by advective flow is much less than the rate of advective transport in the RGA. Diffusion may be a more important process promoting contaminant migration. The upper and middle McNairy Formation members have significant organic carbon content. Horizons of lignite are reported in some soil cores. Partitioning, biological transformation, and abiotic transformation likely are important processes of retardation and degradation of contaminants in the upper and middle members.

Analyses of grab samples of McNairy Formation groundwater samples beneath the TCE plumes from previous Paducah Site investigations [notably the Groundwater Monitoring Phase IV Investigation (DOE 1995a) and the WAG 6 RI (DOE 1999a)] indicate the vertical limit of TCE migration into the McNairy Formation is approximately 50 ft. Figure 4.21 summarizes the combined results.

Because large releases of TCE likely occurred and TCE is expected to have penetrated the thickness of the RGA as a DNAPL, TCE DNAPL likely pooled at the top of the McNairy Formation. Where TCE pools obtained enough height to overcome the interfacial tension between the RGA and McNairy Formation soils, TCE may have migrated to greater depths in the McNairy Formation. These migration depths could be significantly greater if faulting is present beneath C-400. Unless the contaminated, fine-grained sediments of the McNairy Formation are remediated, they will be a long-term source of dissolved TCE to the RGA through back diffusion.

4.10.3 Vapor Intrusion

A vapor intrusion (VI) study was conducted for the C-400 Cleaning Building, and the report was submitted to EPA and KDEP for review and approval on May 29, 2018 (*Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1289&D2/R1/A3/R1), (DOE 2018b) was approved by KDEP and EPA on November 21, 2018, and December 4, 2018, respectively.

TCE-contaminated groundwater and soil adjacent to and under the C-400 Cleaning Building are considered sources of vapors. Subslab vapor sampling at the C-400 Cleaning Building detected primarily TCE, but also detected *cis*-1,2-DCE. Subsurface conditions in the C-400 Complex are considered to allow vapor transport toward the building. Although TCE concentrations in the RGA near the C-400 Cleaning Building have decreased, groundwater concentrations still exceed EPA's groundwater Vapor Intrusion Screening Level (VISL). Similarly, remedial actions have achieved greater than 95% reduction in soil concentrations, though post remedial residual concentrations remain. Vapor concentrations associated with the remaining TCE contamination in groundwater and soil are expected to be orders of magnitude higher than the commercial soil gas and subslab TCE VISL screening level of 100 $\mu g/m^3$ (micrograms per m^3).

Vapor migration from subsurface groundwater and soil sources through the vadose zone is promoted by the presence of sand in the UCRS in the vicinity of the C-400 Complex, as well as the presence of gravel immediately beneath the building. The presence of gravel under the slab was documented by the drilling of sub-slab soil gas ports, which encountered gravel at six of the seven sub-slab probe locations. A possible explanation for why TCE vapors were not present in Location 3 (i.e., North Fan Basement) is that material beneath the slab is clay, rather than the anticipated gravel that was present at the other probe locations. The large number of utilities present in the vicinity of the building also may serve as preferential pathways for vapor migration.

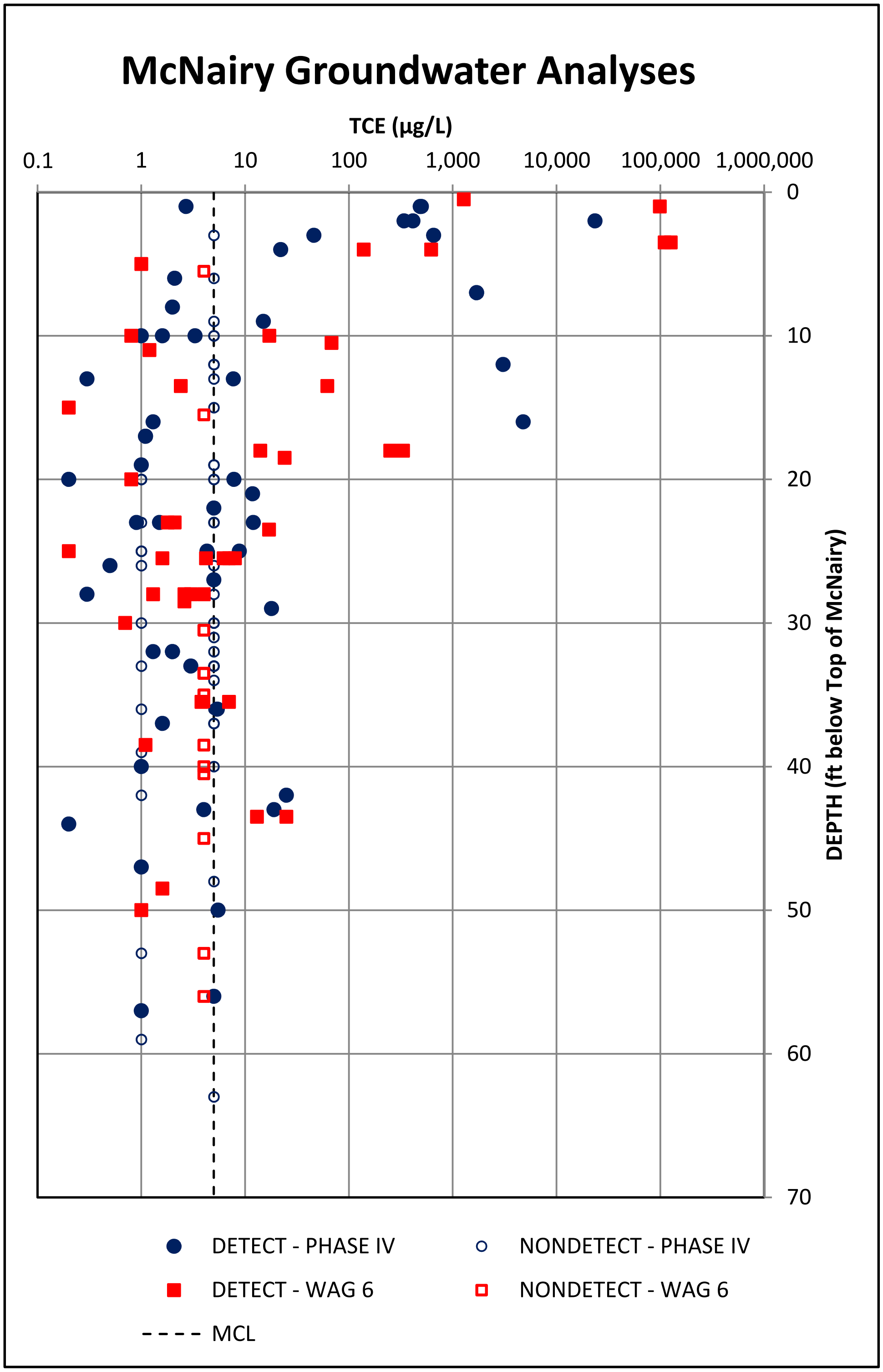


Figure 4.21. McNairy Formation Groundwater Sample TCE Analyses from the Groundwater Monitoring Phase IV Investigation and the WAG 6 RI

The spatial association between elevated indoor air and sub-slab soil gas concentrations is consistent with a conclusion that the VI pathway is complete, particularly in the southern portion of the building. The presence of *cis*-1,2-DCE in sub-slab vapor shows there is an underlying groundwater source of TCE. *Cis*-1,2-DCE is a common breakdown product of TCE dissolved in groundwater, where groundwater conditions support reductive dechlorination. It is rarely present in commercial products, and it generally is not associated with TCE off-gassing from contaminated vadose zone soil because soils typically are sufficiently oxygenated to preclude reductive dechlorination of TCE (Rivett et al. 2011). In the northern portion of C-400 Cleaning Building, at Locations 2, 3, and 4, *cis*-1,2-DCE was not detected in sub-slab soil gas, and TCE concentrations in sub-slab soil gas ranged from 14 to 200 µg/m3, which is consistent with an absence of subsurface sources of TCE [in groundwater] that are significant to the VI pathway. [Vadose zone sources of TCE are present, however.] In the southern portion of C-400 Cleaning Building, near Locations 1, 6, and 7, TCE concentrations in sub-slab soil gas ranged from 75 to 77,000 µg/m3, and *cis*-1,2-DCE was detected in sub-slab soil gas, consistent with a groundwater source of TCE and a complete VI pathway. A recommendation of the VI study was that, based on the presence of TCE in sub-slab soil gas above the EPA sub-slab soil gas screening level, periodic air monitoring be conducted and worker access be restricted. Additionally, increased ventilation may be appropriate if it is anticipated workers will spend substantial time in Locations 5, 6, and 8, the C-400 east basement area or former southeast office area until the building is decommissioned or the source is remediated.

5. CHARACTERIZATION OF SITE/PREVIOUS ANALYTICAL DATA

To facilitate evaluation of the C-400 Complex, the area has been divided into sectors similar to the sectors used in the WAG 6 RI (DOE 1999a). Sector 1, which is the footprint of the C-400 Cleaning Building, was subdivided further into four sectors, 1A through 1D, based on C-400 Cleaning Building historical processes. These sectors are illustrated in Figure 5.1. This section describes the areas for these sectors and discusses process history, previous investigations, baseline risk assessment, and data gaps associated with each sector. Finally, this section describes groundwater characterization of the C-400 Complex vicinity.

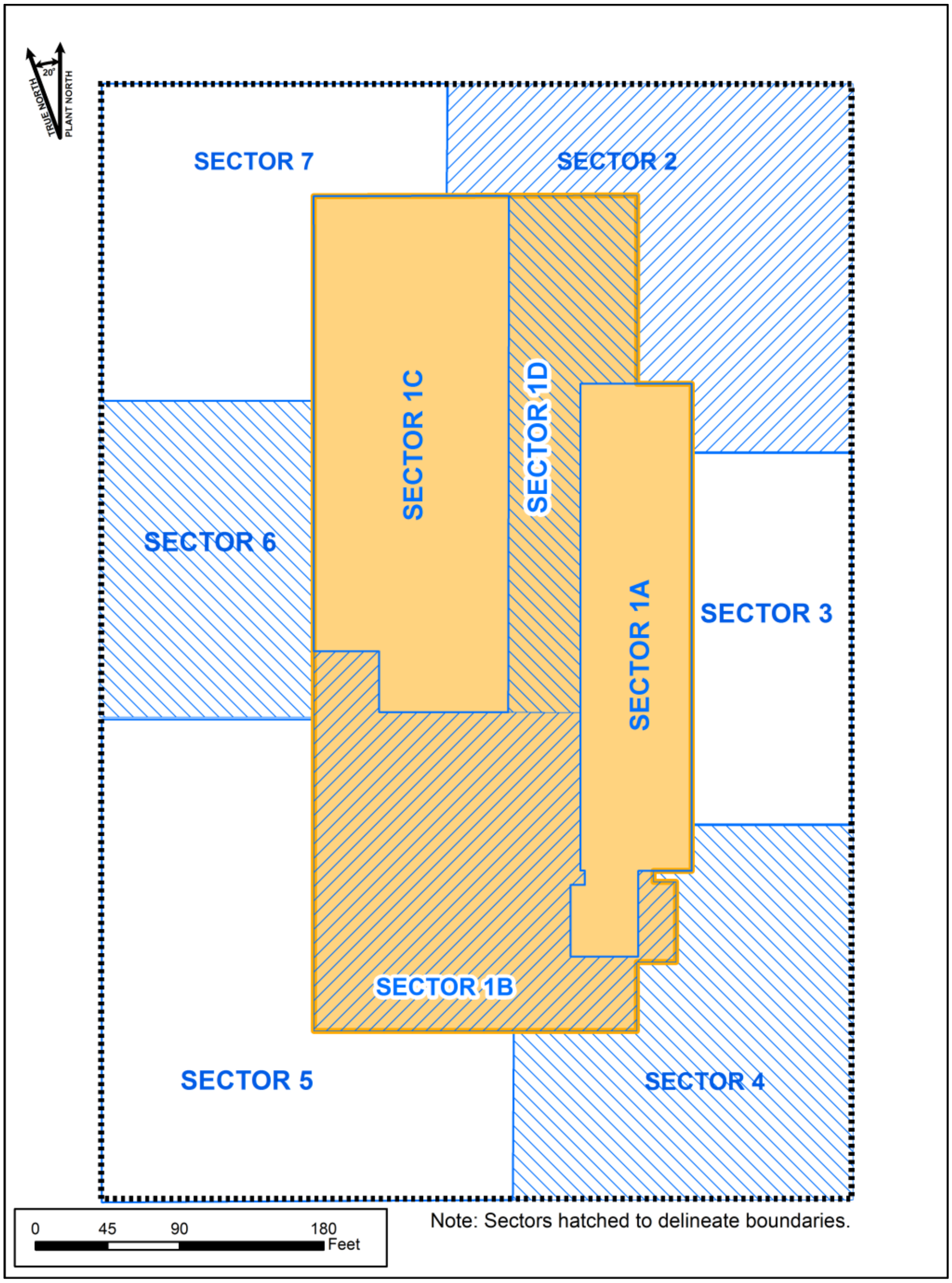


Figure 5.1. C-400 Complex Sectors

Several documents have been produced that contain data pertinent to the C-400 Complex. Additionally, data were downloaded from the Paducah OREIS database in January and March 2018. These data were binned for applicability using the decision rules for historical data determined during project scoping (Section 6.1.1).

The historical data set was used to compile various risk-screening tables required by the Risk Methods Document (RMD) for scoping activities (DOE 2019c). Historical data are provided in Appendix B of this document. Historical information summarized in this section highlights the background of each sector.

Historical summaries within this section include minimum (min), maximum (max) and average (avg) detected values and are compared to the screening values shown below. All screening values are taken from the RMD (DOE 2019c). These quantitative summaries are presented for information only.

The following are soil sample depth descriptions.

- Surface (0–1 ft bgs)—screened against PGDP background values for surface soil, industrial worker action levels (ALs)/no action levels (NALs), and groundwater protection screening levels calculated with dilution attenuation factors (DAFs) of 1 and 20.

- Subsurface (1–16 ft bgs)—screened against PGDP background values for subsurface soil, excavation worker ALs/NALs, and groundwater protection screening levels calculated with DAFs of 1 and 20.

- Deep soil (> 16 ft bgs)—screened against PGDP background values for subsurface soil, excavation worker ALs/NALs, and groundwater protection screening levels calculated with DAFs of 1 and 20.

All historical data have been reviewed in the qualitative summaries regardless of usability in the C-400 Complex risk assessment. Risk assessment results (for direct contact risks, for risks from contaminants migrating from soil to groundwater, and from the C-400 Complex to downgradient locations), which were included in previous investigation reports, are documented as they originally were reported, consistent with the RMD (DOE 2019c). Updates to risk assessment methodology (e.g., methodologies for assessing risk attributable to the dermal exposure route, inhalation exposure route, and mutagenic mode of action); exposure factor values; and toxicity criteria because the time of completion of the historical risk assessments likely would result in changes to the estimates of risk and hazard, including those contaminants and exposure routes driving risk and hazard. Additionally, quantitative summaries of uncertainties from the WAG 6 BHHRA are shown within this section. These summaries show alternate calculations of ELCR and systemic toxicity using site-specific exposure rates for general maintenance workers at PGDP at the time of the WAG 6 RI, omitting common laboratory contaminants, use of EPA default dermal absorption values, omitting analytes infrequently detected, and omitting lead as a COC (DOE 1999a). The summaries provide a lower-bound ELCR and HI for a current industrial worker. The exposure rate for the site-specific worker was reduced from 185 days per year for 25 years to sector-specific exposure rates. (See Subsection 1.6.2.5 of the BHHRA in the WAG 6 RI.) Additionally, default dermal absorption factors for soil were used in the risk assessment, consistent with risk assessment guidance from KDEP. This dermal absorption is more restrictive for the dermal-soil pathway than is recommended by EPA. The alternate calculations assessed risk using dermal absorption factors suggested by EPA. Finally, the alternate calculations for systemic toxicity omitted lead as a COC. Unlike the other analytes included in the WAG 6 risk assessment, the risks from exposure to lead also were estimated using a biokinetic model and comparing detected concentrations to KDEP and EPA screening values. This procedure was followed to address the uncertainty in the provisional reference dose provided by KDEP (which was based on toxicity for tetraethyl lead). Comparisons of representative concentrations of lead within each sector from the WAG 6 RI against regulatory screening values also are shown within this section (DOE 1999a).

5.1 SECTOR 1

Sector 1 was subdivided further into four sectors: 1A through 1D, based on C-400 Cleaning Building historical processes. These sectors and processes are illustrated on Figure 5.2. The sectors are described in subsections 5.1.1 through 5.1.4.

5.1.1 Sector 1A

5.1.1.1 Area description

Sector 1A is approximately 23,000 ft^2. Approximately 21,000 ft^2 of Sector 1A is included in an east C-400 Cleaning Building basement. A concrete slab covers the entire area.

5.1.1.2 Process history

As shown in Figure 5.3, the following are located in the area.

- Detrex degreaser (#1 Degreaser)
- Dip tanks
- Fan room
- Equipment laydown area
- C-400 Basement Sump (SWMU 98)

Based on the *C-400 Process and Structure Review*, the tank bottom of the TCE degreaser rusted out, releasing TCE to the adjacent floor drain and sump (SWMU 98) (DOE 1995b). The cleaning tanks historically drained through the acid lines to the C-403 Neutralization Tank (SWMU 40).

5.1.1.3 Previous investigation results

No historical subsurface soil or groundwater analytical data for this sector are available (Section 5.1.6).

Areas within this sector were sampled as part of an effort to characterize the C-400 Cleaning Building basement slab and subsurface structures (DOE 2018c) (Reference Section 5.1.5.2 and Appendix D of the RI/FS Work Plan).

5.1.2 Sector 1B

5.1.2.1 Area description

Sector 1B is approximately 37,000 ft^2. A concrete slab covers the entire area.

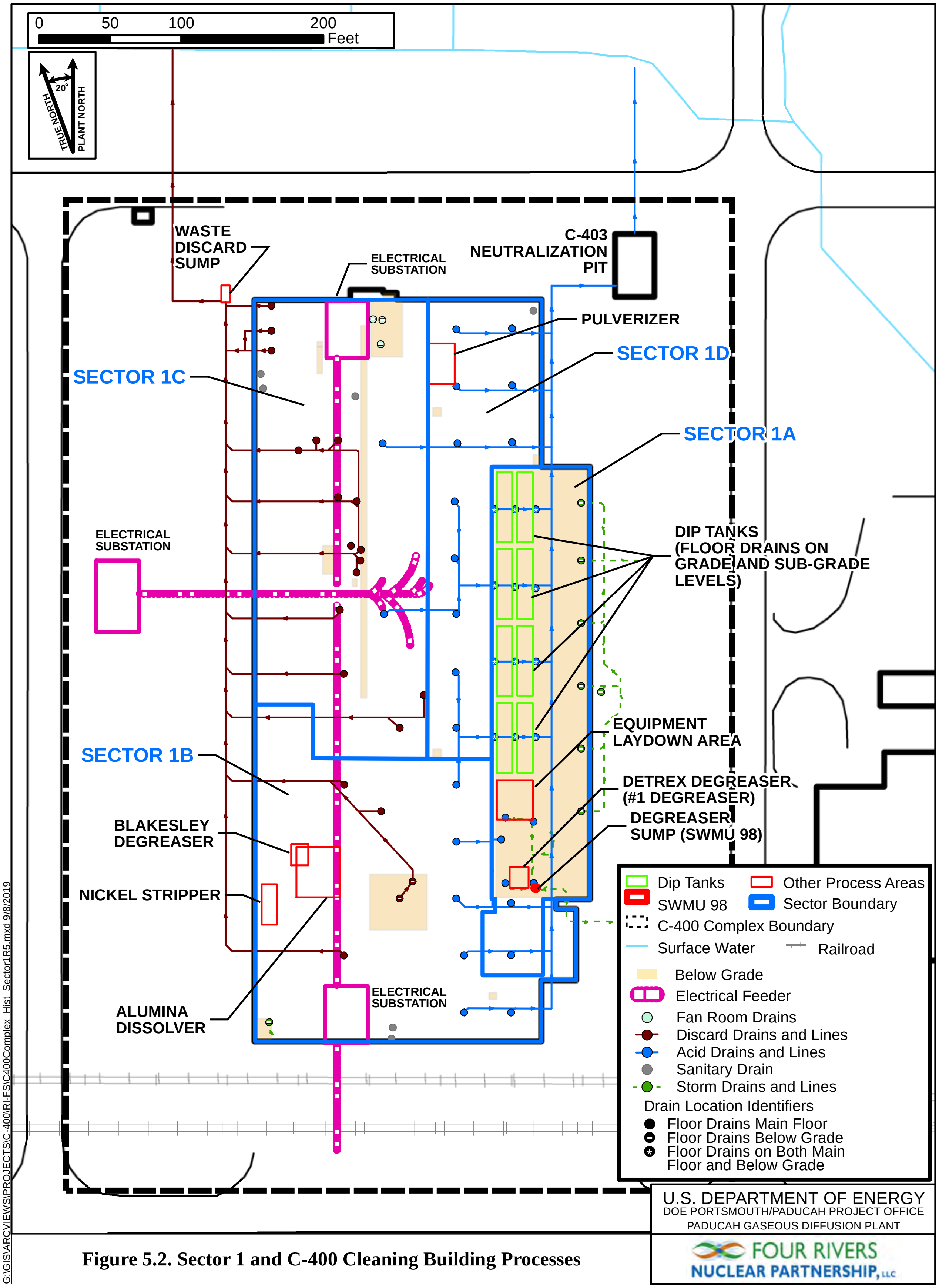


Figure 5.2. Sector 1 and C-400 Cleaning Building Processes

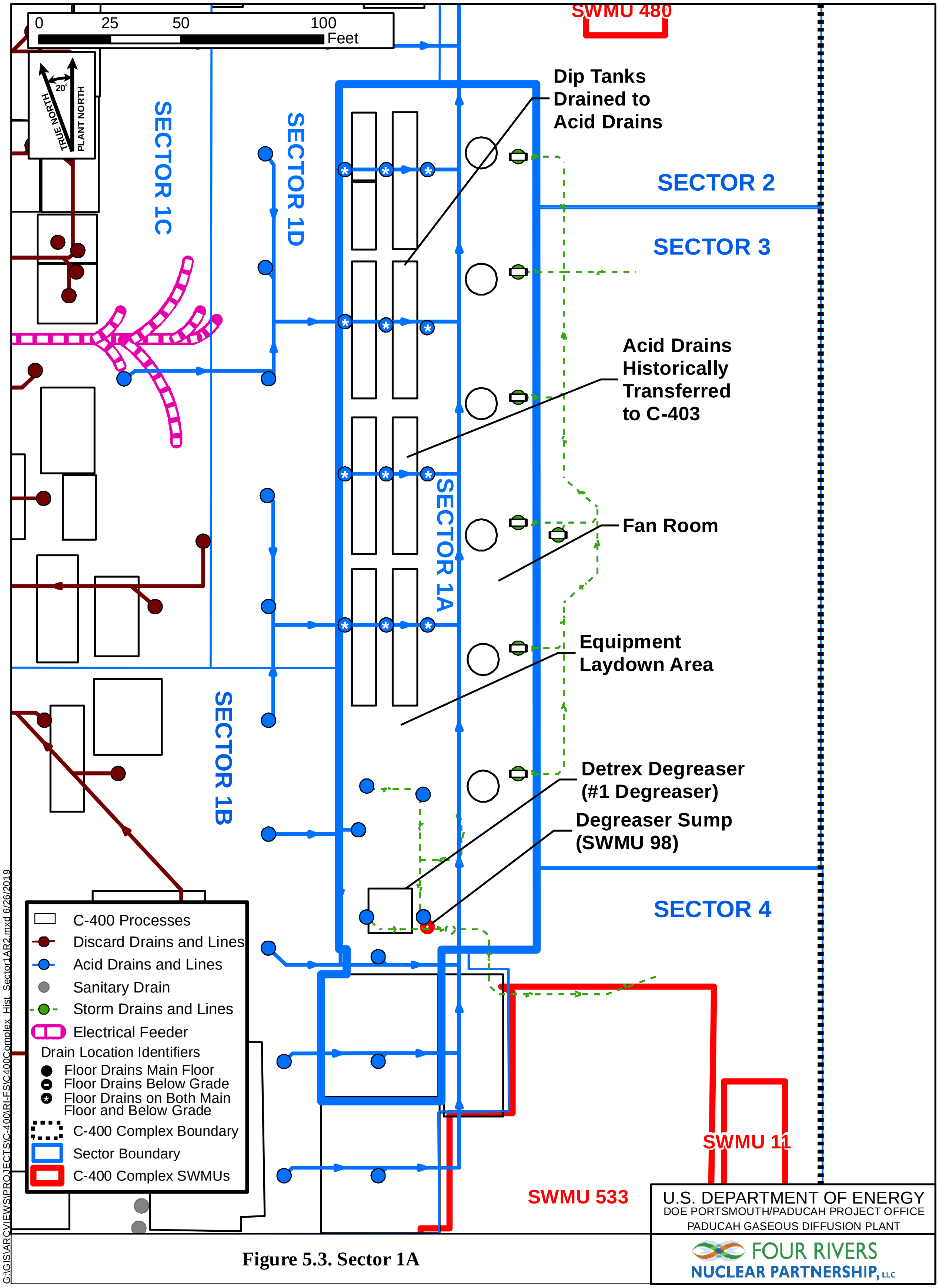


Figure 5.3. Sector 1A

5.1.2.2 Process history

As shown in Figure 5.4, the following are located in the area.

- Blakesly degreaser
- Compressor disassembly pit
- Cylinder cleaning and testing area
- Hand table
- Spray booth
- Spray Booth Tanks
- Alumina dissolver

Based on the Process and Structure Review, metals and radionuclides are the primary COCs associated with the main processes (DOE 1995b). Acids also are of concern in the area. TCA, in addition to TCE, was used in the Blakesly degreaser.

5.1.2.3 Previous investigation results

No historical subsurface soil or groundwater analytical data for this sector are applicable according to the decision rules for historical data determined during project scoping. For information only, as part of the WAG 6 RI, one UCRS soil boring, 400-020, was drilled within the building in this sector. The boring collected 10 soil samples at depths between 8 and 49 ft bgs. Metals, VOCs, and radionuclides were detected in sample analyses. The maximum TCE detected was 2,900 µg/kg. Radionuclides detected were cesium-137 and neptunium-237. Additionally, as part of the WAG 6 RI, one angled soil boring, 400-041, was drilled underneath the building in this sector. The boring was drilled to 125 ft bgs in vertical depth and collected 13 soil samples at depths between 1 and 125 ft bgs. The maximum TCE detected in the soil samples was 5,000 µg/kg. Eight groundwater samples were collected within the RGA; the maximum TCE detected was 126,012 µg/L at 90 ft bgs.

Areas within this sector were sampled as part of an effort to characterize the C-400 Cleaning Building basement slab and subsurface structures (DOE 2018c) (Reference Section 5.1.5.2 and Appendix D of the RI/FS Work Plan).

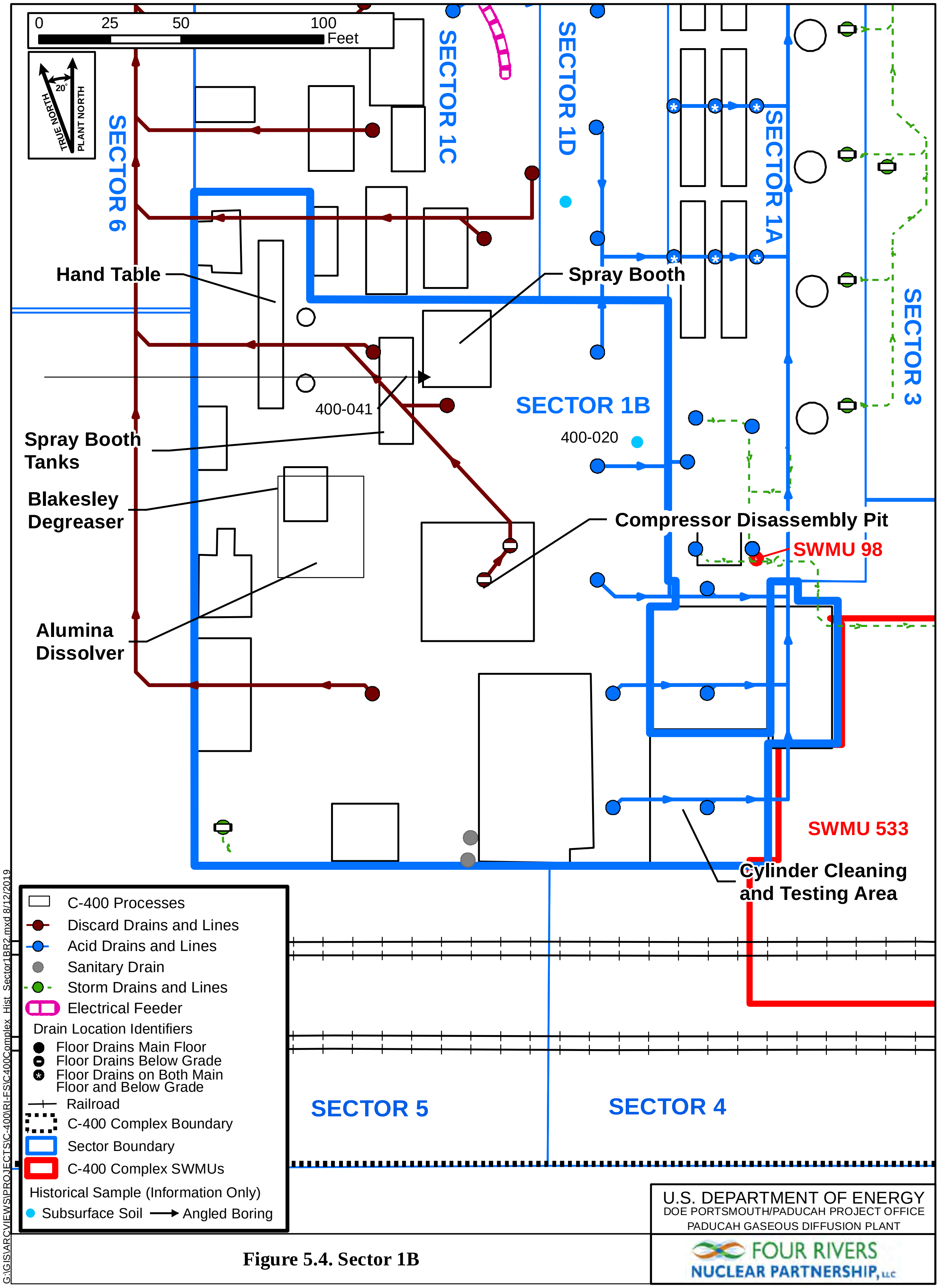


Figure 5.4. Sector 1B

5.1.3 Sector 1C

5.1.3.1 Area description

Sector 1C is approximately 38,000 ft^2. A concrete slab covers the entire area.

5.1.3.2 Process history

As shown in Figure 5.5, the following are located in the area.

- Gold recovery systems
- Cubicle Area (chemical and precious metal storage area)
- Laundry room
- Test loop
- Acidifying tanks
- Tc-99 recovery system
- North Fan Basement
- Uranium solution storage tanks
- No. 5 dissolver solution storage tanks

5.1.3.3 Previous investigation results

No historical subsurface soil and groundwater analytical data for this sector are applicable according to the decision rules for historical data determined during project scoping. For information only, as part of the WAG 6 RI, one angled soil boring, 400-040, was drilled underneath the building in this sector. The boring was drilled to 110 ft bgs in vertical depth and collected 10 soil samples at depths between 12 and 110 ft bgs. The maximum TCE detected in the soil samples was 1,400 µg/kg. Nine groundwater samples were collected within the RGA; the maximum TCE detected was 57,639 µg/L at 80 ft bgs.

Areas within this sector were sampled as part of an effort to characterize the C-400 Cleaning Building basement slab and subsurface structures (DOE 2018c) (Reference Section 5.1.5.2 and Appendix D of the RI/FS Work Plan).

5.1.4 Sector 1D

5.1.4.1 Area description

Sector 1D is approximately 19,000 ft^2. A concrete slab covers the entire area.

5.1.4.2 Process history

As shown in Figure 5.6, the following are located in the area.

- UF_6 Drum Pulverizer
- Drum Washer and Crusher
- Truck Alley

Based on the Process and Structure Review, the UF_6 drum pulverizer was used to pulverize and segregate green salt (uranium tetrafluoride) and ash receiver waste (DOE 1995b).

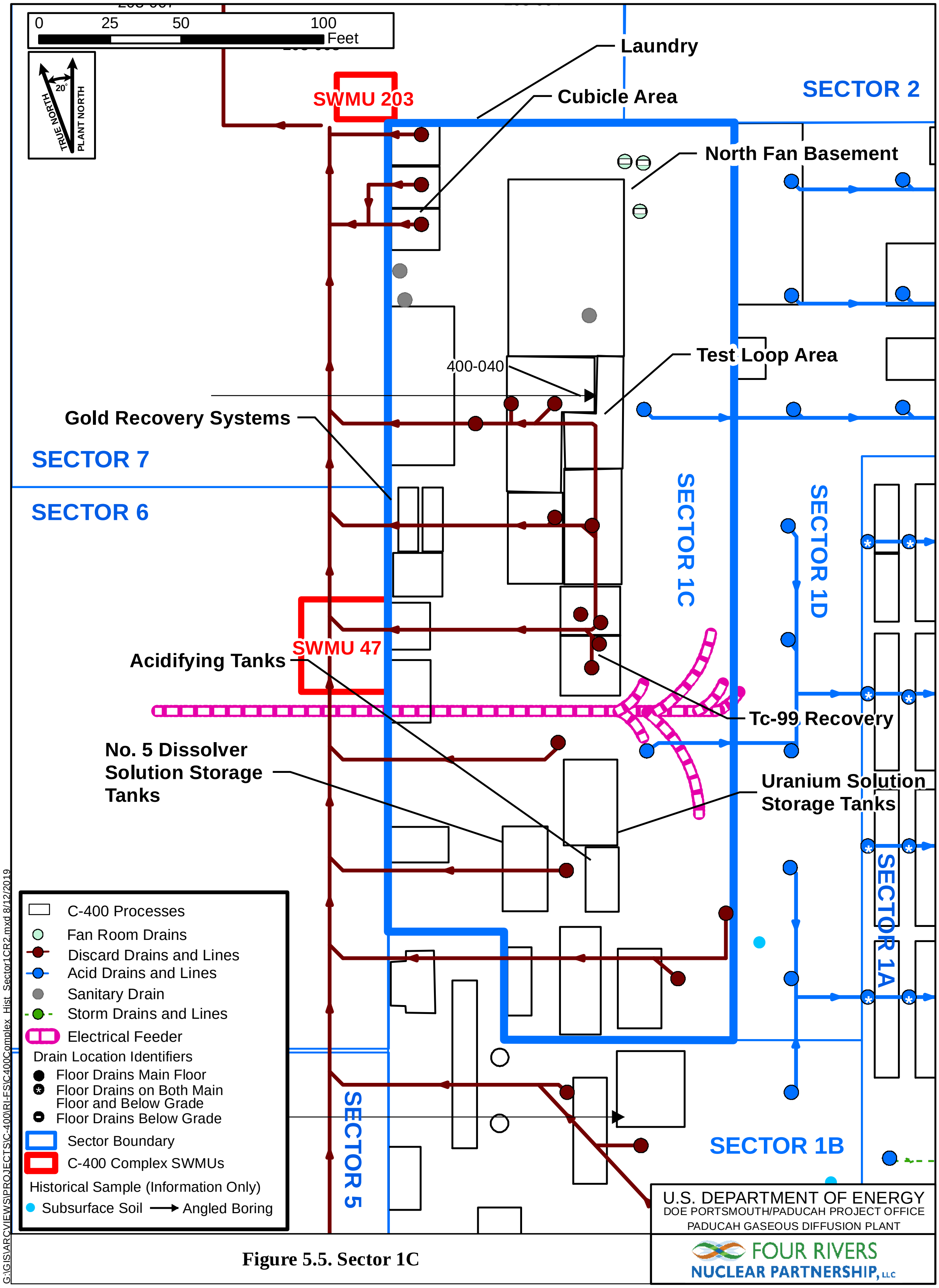


Figure 5.5. Sector 1C

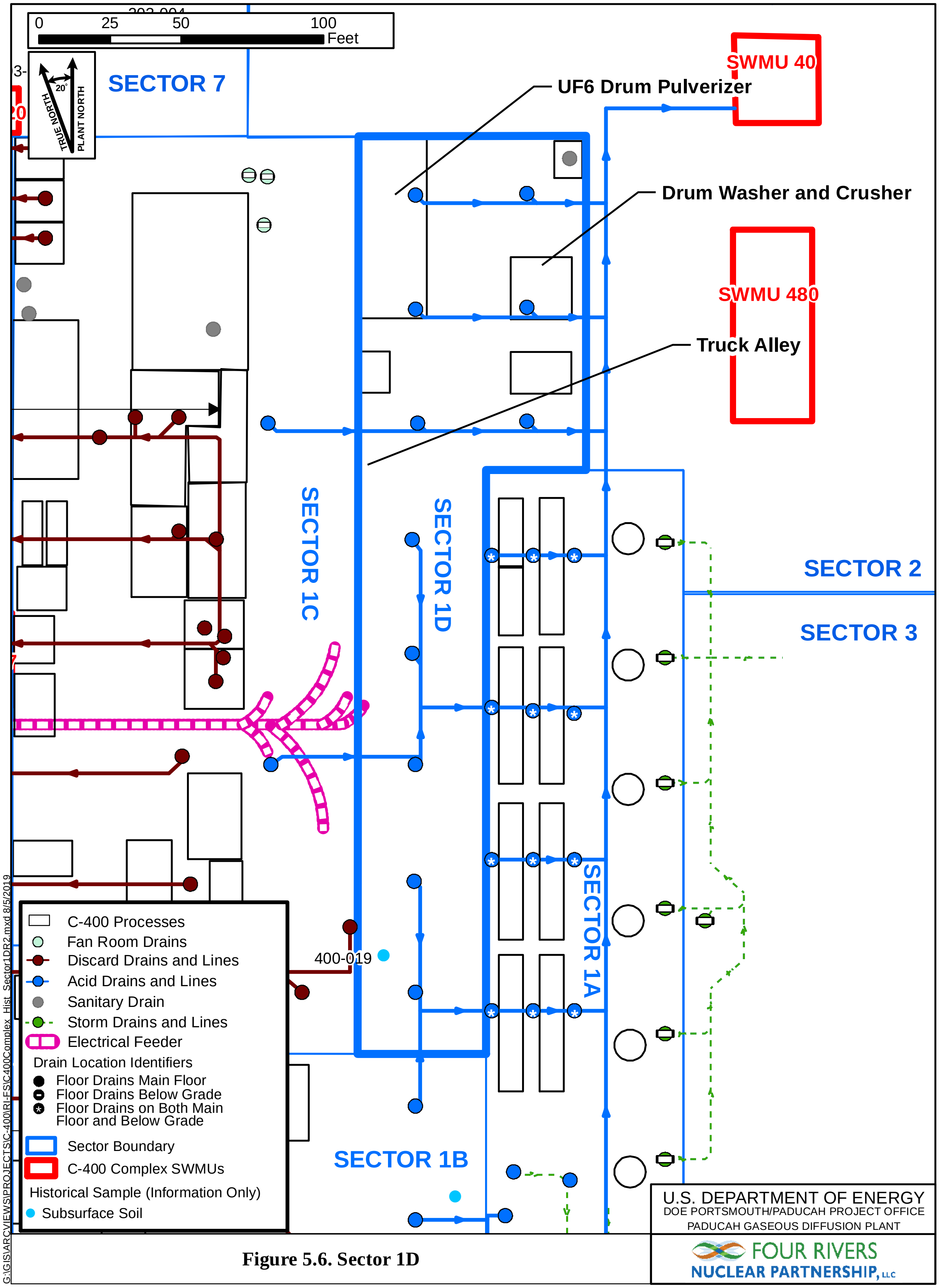


Figure 5.6. Sector 1D

5.1.4.3 Previous investigation results

No historical subsurface soil and groundwater analytical data for this sector are applicable according to the decision rules for historical data determined during project scoping. For information only, as part of the WAG 6 RI, one UCRS soil boring, 400-019, was drilled within the building in this sector. The boring collected 12 soil samples at depths between 4 and 44 ft bgs. The maximum TCE detected was 13 µg/kg. Metals, radionuclides, and SVOCs also were detected.

Areas within this area were sampled as part of an effort to characterize the C-400 Cleaning Building basement slab and subsurface structures (DOE 2018c) (Reference Section 5.1.5.2 and Appendix D of the RI/FS Work Plan).

5.1.5 Previous Investigation Results

5.1.5.1 C-400 Cleaning Building Vapor Intrusion Study

A C-400 Vapor Intrusion Study was conducted in this sector. The spatial association between elevated indoor air and sub-slab soil gas concentrations is consistent with a conclusion that the VI pathway is complete, particularly in the southern portion of the building. The presence of *cis*-1,2-DCE in sub-slab vapor shows there is an underlying groundwater source of TCE. *Cis*-1,2-DCE is a common breakdown product of TCE dissolved in groundwater, where groundwater conditions support reductive dechlorination. It is rarely present in commercial products, and it generally is not associated with TCE off-gassing from contaminated vadose zone soil because soils typically are sufficiently oxygenated to preclude reductive dechlorination of TCE (Rivett et al. 2011). In the northern portion of C-400 Cleaning Building, at Locations 2, 3, and 4, *cis*-1,2-DCE was not detected in sub-slab soil gas, and TCE concentrations in sub-slab soil gas ranged from 14 to 200 µg/m3, which is consistent with an absence of subsurface sources of TCE [in groundwater] that are significant to the VI pathway. [Vadose zone sources of TCE are present, however.] In the southern portion of C-400 Cleaning Building, near Locations 1, 6, and 7, TCE concentrations in sub-slab soil gas ranged from 75 to 77,000 µg/m3, and *cis*-1,2-DCE was detected in sub-slab soil gas, consistent with a groundwater source of TCE and a complete VI pathway. A recommendation of the VI study was that, based on the presence of TCE in sub-slab soil gas above the EPA sub-slab soil gas screening level, periodic air monitoring be conducted and worker access be restricted. Additionally, increased ventilation may be appropriate if it is anticipated workers will spend substantial time in Locations 5, 6, and 8, the C-400 east basement area, or former southeast office area until the building is decommissioned or the source is remediated.

Data from this investigation can be found in the *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant* (DOE 2018b). Refer to Section 4.10.3 for additional details.

5.1.5.2 C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling

Sector 1 was sampled in 2018 as part of an effort to characterize the C-400 Cleaning Building basement slab and subsurface structures (DOE 2018c).

In August 2019, the *Memorandum of Agreement for Resolution of Formal Disputes on EPA Conditional Concurrence on the Removal Notification for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2420&D2 *and the Engineering Evaluation/Cost Analysis for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant,* *Paducah, Kentucky,* DOE/LX/07-2425&D2, was finalized by DOE, EPA, and KDEP (DOE 2019d). The following are the terms and conditions of the dispute resolution in the MOA (DOE 2019d).

1. The FFA parties agree that physical demolition of the C-400 Building down to slab as a NTCRA will not be completed prior to the C-400 Complex RI Field Start date.

2. The FFA parties agree to proceed with the C-400 Complex Remedial Investigation/Feasibility Study (RI/FS) project.

3. The FFA parties agree that a revision to the *Removal Notification for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07/2420&D2, (Removal Notification) submitted on March 8, 2018, to address the EPA conditions is not required at this time because the NTCRA is suspended per this July 2019 SEC Formal Dispute MOA. The parties acknowledge that this MOA does not resolve EPA conditions on the Removal Notification.

4. The FFA parties agree that a revision to the *Engineering Evaluation/Cost Analysis for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2425&D2 C-400 Building Engineering Evaluation/Cost Analysis (EE/CA)] submitted on July 26, 2018, is not required at this time because the NTCRA is suspended per this July 2019 SEC Formal Dispute MOA. Informal dispute agreements reached by the FFA parties on the EPA Conditions shall be addressed in the Primary Documents for the NTCRA when the NTCRA proceeds. The parties acknowledge that this MOA does not resolve four EPA conditions on the EE/CA.

5. The FFA parties agree that a *Memorandum to File* will be added to the Administrative Record documenting the D1 and D2 CERCLA process Primary Documents (Removal Notification, EE/CA, Action Memorandum, Removal Action Work Plan) related to the C-400 Cleaning Building NTCRA are not approved and the NTCRA was suspended per this July 2019 SEC Formal Dispute MOA. In this one instance, EPA and KDEP will review and approve the *Memorandum to File* prior to DOE placement in the Administrative Record file.

6. The FFA parties agree that, to avoid delays in finalizing the C-400 Complex D2 RI/FS Work Plan, reporting of the C-400 Deactivation data will be merged with the D2 RI/FS Work Plan to accelerate the documentation process consistent with FFA Section XX.C. DOE will submit, concurrent with submittal of the D2 RI/FS Work Plan, an Appendix to document the sampling results (available at the time of submittal) from the implementation of the Four Rivers Nuclear Partnership, LLC, July 2018 C-400 Cleaning Building Deactivation Basement Slab and Subsurface Structures, Sampling and Analysis Plan/Quality Assurance Project Plan [i.e., *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan*, DOE/LX/07-2430&D1]. The Appendix will follow the Preliminary Characterization Summary Report outline in Appendix D of the Paducah FFA. The FFA parties will use the information in the Appendix for determining if additional RI/FS sampling associated with the basement areas, subsurface structures, and subgrade environmental media is needed to finalize the C-400 Complex RI/FS Work Plan.

Appendix D of the RI/FS Work Plan documents the sampling results (available at the time of submittal) from the implementation of the *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan* (DOE 2018c) and describes the field investigation, data evaluation, risk evaluation, and summary and conclusions for the sampling. Appendix D of the D2 RI/FS Work Plan was prepared to be equivalent to the guidance for a Preliminary Characterization Summary Report outline in Appendix D of the Paducah FFA and contains additional information regarding sampling and data quality information; therefore Appendix D of the D2 RI/FS Work Plan meets the intent of the MOA (DOE 2019d). The outline used for Appendix D of the D2 RI/FS Work Plan is consistent with conversations held among the FFA parties on August 5, 2019. Data collection associated with this effort was specifically for characterization of the concrete floors and walls (including stained areas), surface coatings on walls and floors, liquids/sludges in floor drains (if available), and caulk located in the sub-grade areas. Additionally, video borescopes were collected of pipes that penetrate and underlie the concrete foundation.

The FFA parties used the information in Appendix D of the RI/FS Work Plan for determining if additional RI/FS sampling associated with the basement areas, subsurface structures, and subgrade environmental media was needed to finalize this work plan. Any additional sampling associated with the basement areas, subsurface structures, and subgrade environmental media has been incorporated into this work plan.

Appendix D of the D2 RI/FS Work Plan also includes technical memoranda for field activities that include samples not collected to date; additional sampling collected under the *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan* (DOE 2018c); and the expected deactivation end state for the C-400 Building subgrade area. Because deactivation activities have not been completed to date, residual solids/sediments on floor were not sampled, and the radiation survey of the floor and walls in the sub-grade areas, as described in Appendix B of the *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan*, was not conducted (DOE 2018c). Residual solids/sediments primarily under the dip tanks, are planned to be removed prior to the RI/FS field work and sampled for waste characterization. These waste characterization samples may be used as process knowledge during the RI/FS, if appropriate. It is anticipated that at least one additional floor drain will become accessible from ongoing building deactivation activities and/or removal of equipment in the basement (e.g., TCE degreaser). This floor drain may be borescoped during building deactivation, sampled (if adequate material is present), and analyzed consistent with sampling described in the SAP for liquid/sludge from floor drains for the same matrix type. Any additional sampling (during the RI or during deactivation activities) will be discussed with the FFA parties (including usability of the data) and will be performed using the methods described in the SAP for the same matrix type. Results from any additional borescoping and/or sampling (during the RI or during deactivation activities) determined to be usable will be considered when siting MIP, Dye-enhanced laser induced fluorescence (DyeLIF), and/or contingency borings (Sections 9.3.11 and 9.3.12); and documented in the C-400 RI/FS Report.

5.1.6 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for Sector 1 in the WAG 6 RI were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.1. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

Table 5.1. Summary of Human Health Risk Characterization for Sector 1 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR*	ELCR COCs	% Total ELCR	ELCR Pathways of Concern (POCs)	% Total ELCR	Total HI*	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future industrial worker at current concentrations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	NE	NE	NE	NE	NE
Future adult rural resident at current concentrations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	NE	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	NE	NE	NE	NE	NE
Future adult recreational user at current concentrations	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future excavation worker at current concentrations	2.0E-06	Cesium-137	83	External exposure	93	1.7	Antimony Chromium Iron	34 21 45	Ingestion of soil Dermal contact with soil	14 86

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

The WAG 6 exposure assessment of the risk assessment evaluated several scenarios that encompassed both current use and several hypothetical future uses. For the Sector 1 area, only the future on-site excavation scenario [direct contact with surface and subsurface soil (soil found 1–15 ft bgs)] was evaluated because soil for direct contact with other scenarios was beneath the building.

The risk characterization performed for the Sector 1 area followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.1. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.1.), Table 5.2 presents a risk characterization for lead alone.

Table 5.2. Comparison of Representative Concentrations[a] of Lead at Sector 1 against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
Sector 1	x	20	x	400	x
Subsurface Soil (mg/kg)[c]					
Sector 1	x	20	x	400	x

Notes: x indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0–1 ft bgs.
[c] Subsurface soil is soil collected from 0–16 ft bgs.

The following are significant results in the risk characterization.

- The overall cancer risk to the excavation worker from exposure to soil in the Sector 1 area exceeds the PGDP *de minimis* level (i.e., 1.0E-06), but is within EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 2.0E-06). The overall hazard also exceeds the *de minimis* level (HI = 1.7). The primary COC for cancer risk to the excavation worker is cesium-137 (83% of total). The driving exposure route for cancer risk to the excavation worker is external exposure (93% of total). The COCs for hazard were iron (45% of total), antimony (34% of total), and chromium (21% of total). The driving exposure routes and their percentage of total hazard were dermal contact (86%) and ingestion (14%). Lead in subsurface soil does not exceed screening levels.

Several uncertainties were determined to affect the risk characterization results. Because no surface soil data were available (it is covered by the C-400 Cleaning Building) to determine risk to the industrial worker, quantification of uncertainties was not determined for Sector 1.

Ecological Risk Assessment Summary. The primary purpose of the ecological assessment of the WAG 6 RI was to determine whether any credible risks to ecological receptors exist in the C-400 Cleaning Building area. Because all soil in Sector 1 is under the C-400 Cleaning Building, chemicals posing potential future risks to nonhuman receptors were not evaluated.

5.1.7 Additional Data Needs

Sector 1 is included in the C-400 Complex RI/FS for further evaluation and/or remediation as potential contributors to soil and groundwater contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.2 SECTOR 2

5.2.1 Area Description

Sector 2 is an L-shaped area of approximately 38,000 ft^2, located at the northeast corner of the C-400 Complex, as shown in Figure 5.7. Concrete and asphalt pavement covers much of the current area; there is limited area of exposed soil. The concrete apron on the north end of the C-400 Cleaning Building is original construction. Additionally, the area contains an acid drain line.

Sector 2 includes the C-403 Neutralization Tank (SWMU 40), which is an in-ground, concrete, open-top tank lined with two layers of acid bricks. The tank is approximately 25-ft square by 26-ft deep.

The C-402 Lime House Building Slab and underlying soils (SWMU 480) also are included in Sector 2. A permanent safety barrier surrounds the perimeter of the concrete slab due to the slab floor being greater than 4 ft from the ground level in areas. The concrete slab is posted as a fixed contamination area (DOE 2007).

5.2.2 Process History

The C-403 Neutralization Tank received influent from the C-400 Cleaning Building for the storage and treatment (i.e., neutralization) of acidic, uranium-bearing waste solutions generated during cleaning operations. During treatment, lime slurry was added to the wastewater from the C-402 Lime House to raise the pH and precipitate out the uranium in the form of a low-level radioactive sludge. Once the pH was raised to the proper level (10 to 12), the effluent was discharged to the C-404 Holding Pond where the sludge was allowed to settle out of the solution.

In 1957, the discharge from the C-403 Neutralization Tank was routed to the NSDD, where it flowed to the Little Bayou Creek. In the late 1970s, flow from the NSDD was routed into the C-616-F Full-Flow Lagoon, and direct discharge to Little Bayou Creek subsequently was discontinued. Although neutralization no longer was carried out at C-403 after 1957, low-level, uranium-bearing wastewater continued to be discharged to C-403 until 1990. These discharges included uranium hexafluoride cylinder hydrostatic-test water, overflow, and runoff from cleaning tanks; discharge from floor drains; and other unknown sources. As discussed in the WAG 6 Report, drawings for C-403 show that a 15-inch vitreous clay pipe was installed between the C-403 Neutralization Tank and the C-410-B Neutralization Lagoon. The pipe was constructed utilizing part of an existing storm-water line. The intended purpose of this line is unknown (DOE 1999a). After 1990, the C-403 Neutralization Tank was removed from service.

The C-402 Lime House was used to neutralize acids, produce magnesium fluoride pellets, and later as a storage facility, according to the SWMU Assessment Report. The C-402 Lime House is a 1,742 ft^2 reinforced concrete building with a ground floor and partial basement. The facility was used to supply lime slurry to the C-403 Neutralization Tank. The building also housed palletizing units and associated vent systems and was used for drummed chemical storage.

The building was radiologically contaminated, and potential asbestos-containing material also was present. In 2006, the C-402 facility structure was demolished to the first floor concrete slab (DOE 2007).

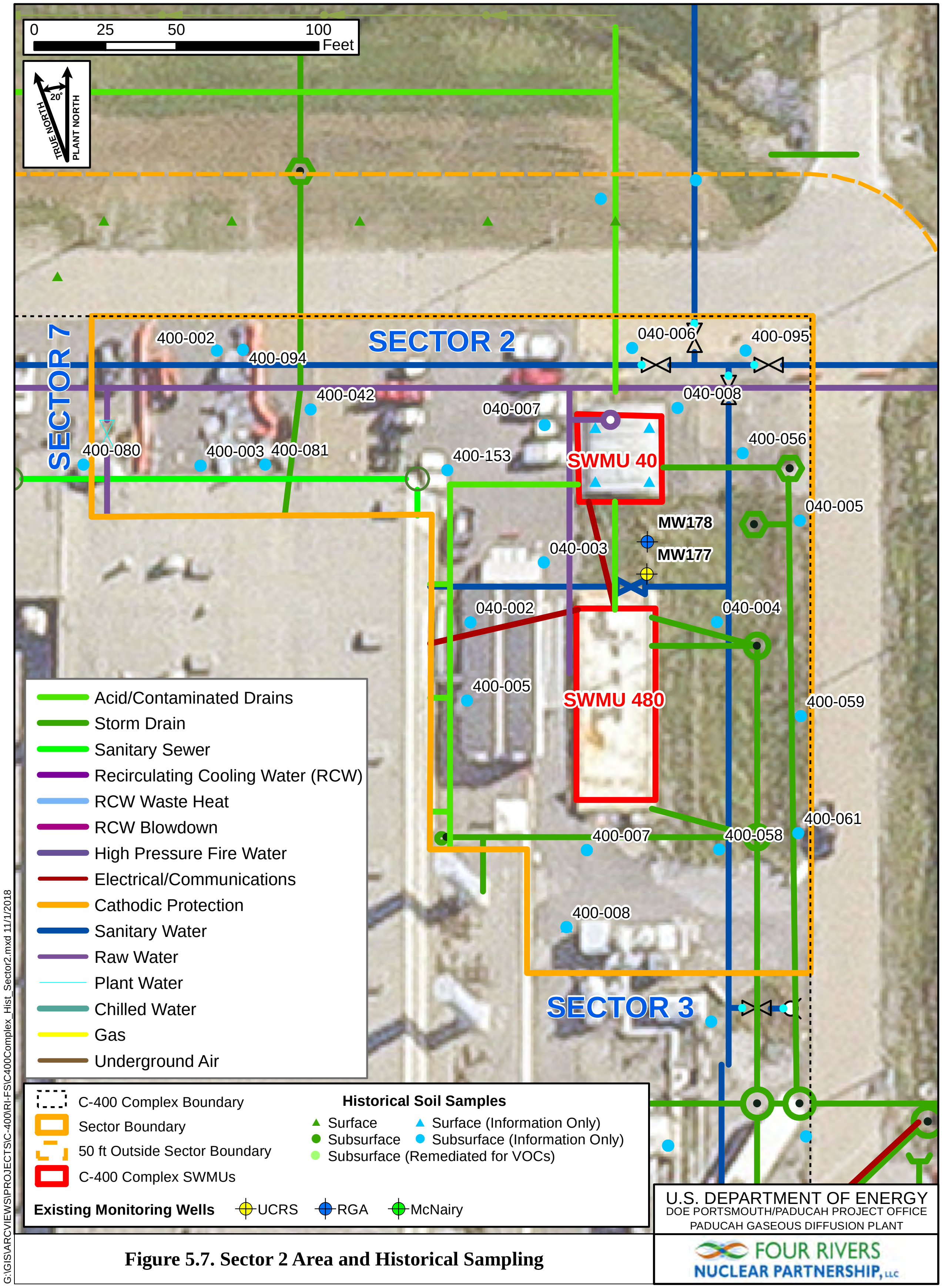


Figure 5.7. Sector 2 Area and Historical Sampling

5.2.3 Previous Investigation Results

No historical sampling data for this sector are applicable according to the decision rules for historical data determined during project scoping. Historical results are summarized below for qualitative purposes.

There have been no previous response actions for the C-403 Neutralization Tank; however, in 1993, nine water and three sediment samples were collected from the C-403 Neutralization Tank. Analytical results indicated that TCE concentrations in the nine water samples ranged from 17 to 1,300 μg/L, and TCE concentrations in the three sediment samples ranged from 35 to 6,700 ppb (DOE 1999a). During the WAG 6 RI, a water line located near the C-403 tank broke, and subsurface water flowed into the tank from one of the remaining fill lines. Approximately 7,000 ft^3 of water accumulated in the tank. Samples of the water from the tank were analyzed in November 1997 and were found to contain TCE at a concentration of 21,000 μg/L. Resampling in January 1998 indicated that TCE concentrations in water were 5,600 μg/L (DOE 1999a), which exceeds the risk-based ALs for the hypothetical industrial worker exposure scenario.

Soil boring and groundwater samples were obtained during the Phase II SI. In addition, SWMU 40 was investigated with Sector 2 of the WAG 6 RI (DOE 1999a). Results of this sampling indicate the potential for radiological, PCB, and PAH contamination.

An Engineering Evaluation/Cost Analysis and Action Memo were prepared to support removal of C-403 as part of an early action for the Soils Inactive Facilities (DOE 2008a; DOE 2008b). Because a 30-inch water line located adjacent to C-403 required rerouting prior to removal and this rerouting would have interfered with USEC facility operations, a change in schedule for the C-403 Neutralization Tank was determined to be necessary during development of the Removal Action Work Plan (DOE 2009). The removal action will be implemented and coordinated with the other anticipated response actions associated with cleanup of the C-400 Complex.

During the WAG 6 RI, three sampling sites were collected on the west and south side of the C-402 Lime House. C-402 is located within Sector 2 of the WAG 6 RI (DOE 1999a). A small area of surface soil between the C-402 Lime House and the C-400 Cleaning Building was found to be impacted with moderate concentrations of several common PAH compounds. The extent of contamination appears to be confined both vertically and horizontally to the surface soil surrounding Boring 400-005. The source of the identified PAH contaminants is unknown, but these compounds could have been derived from any number of one-time surface releases associated with the operation of an industrial facility.

5.2.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for Sector 2 in the WAG 6 RI were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.3. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of the Sector 2 area.

- Current on-site industrial—direct contact with surface soil (soil found 0−1 ft bgs).

- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area. (See Section 5.8 for information regarding use of groundwater.)

Table 5.3. Summary of Human Health Risk Characterization for Sector 2 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR*	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI*	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	1.7E-05	PAHs Uranium-238	88 9	Dermal contact with soil External exposure	86 10	0.4	NE	NE	NE	NE
Future industrial worker at current concentrations	1.7E-05	PAHs Uranium-238	88 9	Dermal contact with soil External exposure	86 10	0.4	NE	NE	NE	NE
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	10.6	Chromium Uranium Zinc	55 40 4	Ingestion of soil Dermal contact with soil Consumption of vegetables	1 23 76
Future adult rural resident at current concentrations	8.1E-04	PAHs PCBs Uranium-235 Uranium-238	84 5 < 1 11	Ingestion of soil Dermal contact with soil External exposure	< 1 5 93	3.0	Chromium Uranium Zinc	51 44 5	Dermal contact with soil Consumption of vegetables	16 84
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations	4.7E-07	NE	NE	NE	NE	< 0.1	NE	NE	NE	NE
Future excavation worker at current concentrations	1.6E-04	Arsenic Beryllium PAHs N-nitroso-di-n-propylamine Uranium-234 Uranium-238	6 44 35 10 < 1 3	Ingestion of soil Dermal contact with soil External exposure	17 81 2	1.2	Aluminum Antimony Chromium Manganese Vanadium	10 20 14 16 28	Ingestion of soil Dermal contact with soil	11 88

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 1-15 ft bgs).

- Future on-site recreational user—consumption of game exposed to contaminated surface soil.

- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.

- Future on-site rural resident—direct contact with surface soil at Sector 2 and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area. (See Section 5.8 for information regarding use of groundwater.)

- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary. (See Section 5.8 for information regarding use of groundwater.)

The risk characterization performed for the Sector 2 area followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.3. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.3.). Table 5.4. presents a risk characterization for lead alone.

Table 5.4. Comparison of Representative Concentrations[a] of Lead at Sector 2 against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
Sector 2	x	20	x	400	x
Subsurface Soil (mg/kg)[c]					
Sector 2	x	20	x	400	x

Notes: x indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0−1 ft bgs.
[c] Subsurface soil is soil collected from 0−16 ft bgs.

The following are significant results in the risk characterization.

- The overall cancer risk to the current and future industrial worker from exposure to soil in the Sector 2 area exceeds the PGDP *de minimis* level (i.e., 1.0E-06), but is within EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 1.7E-05). The overall HI was below the PGDP *de minimis* level (HI < 1). The COCs for cancer risk to the industrial worker are PAHs (88% of total) and uranium-238 (9% of total). The driving exposure routes for cancer risk to the industrial worker are dermal contact with soil (86% of total) and external exposure (10% of total).

- The overall cancer risk to the excavation worker from exposure to soil in the Sector 2 area exceeds both the PGDP *de minimis* level and EPA's generally acceptable risk range (ELCR = 1.6E-04). The overall HI essentially is equal to the *de minimis* level (HI = 1.2). The primary COCs for cancer risk to the excavation worker are beryllium (44% of total), PAHs (35% of total), N-nitroso-di-n-propylamine (10% of total), and arsenic (6% of total). The driving exposure routes for cancer risk to the excavation worker are dermal contact (81% of total), ingestion (17% of total), and external exposure (2% of total).

Several uncertainties were determined to affect the risk characterization results. The effect of some important uncertainties on the risk characterization for the industrial worker is shown in Tables 5.5 and 5.6. As shown there, the lower bound cancer risk and hazard can be shown to be less than the respective *de minimis* levels if alternative methods and parameters are used.

Table 5.5. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 2—ELCR

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR Minus Common Laboratory Contaminants	Default ELCR Calculated using EPA Default Dermal Absorption Values[c]	Default ELCR Minus Analytes Infrequently Detected	Lower-bound ELCR[d]
Sector 2	1.7E-05	1.1E-06	1.7E-05	3.8E-06	1.7E-05	2.4E-07

[a] These values were derived using the default exposure rates for the reasonable maximum exposure (RME) scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5 of the WAG 6 RI.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4 of the WAG 6 RI.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at Sector 2.

Table 5.6. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 2—Systemic Toxicity

Location	Default HI[a]	Default HI without Lead	Site-specific HI without Lead[b]	Default HI Minus Common Laboratory Contaminants without Lead	Default HI Calculated EPA Default Dermal Absorption Values without Lead[c]	Default HI Minus Analytes Infrequently Detected without Lead	Lower-bound HI[d]
Sector 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Notes: < 1 indicates that the HI is less than the *de minimis* level.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5 in the WAG 6 RI.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4 in the WAG 6 RI.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Ecological Risk Assessment Summary. The primary purpose of the ecological assessment was to determine whether any credible risks to ecological receptors exist in the Sector 2 area. Because only abiotic data were available, the assessment was limited to the evaluation of this data. Additional lines of evidence (e.g., media toxicity testing and biological surveys) were not collected.

Table 5.7 lists the contaminants identified as chemicals or radionuclides of potential ecological concern (COPECs) for soil at Sector 2. As shown there, chromium, uranium, and zinc were COPECs for one or more receptors. Additionally, the assessment determined that each receptor considered, except the mouse and deer, had one or more COPECs.

Table 5.7. Summary of Chemicals[a] Posing Potential Future Risks[b] to Nonhuman Receptors at Sector 2

		Chemicals of Potential Ecological Concern									
Location	**Receptor**	**Al**	**As**	**Cd**	**Cr**	**Fe**	**Tl**	**U**	**V**	**Zn**	**PCBs**
Sector 2	Microbe	x	x		1.9	x		nb	x	x	nb
	Plant	x	x		19.3	nb		2.8	x	1.4	x
	Worm	nb	x		48.3	nb		nb	nb	x	nb
	Shrew	x	x		3.4	nb		x	x	x	x
	Mouse	x	x		x	nb		x	x	x	x
	Deer	x	x		x	nb		x	x	x	x

Notes: Al = aluminum; As = arsenic; Cd = cadmium; Cr = chromium; Fe = iron; Tl = thallium; U = uranium; V = vanadium; Zn = zinc
x indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background in that sector.
nb indicates that no toxicological benchmark was available for the chemical/receptor combination.
Blank cells indicate that the analyte was not detected in surface soil in the sector.
[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and a hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Volume 3 of the WAG 6 BHHRA (DOE 1999a).
[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

5.2.5 Additional Data Needs

Sector 2 (which includes SWMUs 40 and 480) is included in the C-400 Complex RI/FS for further evaluation and/or remediation as a potential contributor to soil and groundwater contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.3 SECTOR 3

5.3.1 Area Description

Sector 3 is an area of approximately 23,000 ft^2, located east of the C-400 Cleaning Building, as shown in Figure 5.8. Asphalt pavement and gravel cover much of current area; there is limited area of exposed soil, and Sector 3 does not contain a SWMU.

5.3.2 Process History

No significant historical C-400 Cleaning Building processes have been identified in Sector 3.

5.3.3 Previous Investigation Results

No historical sampling data for this section are applicable according to the decision rules for historical data determined during project scoping. Historical results are summarized as follows for qualitative purposes.

Key context from WAG 6 RI

- Surface Soils collected and analyzed for SVOCs, metals, radionuclides, and PCBs
  - SVOCs
    - Most prevalent in the three surface soil samples
    - Boring 400-011 generally had the highest concentration for each of the detected PAHs

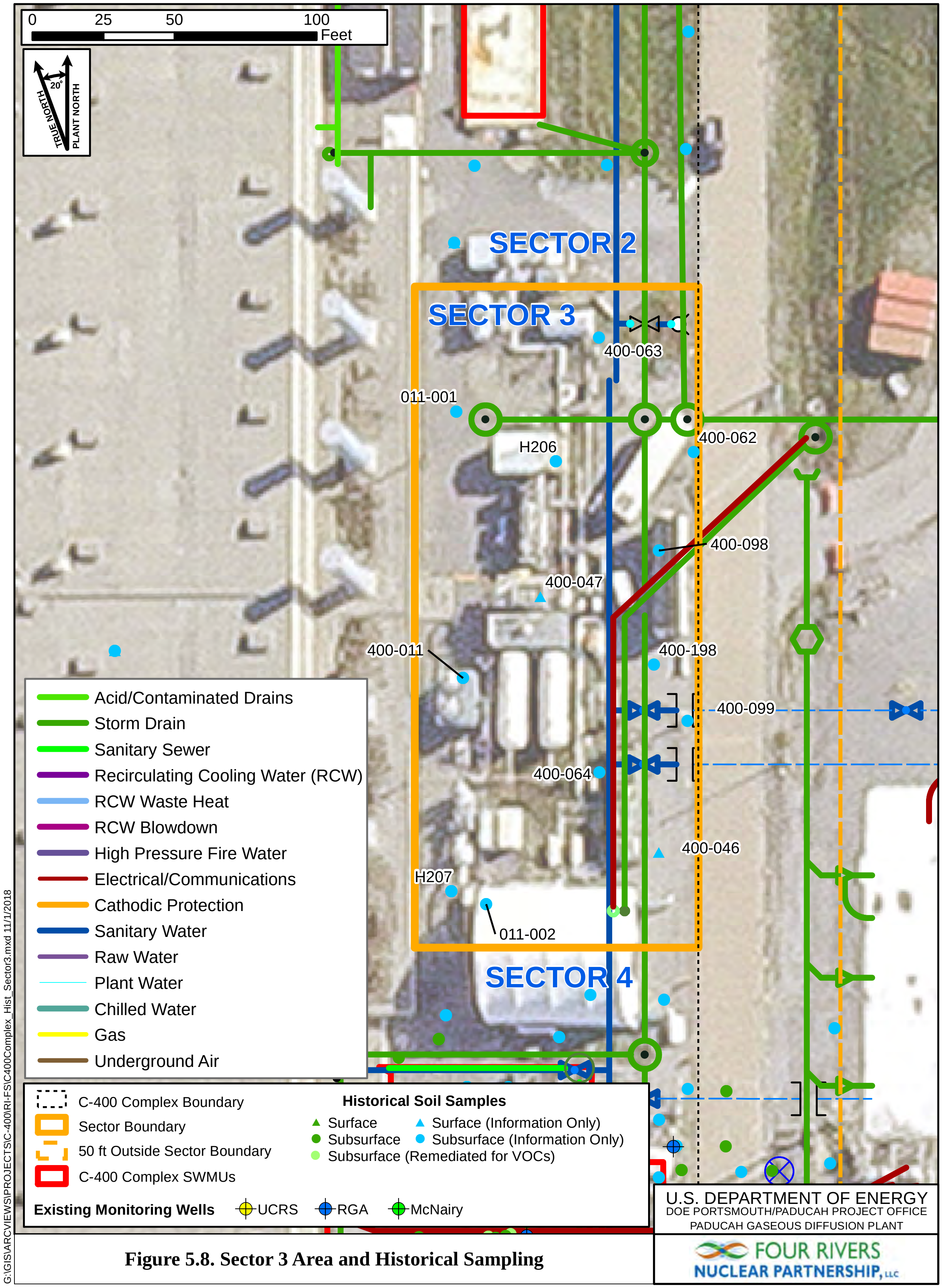


Figure 5.8. Sector 3 Area and Historical Sampling

— PCBs

  – Boring 400-046 was the highest concentration

— Radionuclides

  – Low activities of several radiological isotopes were reported from the surface soils

  – Boring 400-046 contained the most radioisotopes and the highest activities for all of the detected isotopes

- 36 subsurface soil samples from 10 locations

  — Collected from 10 borings at depths between the surface and 50.5 ft bgs

  — Analyzed for VOCs, SVOCs, radionuclides, metals, and PCBs

  — Small quantities of eight PAHs were also detected one or more times in the subsurface soils

  — SVOCs at concentrations above the sample quantitation limit (SQL) were not found in the subsurface

- Identified contamination areas

  — Boring 400-011 (adjacent to the building beside the exterior floor drain collection line)

    – Most significant area of contamination occurs in the surface and subsurface of this boring

    – TCE was found at elevated levels near the surface to total depth of 41 ft bgs

    – Elevated concentrations of arsenic, SVOCs, and PCBs were found in the surface and shallow subsurface soils

  — Boring 400-046 surface soil containing PCBs and radionuclides

5.3.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for Sector 3 in the WAG 6 RI were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.8. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of the Sector 3 area.

- Current on-site industrial—direct contact with surface soil (soil found 0−1 ft bgs).

- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area. (See Section 5.8 for information regarding use of groundwater.)

Table 5.8. Summary of Human Health Risk Characterization for Sector 3 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	8.5E-05	PAHs PCBs Cesium-237 Uranium-238	52 37 6 3	Ingestion of soil Dermal contact with soil External exposure	8 82 10	0.3	NE	NE	NE	NE
Future industrial worker at current concentrations	8.5E-05	PAHs PCBs Cesium-237 Uranium-238	52 37 6 3	Ingestion of soil Dermal contact with soil External exposure	8 82 10	0.3	NE	NE	NE	NE
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations	5.9E-06	PAHs PCBs	16 84	Ingestion of rabbit	86	< 0.1	NE	NE	NE	NE
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	13.3	Cadmium Chromium Uranium	5 31 63	Ingestion of soil Dermal contact with soil Ingestion of vegetables	1 14 84
Future adult rural resident at current concentrations	8.2E-03	PAHs PCBs Cesium-137 Neptunium-237 Uranium-235 Uranium-238	25 72 < 1 < 1 < 1 2	Ingestion of soil Dermal contact with soil Ingestion of vegetables External exposure	< 1 3 96 < 1	4.0	Cadmium Chromium Uranium	5 28 66	Dermal contact with soil Ingestion of vegetables	9 90
Future excavation worker at current concentrations	1.2E-04	Arsenic Beryllium PAHs PCBs Cesium-137	12 61 21 2 1	Ingestion of soil Dermal contact with soil External exposure	15 83 2	0.7	NE	NE	NE	NE

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 1–15 ft bgs).

- Future on-site recreational user—consumption of game exposed to contaminated surface soil.

- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.

- Future on-site rural resident—direct contact with surface soil at Sector 3 and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area. (See Section 5.8 for information regarding use of groundwater.)

- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary. (See Section 5.8 for information regarding use of groundwater.)

The risk characterization performed for the Sector 3 area followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.8. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.8), Table 5.9 presents a risk characterization for lead alone.

Table 5.9. Comparison of Representative Concentrations[a] of Lead at Sector 3 against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
Sector 3	x	20	x	400	x
Subsurface Soil (mg/kg)[c]					
Sector 3	5.7	20	No	400	No

Notes: x indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0–1 ft bgs (DOE 1999a).
[c] Subsurface soil is soil collected from 0–16 ft bgs.

The following are significant results in the risk characterization.

- The overall cancer risk to the current and future industrial worker from exposure to soil in the Sector 3 area exceeds the PGDP *de minimis* level (i.e., 1.0E-06), but is within EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 8.5E-05). The overall HI was below the PGDP *de minimis* level (HI < 1). The COCs for cancer risk to the industrial worker are PAHs (52% of total), PCBs (37% of the total), cesium-137 (6% of the total), and uranium-238 (3% of total). The driving exposure routes for cancer risk to the industrial worker are dermal contact with soil (82% of total), external exposure (10% of total), and ingestion of soil (8% of total).

- The overall cancer risk to the excavation worker from exposure to soil in the Sector 3 area exceeds both the PGDP *de minimis* level and EPA's generally acceptable risk range (ELCR = 1.2E-04). The overall HI was below the PGDP *de minimis* level (HI < 1). The primary COCs for cancer risk to the excavation worker are beryllium (61% of total), PAHs (21% of total), arsenic (12% of total), PCBs (2% of the total), and cesium-137 (1% of total). The driving exposure routes for cancer risk to the excavation worker are dermal contact (83% of total), ingestion (15% of total), and external exposure (2% of total).

Several uncertainties were determined to affect the risk characterization results. The effect of some important uncertainties on the risk characterization for the industrial worker is shown in Tables 5.10 and 5.11. As shown there, the lower bound cancer risk and hazard can be shown to be less than the respective *de minimis* levels if alternative methods and parameters are used.

Table 5.10. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 3—ELCR

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR Minus Common Laboratory Contaminants	Default ELCR Calculated using EPA Default Dermal Absorption Values[c]	Default ELCR Minus Analytes Infrequently Detected	Lower-bound ELCR[d]
Sector 3	8.5E-05	5.4E-06	8.5E-05	3.0E-05	8.5E-05	1.9E-06

[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5 of the WAG 6 RI.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4 of the WAG 6 RI.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at Sector 3.

Table 5.11. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 3—Systemic Toxicity

Location	Default HI[a]	Default HI without Lead	Site-specific HI without Lead[b]	Default HI Minus Common Laboratory Contaminants without Lead	Default HI Calculated EPA Default Dermal Absorption Values without Lead[c]	Default HI Minus Analytes Infrequently Detected without Lead	Lower-bound HI[d]
Sector 3	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Notes: < 1 indicates that the HI is less than the *de minimis* level.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5 in the WAG 6 RI.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4 in the WAG 6 RI.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Ecological Risk Assessment Summary. The primary purpose of the ecological assessment was to determine whether any credible risks to ecological receptors exist in the Sector 3 area. Because only abiotic data were available, the assessment was limited to the evaluation of this data. Additional lines of evidence (e.g., media toxicity testing and biological surveys) were not collected.

Table 5.12 lists the contaminants identified as COPECs for soil at Sector 3. As shown there, chromium, thallium, uranium, and PCBs were COPECs for one or more receptors. Additionally, the assessment determined that each receptor considered, except the deer, had one or more COPECs.

Table 5.12. Summary of Chemicals[a] Posing Potential Future Risks[b] to Nonhuman Receptors at Sector 3

Location	Receptor	Chemicals of Potential Ecological Concern									
		Al	As	Cd	Cr	Fe	Tl	U	V	Zn	PCBs
Sector 3	Microbe	x	x	x	1.8	x	nb	nb	x	x	nb
	Plant	x	x	x	18.2	nb	1.2	5.5	x	x	x
	Worm	nb	x	x	45.5	nb	nb	nb	nb	x	nb
	Shrew	x	x	x	2.4	nb	x	x	x	x	37.1
	Mouse	x	x	x	x	nb	x	x	x	x	5.2
	Deer	x	x	x	x	nb	x	x	x	x	x

Notes: Al = aluminum; As = arsenic; Cd = cadmium; Cr = chromium; Fe = iron; Tl = thallium; U = uranium; V = vanadium; Zn = zinc
x indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background in that sector.
nb indicates that no toxicological benchmark was available for the chemical/receptor combination.
Blank cells indicate that the analyte was not detected in surface soil in the sector.
[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and a hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Volume 3 of the WAG 6 BHHRA (DOE 1999a).
[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

5.3.5 Additional Data Needs

Sector 3 is included in the C-400 Complex RI/FS for further evaluation and/or remediation as a potential contributor to soil and groundwater contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.4 SECTOR 4

5.4.1 Area Description

Sector 4 encompasses an area of approximately 37,000 ft^2, located southeast of the C-400 Cleaning Building, as shown in Figure 5.9. The Sector 4 area is covered primarily in concrete, asphalt pavement, and gravel. The concrete apron on the south end of the building is original construction. There is limited area of exposed soil.

The C-400 Trichloroethylene Leak Site (SWMU 11) and the TCE Spill Site from TCE Unloading Operations at C-400 (SWMU 533) are located within Sector 4. Additionally, the area contains an acid drain line.

5.4.2 Process History

A leak of TCE from the sump in the C-400 Cleaning Building degreaser area to the storm sewer was discovered in 1986. TCE was released at various times through broken pipes and joints in a leaking underground storm sewer pipe from the C-400 Cleaning Building. It had not been known previously that the sump discharged to the sewer. After the leak was discovered, discharge lines from the sump in the basement of the C-400 Cleaning Building were disconnected from the storm sewer, and soils were excavated in an attempt to reduce the contamination in the area. Excavation was halted to prevent structural damage to the adjacent TCE storage tank and to 11th Street. Approximately 310 ft^3 of TCE-contaminated soil was drummed and disposed of off-site. The excavation was backfilled with clean soil, and the area was capped with a layer of clay. The amount of released TCE and the amount of removed TCE by the soil excavation are not known. Figure 5.10 illustrates the excavation.

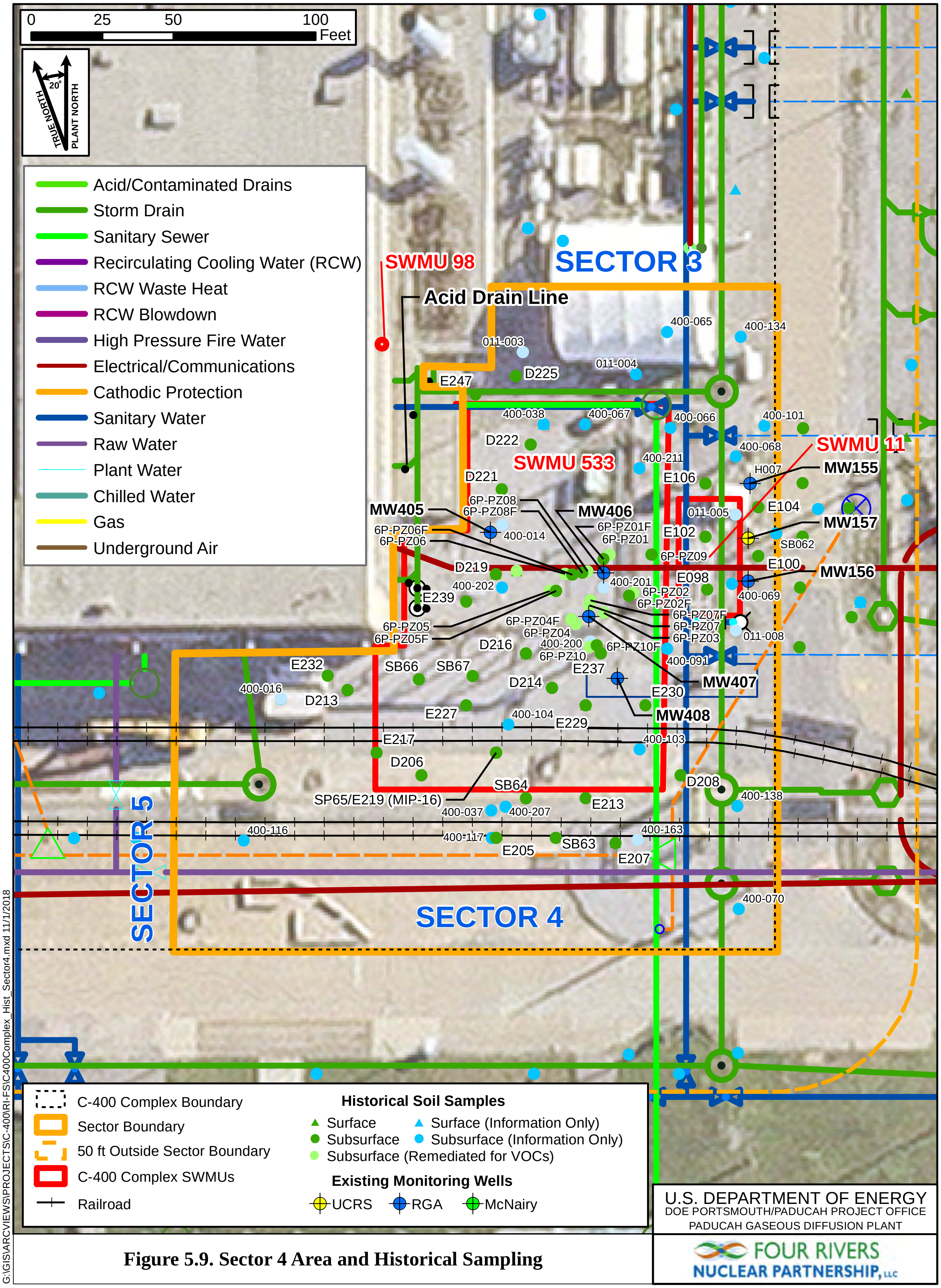
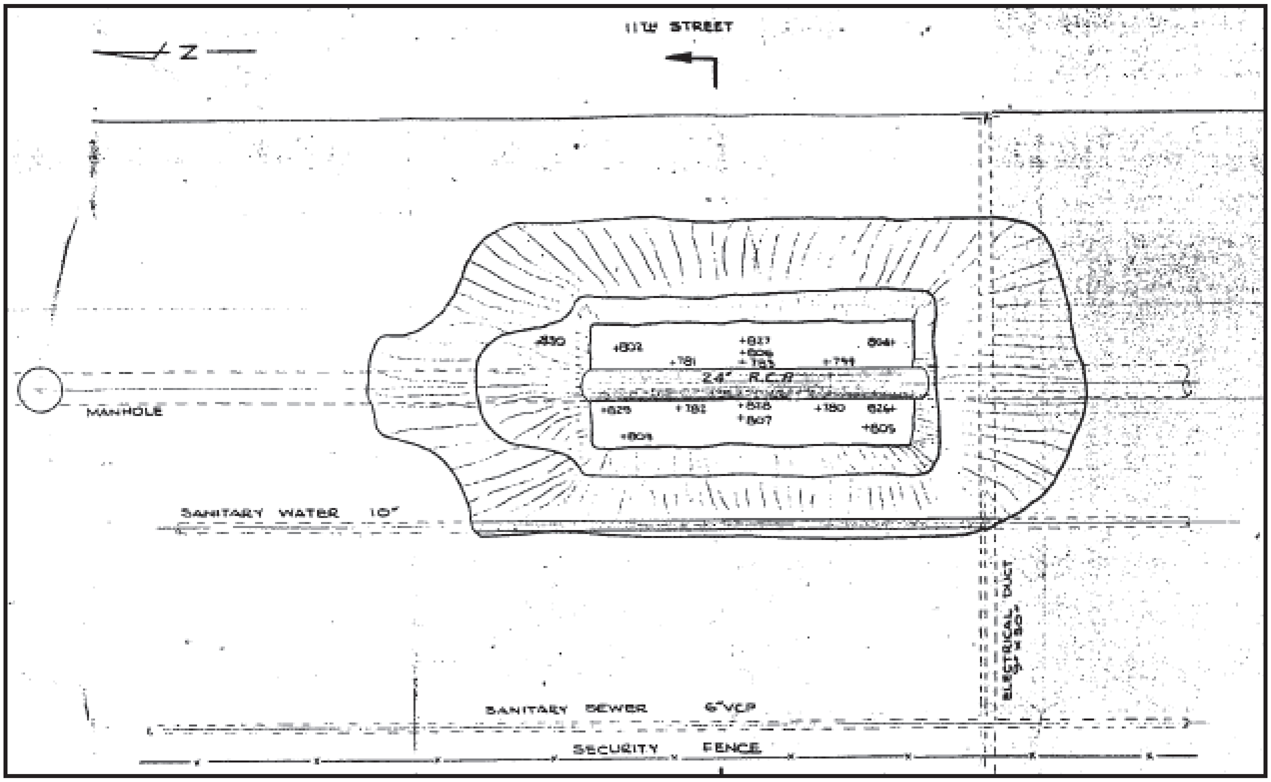


Figure 5.9. Sector 4 Area and Historical Sampling



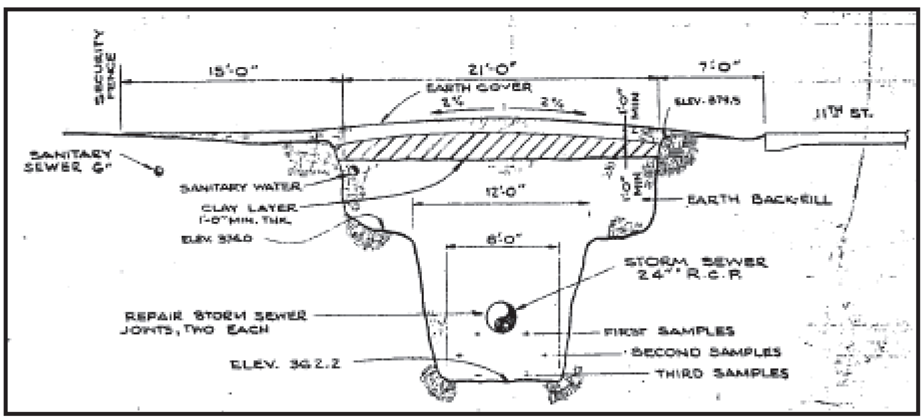


Figure 5.10. SWMU 11 Excavation (circa 1986) (EDGe 1988)

The subsurface soils at Sector 4 (including the upper RGA) have been treated by ERH (targeting 20 ft to 60 ft bgs).

5.4.3 Previous Investigation Results

Historical sampling data exceeding screening values for this sector that are applicable according to the decision rules for historical data determined during project scoping are summarized in Tables 5.13–5.15 for surface soil, subsurface soil, and deep soil. The entire data summary is available in Appendix B of this document. Other historical results are summarized below for qualitative purposes.

TCE concentrations as high as 7,000,000 µg/kg were reported in soil samples collected adjacent to and below the storm sewer line during removal of the contaminated soil in 1986 (EDGe 1988). Approximately 9,200 ft^3 of contaminated soil and bedding material was excavated, containerized, and stored as hazardous waste for treatment and disposal. Some of the contaminated soil is known to have been left in place because of concerns about the structural integrity of 11th Street and the TCE Tank Pad, located to the west between the spill site and the C-400 Cleaning Building (CH2M HILL 1992). The excavated area was backfilled with clean fill material and capped with a layer of clay after excavation activities were completed.

The Trichloroethylene Leak Site (SWMU 11) was investigated under the Phase I and Phase II SIs completed between 1989 and 1991 (CH2M HILL 1991; CH2M HILL 1992). The field activities for Phase I consisted of drilling a deep boring within the leak area and collecting groundwater samples from MW68 through MW71 (see Figure 9.3 for locations). All samples were analyzed for VOCs, SVOCs, PCBs, metals, and selected RADs, including uranium-238, uranium-235, Tc-99, thorium-230, plutonium-239, as well as gross alpha activity and gross beta activity. The analytical results for the soil samples collected from the deep boring showed that TCE was detected in the soils at concentrations throughout the interval sampled (4 to 93 ft bgs) and that the highest concentration was from the sample collected at approximately 55–60 ft bgs. Tc-99 was detected at 10–15 ft bgs (at 6.6 pCi/g). No other compounds or analytes were detected in any of the samples analyzed (DOE 1999a). Phase II SI installed a well cluster in the area and detected TCE at 360,000 µg/L.

SWMU 11 was investigated with Sector 4 of the WAG 6 RI (DOE 1999a). The WAG 6 RI found a widespread TCE-impacted area located primarily between the C-400 Cleaning Building and 11th Street and north of Tennessee Avenue. In that area, a large zone of shallow soil contained greater than 225,000 µg/kg TCE, indicating that a chlorinated solvent source zone was present in UCRS soil. TCE and its degradation products were found in soils throughout the UCRS.

The highest concentrations were found below the backfilled excavation at SWMU 11 (8,208,600 µg/kg) and adjacent to the TCE off-loading pumps (11,055,000 µg/kg), now known as SWMU 533.

Table 5.13. Surface Soil Data Summary: Sector 4

Analysis	Unit	Detected Results			FOD	Background (Bkgd)		Industrial Worker		Industrial Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
METAL														
Chromium	mg/kg	1.33E+01	1.33E+01	1.33E+01	1/1	0/1	1.60E+01	1/1	1.23E+01	0/1	1.23E+03	0/1	0/1	2.5 - 2.5
RADS														
Uranium-238	pCi/g	5.29E+00	5.29E+00	5.29E+00	1/1	1/1	1.20E+00	1/1	1.66E+00	0/1	1.66E+02	1/1	1/1	0.682 - 0.682

Legend:

(orange) One or more samples exceed background value.

(green) One or more samples exceed NAL value.

(red) One or more samples exceed AL value.

(blue) One or more samples exceed a groundwater protection screening value.

NOTE: Data were downloaded from the Paducah OREIS database in January and March 2018. See Section 6.1.1 for additional information.

Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted). Field replicates or separate samples are counted independently.

Table 5.14. Subsurface Soil Data Summary: Sector 4

Analysis	Unit	Detected Results			FOD	Background (Bkgd)		Excavation Worker		Excavation Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
METAL														
Aluminum	mg/kg	2.54E+03	1.63E+04	8.93E+03	155/155	18/155	1.20E+04	0/155	3.26E+04	0/155	1.00E+05	0/155	153/155	20 - 20
Arsenic	mg/kg	5.06E+00	2.29E+01	7.49E+00	26/155	6/155	7.90E+00	26/155	3.74E+00	0/155	3.60E+02	16/155	26/155	5 - 20
Barium	mg/kg	1.46E+01	1.62E+03	9.51E+01	155/155	8/155	1.70E+02	0/155	6.47E+03	0/155	1.00E+05	0/155	62/155	2.5 - 2.5
Calcium	mg/kg	2.40E+02	2.52E+05	7.65E+03	155/155	20/155	6.10E+03	0/155	N/A	0/155	N/A	N/A	N/A	100 - 2000
Chromium	mg/kg	6.16E+00	1.17E+02	1.60E+01	155/155	2/155	4.30E+01	144/155	9.14E+00	0/155	9.14E+02	0/155	0/155	2.5 - 2.5
Iron	mg/kg	4.36E+03	5.51E+04	1.47E+04	155/155	4/155	2.80E+04	13/155	2.30E+04	0/155	1.00E+05	155/155	155/155	20 - 20
Lead	mg/kg	2.19E+01	1.07E+02	4.60E+01	6/155	5/155	2.30E+01	0/155	8.00E+02	0/155	8.00E+02	0/155	6/155	20 - 20
Magnesium	mg/kg	1.16E+02	7.84E+03	1.33E+03	155/155	7/155	2.10E+03	0/155	N/A	0/155	N/A	N/A	N/A	2.5 - 5
Manganese	mg/kg	5.95E+01	3.05E+03	3.66E+02	155/155	9/155	8.20E+02	10/155	7.74E+02	0/155	2.32E+04	155/155	155/155	2.5 - 5
Mercury	mg/kg	2.90E-01	5.70E-01	4.30E-01	2/155	2/155	1.30E-01	0/155	9.86E+00	0/155	2.96E+02	0/155	1/155	0.2 - 0.2
Nickel	mg/kg	5.00E+00	7.36E+01	9.74E+00	117/155	1/155	2.20E+01	0/155	6.52E+02	0/155	1.96E+04	1/155	117/155	5 - 5
Potassium	mg/kg	1.61E+02	1.07E+03	4.45E+02	153/155	2/155	9.50E+02	0/155	N/A	0/155	N/A	N/A	N/A	100 - 200
Selenium	mg/kg	1.03E+00	1.77E+00	1.20E+00	14/147	14/147	7.00E-01	0/147	1.64E+02	0/147	4.92E+03	0/147	14/147	1 - 20
Sodium	mg/kg	2.06E+02	4.94E+02	3.31E+02	80/155	31/155	3.40E+02	0/155	N/A	0/155	N/A	N/A	N/A	200 - 250
Uranium	mg/kg	1.06E+02	3.40E+02	1.78E+02	37/155	37/155	4.60E+00	37/155	6.58E+00	15/155	1.97E+02	2/155	37/155	100 - 1000
Vanadium	mg/kg	8.44E+00	5.22E+01	2.38E+01	155/155	11/155	3.70E+01	0/155	1.65E+02	0/155	4.95E+03	0/155	154/155	2.5 - 2.5

Table 5.14. Subsurface Soil Data Summary: Sector 4 (Continued)

Analysis	Unit	Detected Results			FOD	Background (Bkgd)		Excavation Worker		Excavation Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
VOC														
1,1-DCE	mg/kg	3.78E-04	7.96E-02	2.13E-02	6/141	0/141	N/A	0/141	1.26E+02	0/141	3.78E+03	1/141	2/141	0.000862 - 1.3
1,2-DCE	mg/kg	1.10E+01	1.10E+01	1.10E+01	1/8	0/8	N/A	0/8	2.96E+02	0/8	8.88E+03	1/8	1/8	0.14 - 4.7
cis-1,2-DCE	mg/kg	1.13E-03	1.10E+01	1.50E+00	52/134	0/134	N/A	0/134	6.58E+01	0/134	1.97E+03	22/134	35/134	0.000862 - 2.4
trans-1,2-DCE	mg/kg	5.24E-04	1.46E-01	3.32E-02	10/134	0/134	N/A	0/134	5.67E+01	0/134	1.70E+03	0/134	2/134	0.000862 - 1.3
TCE	mg/kg	7.47E-04	1.40E+02	6.29E+00	122/145	0/145	N/A	35/145	2.26E+00	4/145	6.78E+01	91/145	120/145	0.000862 - 6.15
Vinyl chloride	mg/kg	5.97E-04	5.63E-01	9.54E-02	12/141	0/141	N/A	0/141	4.72E+00	0/141	4.72E+02	7/141	11/141	0.000862 - 1.3
RADS														
Neptunium-237	pCi/g	1.53E-01	2.19E-01	1.86E-01	2/155	0/155	N/A	0/155	1.63E+00	0/155	1.63E+02	0/155	2/155	0.0293 - 0.144
Plutonium-239/240	pCi/g	5.94E-02	2.49E-01	9.97E-02	7/156	0/156	N/A	0/156	1.83E+01	0/156	1.83E+03	0/156	1/156	0.05 - 0.0731
Technetium-99	pCi/g	2.30E+00	1.53E+01	4.17E+00	15/156	11/156	2.80E+00	0/156	1.55E+03	0/156	1.00E+05	15/156	15/156	1.58 - 4.76
Thorium-230	pCi/g	1.49E-01	1.85E+00	4.05E-01	149/156	1/156	1.40E+00	0/156	2.82E+01	0/156	2.82E+03	0/156	1/156	0.0852 - 0.418
Uranium-234	pCi/g	1.23E+00	3.32E+00	2.27E+00	10/114	10/114	1.20E+00	0/114	4.30E+01	0/114	4.30E+03	10/114	10/114	0.061 - 1.43
Uranium-235	pCi/g	2.55E-02	2.01E-01	6.28E-02	117/155	36/155	6.00E-02	0/155	2.62E+00	0/155	2.62E+02	0/155	59/155	0.0176 - 0.0971
Uranium-238	pCi/g	5.14E-01	4.37E+00	1.41E+00	111/123	51/123	1.20E+00	0/123	8.98E+00	0/123	8.98E+02	97/123	111/123	0.125 - 1.47

Legend:

- (orange) One or more samples exceed background value.
- (green) One or more samples exceed NAL value.
- (red) One or more samples exceed AL value.
- (blue) One or more samples exceed a groundwater protection screening value.

NOTE: Data were downloaded from the Paducah OREIS database in January and March 2018. See Section 6.1.1 for additional information.
Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted).
Field replicates or separate samples are counted independently.

Table 5.15. Deep Soil Data Summary: Sector 4

Analysis	Unit	Detected Results			FOD	Background (Bkgd)		Excavation Worker		Excavation Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
METAL														
Aluminum	mg/kg	4.68E+02	2.02E+04	6.48E+03	389/389	25/389	1.20E+04	0/389	3.26E+04	0/389	1.00E+05	0/389	346/389	20 - 20
Arsenic	mg/kg	5.04E+00	5.26E+01	1.30E+01	9/389	2/389	7.90E+00	9/389	3.74E+00	0/389	3.60E+02	6/389	9/389	5 - 200
Barium	mg/kg	2.68E+00	1.82E+02	2.56E+01	389/389	1/389	1.70E+02	0/389	6.47E+03	0/389	1.00E+05	0/389	4/389	2.5 - 2.5
Cadmium	mg/kg	5.39E-01	5.39E-01	5.39E-01	1/3	1/3	2.10E-01	0/3	2.53E+01	0/3	7.59E+02	0/3	1/3	0.5 - 0.5
Chromium	mg/kg	2.50E+00	1.11E+02	1.35E+01	377/389	16/389	4.30E+01	187/389	9.14E+00	0/389	9.14E+02	0/389	0/389	2.5 - 2.5
Cobalt	mg/kg	1.20E+01	1.20E+01	1.20E+01	1/3	0/3	1.30E+01	1/3	9.84E+00	0/3	2.95E+02	1/3	1/3	5 - 5
Iron	mg/kg	1.29E+03	1.20E+05	1.02E+04	389/389	13/389	2.80E+04	20/389	2.30E+04	1/389	1.00E+05	389/389	389/389	20 - 200
Manganese	mg/kg	2.72E+00	7.86E+02	3.95E+01	387/389	0/389	8.20E+02	1/389	7.74E+02	0/389	2.32E+04	62/389	386/389	2.5 - 5
Mercury	mg/kg	3.00E-01	3.00E-01	3.00E-01	1/389	1/389	1.30E-01	0/389	9.86E+00	0/389	2.96E+02	0/389	1/389	0.02 - 0.2
Nickel	mg/kg	5.02E+00	2.63E+02	1.24E+01	45/389	1/389	2.20E+01	0/389	6.52E+02	0/389	1.96E+04	1/389	45/389	5 - 5
Selenium	mg/kg	1.02E+00	2.34E+00	1.48E+00	15/377	15/377	7.00E-01	0/377	1.64E+02	0/377	4.92E+03	0/377	15/377	1 - 200

Table 5.15. Deep Soil Data Summary: Sector 4 (Continued)

Analysis	Unit	Detected Results			FOD	Background (Bkgd)		Excavation Worker		Excavation Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
METAL (continued)														
Uranium	mg/kg	1.01E+02	7.91E+02	1.83E+02	39/389	39/389	4.60E+00	39/389	6.58E+00	12/389	1.97E+02	3/389	39/389	0.893 - 1000
Vanadium	mg/kg	2.58E+00	1.85E+02	2.02E+01	387/389	35/389	3.70E+01	1/389	1.65E+02	0/389	4.95E+03	1/389	333/389	2.5 - 2.5
PCB														
PCB	mg/kg	1.46E-03	8.69E-02	1.74E-02	27/122	0/122	N/A	0/122	1.12E+00	0/122	1.12E+02	0/122	1/122	0.00341 - 0.1
SVOC														
Bis(2-ethylhexyl)phthalate	mg/kg	1.05E-01	1.77E+00	5.33E-01	4/122	0/122	N/A	0/122	1.90E+02	0/122	1.14E+04	0/122	1/122	0.341 - 0.726
VOC														
1,1-DCE	mg/kg	1.80E-03	6.41E-02	3.30E-02	2/400	0/400	N/A	0/400	1.26E+02	0/400	3.78E+03	1/400	1/400	0.000763 - 47
1,2-DCE	mg/kg	5.50E-03	5.50E-03	5.50E-03	1/26	0/26	N/A	0/26	2.96E+02	0/26	8.88E+03	0/26	1/26	0.0086 - 2.6
cis-1,2-DCE	mg/kg	3.41E-04	6.18E+00	2.33E-01	118/379	0/379	N/A	0/379	6.58E+01	0/379	1.97E+03	16/379	78/379	0.000763 - 47
TCE	mg/kg	3.38E-04	5.62E+03	3.46E+01	315/417	0/417	N/A	85/417	2.26E+00	12/417	6.78E+01	203/417	284/417	0.000763 - 420
Vinyl chloride	mg/kg	3.58E-03	1.57E-01	6.45E-02	3/401	0/401	N/A	0/401	4.72E+00	0/401	4.72E+02	2/401	3/401	0.000763 - 47
RADS														
Technetium-99	pCi/g	1.95E+00	5.58E+00	2.90E+00	22/382	9/382	2.80E+00	0/382	1.55E+03	0/382	1.00E+05	22/382	22/382	1.58 - 4.76
Uranium-234	pCi/g	7.47E-01	2.42E+00	1.86E+00	8/241	7/241	1.20E+00	0/241	4.30E+01	0/241	4.30E+03	7/241	8/241	0.0514 - 2.35
Uranium-235	pCi/g	1.64E-02	2.07E-01	4.90E-02	244/382	38/382	6.00E-02	0/382	2.62E+00	0/382	2.62E+02	0/382	86/382	0.0146 - 0.231
Uranium-238	pCi/g	4.16E-01	6.75E+00	1.09E+00	228/266	55/266	1.20E+00	0/266	8.98E+00	0/266	8.98E+02	161/266	228/266	0.0089 - 2.34

Legend:

(orange) One or more samples exceed background value.
(green) One or more samples exceed NAL value.
(red) One or more samples exceed AL value.
(blue) One or more samples exceed a groundwater protection screening value.

NOTE: Data were downloaded from the Paducah OREIS database in January and March 2018. See Section 6.1.1 for additional information.
Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted). Field replicates or separate samples are counted independently.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of the Sector 4 area.

- Current on-site industrial—direct contact with surface soil (soil found 0–1 ft bgs).
- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area. (See Section 5.8 for information regarding use of groundwater.)
- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 1–16 ft bgs).
- Future on-site recreational user—consumption of game exposed to contaminated surface soil.
- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.
- Future on-site rural resident—direct contact with surface soil at Sector 4 and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area. (See Section 5.8 for information regarding use of groundwater.)
- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary. (See Section 5.8 for information regarding use of groundwater.)

The risk characterization performed for the SWMU 11 area followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.16. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.16), Table 5.17 presents a risk characterization for lead alone.

5.4.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for the Sector 4 area were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.16. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

The following are significant results in the risk characterization.

- The overall cancer risk to the current and future industrial worker from exposure to soil in Sector 4 exceeds the PGDP *de minimis* level (i.e., 1.0E-06), but is within EPA’s generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 3.7E-06). The overall HI essentially was equal to the PGDP *de minimis* level of 1 (HI = 1.0). The COC for cancer risk to the industrial worker is PAHs (95% of total). The driving exposure route for cancer risk was dermal contact with soil (96% of total). There were no COCs for hazard to the industrial worker. Lead in surface soil does not exceed screening levels.

Table 5.16. Summary of Human Health Risk Characterization for Sector 4 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR*	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI*	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	3.7E-06	PAHs	95	Dermal contact with soil	96	1.0	None	--	None	--
Future industrial worker at current concentrations	3.7E-06	PAHs	95	Dermal contact with soil	96	1.0	None	--	None	--
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations	1.5E-07	NE	NE	NE	NE	< 0.1	NE	NE	NE	NE
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	24.8	Aluminum Antimony Cadmium Chromium	59 9 2 29	Ingestion of soil Dermal contact with soil Ingestion of vegetables	1 23 76
Future adult rural resident at current concentrations	1.9E-04	PAHs PCBs	83 17	Ingestion of soil Dermal contact with soil Ingestion of vegetables	< 1 5 94	7.1	Aluminum Antimony Cadmium Chromium	62 9 2 27	Dermal contact with soil Ingestion of vegetables	16 84
Future excavation worker at current concentrations	3.6E-04	Arsenic Beryllium 1,1-Dichloroethene PAHs PCBs Trichloroethene Vinyl chloride Cesium-137	3 22 1 11 < 1 < 1 61 < 1	Ingestion of soil Dermal contact with soil Inhalation of vapors and particles External exposure	6 32 62 < 1	1.6	Aluminum Antimony Chromium Iron Manganese Vanadium	7 6 10 29 12 20	Ingestion of soil Dermal contact with soil	15 85

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

Table 5.17. Comparison of Representative Concentrations[a] of Lead at Sector 4 against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
SWMU 11 area	x	20	x	400	x
Subsurface Soil (mg/kg)[c]					
SWMU 11 area	5.53	20	No	400	No

x indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0−1 ft bgs.
[c] Subsurface soil is soil collected from 0−16 ft bgs.

- The overall cancer risk to the excavation worker from exposure to soil in Sector 4 exceeds the PGDP *de minimis* level and EPA generally acceptable risk range (ELCR = 3.6E-04). The overall hazard also exceeds the *de minimis* level (HI = 1.6). The COCs for cancer risk to the excavation worker were vinyl chloride (66% of total), beryllium (22% of total), PAHs (11% of total), arsenic (3% of total), and 1,1-DCE (1% of total). The driving exposure routes for cancer risk were inhalation of vapors and particles (62% of total) and dermal contact with soil (32% of total). The COCs for hazard were iron (29% of total), vanadium (20% of total), manganese (12% of total), chromium (10% of total), aluminum (7% of total), and antimony (6% of total). The driving exposure routes and their percentage of total hazard were dermal contact (85%) and ingestion (15%). Lead in subsurface soil does not exceed screening levels.

Several uncertainties were determined to affect the risk characterization results. The effect of some of the important uncertainties on the risk characterization for the industrial worker is shown in Tables 5.18 and 5.19. As shown there, the lower bound cancer risk and hazard can be shown to be less than the respective *de minimis* levels if alternative methods and parameters are used.

Table 5.18. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 4—ELCR

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR Minus Common Laboratory Contaminants	Default ELCR Calculated using EPA Default Dermal Absorption Values[c]	Default ELCR Minus Analytes Infrequently Detected	Lower-bound ELCR[d]
Sector 4	3.7E-06	2.3E-07	3.7E-06	5.9E-07	3.7E-06	3.8E-08

[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. [See Subsection 1.6.2.5 of WAG 6 BHHRA (DOE 1999a).]
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. [See Subsection 1.6.2.4 of WAG 6 BHHRA (DOE 1999a).]
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Table 5.19. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 4—Systemic Toxicity

Location	Default HI[a]	Default HI without Lead	Site-specific HI without Lead[b]	Default HI Minus Common Laboratory Contaminants without Lead	Default HI Calculated EPA Default Dermal Absorption Values without Lead[c]	Default HI Minus Analytes Infrequently Detected without Lead	Lower-bound HI[d]
Sector 4	< 1	< 1	< 1	< 1	< 1	< 1	< 1

< 1 indicates that the HI is less than the *de minimis* level.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. [See Subsection 1.6.2.5 of WAG 6 BHHRA (DOE 1999a).]
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. [See Subsection 1.6.2.4 of WAG 6 BHHRA (DOE 1999a).]
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Ecological Risk Assessment Summary. The primary purpose of the ecological assessment was to determine whether any credible risks to ecological receptors exist in the Sector 4 area. Because only abiotic data were available, the assessment was limited to the evaluation of these data. Additional lines of evidence (e.g., media toxicity testing and biological surveys) were not collected.

Table 5.20 lists the contaminants identified as COPECs for soil at Sector 4. As shown there, aluminum and chromium were COPECs for one or more receptors. Additionally, the assessment determined that each receptor considered had one or more COPECs.

Table 5.20. Summary of Chemicals[a] Posing Potential Future Risks[b] to Nonhuman Receptors at Sector 4

		Chemicals of Potential Ecological Concern									
Location	**Receptor**	**Al**	**As**	**Cd**	**Cr**	**Fe**	**Tl**	**U**	**V**	**Zn**	**PCBs**
Sector 4	Microbe	23.7	x	x	2.4	x		nb	x	x	nb
	Plant	284.0	x	x	23.6	nb		x	x	x	x
	Worm	nb	x	x	59.0	nb		nb	nb	x	nb
	Shrew	92.1	x	x	4.2	nb		x	x	x	x
	Mouse	8.8	x	x	x	nb		x	x	x	x
	Deer	6.0	x	x	x	nb		x	x	x	x

Al = aluminum; As = arsenic; Cd = cadmium; Cr = chromium; Fe = iron; Tl = thallium; U = uranium; V = vanadium; Zn = zinc.
x indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background in that sector.
nb indicates that no toxicological benchmark was available for the chemical/receptor combination.
Blank cells indicate that the analyte was not detected in surface soil in the sector.
[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and a hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Volume 3 of the WAG 6 BHHRA (DOE 1999a).
[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

5.4.5 Additional Data Needs

Sector 4, including SWMUs 11 and 533, has been placed in the C-400 Complex RI/FS for further evaluation and/or remediation as a potential contributor to subsurface soil contamination. Additional sampling is required to determine if the concentration of analytes other than TCE poses a risk, as defined in the DQOs, and to determine the nature and extent of contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.5 SECTOR 5

5.5.1 Area Description

Sector 5 encompasses an L-shaped area of approximately 53,000 ft^2, located southwest of the C-400 Cleaning Building, as shown in Figure 5.11. The Sector 5 area is primarily a concrete apron on the south end of the building and a mixture of soil and graveled areas and small concrete drive on the west. Sector 5 does not contain a SWMU, but part of the Phase I ERH remedial action occurred in this sector.

A stack on the west side the C-400 Cleaning Building will be removed during deactivation of the building. Overhead pipelines traverse the sector north-to-south. Some of these overhead lines are expected to remain in place after C-400 Cleaning Building deactivation. Also remaining in place after deactivation is equipment/piping associated with the waste heat recovery system in the western portion of the sector.

5.5.2 Process History

Two contamination areas were identified in Sector 5 from the WAG 6 RI.

- A VOC source area was located in soils on the southwest corner of the building with a maximum TCE value of 168,200 µg/kg at an estimated depth of 48 ft. This area was treated by the Phase I ERH remedial action (Southwest Area) (Figure 4.2).

- A VOC contaminant area was adjacent to the C-400 Cleaning Building in the northeast corner of Sector 5 with a maximum TCE concentration of 110 µg/kg. The area is overlain by the Discard Waste System drain line.

5.5.3 Previous Investigation Results

Historical sampling data that exceeds screening values for this sector that are applicable according to the decision rules for historical data determined during project scoping are summarized in Table 5.21 for deep soil. No surface or subsurface soil data are available. The entire data summary is available in Appendix B of this document. Other historical results are summarized below for qualitative purposes.

The WAG 6 RI collected surface soil samples and found that PAHs are present (detects in 6 of 7 samples) and locally elevated and that PCBs are present above the WAG 6 screening level in 3 samples.

The WAG 6 RI collected 107 subsurface soil samples from 28 locations in Sector 5, ranging in depths from 1 to 48 ft bgs. Samples were analyzed for VOCs, SVOCs, PCBs, radioactive isotopes, and metals. The maximum VOC concentration in soil was detected at 168,200 µg/kg. Eleven samples were screened for PCBs with a maximum level of 38 µg/kg. PAHs were present near the building (92 analyses with detections as high as 16,000 µg/kg). Four metals (antimony, arsenic, silver, and thallium) exceeded PGDP subsurface concentrations by a factor of two or more. Beryllium was detected above background levels in 14 samples, with the highest detect at 1.05 mg/kg.

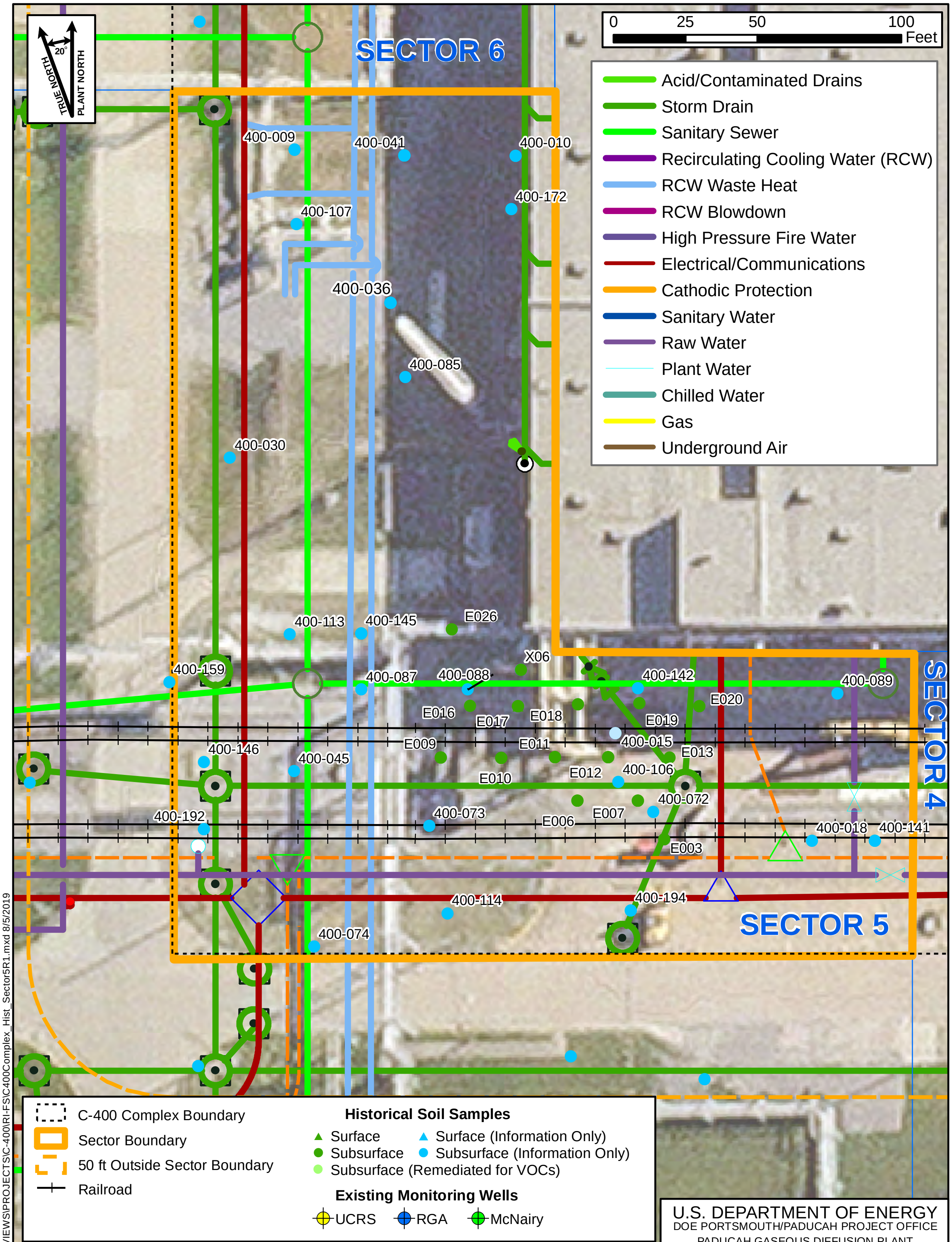


Figure 5.11. Sector 5 Area and Historical Sampling

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Table 5.21. Deep Soil Data Summary: Sector 5

		Detected Results				Background (Bkgd)		Excavation Worker		Excavation Worker		GW Protection Screen		
Analysis	**Unit**	**Min**	**Max**	**Avg**	**FOD**	**FOE**	**Bkgd**	**FOE**	**NAL**	**FOE**	**AL**	**DAF 20**	**DAF 1**	**DL Range**
METAL														
Aluminum	mg/kg	4.39E+03	9.45E+03	6.92E+03	2/2	0/2	1.20E+04	0/2	3.26E+04	0/2	1.00E+05	0/2	2/2	20 - 20
Cadmium	mg/kg	6.38E-01	6.38E-01	6.38E-01	1/2	1/2	2.10E-01	0/2	2.53E+01	0/2	7.59E+02	0/2	1/2	0.5 - 0.5
Chromium	mg/kg	7.00E+00	1.21E+01	9.55E+00	2/2	0/2	4.30E+01	1/2	9.14E+00	0/2	9.14E+02	0/2	0/2	2.5 - 2.5
Iron	mg/kg	4.24E+03	1.14E+04	7.82E+03	2/2	0/2	2.80E+04	0/2	2.30E+04	0/2	1.00E+05	2/2	2/2	20 - 20
Manganese	mg/kg	3.01E+01	8.50E+01	5.76E+01	2/2	0/2	8.20E+02	0/2	7.74E+02	0/2	2.32E+04	1/2	2/2	2.5 - 2.5
Vanadium	mg/kg	7.40E+00	1.84E+01	1.29E+01	2/2	0/2	3.70E+01	0/2	1.65E+02	0/2	4.95E+03	0/2	1/2	2.5 - 2.5
VOC														
cis-1,2-DCE	mg/kg	3.00E-03	3.87E-01	7.28E-02	7/99	0/99	N/A	0/99	6.58E+01	0/99	1.97E+03	0/99	3/99	0.001 - 0.115
TCE	mg/kg	5.01E-03	8.67E+00	3.30E-01	40/102	0/102	N/A	1/102	2.26E+00	0/102	6.78E+01	15/102	40/102	0.001 - 5

Legend:

One or more samples exceed background value.
One or more samples exceed NAL value.
One or more samples exceed AL value.
One or more samples exceed a groundwater protection screening value.

NOTE: Data were downloaded from the Paducah OREIS database in January and March 2018. See Section 6.1.1 for additional information.
Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted). Field replicates or separate samples are counted independently.

5.5.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for Sector 5 were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.22. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of the Sector 5 area.

- Current on-site industrial—direct contact with surface soil (soil found 0–1 ft bgs).
- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area. (See Section 5.8 for information regarding use of groundwater.)
- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 1–15 ft bgs).
- Future on-site recreational user—consumption of game exposed to contaminated surface soil.
- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.
- Future on-site rural resident—direct contact with surface soil at Sector 5 and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area. (See Section 5.8 for information regarding use of groundwater.)
- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary. (See Section 5.8 for information regarding use of groundwater.)
- The risk characterization performed for the Sector 5 area followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.22. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.22), Table 5.23 presents a risk characterization for lead alone.

Table 5.22. Summary of Human Health Risk Characterization for Sector 5 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	4.0E-04	Beryllium PAHs Uranium-238	31 68 1	Ingestion of soil Dermal contact with soil External exposure	3 96 2	1.8	Antimony Chromium Iron	22 26 47	Dermal contact with soil	98
Future industrial worker at current concentrations	4.0E-04	Beryllium PAHs Uranium-238	31 68 1	Ingestion of soil Dermal contact with soil External exposure	3 96 2	1.8	Antimony Chromium Iron	22 26 47	Dermal contact with soil	98
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations	2.5E-05	PAHs	99	Ingestion of deer Ingestion of rabbit Ingestion of quail	9 82 9	< 0.1	NE	NE	NE	NE
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	85.5	Antimony Beryllium Cadmium Chromium Iron Uranium Zinc PAHs	7 < 1 < 1 8 66 18 < 1 < 1	Ingestion of soil Dermal contact with soil Ingestion of vegetables	1 11 87
Future adult rural resident at current concentrations	1.4E-02	Beryllium PAHs PCBs Neptunium-237 Uranium-235 Uranium-238	5 92 < 1 < 1 < 1 < 1	Ingestion of soil Dermal contact with soil Ingestion of vegetables External exposure	< 1 8 91 < 1	25.6	Antimony Cadmium Chromium Iron Uranium	6 < 1 7 67 19	Ingestion of soil Dermal contact with soil Ingestion of vegetables	< 1 8 92
Future excavation worker at current concentrations	2.3E-04	Arsenic Beryllium PAHs N-nitrosodi-n-propylamine Vinyl chloride Cesium-137	6 34 21 10 27 < 1	Ingestion of soil Dermal contact with soil Inhalation of particulates and vapors External exposure	12 60 27 1	1.6	Aluminum Antimony Chromium Iron Manganese Vanadium	7 15 9 30 12 18	Ingestion of soil Dermal contact with soil	15 86

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

Table 5.23. Comparison of Representative Concentrations[a] of Lead at Sector 5 against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
Sector 5	x	20	x	400	x
Subsurface Soil (mg/kg)[c]					
Sector 5	5.54	20	No	400	No

Notes: x indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0−1 ft bgs (DOE 1999a).
[c] Subsurface soil is soil collected from 0−16 ft bgs.

The following are significant results in the risk characterization.

- The overall cancer risk to the current and future industrial worker from exposure to soil in Sector 5 exceeds PGDP *de minimis* level (i.e., 1.0E-06) and EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 4.0E-04). The overall hazard also exceeds the *de minimis* level (HI = 1.8). The COCs for cancer risk to the industrial worker were PAHs (68% of total); beryllium (31% of total); and uranium-238 (1% of total). The driving exposure route for cancer risk was dermal contact with soil (96% of total). The COCs for hazard to the industrial worker were antimony (22% of total), chromium (26% of total), and iron (47% of total). The driving exposure route for hazard was dermal contact with soil (98% of total). Lead in surface soil does not exceed screening levels.

- The overall cancer risk to the excavation worker from exposure to soil in Sector 5 exceeds PGDP *de minimis* level and EPA generally acceptable risk range (ELCR = 2.3E-04). The overall HI was similar to PGDP *de minimis* level of 1 (HI = 1.6). The COCs for cancer risk to the excavation worker were beryllium (34% of total); vinyl chloride (27% of total); PAHs (21% of total); n-nitosodi-n-propylamine (10% of total); and arsenic (6% of total). The driving exposure routes for cancer risk were dermal contact with soil (60% of total); inhalation (27% of total); and ingestion of soil (12% of total). The COCs for hazard were iron (30% of total); vanadium (18% of total); antimony (15% of total); manganese (12% of total); chromium (9% of total); and aluminum (7% of total). The driving exposure routes and their percentage of total hazard were dermal contact (86%) and ingestion (15%). Lead in subsurface soil does not exceed screening levels.

Several uncertainties were determined to affect the risk characterization results. The effect of some important uncertainties on the risk characterization for the industrial worker is shown in Tables 5.24 and 5.25. As shown there, the lower bound cancer risk and hazard can be shown to be close or less than the respective *de minimis* levels if alternative methods and parameters are used.

Table 5.24. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 5—ELCR

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR Minus Common Laboratory Contaminants	Default ELCR Calculated using EPA Default Dermal Absorption Values[c]	Default ELCR Minus Analytes Infrequently Detected	Lower-bound ELCR[d]
Sector 5	4.0E-04	2.6E-05	4.0E-04	4.5E-05	4.0E-04	2.9E-06

[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5 of the WAG 6 RI.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4 of the WAG 6 RI.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at Sector 3.

Table 5.25. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 5—Systemic Toxicity

Location	Default HI[a]	Default HI without Lead	Site-specific HI without Lead[b]	Default HI Minus Common Laboratory Contaminants without Lead	Default HI Calculated EPA Default Dermal Absorption Values without Lead[c]	Default HI Minus Analytes Infrequently Detected without Lead	Lower-bound HI[d]
Sector 5	1.8	1.8	< 1	1.8	< 1	1.8	< 1

Notes: < 1 indicates that the HI is less than the *de minimis* level.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5 in the WAG 6 RI.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4 in the WAG 6 RI.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Ecological Risk Assessment Summary. The primary purpose of the ecological assessment was to determine whether any credible risks to ecological receptors exist in the Sector 5 area. Because only abiotic data were available, the assessment was limited to the evaluation of this data. Additional lines of evidence (e.g., media toxicity testing and biological surveys) were not collected.

Table 5.26 lists the contaminants identified as COPECs for soil at Sector 5. As shown there, chromium, iron, thallium, uranium, and zinc were COPECs for one or more receptors. Additionally, the assessment determined that each receptor considered, except the mouse and deer, had one or more COPECs.

Table 5.26. Summary of Chemicals[a] Posing Potential Future Risks[b] to Nonhuman Receptors at Sector 5

		Chemicals of Potential Ecological Concern									
Location	**Receptor**	**Al**	**As**	**Cd**	**Cr**	**Fe**	**Tl**	**U**	**V**	**Zn**	**PCBs**
Sector 5	Microbe	x	x	x	4.8	185.0	nb	nb	x	1.1	nb
	Plant	x	x	x	48.0	nb	1.5	10.0	x	2.2	x
	Worm	nb	x	x	120.0	nb	nb	nb	nb	x	nb
	Shrew	x	x	x	3.7	nb	x	x	x	x	x
	Mouse	x	x	x	x	nb	x	x	x	x	x
	Deer	x	x	x	x	nb	x	x	x	x	x

Notes: Al = aluminum; As = arsenic; Cd = cadmium; Cr = chromium; Fe = iron; Tl = thallium; U = uranium; V = vanadium; Zn = zinc
x indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background in that sector.
nb indicates that no toxicological benchmark was available for the chemical/receptor combination.
Blank cells indicate that the analyte was not detected in surface soil in the sector.
[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and a hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Volume 3 of the WAG 6 BHHRA (DOE 1999a).
[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

5.5.5 Additional Data Needs

Sector 5 is included in the C-400 Complex RI/FS for further evaluation and/or remediation as a potential contributor to soil and groundwater contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.6 SECTOR 6

5.6.1 Area Description

Sector 6 encompasses an area of approximately 26,000 ft^2, located west of the C-400 Cleaning Building, as shown in Figure 5.12. The Sector 6 area is covered primarily in grassy soils with gravel roadways and concrete pads. The former C-400 Technetium Storage Tank and associated bermed area (SWMU 47) are included in Sector 6. Prior to dismantling and disposal, the 4,000 gal tank was located on a concrete pad on the west side of the C-400 Cleaning Building.

A stack on the west side the C-400 Cleaning Building will be removed during deactivation of the building. Overhead pipelines traverse the sector north-to-south. Some of these overhead lines are expected to remain in place after C-400 Cleaning Building deactivation. Also remaining in place after deactivation is an electrical transformer area in the west central portion of the sector. During scoping, it was discussed that the electrical transformers and feeder line do not contain PCBs, per the engineering drawings.

5.6.2 Process History

From the early 1960s to 1986, the C-400 Technetium Storage Tank was used in the technetium recovery process to store a waste solution of chromium and Tc-99.

The technetium recovery process consisted of dissolution of technetium-bearing material, precipitation of uranium and impurities from the solution, and the recovery of the technetium via ion exchange. The tank contained extracted liquid from process operations in the C-400 Cleaning Building.

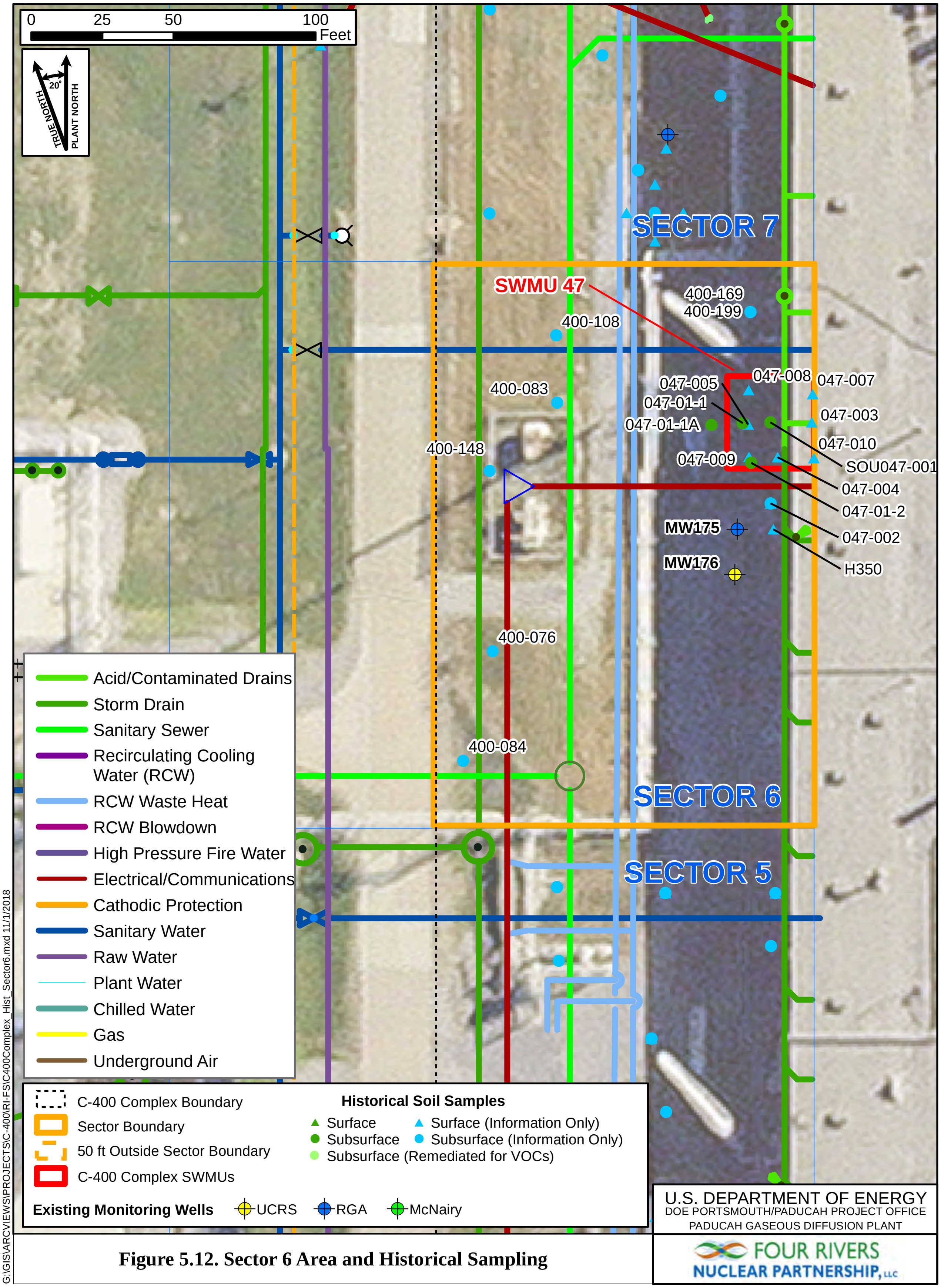

Figure 5.12. Sector 6 Area and Historical Sampling

5.6.3 Previous Investigation Results

Historical sampling data exceeding screening values for this sector, that are applicable according to the decision rules for historical data determined during project scoping, are summarized in Tables 5.27 and 5.28 for surface soil and subsurface soil. No deep soil data are available. The entire data summary is available in Appendix B of this document. Other historical results are summarized below for qualitative purposes.

The WAG 6 RI collected 21 surface and subsurface soil samples primarily around the SWMU 47 pad. The following were highlighted from these results.

- Five VOCs were detected in the subsurface soil samples collected between 1 and 29.5 ft bgs.
- Numerous SVOCs were reported from the soil samples submitted for analysis from Sector 6.
- Of the SVOCs detected above the SQL (15 PAHs and one phenol), all are closely related spatially with the bermed area around the former Technetium Storage Tank site.
- Two surface soil samples collected exhibited PCBs above the SQL. No PCBs were detected in the subsurface soil samples.
- Numerous metals were detected at concentrations above PGDP background screening levels. Most of the metal concentrations were only slightly above background levels. However, one surface soil sample from Boring 047-002 contained cadmium at 4.25 mg/kg, which is approximately 20 times PGDP background level.
- Nine radionuclides, americium-241, cesium-137, thorium-230, neptunium-237, plutonium-239, Tc-99, uranium-234, uranium-235, and uranium-238, exceeded PGDP background screening levels. The maximum activities of seven of the nine isotopes were found in the surface soil sample from Boring 047-002, adjacent to the bermed area. Results of this sampling indicate the potential for radiological, chromium, and PAH contamination.

The tank was emptied of liquids (approximately 200 gal of solution) and removed in 1986, as part of RCRA permitting activities. The remaining two inches of sludge was sampled in 1999 for RCRA constituents in order to determine if the sludge was hazardous. Total concentrations indicated that the sludge should be considered RCRA-hazardous for chromium and mercury.

5.6.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary (WAG 6). The direct contact risks for Sector 6 were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.29. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

Table 5.27. Surface Soil Data Summary: Sector 6

Analysis	Unit	Detected Results			FOD	Background (Bkgd)		Industrial Worker		Industrial Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
METAL														
Aluminum	mg/kg	6.12E+03	6.12E+03	6.12E+03	1/1	0/1	1.30E+04	0/1	1.00E+05	0/1	1.00E+05	0/1	1/1	5 - 5
Antimony	mg/kg	6.98E+01	6.98E+01	6.98E+01	1/2	1/2	2.10E-01	0/2	9.34E+01	0/2	2.80E+03	1/2	1/2	0.5 - 30
Arsenic	mg/kg	1.60E+01	2.24E+01	1.92E+01	2/2	2/2	1.20E+01	2/2	1.60E+00	0/2	1.60E+02	2/2	2/2	1 - 11
Barium	mg/kg	3.25E+02	3.25E+02	3.25E+02	1/2	1/2	2.00E+02	0/2	4.04E+04	0/2	1.00E+05	0/2	1/2	2 - 100
Cadmium	mg/kg	1.90E+00	1.90E+00	1.90E+00	1/2	1/2	2.10E-01	0/2	6.05E+01	0/2	1.82E+03	0/2	1/2	0.05 - 12
Chromium	mg/kg	5.39E+01	5.39E+01	5.39E+01	1/2	1/2	1.60E+01	1/2	1.23E+01	0/2	1.23E+03	0/2	0/2	1 - 85
Cobalt	mg/kg	7.30E+00	7.30E+00	7.30E+00	1/1	0/1	1.40E+01	0/1	6.87E+01	0/1	2.06E+03	1/1	1/1	0.2 - 0.2
Iron	mg/kg	2.31E+04	2.95E+04	2.63E+04	2/2	1/2	2.80E+04	0/2	1.00E+05	0/2	1.00E+05	2/2	2/2	5 - 100
Lead	mg/kg	2.84E+01	4.89E+01	3.86E+01	2/2	1/2	3.60E+01	0/2	8.00E+02	0/2	8.00E+02	0/2	2/2	0.3 - 13
Manganese	mg/kg	2.16E+02	2.72E+02	2.44E+02	2/2	0/2	1.50E+03	0/2	4.72E+03	0/2	1.00E+05	2/2	2/2	0.2 - 85
Molybdenum	mg/kg	1.70E+00	1.70E+00	1.70E+00	1/2	0/2	N/A	0/2	1.16E+03	0/2	3.48E+04	0/2	1/2	0.5 - 15
Nickel	mg/kg	8.25E+01	8.25E+01	8.25E+01	1/2	1/2	2.10E+01	0/2	4.30E+03	0/2	1.00E+05	1/2	1/2	0.5 - 65
Selenium	mg/kg	8.90E-01	8.90E-01	8.90E-01	1/2	1/2	8.00E-01	0/2	1.17E+03	0/2	3.51E+04	0/2	1/2	0.5 - 20
Silver	mg/kg	7.90E-01	7.90E-01	7.90E-01	1/2	0/2	2.30E+00	0/2	1.17E+03	0/2	3.51E+04	0/2	1/2	0.2 - 10
Uranium	mg/kg	2.83E+01	3.23E+01	3.03E+01	2/2	2/2	4.90E+00	0/2	4.66E+01	0/2	1.40E+03	0/2	2/2	0.1 - 20
Vanadium	mg/kg	3.28E+01	3.28E+01	3.28E+01	1/2	0/2	3.80E+01	0/2	1.15E+03	0/2	3.45E+04	0/2	1/2	1 - 70
Zinc	mg/kg	1.09E+02	1.72E+02	1.40E+02	2/2	2/2	6.50E+01	0/2	7.01E+04	0/2	1.00E+05	0/2	2/2	2 - 25
PCB														
PCB	mg/kg	5.40E-01	5.40E-01	5.40E-01	1/2	0/2	N/A	1/2	2.93E-01	0/2	2.93E+01	0/2	1/2	1.3 - 5
SVOC														
Bis(2-ethylhexyl)phthalate	mg/kg	7.00E+00	7.00E+00	7.00E+00	1/1	0/1	N/A	0/1	5.80E+01	0/1	5.80E+03	0/1	1/1	0.69 - 0.69
Total PAH	mg/kg	5.56E-01	5.56E-01	5.56E-01	1/1	0/1	N/A	0/1	6.43E-01	0/1	6.43E+01	0/1	1/1	-
RADS														
Cesium-137	pCi/g	1.17E-01	1.17E-01	1.17E-01	1/1	0/1	4.90E-01	1/1	1.08E-01	0/1	1.08E+01	0/1	0/1	0.07 - 0.07
Neptunium-237	pCi/g	1.15E-01	1.15E-01	1.15E-01	1/1	1/1	1.00E-01	0/1	2.49E-01	0/1	2.49E+01	0/1	1/1	0.011 - 0.011
Plutonium-239/240	pCi/g	4.11E+00	4.11E+00	4.11E+00	1/1	1/1	2.50E-02	0/1	2.27E+01	0/1	2.27E+03	0/1	1/1	0.01 - 0.01
Technetium-99	pCi/g	6.97E+01	6.97E+01	6.97E+01	1/1	1/1	2.50E+00	0/1	1.27E+03	0/1	1.00E+05	1/1	1/1	0.5 - 0.5
Thorium-230	pCi/g	4.11E+01	4.11E+01	4.11E+01	1/1	1/1	1.50E+00	1/1	3.13E+01	0/1	3.13E+03	1/1	1/1	0.02 - 0.02
Uranium-234	pCi/g	6.85E+00	6.85E+00	6.85E+00	1/1	1/1	1.20E+00	0/1	5.01E+01	0/1	5.01E+03	1/1	1/1	0.02 - 0.02
Uranium-235/236	pCi/g	5.00E-01	5.00E-01	5.00E-01	1/1	1/1	6.00E-02	0/1	N/A	0/1	N/A	0/1	1/1	0.01 - 0.01
Uranium-238	pCi/g	7.93E+00	7.93E+00	7.93E+00	1/1	1/1	1.20E+00	1/1	1.66E+00	0/1	1.66E+02	1/1	1/1	0.02 - 0.02

Legend:

- (orange) One or more samples exceed background value.
- (green) One or more samples exceed NAL value.
- (red) One or more samples exceed AL value.
- (blue) One or more samples exceed a groundwater protection screening value.

NOTE: Data were downloaded from the Paducah OREIS database in January and March 2018. See Section 6.1.1 for additional information.
Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted).
Field replicates or separate samples are counted independently.

Table 5.28. Subsurface Soil Data Summary: Sector 6

Analysis	Unit	Detected Results			FOD	Background (Bkdg)		Excavation Worker		Excavation Worker		GW Protection Screen		DL Range
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	AL	DAF 20	DAF 1	
METAL														
Aluminum	mg/kg	4.63E+03	1.55E+04	9.12E+03	5/5	1/5	1.20E+04	0/5	3.26E+04	0/5	1.00E+05	0/5	5/5	5 - 5.8
Antimony	mg/kg	2.60E-01	7.10E+01	4.00E+01	5/5	5/5	2.10E-01	3/5	1.32E+01	0/5	3.96E+02	3/5	4/5	0.5 - 30
Arsenic	mg/kg	3.20E+00	1.01E+01	6.44E+00	5/5	1/5	7.90E+00	4/5	3.74E+00	0/5	3.60E+02	4/5	5/5	1 - 11
Barium	mg/kg	4.45E+01	4.21E+02	2.76E+02	5/5	3/5	1.70E+02	0/5	6.47E+03	0/5	1.00E+05	0/5	4/5	2 - 100
Cadmium	mg/kg	1.30E-02	1.51E+01	3.80E+00	4/5	1/5	2.10E-01	0/5	2.53E+01	0/5	7.59E+02	1/5	1/5	0.05 - 12
Chromium	mg/kg	1.29E+01	3.60E+01	1.81E+01	5/5	0/5	4.30E+01	5/5	9.14E+00	0/5	9.14E+02	0/5	0/5	1 - 85
Cobalt	mg/kg	5.60E+00	1.69E+01	1.05E+01	5/5	2/5	1.30E+01	3/5	9.84E+00	0/5	2.95E+02	5/5	5/5	0.2 - 0.23
Iron	mg/kg	1.24E+04	2.02E+04	1.65E+04	5/5	0/5	2.80E+04	0/5	2.30E+04	0/5	1.00E+05	5/5	5/5	5 - 100
Lead	mg/kg	5.30E+00	1.78E+01	1.14E+01	5/5	0/5	2.30E+01	0/5	8.00E+02	0/5	8.00E+02	0/5	1/5	0.3 - 13
Manganese	mg/kg	2.49E+02	1.69E+03	6.55E+02	5/5	1/5	8.20E+02	1/5	7.74E+02	0/5	2.32E+04	5/5	5/5	0.2 - 85
Molybdenum	mg/kg	6.50E-01	8.40E-01	7.45E-01	2/5	0/5	N/A	0/5	1.64E+02	0/5	4.92E+03	0/5	2/5	0.5 - 15
Nickel	mg/kg	4.00E+00	1.76E+01	9.50E+00	5/5	0/5	2.20E+01	0/5	6.52E+02	0/5	1.96E+04	0/5	5/5	0.5 - 65
Selenium	mg/kg	5.30E-01	1.60E+00	1.12E+00	5/5	3/5	7.00E-01	0/5	1.64E+02	0/5	4.92E+03	0/5	5/5	0.5 - 20
Sodium	mg/kg	2.92E+01	3.76E+02	1.89E+02	5/5	1/5	3.40E+02	0/5	N/A	0/5	N/A	N/A	N/A	20 - 23.2
Thallium	mg/kg	1.10E-01	3.50E-01	2.46E-01	5/5	1/5	3.40E-01	2/5	3.29E-01	0/5	9.87E+00	0/5	4/5	0.2 - 0.23
Uranium	mg/kg	9.60E-01	4.17E+01	9.66E+00	5/5	1/5	4.60E+00	1/5	6.58E+00	0/5	1.97E+02	0/5	1/5	0.1 - 20
Vanadium	mg/kg	1.88E+01	3.61E+01	2.51E+01	5/5	0/5	3.70E+01	0/5	1.65E+02	0/5	4.95E+03	0/5	5/5	1 - 70
Zinc	mg/kg	9.80E+00	4.53E+01	2.85E+01	5/5	0/5	6.00E+01	0/5	9.86E+03	0/5	1.00E+05	0/5	2/5	2 - 25
RADS														
Neptunium-237	pCi/g	1.46E-01	1.46E-01	1.46E-01	1/3	0/3	N/A	0/3	1.63E+00	0/3	1.63E+02	0/3	1/3	0.012 - 0.025
Plutonium-239/240	pCi/g	6.30E-03	4.19E+00	2.10E+00	2/3	0/3	N/A	0/3	1.83E+01	0/3	1.83E+03	0/3	1/3	0.0043 - 0.02
Technetium-99	pCi/g	5.05E+01	5.05E+01	5.05E+01	1/3	1/3	2.80E+00	0/3	1.55E+03	0/3	1.00E+05	1/3	1/3	0.49 - 0.5
Thorium-230	pCi/g	1.02E+00	5.45E+01	1.89E+01	3/3	1/3	1.40E+00	1/3	2.82E+01	0/3	2.82E+03	1/3	1/3	0.007 - 0.02
Uranium-234	pCi/g	7.50E-01	8.10E+00	3.21E+00	3/3	1/3	1.20E+00	0/3	4.30E+01	0/3	4.30E+03	1/3	3/3	0.02 - 0.02
Uranium-235/236	pCi/g	2.90E-02	3.90E-01	1.58E-01	3/3	1/3	6.00E-02	0/3	N/A	0/3	N/A	0/3	2/3	0.01 - 0.026
Uranium-238	pCi/g	7.40E-01	8.21E+00	3.25E+00	3/3	1/3	1.20E+00	0/3	8.98E+00	0/3	8.98E+02	2/3	3/3	0.009 - 0.02

Legend:

- (orange) One or more samples exceed background value.
- (green) One or more samples exceed NAL value.
- (red) One or more samples exceed AL value.
- (blue) One or more samples exceed a groundwater protection screening value.

NOTE: Data were downloaded from the Paducah OREIS database in January and March 2018. See Section 6.1.1 for additional information.
Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted). Field replicates or separate samples are counted independently.

Table 5.29. Summary of Human Health Risk Characterization for Sector 6 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	1.1E-03	Arsenic Beryllium PAHs PCBs Cesium-137 Neptunium-237 Uranium-238	3 9 86 < 1 < 1 < 1 < 1	Ingestion of soil Dermal contact with soil External exposure	3 95 1	1.2	Aluminum Antimony Arsenic Chromium PCBs	13 22 20 22 13	Dermal contact with soil	95
Future industrial worker at current concentrations	1.1E-03	Arsenic Beryllium PAHs PCBs Cesium-137 Neptunium-237 Uranium-238	3 9 86 < 1 < 1 < 1 < 1	Ingestion of soil Dermal contact with soil External exposure	3 95 1	1.2	Aluminum Antimony Arsenic Chromium PCBs	13 22 20 22 13	Dermal contact with soil	95
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations	3.2E-03	PAHs	98	Ingestion of deer Ingestion of rabbit Ingestion of quail	9 81 10	< 0.1	NE	NE	NE	NE

Table 5.29. Summary of Human Health Risk Characterization for Sector 6 without Lead as a COC (DOE 1999a) (Continued)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	119	Aluminum	6	Ingestion of soil	1
							Antimony	3	Dermal contact with soil	6
							Arsenic	36	Ingestion of vegetables	93
							Beryllium	< 1		
							Cadmium	1		
							Chromium	3		
							Uranium	9		
							Zinc	< 1		
							PAHs	2		
							PCBs	38		
Future adult rural resident at current concentrations	5.0E-02	Arsenic	9	Ingestion of soil	< 1	36.4	Aluminum	6	Ingestion of soil	< 1
		Beryllium	1	Dermal contact with soil	6		Antimony	3	Dermal contact with soil	4
		PAHs	88	Ingestion of vegetables	93		Arsenic	36	Ingestion of vegetables	96
		PCBs	1	External exposure	< 1		Cadmium	1		
		Cesium-137	< 1				Chromium	3		
		Neptunium-237	< 1				Uranium	10		
		Uranium-234	< 1				PAHs	2		
		Uranium-235	< 1				PCBs	38		
		Uranium-238	< 1							
Future excavation worker at current concentrations	5.5E-04	Arsenic	31	Ingestion of soil	29	2.1	Aluminum	7	Ingestion of soil	31
		Beryllium	14	Dermal contact with soil	69		Antimony	8	Dermal contact with soil	69
		PAHs	52	External exposure	2		Arsenic	50		
		PCBs	< 1				Chromium	9		
		Cesium-137	< 1				Vanadium	16		
		Neptunium-237	< 1							
		Uranium-234	< 1							
		Uranium-238	1							

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of Sector 6.

- Current on-site industrial—direct contact with surface soil (soil found 0–1 ft bgs).
- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area. (See Section 5.8 for information regarding use of groundwater.)
- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 1–16 ft bgs).
- Future on-site recreational user—consumption of game exposed to contaminated surface soil.
- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.
- Future on-site rural resident—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area.
- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary. (See Section 5.8 for information regarding use of groundwater.)

The risk characterization performed for Sector 6 followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.29. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.29). Table 5.30 presents a risk characterization for lead alone.

Table 5.30. Comparison of Representative Concentrations[a] of Lead at Sector 6 against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
Sector 6	x	20	x	400	x
Subsurface Soil (mg/kg)[c]					
Sector 6	x	20	x	400	x

Notes: x indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0–1 ft bgs (DOE 1999a).
[c] Subsurface soil is soil collected from 0–16 ft bgs.

The following are significant results in the risk characterization.

- The overall cancer risk to the current and future industrial worker from exposure to soil in Sector 6 exceeds PGDP *de minimis* level (i.e., 1.0E-06) and EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 1.1E-03). The overall HI was similar to PGDP *de minimis* level of 1 (HI = 1.2). The COCs for cancer risk to the industrial worker were PAHs (86% of total) and beryllium (9% of total). The driving exposure route for cancer risk was dermal contact with soil (95% of total). The COCs for hazard to the industrial worker were antimony (22% of total); chromium (22% of total); arsenic (20% of total); aluminum (13% of total); and PCBs (13% of total). The driving exposure route for hazard was dermal contact with soil (95% of total). Lead in surface soil does not exceed screening levels.

- The overall cancer risk to the excavation worker from exposure to soil in Sector 6 exceeds PGDP *de minimis* level and EPA generally acceptable risk range (ELCR = 5.5E-04). The overall hazard also exceeds the *de minimis* level (HI = 2.1). The COCs for cancer risk to the excavation worker were PAHs (52% of total); arsenic (31% of total); and beryllium (14% of total). The driving exposure routes for cancer risk were dermal contact with soil (69% of total) and ingestion of soil (29% of total). The COCs for hazard were arsenic (50% of total); vanadium (16% of total); chromium (9% of total); antimony (8% of total); and aluminum (7% of total). The driving exposure routes and their percentage of total hazard were dermal contact (69%) and ingestion (31%). Lead in subsurface soil does not exceed screening levels.

Several uncertainties were determined to affect the risk characterization results. The effects of some important uncertainties on the risk characterization for the industrial worker are shown in Tables 5.31 and 5.32. As shown there, the lower bound cancer risk falls within the EPA generally acceptable risk range (ELCR = 9.8E-06) and hazard can be shown to be less than its *de minimis* level if alternative methods and parameters are used.

Table 5.31. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 6—ELCR

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR Minus Common Laboratory Contaminants	Default ELCR Calculated using EPA Default Dermal Absorption Values[c]	Default ELCR Minus Analytes Infrequently Detected	Lower-bound ELCR[d]
Sector 6	1.1E-03	7.3E-05	1.1E-03	1.5E-04	1.1E-03	9.8E-06

[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. [See Subsection 1.6.2.5 of WAG 6 BHHRA (DOE 1999a).]
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. [See Subsection 1.6.2.4 of WAG 6 BHHRA (DOE 1999a).]
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Table 5.32. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 6—Systemic Toxicity

Location	Default HI[a]	Default HI without Lead	Site-specific HI without Lead[b]	Default HI Minus Common Laboratory Contaminants without Lead	Default HI Calculated EPA Default Dermal Absorption Values without Lead[c]	Default HI Minus Analytes Infrequently Detected without Lead	Lower-bound HI[d]
Sector 6	1.2	1.2	< 1	1.2	< 1	1.2	< 1

< 1 indicates that the HI is less than the *de minimis* level.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. [See Subsection 1.6.2.5 of WAG 6 BHHRA (DOE 1999a).]
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. [See Subsection 1.6.2.4 of WAG 6 BHHRA (DOE 1999a).]
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Human Health Risk Assessment Summary (Soils OU—SWMU 47). The direct contact risks for SWMU 47 within Sector 6 were assessed and reported in the Soils OU RI Report (D1 Version) (DOE 2011b). The risk characterization performed for Sector 6 followed the guidance in the 2011 revision of the RMD (DOE 2011c). The results of the risk characterization are shown in Table 5.33.

The following are significant results in the risk characterization.

- The overall cancer risk to the future industrial worker from exposure to soil in SWMU 47 exceeds PGDP *de minimis* level (i.e., 1.0E-06) and EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 1.03E-03). The overall HI was less than PGDP *de minimis* level of 1. The significant COCs for cancer risk to the industrial worker were PAHs (89% of total), beryllium (5% of total), and arsenic (4% of total). The driving exposure routes for cancer risk were dermal contact with soil (91% of total) and ingestion of soil (8% of total).

- The overall cancer risk to the excavation worker from exposure to soil in SWMU 47 exceeds PGDP *de minimis* level (i.e., 1.0E-06), but is within EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 1.68E-05). The overall HI was less than PGDP *de minimis* level of 1. The significant COCs for cancer risk to the excavation worker were PAHs (83% of total); arsenic (8% of total); beryllium (3% of total); thorium-230 (2% of total); and TCE (2% of total). The driving exposure routes for cancer risk were dermal contact with soil (52% of total) and ingestion of soil (46% of total).

Table 5.33. Summary of Human Health Risk Characterization for SWMU 47 (DOE 2011c)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	5.76E-05	Arsenic	4.4	Ingestion of soil	8.3	< 0.1	NE	NE	NE	NE
		Beryllium	4.9	Inhalation of particulates	< 1					
		PAHs	88.9	Dermal contact with soil	90.6					
				External exposure	< 1					
Future industrial worker at current concentrations	1.03E-03	Arsenic	4.4	Ingestion of soil	8.3	0.9	Arsenic	30.8	Ingestion of soil	14.9
		Beryllium	4.9	Inhalation of particulates	< 1		Cobalt	14.7	Inhalation of particulates	3.8
		Cadmium	< 1	Dermal contact with soil	90.6		Iron	12.7	Dermal contact with soil	81.3
		Chromium	< 1	External exposure	< 1		Nickel	20.9		
		PCBs	< 1							
		PAHs	88.9							
		Thorium-230	< 1							
		Uranium-235	< 1							
		Uranium-238	< 1							
Outdoor Worker (Surface Soil)	1.31E-03	Arsenic	8.3	Ingestion of soil	46.7	1.56	Arsenic	43.6	Ingestion of soil	62.7
		Beryllium	3.1	Inhalation of particulates	< 1		Cobalt	16.0	Inhalation of particulates	1.7
		Cadmium	< 1	Dermal contact with soil	52.7		Iron	14.0	Dermal contact with soil	35.7
		Chromium	< 1	External exposure	< 1		Nickel	10.0		
		PCBs	< 1							
		PAHs	85.3							
		Plutonium-239/240	< 1							
		Thorium-230	1.4							
		Uranium-234	< 1							
		Uranium-238	< 1							
Outdoor Worker (Subsurface Soil)	1.34E-03	Arsenic	8.1	Ingestion of soil	46.3	1.84	Arsenic	37.0	Ingestion of soil	60.2
		Beryllium	3.0	Inhalation of particulates	1.8		Cobalt	16	Inhalation of particulates	4.7
		Cadmium	< 1	Dermal contact with soil	51.6		Iron	11.9	Dermal contact with soil	35.1
		PCBs	< 1	External exposure	< 1		Nickel	8.4		
		PAHs	83.1							
		Trichloroethene	1.7							
		Plutonium-239/240	< 1							
		Thorium-230	1.9							
		Uranium-234	< 1							
		Uranium-238	< 1							
Excavation Worker (Subsurface Soil)	1.68E-05	Arsenic	8.1	Ingestion of soil	46.3	0.58	Arsenic	37	Ingestion of soil	60.2
		PAHs	83.1	Inhalation of particulates	1.8				Inhalation of particulates	4.7
				Dermal contact with soil	51.6				Dermal contact with soil	35.1
				External exposure	< 1					

Table 5.33. Summary Human Health Risk Characterization for SWMU 47 (DOE 2011c) (Continued)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future adult resident	3.18E-03	Arsenic	6.0	Ingestion of soil	23.6	1.69	Arsenic	33.2	Ingestion of soil	22.7
		Beryllium	4.1	Inhalation of particulates	< 1		Cobalt	15.0	Inhalation of particulates	1.9
		Cadmium	< 1	Dermal contact with soil	75.2		Iron	13.1	Dermal contact with soil	75.3
		Chromium	< 1	External exposure	< 1		Nickel	19.4		
		Naphthalene	< 1							
		PAHs	87.6							
		PCBs	< 1							
		Neptunium-237	1.0							
		Plutonium-239/240	< 1							
		Thorium-230	< 1							
		Uranium-234	< 1							
		Uranium-235	< 1							
		Uranium-238	< 1							
Future child resident	3.18E-03	Arsenic	6.0	Ingestion of soil	23.6	6.67	Aluminum	5.1	Ingestion of soil	53.9
		Beryllium	4.1	Inhalation of particulates	< 1		Antimony	2.4	Inhalation of particulates	2.3
		Cadmium	< 1	Dermal contact with soil	75.2		Arsenic	41.2	Dermal contact with soil	43.8
		Chromium	< 1	External exposure	< 1		Cobalt	15.7		
		Naphthalene	< 1				Iron	13.7		
		PAHs	87.6				Nickel	11.9		
		PCBs	< 1				Uranium	3.5		
		Neptunium-237	1.0				Napthalene	1.6		
		Plutonium-239/240	< 1				Pyrene	2.0		
		Thorium-230	< 1							
		Uranium-234	< 1							
		Uranium-235	< 1							
		Uranium-238	< 1							
Future Teen Recreational User	6.68E-04	Arsenic	3.8	Ingestion of soil	2.3	1.16	Arsenic	28.6	Ingestion of soil	4.5
		Beryllium	5.2	Inhalation of particulates	< 1		Cobalt	14.6	Inhalation of particulates	1.2
		PAHs	90.1	Dermal contact with soil	97.4		Nickel	12.8	Dermal contact with soil	94.3
		PCBs	< 1	External exposure	< 1					

Total ELCR and total HI represent total risk or hazard summed across all routes of exposure for all COPCs.
NE = Land use scenario not of concern.
ELCR for future adult resident and future child resident are the combined lifetime scenario.
[a] Total ELCR and total HI columns reflect values from Table 6.R1, from the Soils OU RI Report (DOE 2011b).

Ecological Risk Assessment Summary (WAG 6). The primary purpose of the ecological assessment was to determine whether any credible risks to ecological receptors exist in the Sector 6 area. Because only abiotic data were available, the assessment was limited to the evaluation of this data. Additional lines of evidence (e.g., media toxicity testing and biological surveys) were not collected.

Table 5.34 lists the contaminants identified as COPECs for soil at Sector 6. As shown there, aluminum, arsenic, cadmium, chromium, uranium, and zinc were COPECs for one or more receptors. Additionally, the assessment determined that each receptor considered had one or more COPECs.

Table 5.34. Summary of Chemicals[a] Posing Potential Future Risks[b] to Nonhuman Receptors at Sector 6

		Chemicals of Potential Ecological Concern									
Location	**Receptor**	**Al**	**As**	**Cd**	**Cr**	**Fe**	**Tl**	**U**	**V**	**Zn**	**PCBs**
Sector 6	Microbe	29.5	x	x	4.6	x		nb	x	x	nb
	Plant	354.0	4.5	1.4	45.8	nb		23.8	x	1.5	x
	Worm	nb	x	x	115.0	nb		nb	nb	x	nb
	Shrew	47.2	5.0	x	2.2	nb		x	x	x	x
	Mouse	4.5	x	x	x	nb		x	x	x	x
	Deer	3.1	x	x	x	nb		x	x	x	x

Notes: Al = aluminum; As = arsenic; Cd = cadmium; Cr = chromium; Fe = iron; Tl = thallium; U = uranium; V = vanadium; Zn = zinc
X indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background in that sector.
nb indicates that no toxicological benchmark was available for the chemical/receptor combination.
Blank cells indicate that the analyte was not detected in surface soil in the sector.
[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and a hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Volume 3 of the WAG 6 BHHRA (DOE 1999a).
[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

5.6.5 Additional Data Needs

Sector 6 is included in the C-400 Complex RI/FS for further evaluation and/or remediation as a potential contributor to soil and groundwater contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.7 SECTOR 7

5.7.1 Area Description

Sector 7 encompasses an area of approximately 32,000 ft^2, located northwest of the C-400 Cleaning Building, as shown in Figure 5.13. The surface of the sector is predominantly covered by gravel and concrete; there is a limited area of exposed soil. The C-400 Discard Waste System (SWMU 203) is included in Sector 7. Overhead pipelines traverse the sector north-to-south. Some of these overhead lines are expected to remain in place after C-400 deactivation.

5.7.2 Process History

The C-400 Discard Waste System (SWMU 203), located at the northwest corner of the building, was a convergence point for effluent from the C-400 Cleaning Building (primarily from the west side). The unit is a 6-ft wide × 11-ft long × 6-ft deep concrete pit that includes a 4-ft diameter × 4-½-ft deep sump in the floor. The concrete walls of the sump are lined with acid-proof brick. Influent to the system was discharged directly into the sump, which emptied into the NSDD.

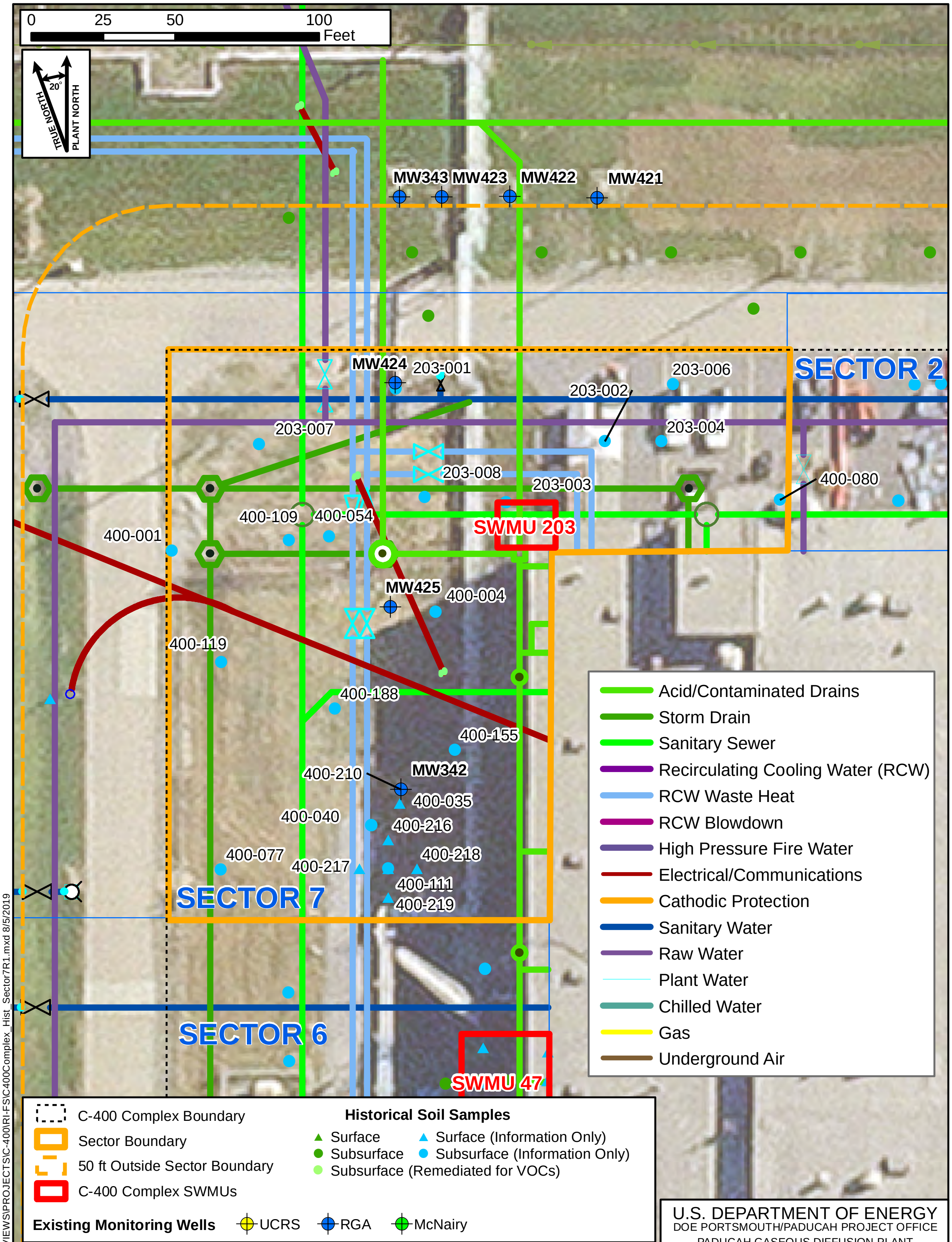

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Figure 5.13. Sector 7 Area and Historical Sampling

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5.7.3 Previous Investigation Results

No historical sampling data for this section are applicable according to the decision rules for historical data determined during project scoping. Historical results are summarized below for qualitative purposes.

SWMU 203 was investigated with Sector 7 of the WAG 6 RI (DOE 1999a). The WAG 6 RI found surface and subsurface soils contamination in one area associated with the Discard Waste System. A surface soil sample collected in the area surrounding the Discard Waste System contained mercury at a concentration that exceeded PGDP background level by a factor of 41. The same sample exhibited high radioactivity from Tc-99. While mercury was not detected in subsurface samples collected from approximately 15 and 32 ft bgs at this location, Tc-99 activity slightly exceeded the background value at 15 ft bgs. The WAG 6 RI concluded that both mercury and Tc-99 probably were related to surface spills and releases of C-400 Cleaning Building effluent to the Discard Waste System. TCE also was detected at 4,500 mg/kg at a depth of 28.5–32 ft bgs in the same boring that contained elevated metals and radioactivity. The RI report stated that the source for TCE may have been the Discard Waste System, but lack of TCE at shallow depths near the sump suggested a different source. A subsurface spill or release from the northwest corner of the C-400 Cleaning Building, which is located approximately 25 ft to the southeast, may have been the source of the TCE.

5.7.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for Sector 7 were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.35. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of the Sector 7 area.

- Current on-site industrial—direct contact with surface soil (soil found 0−1 ft bgs).
- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area. (See Section 5.8 for information regarding use of groundwater.)
- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 1−16 ft bgs).
- Future on-site recreational user—consumption of game exposed to contaminated surface soil.
- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.
- Future on-site rural resident—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area. (See Section 5.8 for information regarding use of groundwater.)

Table 5.35. Summary of Human Health Risk Characterization for Sector 7 without Lead as a COC (DOE 1999a)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Current industrial worker at current concentrations	1.2E-04	Beryllium PAHs Uranium-238	85 14 < 1	Dermal contact with soil	98	1.6	Antimony Chromium Iron Vanadium	6 26 36 30	Dermal contact with soil	99
Future industrial worker at current concentrations	1.2E-04	Beryllium PAHs Uranium-238	85 14 < 1	Dermal contact with soil	98	1.6	Antimony Chromium Iron Vanadium	6 26 36 30	Dermal contact with soil	99
Future child recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations	N/A	N/A	N/A	N/A	N/A	< 0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations	5.1E-07	NE	NE	NE	NE	< 0.1	NE	NE	NE	NE
Future child rural resident at current concentrations	N/A	N/A	N/A	N/A	N/A	53.6	Antimony Beryllium Cadmium Chromium Iron Vanadium	3 < 1 < 1 12 75 9	Ingestion of soil Dermal contact with soil Ingestion of vegetables	1 18 81
Future adult rural resident at current concentrations	1.5E-03	Beryllium PAHs Uranium-238	41 55 4	Ingestion of soil Dermal contact with soil Ingestion of vegetables External exposure	< 1 24 75 < 1	15.7	Antimony Chromium Iron Vanadium	3 10 78 8	Dermal contact with soil Ingestion of vegetables	12 88
Future excavation worker at current concentrations	1.3E-04	Arsenic Beryllium PAHs n-nitroso-di-n-propylamine PCBs Uranium-238	8 62 12 14 1 < 1	Ingestion of soil Dermal contact with soil External exposure	13 86 1	1.7	Aluminum Antimony Chromium Iron Manganese Vanadium	7 12 11 29 12 22	Ingestion of soil Dermal contact with soil	14 86

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a). Also, values in this table do not include contributions from water ingestion or use because groundwater was evaluated on an area basis. For risks due to water use, see Table 5.41.

- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary. (See Section 5.8 for information regarding use of groundwater.)

The risk characterization performed for Sector 7 followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.35. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.35), Table 5.36 presents a risk characterization for lead alone.

Table 5.36. Comparison of Representative Concentrations[a] of Lead at Sector 7 against Regulatory Screening Values

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Surface Soil (mg/kg)[b]					
Sector 7 area	13.0	20	No	400	No
Subsurface Soil (mg/kg)[c]					
Sector 7 area	6.22	20	No	400	No

Notes: – indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
[b] Surface soil is soil collected from 0–1 ft bgs (DOE 1999a).
[c] Subsurface soil is soil collected from 0–16 ft bgs.

The following are significant results in the risk characterization.

- The overall cancer risk to the current and future industrial worker from exposure to soil in Sector 7 exceeds PGDP *de minimis* level (i.e., 1.0E-06) and EPA's generally acceptable risk range of 1.0E-04 and 1.0E-06 (ELCR = 1.2E-04). The overall HI was similar to PGDP *de minimis* level of 1 (HI = 1.6). The COCs for cancer risk to the industrial worker were beryllium (85% of total) and PAHs (14% of total). The driving exposure route for cancer risk was dermal contact with soil (98% of total). The COCs for hazard to the industrial worker were iron (36% of total), vanadium (30% of total), chromium (26% of total), and antimony (6% of total). The driving exposure route for hazard was dermal contact with soil (99% of total). Lead in surface soil does not exceed screening levels.

- The overall cancer risk to the excavation worker from exposure to soil in Sector 7 exceeds PGDP *de minimis* level and EPA generally acceptable risk range (ELCR = 1.3E-04). The overall hazard also exceeds the *de minimis* level (HI = 1.7). The COCs for cancer risk to the excavation worker were beryllium (62% of total); n-nitroso-di-n-propylamine (14% of total); PAHs (12% of total); and arsenic (8% of total). The driving exposure routes for cancer risk were dermal contact with soil (86% of total) and ingestion of soil (13% of total). The COCs for hazard were iron (29% of total); vanadium (22% of total); antimony (12% of total); manganese (12% of total); chromium (11% of total); and aluminum (7% of total). The driving exposure routes and their percentage of total hazard were dermal contact (86%) and ingestion (14%). Lead in subsurface soil does not exceed screening levels.

Several uncertainties were determined to affect the risk characterization results. The effects of some important uncertainties on the risk characterization for the industrial worker are shown in Tables 5.37 and 5.38. As shown there, both the lower bound cancer risk and hazard can be shown to be less than their *de minimis* levels if alternative methods and parameters are used.

Table 5.37. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 7—ELCR

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR Minus Common Laboratory Contaminants	Default ELCR Calculated using EPA Default Dermal Absorption Values[c]	Default ELCR Minus Analytes Infrequently Detected	Lower-bound ELCR[d]
Sector 7	1.2E-04	7.9E-06	1.2E-04	5.7E-06	1.2E-04	3.7E-07

Notes: NV indicates that a value is not available because the sector encompasses the area below the C-400 Cleaning Building.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsection 1.6.2.5.)
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsection 1.6.2.4.)
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Table 5.38. Quantitative Summary of Uncertainties for the Current Industrial Worker at Sector 7—Systemic Toxicity

Location	Default HI[a]	Default HI without Lead	Site-specific HI without Lead[b]	Default HI Minus Common Laboratory Contaminants without Lead	Default HI Calculated EPA Default Dermal Absorption Values without Lead[c]	Default HI Minus Analytes Infrequently Detected without Lead	Lower-bound HI[d]
Sector 7	1,890	1.6	< 1	1.6	< 1	1.6	< 1

Notes:
< 1 indicates that the HI is less than the *de minimis* level.
[a] These values were derived using the default exposure rates for the RME scenario approved by regulatory agencies.
[b] These values were derived using site-specific exposure rates for general maintenance workers at PGDP. [See Subsection 1.6.2.5 of WAG 6 BHHRA (DOE 1999a).]
[c] The values were calculated using the soil dermal absorption rates suggested by EPA. [See Subsection 1.6.2.4 of WAG 6 BHHRA (DOE 1999a).]
[d] These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

Ecological Risk Assessment Summary. The primary purpose of the ecological assessment was to determine whether any credible risks to ecological receptors exist in Sector 7. Because only abiotic data were available, the assessment was limited to the evaluation of this data. Additional lines of evidence (e.g., media toxicity testing and biological surveys) were not collected.

Table 5.39 lists the contaminants identified as COPECs for soil at Sector 7. As shown there, chromium, iron, uranium, and vanadium were COPECs for one or more receptors. Additionally, the assessment determined that all receptors, except mice and deer, had one or more COPECs.

Table 5.39. Summary of Chemicals[a] Posing Potential Future Risks[b] to Nonhuman Receptors at Sector 7

		Chemicals of Potential Ecological Concern									
Location	**Receptor**	**Al**	**As**	**Cd**	**Cr**	**Fe**	**Tl**	**U**	**V**	**Zn**	**PCBs**
Sector 7	Microbe	x	x	x	6.6	153.0		nb	2.1	x	
	Plant	x	x	x	66.0	nb		1.9	21.2	x	
	Worm	nb	x	x	165.0	nb		nb	nb	x	
	Shrew	x	x	x	3.6	nb		x	x	x	
	Mouse	x	x	x	x	nb		x	x	x	
	Deer	x	x	x	x	nb		x	x	x	

Notes: Al = aluminum; As = arsenic; Cd = cadmium; Cr = chromium; Fe = iron; Tl = thallium; U = uranium; V = vanadium; Zn = zinc;
X indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background in that sector.
nb indicates no toxicological benchmark was available for the chemical/receptor combination.
A blank cell indicates that the analyte was not detected in surface soil in the sector.
[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and a hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Appendix A of the WAG 6 BHHRA (DOE 1999a).
[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

5.7.5 Additional Data Needs

The C-400 Discard Waste System slab and underlying soils are included in the C-400 Complex RI/FS for further evaluation and/or remediation as potential contributors to soil and groundwater contamination. Additional sampling is required to determine if the concentration of analytes other than TCE poses a risk, as defined in the DQOs, and to determine the nature and extent of contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

5.8 GROUNDWATER

5.8.1 Area Description

Groundwater within the C-400 Complex consists of a shallow saturated zone (the UCRS), the shallow aquifer (the RGA), and the underlying McNairy Formation. This section focuses on the characterization and previous analytical data for the RGA and the McNairy.

5.8.2 Area Background

The RGA contains at least two significant plumes of groundwater contamination believed to be sourced from the C-400 Complex (Figures 5.14 and 5.15). Horizontal gradient within the RGA at the C-400 Complex bifurcates northwest to the Northwest Plume and east to the Northeast Plume. These horizontal gradients are governed by pumping rates in pump-and-treat well fields.

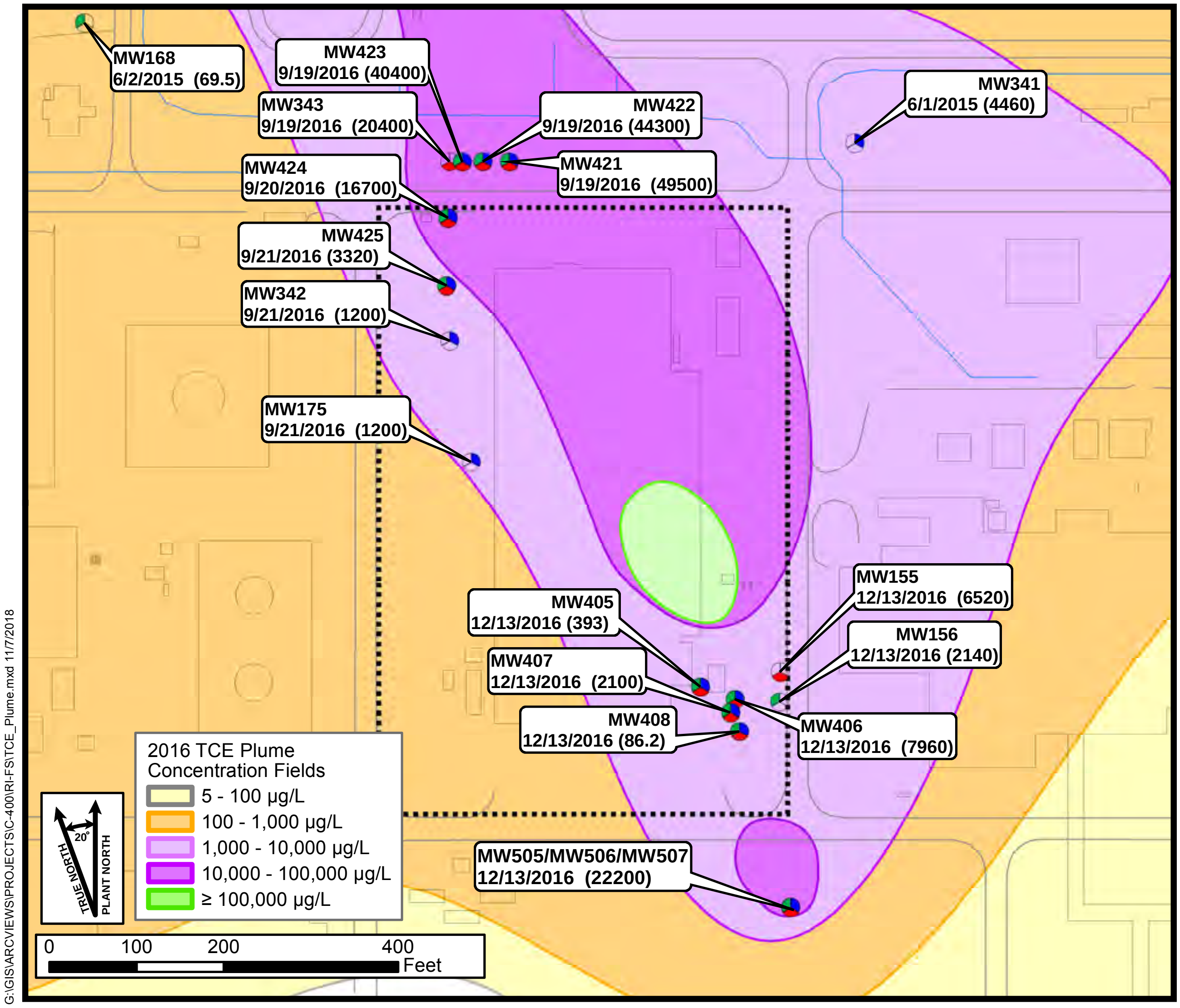

Figure 5.14. TCE Contamination in the RGA in the C-400 Complex Vicinity

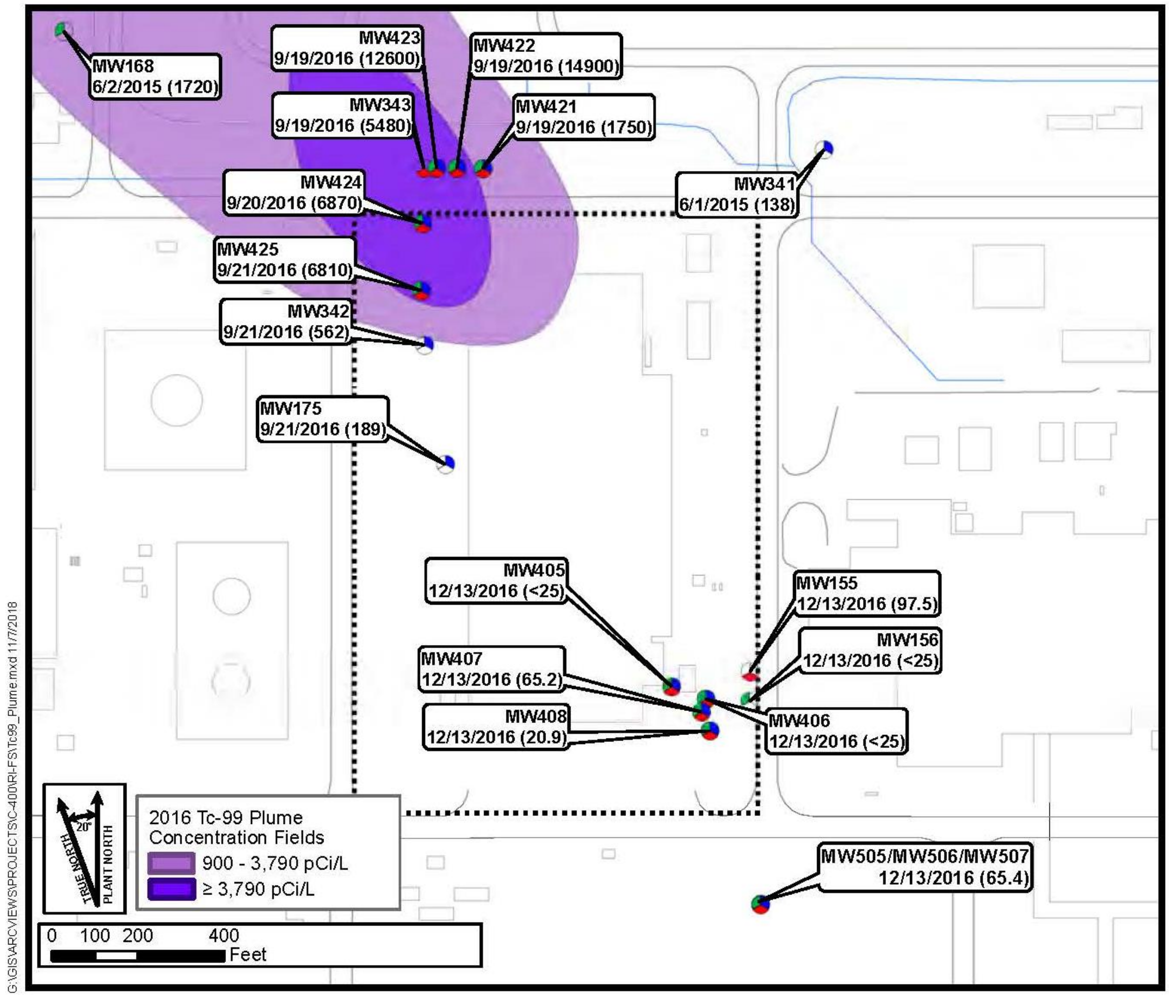

Figure 5.15. Tc-99 Contamination in the RGA at the C-400 Complex

5.8.3 Previous Investigation Results

Historical sampling data for this section are applicable according to the decision rules for historical data determined during project scoping and are summarized in Table 5.40. Only RGA data have been determined applicable. Other historical results are summarized below for qualitative purposes.

Table 5.40. Groundwater Data Summary: C-400 Complex

			Detected Results			Background (Bkgd)		Resident		Resident		Maximum Contaminant Level (MCL)	
Type	**Analysis**	**Unit**	**Min**	**Max**	**FOD**	**FOE**	**Bkgd**	**FOE**	**NAL**	**FOE**	**AL**	**FOE**	**MCL**
ANION	Chloride	mg/L	3.25E+00	1.90E+02	412/412	76/412	9.10E+01	0/412	N/A	0/412	N/A	0/412	N/A
ANION	Fluoride	mg/L	1.17E-01	1.20E-01	2/2	0/2	2.70E-01	2/2	7.99E-02	0/2	2.40E+00	0/2	4.00E+00
METAL	Arsenic	mg/L	1.47E-03	1.80E-03	2/2	0/2	5.00E-03	2/2	5.17E-05	0/2	5.17E-03	0/2	1.00E-02
METAL	Chromium	mg/L	2.60E-02	2.16E-01	2/2	1/2	1.44E-01	2/2	3.50E-05	2/2	3.50E-03	1/2	1.00E-01
METAL	Cobalt	mg/L	3.30E-03	3.31E-03	2/2	0/2	4.50E-02	2/2	6.01E-04	0/2	1.80E-02	0/2	N/A
METAL	Iron	mg/L	5.47E-01	2.59E+00	2/2	0/2	5.03E+00	1/2	1.40E+00	0/2	4.20E+01	0/2	N/A
METAL	Molybdenum	mg/L	1.02E-03	1.45E-02	2/2	0/2	N/A	1/2	9.98E-03	0/2	2.99E-01	0/2	N/A
METAL	Nickel	mg/L	4.33E-02	4.74E-02	2/2	0/2	6.82E-01	2/2	3.92E-02	0/2	1.18E+00	0/2	N/A
SVOC	Napthalene	mg/L	3.50E-02	1.90E+00	7/85	0/85	N/A	7/85	1.65E-04	7/85	1.65E-02	0/85	N/A
VOC	1,1,2-Trichloroethane	mg/L	8.30E-04	8.30E-04	1/100	0/100	N/A	1/100	4.15E-05	0/100	1.25E-03	0/100	5.00E-03
VOC	1,1-Dichloroethene	mg/L	1.80E-04	1.70E-01	41/656	0/656	N/A	41/656	1.71E-04	16/656	1.71E-02	25/656	7.00E-03
VOC	Carbon tetrachloride	mg/L	7.38E-02	8.90E-02	4/235	0/235	N/A	4/235	4.55E-04	4/235	4.55E-02	4/235	5.00E-03
VOC	Chloroform	mg/L	1.10E-04	8.10E-03	4/100	0/100	N/A	3/100	2.21E-04	0/100	2.21E-02	0/100	8.00E-02
VOC	*cis*-1,2-Dichloroethene	mg/L	3.80E-04	7.50E+01	472/645	0/645	N/A	452/645	3.61E-03	230/645	1.08E-01	294/645	7.00E-02
VOC	Tetrachloroethene	mg/L	3.00E-04	2.18E-02	12/235	0/235	N/A	2/235	4.06E-03	0/235	1.22E-01	2/235	5.00E-03
VOC	*trans*-1,2-Dichloroethene	mg/L	1.20E-04	1.05E-02	28/645	0/645	N/A	1/645	9.29E-03	0/645	2.79E-01	0/645	1.00E-01
VOC	Trichloroethene	mg/L	9.44E-03	1.40E+03	655/656	0/656	N/A	655/656	2.83E-04	655/656	8.49E-03	655/656	5.00E-03
VOC	Vinyl chloride	mg/L	1.20E-04	1.80E-01	17/645	0/645	N/A	17/645	1.88E-05	10/645	1.88E-03	10/645	2.00E-03
RADS	Alpha activity	pCi/L	1.68E+00	1.13E+03	67/138	43/138	5.80E+00	0/138	N/A	0/138	N/A	33/138	1.50E+01
RADS	Beta activity	pCi/L	5.57E+00	8.87E+03	134/138	128/138	1.38E+01	0/138	N/A	0/138	N/A	0/138	N/A
RADS	Technetium-99	pCi/L	5.65E+00	1.50E+04	566/642	549/642	2.23E+01	553/642	1.90E+01	135/642	1.90E+03	179/642	9.00E+02

Legend:

One or more samples exceed background value.
One or more samples exceed NAL value.
One or more samples exceed AL value.
One or more samples exceed MCL.

NOTE: Data were downloaded from the Paducah OREIS database in April 2018. See Section 6.1.1 for additional information.
Counts of analyses are based on the maximum detected result from a sample (i.e., if a sample has analytical results from two different labs, only the maximum value is counted).
Field replicates or separate samples are counted independently.

Two RGA borings (angled) drilled during the WAG 6 RI, 400-040 and 400-041, were sampled for groundwater beneath the C-400 Cleaning Building. Fourteen grab groundwater samples were collected from the RGA and McNairy. The maximum TCE detected was 126,012 µg/L at 90-ft depth. The maximum Tc-99 detected was 537 pCi/L at 66-ft depth.

5.8.4 Baseline Risk Assessment Summary

Human Health Risk Assessment Summary. The direct contact risks for groundwater from the WAG 6 area were assessed following the procedures presented in the 1996 revision of the RMD (DOE 1996). A summary of the results of the WAG 6 RI BHHRA is in Table 5.41. This summary lists the COCs and the exposure routes of concern for each exposure scenario assessed. The relative contribution of each COC and exposure route of concern to exposure scenario total risk and hazard also is shown.

The exposure assessment of the risk assessment evaluated the following scenarios that encompassed both current use and several hypothetical future uses of the C-400 Complex area.

- Future on-site industrial—use of groundwater drawn from aquifers below the WAG 6 area.
- Future on-site rural resident—use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area.
- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary.

Table 5.41. Summary of Human Health Risk Characterization for WAG 6 Area Groundwater without Lead as a COC (DOE 1999a)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future industrial worker at current concentrations (RGA groundwater only from below the WAG 6 area)	2.7E-03	Arsenic	6	Ingestion of groundwater	85	37.7	Aluminum	1	Ingestion of groundwater	82
		Beryllium	8	Dermal contact with groundwater	8		Antimony	1	Dermal contact with groundwater	16
		1,1-Dichloroethene	1	Inhalation while showering	7		Arsenic	3	Inhalation while showering	2
		Carbon tetrachloride	2				Chromium	< 1		
		Chloroform	< 1				Iron	34		
		N-nitroso-di-n-propylamine	< 1				Manganese	2		
		Tetrachloroethene	< 1				Nitrate	< 1		
		Trichloroethene	20				Vanadium	< 1		
		Vinyl chloride	37				Carbon tetrachloride	5		
		Americium-241	< 1				Trichloroethene	49		
		Cesium-137	< 1				*cis*-1,2-Dichloroethene	1		
		Lead-210	24							
		Neptunium-237	< 1							
		Technetium-99	< 1							
		Thorium-228	< 1							
		Uranium-238	< 1							
Future industrial worker at current concentrations (McNairy Formation groundwater only from below the WAG 6 area)	4.5E-03	Arsenic	31	Ingestion of groundwater	98	20.6	Aluminum	4	Ingestion of groundwater	94
		Beryllium	4	Dermal contact with groundwater	1		Arsenic	42	Dermal contact with groundwater	6
		1,1-Dichloroethene	< 1	Inhalation while showering	< 1		Chromium	3		
		Bromodichloromethane	< 1				Iron	35		
		Chloroform	< 1				Manganese	2		
		Dibromochloromethane	< 1				Vanadium	9		
		Tetrachloroethene	< 1				Zinc	1		
		Trichloroethene	< 1				Di-N-octylphthalate	1		
		Vinyl chloride	2							
		Cesium-137	< 1							
		Lead -210	59							
		Lead-212	< 1							
		Neptunium-237	< 1							
		Plutonium-239	< 1							
		Potassium-40	< 1							
		Technetium-99	< 1							
		Thorium-228	< 1							
		Thorium-234	2							
		Uranium-235	< 1							

Table 5.41. Summary of Human Health Risk Characterization for WAG 6 Area Groundwater without Lead as a COC (DOE 1999a) (Continued)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future child rural resident at current concentrations (McNairy Formation groundwater only from below the WAG 6 area)	N/A	N/A	N/A	N/A	N/A	224	Aluminum	4	Ingestion of groundwater	58
							Arsenic	44	Dermal contact with groundwater	2
							Barium	< 1		
							Beryllium	< 1	Consumption of vegetables	40
							Cadmium	< 1	Inhalation from household use	< 1
							Chromium	3		
							Cobalt	< 1		
							Iron	36		
							Manganese	1		
							Nickel	< 1		
							Selenium	< 1		
							Vanadium	8		
							Zinc	2		
							1,1-Dichloroethene	< 1		
							1,2-Dichloroethane	< 1		
							Chloroform	< 1		
							Di-N-octylphthalate	< 1		
							Tetrachloroethene	< 1		
							Trichloroethene	< 1		
							cis-1,2-Dichloroethene	< 1		

Table 5.41. Summary of Human Health Risk Characterization for WAG 6 Area Groundwater without Lead as a COC (DOE 1999a) (Continued)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future adult rural resident at current concentrations (McNairy Formation groundwater only from below WAG 6 area)	3.5E-02	Arsenic	33	Ingestion of groundwater	57	84.4	Aluminum	4	Ingestion of groundwater	64
		Beryllium	3	Dermal contact with groundwater	< 1		Arsenic	44	Dermal contact with groundwater	2
		1,1-Dichloroethene	3				Barium	< 1		
		1,2-Dichloroethane	< 1	Inhalation while showering	< 1		Cadmium	< 1	Consumption of vegetables	34
		Bis(2-ethylhexyl)phthalate	< 1	Consumption of vegetables	40		Chromium	3		
		Bromodichloromethane	< 1				Iron	36		
		Chloroform	< 1				Manganese	1		
		Dibromochloromethane	< 1				Nickel	< 1		
		Tetrachloroethene	< 1				Selenium	< 1		
		Trichloroethene	< 1				Vanadium	8		
		Vinyl chloride	6				Zinc	2		
		Actinium-228	< 1				Di-N-octylphthalate	< 1		
		Cesium-137	< 1				Trichloroethene	< 1		
		Lead-210	43							
		Lead-212	< 1							
		Neptunium-237	< 1							
		Plutonium-239	< 1							
		Potassium-40	< 1							
		Technetium-99	10							
		Thorium-228	< 1							
		Thorium-230	< 1							
		Thorium-234	1							
		Uranium-234	< 1							
		Uranium-235	< 1							
		Uranium-238	< 1							

Table 5.41. Summary of Human Health Risk Characterization for WAG 6 Area Groundwater without Lead as a COC (DOE 1999a) (Continued)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future child rural resident at current concentrations (RGA groundwater only)	N/A	N/A	N/A	N/A	N/A	475	Aluminum	1	Ingestion of groundwater	44
							Antimony	< 1	Dermal contact with groundwater	3
							Arsenic	2		
							Barium	< 1	Consumption of vegetables	41
							Beryllium	< 1	Inhalation while showering	< 1
							Cadmium	< 1	Inhalation from household use	10
							Chromium	< 1		
							Cobalt	< 1		
							Copper	< 1		
							Iron	30		
							Manganese	1		
							Nickel	< 1		
							Nitrate	< 1		
							Silver	< 1		
							Uranium	< 1		
							Vanadium	< 1		
							Zinc	< 1		
							1,1-Dichloroethene	< 1		
							Carbon tetrachloride	14		
							Chloroform	< 1		
							Di-N-octylphthalate	< 1		
							Tetrachloroethene	< 1		
							Toluene	< 1		
							Trichloroethene	46		
							cis-1,2-Dichloroethene	1		
							trans-1,2-Dichloroethene	< 1		

Table 5.41. Summary of Human Health Risk Characterization for WAG 6 Area Groundwater without Lead as a COC (DOE 1999a) (Continued)

Receptor	Total ELCR[a]	ELCR COCs	% Total ELCR	ELCR POCs	% Total ELCR	Total HI [a]	Systemic Toxicity COCs	% Total HI	Systemic Toxicity POCs	% Total HI
Future adult rural resident at current concentrations (RGA groundwater only)	6.4E-02	Arsenic	2	Ingestion of groundwater	17	169	Aluminum	2	Ingestion of groundwater	52
		Beryllium	2	Dermal contact with groundwater	< 1		Antimony	< 1	Dermal contact with groundwater	5
		1,1-Dichloroethene	1				Arsenic	2		
		Bromodichloromethane	< 1	Inhalation while showering	1		Barium	< 1	Consumption of vegetables	37
		Carbon tetrachloride	< 1	Consumption of vegetables	69		Cadmium	< 1	Inhalation while showering	< 1
		Chloroform	< 1				Chromium	< 1	Inhalation from household use	6
		N-nitroso-di-n-propylamine	< 1				Copper	< 1		
		Tetrachloroethene	< 1				Iron	32		
		Trichloroethene	12				Manganese	1		
		Vinyl chloride	30				Nickel	< 1		
		Americium-241	< 1				Nitrate	< 1		
		Cesium-137	< 1				Silver	< 1		
		Lead-210	6				Vanadium	< 1		
		Neptunium-237	< 1				Zinc	< 1		
		Technetium-99	45				Carbon tetrachloride	10		
		Thorium-228	< 1				Chloroform	< 1		
		Thorium-230	< 1				Tetrachloroethene	< 1		
		Uranium-234	< 1				Trichloroethene	48		
		Uranium-238	< 1				*cis*-1,2-Dichloroethene	1		
							trans-1,2-Dichloroethene	< 1		

Note: N/A = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern.
[a] Total ELCR and total HI columns reflect values from Tables 1.68 to 1.77, without lead included, from the WAG 6 BHHRA (DOE 1999a).

The risk characterization performed for the WAG 6 area followed the guidance in the 1996 revision of the RMD (DOE 1996). The results of the risk characterization are shown in Table 5.41. Because lead was treated as a special case in the WAG 6 RI (as indicated by the title of Table 5.41), Table 5.42 presents a risk characterization for lead alone.

Table 5.42. Comparison of Representative Concentrations[a] of Lead in WAG 6 Groundwater against Regulatory Screening Values (DOE 1999a)

Location	Representative Concentration	KDEP Screening Value	Exceed?	EPA Screening Value	Exceed?
Groundwater (μg/L)[b]					
WAG 6 RGA	32.7	4	Yes	15	Yes
WAG 6 McNairy	114	4	Yes	15	Yes

Notes: – indicates that lead was not a COPC for that location; therefore, a representative concentration is not available.
[a] As shown in Subsection 1.2.3.1 of the WAG 6 BHHRA, the representative concentration is the lesser of the maximum detected concentration and the upper 95% confidence level on the mean concentration (DOE 1999a).
As discussed elsewhere in the WAG 6 BHHRA, groundwater was evaluated on an area basis because all locations are contiguous.

In addition to COCs in RGA and McNairy groundwater at current conditions, risks from contaminants migrating from soil to groundwater and from the C-400 Complex to downgradient locations (i.e., at the fence boundary) for a future rural resident were selected using a comparison between maximum modeled concentrations and human health risk-based concentrations.

The WAG 6 BHHRA presented the chemical-specific HIs for household use of water by a rural resident from exposure to the maximum modeled concentrations of contaminants in the RGA at the point of exposure. Three chemicals within the C-400 Complex have chemical-specific HIs at the maximum modeled concentration that exceed 1. These chemicals and their sources are presented in the following bullets.

- Sector 4—TCE
- Sector 5—TCE
- Sector 7—antimony
- RGA—iron

The WAG 6 BHHRA presented the chemical-specific ELCR for household use of water by a rural resident from exposure to maximum modeled concentrations of contaminants in the RGA at the point of exposure. Eight organic compounds within the C-400 Complex have chemical-specific ELCR at the maximum modeled concentration that exceed 1E-06. These chemicals and their sources are presented in the following bullets.

- Sector 2—n-nitroso-di-n-propylamine
- Sector 3—TCE
- Sector 4—1,1-DCE; carbon tetrachloride; tetrachloroethene; TCE; and vinyl chloride
- Sector 5—TCE and vinyl chloride
- Sector 6—1,2-DCE; *trans*-1,2-DCE; and TCE
- Sector 7—TCE

Tables 5.43 and 5.44, taken from the WAG 6 RI Report, present the COCs for systemic toxicity and ELCR in water over both the RGA and McNairy Formation for the entire WAG 6 area (including those portions outside the C-400 Complex) (DOE 1999a).

Table 5.43. Contaminants of Concern for Systemic Toxicity in Water across All Locations in WAG 6

Location and Scenarios / Chemicals of Potential Concern*	WAG 6 Area RGA			WAG 6 Area McNairy Formation	
	Future Industrial Worker	Future On-site Rural Resident	Future Off-site Rural Resident	Future Industrial Worker	Future On-site Rural Resident
Aluminum	X			X	■
Antimony	X	■	■		
Arsenic	X	■		■	■
Barium		X			X
Beryllium		X			X
Cadmium		X			X
Chromium	X	■		X	■
Cobalt		X			X
Copper		X	X		
Iron	■	■	■	■	■
Lead	■	■		■	■
Manganese	X	■	X	X	■
Nickel		■			X
Nitrate	X	■			
Selenium					X
Silver		X			
Uranium		X			
Vanadium	X	■		■	■
Zinc		X		X	■
1,1-Dichloroethene		X			X
1,2-Dichloroethene			X		
1,2-Dichloroethane					X
2,4-Dinitrotoluene			■		
Carbon tetrachloride	X	■	X		
Chloroform		X			X
Di-n-octylphthalate		X		X	X
Tetrachloroethene		X			X
Toluene		X			
Trichloroethene	■	■	■		X
cis-1,2-Dichloroethene	X	■			X
trans-1,2-Dichloroethene		X	X		

Notes: X indicates that the chemical of potential concern is a contaminant of concern, and chemical-specific HI is between 0.1 and 1 for the scenario.
Solid cell indicates that the chemical of potential concern is a chemical of concern, and chemical-specific HI is greater than 1 for the scenario.
Blank cell indicates that the chemical of potential concern is not a chemical of concern for the scenario.
* Only chemicals of potential concern which have a chemical-specific HI greater than 1 for one or more land use scenarios of concern are listed.

Table 5.44. Contaminants of Concern for ELCR in Water across All Locations in WAG 6

Location and Scenarios / Chemicals of Potential Concern[a]	WAG 6 Area RGA			WAG 6 Area McNairy Formation	
	Future Industrial Worker	**Future On-site Rural Resident**	**Future Off-site Rural Resident**	**Future Industrial Worker**	**Future On-site Rural Resident**
Arsenic	■	■		■	■
Beryllium	■	■		■	■
1,1-Dichloroethene	X	■	■	X	■
1,2-Dichloroethane					X
2,4-Dinitrotoluene			■		
Bis(2-ethylhexyl)phthalate					X
Bromodichloromethane		X		X	X
Carbon tetrachloride	X	■	X		
Chloroform	X	X		X	X
Dibromochloromethane				X	X
N-nitroso-di-n-propylamine	X	■	■		
Tetrachloroethene	X	X	X	X	X
Trichloroethene	■	■	■	X	X
Vinyl chloride	■	■	X	■	■
Actinium-228					X
Americium-241	X	X			
Cesium-137	X	X		X	X
Lead-210	■	■		■	■
Lead-212				X	X
Neptunium-237	X	■		X	X
Plutonium-239				X	X
Potassium-40				X	X
Technetium-99	X	■	X[b]	X	■
Thorium-228	X	X		X	X
Thorium-230		X			X
Thorium-234				X	■
Uranium-234		X			X
Uranium-235				X	X
Uranium-238	X	X			X

Notes: X indicates that the chemical of potential concern is a contaminant of concern, and chemical-specific ELCR is between 1E-06 and 1E-04 for the scenario.
Solid cell indicates that the chemical of potential concern is a chemical of concern, and chemical-specific ELCR is greater than 1E-04 for the scenario.
Blank cell indicates that the chemical of potential concern is not a chemical of concern for the scenario.
[a] Only chemicals of potential concern which have a chemical-specific ELCR greater than 1E-06 for one or more land use scenarios of concern are listed.
[b] The Tc-99 source in the RGA was not modeled to the off-site location because it was determined *a priori* that Tc-99 was a contaminant of concern for off-site users.

Considering the magnitude of the chemical-specific HIs and ELCRs, the following COCs were considered “priority COCs” in water at WAG 6 over both RGA and McNairy for the most likely future use (i.e., industrial use):

- **Inorganic chemicals**–arsenic, beryllium, iron, lead, vanadium
- **Organic compounds**–TCE, vinyl chloride
- **Radionuclides**–lead-210

Each of these COCs presents either a chemical-specific HI or ELCR to the future industrial worker through water use that exceeds 1 or 1E-04, respectively.

The following chemicals were priority COCs for off-site use of groundwater (i.e., rural residential use in the home). These chemicals all are COCs that may migrate from a source in WAG 6 to an off-site location and present a chemical-specific HI or ELCR to the rural resident that is greater than 0.1 or 1E-06, respectively.

- **Inorganic chemicals**–antimony; copper; iron; manganese

- **Organic compounds**–1,1-dichloroethene; 2,4-dinitrotoluene; carbon tetrachloride; n-nitroso-di-n-propylamine; tetrachloroethene; TCE; vinyl chloride

- **Radionuclides**–Tc-99

The following are significant results in the risk characterization.

- The overall cancer risk to the hypothetical residential groundwater user in the WAG 6 area exceeded both PGDP *de minimis* level and EPA's generally acceptable risk range for both the RGA and McNairy Formation (6.4E-02 and 3.5E-02, respectively). The overall HIs also were greater than the *de minimis* level for water drawn from the two water sources (475 and 224, respectively, for the child resident). The primary COCs for cancer risk for water drawn from the RGA are Tc-99 (45% of total); vinyl chloride (30% of total); TCE (12% of total); and lead-210 (6% of total). The primary COCs for hazard for water drawn from the RGA are TCE (46% of total); iron (30% of total); and carbon tetrachloride (14% of total). The primary COCs for cancer risk for water drawn from the McNairy Formation are lead-210 (43% of total); arsenic (33% of total); Tc-99 (10% of total); and vinyl chloride (6% of total). The primary COCs for hazards for water drawn from the McNairy Formation are arsenic (44% of total); iron (36% of total); and vanadium (8% of total). The driving exposure routes for both cancer risk and hazard for both the water sources were ingestion of water and consumption of vegetables from irrigated gardens. Additionally, lead is a COC for both water sources.

5.8.5 Additional Data Needs

Groundwater is included in the C-400 Complex RI/FS for further evaluation and/or remediation. Additional sampling is required to determine if the concentration of analytes other than TCE poses a risk, as defined in the DQOs, and to determine the nature and extent of contamination. Additional information is needed to complete the DQOs and to evaluate remedial alternatives.

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6. INITIAL EVALUATIONS

In order to facilitate evaluation of the C-400 Complex, the area has been divided into sectors. Each sector outside the building is close to one-half acre. (One-half acre is significant because it typically is used in the industrial and residential exposure scenarios as the size of an exposure unit for risk evaluation purposes.) Human health and ecological risk information will be aggregated into sectors for evaluation.

6.1 RISK ASSESSMENT

Consistent with agreements reached during project scoping and because the C-400 Complex area already has been subjected to a full BHHRA that concluded action needed to be taken at the site, a new BHHRA will not be performed under this RI/FS. Instead, a screening risk evaluation of the combined, newly generated data and historical data (as described in Section 6.1.1) will be conducted. This screening risk evaluation allows RI/FS sampling to be targeted and builds upon earlier investigations where data screening previously was completed. As discussed during scoping and consistent with the RMD, it is anticipated that risk assessment scoping will occur after the fieldwork is complete and before the RI/FS Report is written (DOE 2019c).

The screening risk evaluation will identify COPCs; assess pathways of exposure under industrial use; 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.

As part of the C-400 Complex RI/FS, a comprehensive summary of baseline risks taken from the WAG 6 RI (DOE 1999a), GWOU FS (DOE 2001b), and the Soils OU RI (SWMU 47) (DOE 2011b) will be compiled. No additional evaluation for the receptors to the range of potential land uses will be necessary. Historical risk assessments previously identified unacceptable risk/hazard to future potential residents and other receptors.

For the C-400 Complex RI/FS, newly generated data and historical data will be screened against maximum results to identify chemicals or COPCs as follows.

1. Surface (0–1 ft bgs) soil data aggregates against surface soil background and the industrial worker NALs from the RMD (DOE 2019c).

2. Surface and subsurface (0–16 ft bgs) soil data aggregates against subsurface soil background and the excavation worker NALs from the RMD (DOE 2019c).

3. Screen the following C-400 Complex soil aggregates for protection of groundwater using subsurface soil background and soil screening levels (SSLs) for groundwater protection derived using DAFs of 1, 20, and site-specific.[7]

    - Surface (0–1 ft bgs)
    - Subsurface (1–16 ft bgs)
    - Deep soil (> 16 ft bgs)

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[7] SSLs for DAFs of 1 and 20 will be taken from the RMD (DOE 2019c). The site-specific SSL will be derived as determined following the Fate and Transport evaluations in the RI/FS.

4. Screen all C-400 Complex groundwater samples against background and the residential use NALs and against primary MCLs using individual results and data aggregate statistics for the following:

   - UCRS (shallow percolating groundwater)
   - RGA (shallow aquifer)
   - McNairy (deep aquifer)

Once COPCs are determined, upper confidence limit (UCL) 95 will be calculated for COPCs, and a derivation of risk estimates will be performed. Risk estimates will be calculated following guidance in the RMD (DOE 2019c).

Appendix D of the RI/FS Work Plan documents the sampling results (available at the time of submittal) from the implementation of the *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan* (DOE 2018c) and describes the field investigation, data evaluation, risk evaluation, and summary and conclusions for the sampling (Reference Section 5.1.5.2 for additional details).

A VI study was conducted for the C-400 Cleaning Building, as discussed in Section 4.10.3. Groundwater results will be evaluated to determine if a remedy needs to be put into place to protect current and future workers. This will be especially pertinent to new construction.

To support the risk evaluation, and consistent with the RMD (DOE 2019c), fate and transport modeling will be completed, including probabilistic modeling, if needed for decision making. The RMD provides for different types of modeling based on the objective of the modeling such as Spatial Analysis and Decision Assistance (SADA); SESOIL; Analytical Transient 1-,2-,3- Dimensional (AT123D); and others referenced in the RMD. 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. Probabilistic modeling may be used because this modeling can account for uncertainties in the size of the source zones and transport parameters and allows for an evaluation of error bounds.

6.1.1 Data Evaluation

When fieldwork is completed and data have been verified, validated, assessed, and evaluated (as described in Section 12), data will be screened as described in the RMD (DOE 2019c) to determine COPCs for each sector. These COPCs will be documented in the RI/FS Report. The primary purpose of the RI/FS report will be to present the results from the field investigation and support evaluation of alternatives.

Data Quality Analysis. The field sampling strategy for this RI/FS includes elements of judgmental sampling, stratified sampling, systematic (or grid) sampling, and composite sampling (EPA 2002). Analysis of these samples will be a combination of field laboratory data and fixed-base laboratory data. The RI/FS Report will include a data quality analysis to 1) examine differences and comparability of fixed-base laboratory data and field laboratory data generated by this RI/FS and 2) evaluate the use of historical data for the C-400 Complex. The following are decision rules that will be used in the data quality analysis when determining the usability of historical data.

- Historical data that are dated 1999 or before have been used qualitatively to inform sample selection, but are not used quantitatively. Data that are dated 2000 or more recently will be utilized after evaluation for quality and representativeness of current conditions. Additional information is included below.

- Groundwater data will be used quantitatively (for screening and maps) for samples collected 2012-present in order to focus on current conditions. Historical data (e.g., WAG 6, remedial action work plan/remedial action completion report, post remediation data) is important for qualitative use.

- Soil data will be used quantitatively (for screening and maps) by analyte group for samples as follows in order to focus on current conditions.

  — Metals and Rads: 2000–present

  — VOCs: 2012–present (i.e., last 5 years) for surface soil; 2000–present for deeper soils (unless coded as not representative)

  — SVOCs: 2000–present

  — PCBs: 2000–present

- Historical Soil data outside sector boundaries, up to 50 ft, as shown on Figures 5.7–5.9 and Figures 5.11–5-13, have been used to inform sample selection, but are not used quantitatively.

- For groundwater data, all data within the C-400 Complex boundary, up to 300 ft outside C-400 Complex boundary will be included.

- Historical data that have been qualified as rejected by data validation or by data assessment are not included in the historical dataset.

- Historical data that contain units inconsistent with the sampled media or with the analysis are not included in the historical dataset (e.g., a soil sample with analytical units reported in mg/L or a radiological result with units reported in mg/kg).

- Historical data for radionuclide results with no minimum detectable concentration (MDC) recorded are included in the historical dataset on a case-by-case basis.

- Historical data for nonradionuclide results with no reported result and no detection limit recorded are not included in the historical dataset.

- Historical data for radionuclide results with a null or zero recorded as a counting error are included in the historical dataset on a case-by case basis.

- Data assessment qualifiers previously placed on the data will be noted and applied as appropriate.

- Data in which results are equal to detection limit, but not qualified as nondetect, will be decided as detect or nondetect on a case-by-case basis.

- A result will be considered a nondetect if it is qualified by the reporting laboratory and includes a “U” qualifier or a “<” qualifier.

- A result will be considered a nondetect if it has a “U” validation code or a “U” data assessment code, including UJ and U* validation codes and U* and U-RAD data assessment codes.

- A radiological result may be considered a nondetect if the reported total propagated uncertainty is greater than the reported result.

- Negative radiological results will be considered nondetects.

- Not representative of current conditions, as coded in Paducah OREIS. Paducah OREIS maintains environmental data collected at the Paducah Site. The data set includes historical and current data. The body of data related to a particular geographic area may represent its past and present characteristics and it is difficult to identify which data no longer represents the current characteristics due to remediation efforts. A data field is included in Paducah OREIS that can be used to help flag data that is not representative of the current characteristics of an area. Soil and sediment samples in Paducah OREIS have been flagged as "RA" if they were collected in a location that has been removed (e.g., excavated) since sampling. These samples were collected *in situ* prior to removal, and are no longer representative of current conditions. Soil samples in Paducah OREIS have been flagged as "RM" if they were collected in a location that has undergone remediation, with an additional denotation for the type of remediation (e.g., VO for volatiles). In these instances, only post remediation or post excavation samples (including verification samples) have been marked as representative.

- Indicator chemicals are not included in the historical data set [i.e., alpha activity, beta activity, uranium-235 (wt.%), mass of uranium-235 (μg/g), total uranium (reported in pCi/g with no isotopes), and moisture].

- Data have been examined to ensure that the samples from which data were derived were collected using sampling methods that are adequate to determine the nature and extent of contamination for the particular unit or area being assessed. Data not from the unit or area under investigation or not useful in determining contaminant migration from the unit or area have not been used quantitatively in the assessment because these data are not representative of the unit or area for which remedial actions are being considered.

- Data have been examined to ensure that the sampling methods and analytical methods used in the laboratory are consistent with EPA-approved methods for nonradionuclides. Data for nonradionuclides not from EPA-approved methods will not be used quantitatively in the risk assessment, but may be used qualitatively. Methods for radionuclides will be evaluated during the DQO process to ensure that data quality requirements can be achieved. Only results from unfiltered samples will be used quantitatively in BHHRAs performed at the Paducah Site. Note: Filtered groundwater and surface water data may be used in the uncertainty section of the assessment when discussing data sources and their effects on risk estimates.

- Evaluation of radionuclide data will follow rules agreed upon by the Commonwealth of Kentucky Radiation Health Branch (KYRHB) and DOE Risk Assessment Working Group meeting minutes from 2000. The following are data assessment qualifiers that will appear and their description.

    — **KYRHB-LT:** KYRHB has performed an independent data assessment and the results are less than the MDC or detection limit and should not be plotted. NOTE: For the C-400 Complex RI/FS, if the results are less than the MDC and have acceptable error and MDC, the data will be plotted as non-detects.

    — **KYRHB-50:** KYRHB has performed an independent data assessment and the radiation counting uncertainty is greater than 50% of the analytical results. NOTE: For the C-400 Complex RI/FS, the data can be plotted as non-detects.

— **KYRHB-ER:** KYRHB has performed an independent data assessment and the data present error problems (i.e., no counting uncertainty or zero counting uncertainty). NOTE: For the C-400 Complex RI/FS, the data will not be plotted as nondetects.

— **KYRHB-OK:** KYRHB has performed an independent data assessment and the data are acceptable for use.

Any exceptions to these rules will be documented in the data quality analysis as part of the RI/FS Report.

Grid Sampling/Data Use. Grid sampling for the RI/FS is set up primarily on approximately 50-ft centers within sectors where there is exposed soil and approximately 50-ft stretches along the railroad in the southern end of the complex. Sampling will consist of compositing five grab samples within each grid for two horizons: surface and subsurface (see Section 9 for additional information).

Fixed-base analytical data will be obtained for each horizon for each sector as described in Section 9.1.2.1. Samples from which additional fixed-base analytical data will be obtained from randomly selected grids among the samples on each horizon (i.e., the surface grid sample and the subsurface grid sample submitted for additionally fixed-base laboratory analysis may not be from the same grid location). Acceptable historical data, as determined by the data quality analysis, will be assigned to an appropriate grid before beginning the data analysis described below. For each grid, a detect or nondetect flag will be assigned for each analyte using newly-generated composite samples data, newly-generated grab samples, and/or historical data. If any of the samples within the grid is a detect, a detect flag is assigned. A nondetect flag is set only if all results are nondetect or not available.

For each grid, a concentration for each analyte will be assigned.

(1) If the analyte has a nondetect flag for the grid, then the concentration will be set as the lowest detection limit.

(2) If the analyte has a detect flag, then the concentration will be set as the maximum detected value.

The following is how data will be grouped.

- For groundwater sample depths/groupings: UCRS, RGA, McNairy. Data for the entire complex will be assessed together (i.e., it will not be segregated by sector).

- Soil data will be segregated by sectors (i.e., Sectors 2-7 and Sector 1, which is subdivided into Sectors 1A–1D). Data will not be separated by individual SWMUs. For soil sample depths (ft bgs), categories will be set as follows.

  – Surface = 0-1
  – Subsurface = 1-16
  – Deep = > 16-top of RGA
  – RGA soils
  – McNairy soils

Background values are compared on a sector basis by examining the results across all the grids within the sector. If the maximum sample quantitation limit for an analyte (over all samples within a medium) is greater than background and the analyte is not detected in any sample, then the data for that analyte will be deemed suspect. If an analyte is detected in one or more grids within the sector, then the maximum detected value across all grids within the sector is used for background comparison. (If the maximum detected value is greater than background, then the analyte is present above background. If the maximum detected value is less than background, then the analyte is not present above background.) Analytes not retained for the risk analysis on the basis of the background comparison will be considered further in the risk assessment uncertainty analysis.

COPCs will be selected for each sector for those analytes that are detected above background and whose maximum detected value is greater than the no action level [as defined in the RMD (DOE 2019b) for the industrial worker scenario]. If the maximum sample quantitation limit for an analyte (over all samples within a medium) is greater than the concentration that may pose an unacceptable risk or hazard to human health and the analyte is not detected in any sample, then the data for that analyte will be deemed suspect. Data from these analytes will not be used quantitatively in the risk assessment, but the potential risk or hazard from exposure to media potentially containing these analytes will be examined qualitatively. In developing the qualitative assessment for these data, the maximum quantitation limit for the analyte (in all samples from a medium) will be compared to the appropriate no-action residential PRG if historical or process information indicates that the analyte potentially could be present. One-half the maximum quantitation limit for the analyte (in all samples from a medium) will be used in this comparison if historical or process information indicates that the analyte is not expected to be present. (Some exceptions to this may be utilized in the screening level risk assessment, as deemed appropriate. For example, a unit from a PCB area may retain PCB as a COPC even if it is not detected during sampling. These are considered site-related contaminants.) Data quality will be assessed to ensure the detection limit meets the DQOs for the project before deciding whether to exclude a constituent.

Exposure point calculations will be performed for each sector for those analytes that are retained as COPCs (see exception for site-related contaminants, also). For each COPC, data will be summarized within each sampling location before calculating the exposure point concentration (EPC) for the sector. This is necessary to ensure that each location is represented equally in the sector EPC calculation.

After the dataset is built for each analyte within the sector, the rules for EPC calculation in the RMD would be followed. These rules are as follows:

(1) If results from fewer than ten samples are available, then the EPC will be the maximum detected concentration.

(2) If results from ten or more samples are available, then the most recent version of EPA's ProUCL software will be used to determine the EPC. The "all statistics option" will be used in ProUCL when determining the population distribution for each data set. The value selected as the EPC will be the value recommended by ProUCL, noted as the "Potential UCL to Use" for the 95% UCL. Nondetect values should be handled according to the recommendations in the ProUCL User Guide (EPA 2015). If the 95% UCL exceeds the maximum detected concentration, then the uncertainty will be discussed in the risk evaluation.

6.1.2 Exposure Assessment

The C-400 Complex is located within a large industrial facility; therefore, the current land use is industrial. Industrial land use, as stated in this work plan, necessitates that the current exposure scenario be industrial worker (with exposure to the first ft of surface soil). Additionally, an excavation worker (with potential exposure to soil in the 0–16 ft bgs depth) will be used for subsurface soil. For determining COPCs in soil, the residential scenario will be used. The current scenarios (i.e., industrial worker for surface soil and excavation worker for subsurface soil) do not include any current use of groundwater drawn from the RGA at the sources; therefore, the child resident exposure scenario will be used for hazard, and the residential scenario will be used for ELCR.

The current land use can be expected to continue in the foreseeable future, and the most plausible future land use of the C-400 Complex also is industrial, as agreed to during scoping meetings. In the future, the expected exposure frequencies and durations may be higher than duration and frequency of the current, site-specific exposure. Additionally, use of groundwater drawn from the RGA at the C-400 Complex is not expected; however, uses of areas surrounding the Paducah Site indicate that it would be prudent to examine a range of land uses to provide decision makers with estimates of the risk that may be posed to humans under alternate uses, however unlikely. These factors should be considered in examination of risk information provided in the C-400 Complex RI/FS Report. The following future land uses were included in the WAG 6 RI BHHRA, GWOU FS BHHRA, and the Soils OU RI BHHRA (SWMU 47).

- Future on-site industrial use—direct contact with surface soil (0 to 1 ft bgs).
- Future on-site excavation worker—direct contact with surface and subsurface soil (0 to 16 ft bgs).
- Future on-site recreational user—direct contact with surface soils and consumption of game exposed to contaminated surface soil.
- Future on-site rural resident—direct contact with surface soil and use of modeled groundwater concentrations from the RGA at source areas, as well as VI into a residential basement located above the source.
- Future off-site rural resident—use in the home of groundwater drawn from the RGA as well as VI into basements at the DOE plant boundary, the DOE property boundary, at Little Bayou seeps (when appropriate) and at the Ohio River.

6.1.3 Toxicity Assessment

Toxicity information considered in previous BHHRAs of potential carcinogenic risks includes (1) a weight-of-evidence classification and (2) a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that an agent is a human carcinogen, based on the available data from animal and human studies. The slope factor for chemicals is defined as a plausible upperbound estimate of the probability of a response (i.e., development of cancer) per unit intake of a chemical over a lifetime (EPA 1989). Slope factors are specific for each chemical and route of exposure. Significant changes since the WAG 6 RI BHHRA have been made to the classification for one of the WAG 6 COCs. Beryllium no longer is considered cancerous through the oral and dermal pathways. Toxicity values used in risk calculations also include the chronic reference dose (RfD), which is used to estimate the potential for systemic toxicity or noncarcinogenic risk. The chronic RfD is defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA 1989). RfD values also are specific to the chemical and route of exposure.

Dermal contact with soil was a driving exposure route in previous BHHRAs, with most of this risk arising from contact with metals (e.g., beryllium, vanadium). This was a direct result of using dermal absorption factors that exceed gastrointestinal absorption values and may be overly conservative. Since the previous assessment, revisions have been made to methods presented in EPA's Risk Assessment Guidance for Superfund: Part E, and incorporated into the RMD (DOE 2019c).

6.1.4 Risk Characterization

Risk characterization is the final step in the risk assessment process. Quantitative estimates of both carcinogenic health risks and noncarcinogenic hazard potential from the WAG 6 RI BHHRA, the GWOU

FS BHHRA, and the Soils OU RI BHHRA (SWMU 47) are summarized in Section 5. Consistent with the RMD, no updates to any values contained in the earlier reports have been made (DOE 2019c).

For the C-400 Complex RI/FS, risk characterization will be performed by methods consistent with the RMD or the most recent version (DOE 2019c).

6.1.5 Preliminary Remediation Goals

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 will be discussed in the RI/FS 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 final action recommendations. PRGs for this project will be the lesser of the no action cancer- and no action hazard-based PRGs for the appropriate future use taken from Appendix A of the RMD (DOE 2019c). Prior to screening, the risk evaluation will determine the most up-to-date sources of criteria.

6.1.6 Evaluation of Uncertainties

Uncertainties are associated with each of the steps of a risk evaluation. Following a general discussion of uncertainties in risk assessment, this section presents the uncertainties that will be addressed as part of the risk evaluation to be completed for the C-400 Complex RI/FS. The direction or effect of any uncertainty-associated biases on reported risk estimates will be included in uncertainty discussions.

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 discussed qualitatively in the C-400 Complex RI/FS risk evaluation.

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 Volume 2 of the RMD (DOE 2019b). Ecological risks will be evaluated quantitatively using the data collected in areas where soils will be left in place (i.e., Sectors 5, 6, and 7). Areas that will be excavated will be back filled with clean materials. At minimum, the SERA 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, the Paducah Site 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 (BERA) process outlined in the RMD, as appropriate (DOE 2019b). The level of effort for these additional steps will be dependent on the ecological information available from historical environmental monitoring activities at the Paducah Site 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.

As agreed upon by the FFA parties, the overall approach of ecological risk for the C-400 Complex OU is to conduct a SERA through Steps 3b, as appropriate. As described in the Ecological RMD, a brief description of a SERA through Steps 3b is included below (DOE 2019b).

Steps 1 and 2 of the SERA process contain the following elements:

- Site visit (if needed),
- Screening-level problem formulation (CSM),
- Screening-level effects evaluation (toxicity threshold benchmarks),
- Screening-level exposure estimate (site maximum concentration data), and
- Screening-level risk calculation (site concentration data screens).

Step 3a of SERAs for PGDP sites include the following activities:

- Compare site and background concentrations;

- Evaluate frequency and distribution of concentrations exceeding benchmarks and/or referenced site values;

- Evaluate site-specific tissue concentrations against benchmarks for direct risk to organism sampled (if available);

- Calculate preliminary hazard quotients for bioaccumulating constituents and for selected PGDP wildlife receptors;

- Evaluate site-specific exposure data and assumptions (e.g., area use factor ingestion rates and diet);

- Consider alternative toxicity data and benchmarks for receptors exposed by direct contact;

- Compare site and reference concentrations; and

- Evaluate site-specific tissue concentrations (if available) to calculate risk from food chain uptake.

Step 3b of SERAs for PGDP sites includes the following activities:

- Summarizing ecotoxicity of COPECs,

- Identifying assessment endpoints,
- Describing habitat,
- Presenting the CSM, and
- Specifying risk questions and hypotheses for the site.

As agreed to by the FFA parties during comment resolution meetings, the last two bullets of Step 3a will not be performed for the C-400 Complex.

Additionally, as agreed to by the FFA parties, the following information is pertinent to the C-400 Complex OU SERA;

- No ecological modeling will be performed;

- Shallow groundwater will be screened against surface water screening benchmarks [results of total analyses in groundwater will be used (not dissolved analyses)];

- Possible receptors will be listed as part of Step 3;

- Area use factors will not be used, data will be screened consistent with the sectors established for the project;

- Sectors will be retained, wide-ranging receptors will be recognized, and the uncertainty will be discussed with the FFA parties; and

- Ecological assessment of surface soil will be consistent with human health assessment (i.e., only Sectors 2-7 will be assessed; see Section 9.3 for additional information).

6.2 PRELIMINARY DATA EVALUATION

Existing data and information for the C-400 Complex form the basis for determining the amount of additional characterization data necessary to reach a final action decision. In addition to analytical data, process knowledge, personnel interviews, and records/document searches, are useful in that determination. The site conceptual model for contaminant transport determines the applicability of each type of preliminary information/data, which in turn is used in support of a risk assessment.

Existing information about the C-400 Complex that is collected includes, but is not limited to, the following:

- Compiling facility records, personnel interview records, and process description information for the C-400 Complex;

- Defining processes and materials used, where chemicals and materials were used/disposed, and where and how potential contaminants may have been introduced to the C-400 Complex and subsequently released to the environment;

- Compiling all analytical data for the C-400 Complex and surrounding area, including radiological surveys, geophysical surveys, sample results, geotechnical information, historical photographs, maps, and drawings; and

- Collecting and evaluating any existing computational assessments (risk assessment) or conceptual evaluations and the results and conclusions of any previous investigations.

6.2.1 Characterization and Inventory of Wastes

Information concerning characterization of the C-400 Complex is given in a sector-specific format in Chapter 5 of this work plan.

6.2.2 Evaluation of Analytical Limits

QAPP Worksheets 15-A through 15-K in Section 11 compare the child residential scenario NALs with the fixed-base laboratory detection limits and MDCs. These tables show that for most analytes, the detection limits are less than all screening criteria. Fixed-base laboratory detection limits that are higher than no action levels will be addressed as an uncertainty in the risk evaluation.

6.2.3 Information Status of Key Assessment Factors

During the scoping process, progress was made in defining sample locations, clarifying concepts and identifying data needs, exchanging ideas on investigation methods, and identifying and resolving critical items.

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 1999 and 2011.

As part of this summary, previously completed transport models were categorized into one of the four modeling tiers described in Table 3.2 of the RMD (DOE 2019c). 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 RESRAD and SESOIL. 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 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 industrialized area, DOE property boundary, Little Bayou Creek/Bayou Creek, and the Ohio River).

Tier 4: Results are derived using numerical models, such as MODFLOW. 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 appropriate to the selected remedy.

Generally, all modeling that has been performed for the C-400 Complex falls within Tier 2; however, in most cases, modeling to downgradient points of exposure (i.e., the industrialized area and/or DOE property boundary) was included. Modeling to the downgradient points is similar to the Tier 3 requirement.

Below is a summary of the modeling performed for the C-400 Complex. Risk and hazard estimates calculated from the modeling, included in Chapter 5, are for hypothetical residential use of groundwater drawn from the RGA.

Fate and transport modeling during the WAG 6 RI included MEPAS (DOE 1999a). Concentrations were modeled to two receptor points: the industrialized area (i.e., the plant fence), approximately 3,300 ft from source areas, and the DOE property boundary, 5,500 ft from the source areas.

Fate and transport modeling during the Soils OU RI for SWMU 47 (within Sector 6) included SESOIL and AT123D modeling, determined maximum potential RGA groundwater concentrations at the SWMU 47 boundary, the DOE property boundary, the surface water discharge location, and the Ohio River that resulted from residual TCE soil contamination (DOE 2011b). In addition to UCRS and RGA groundwater concentrations, modeling determined expected UCRS VOC vapor concentrations associated with residual TCE soil contamination.

Contaminant concentrations in groundwater at the point of exposure from TCE sources in the RGA at the C-400 Cleaning Building area were estimated using information developed using the MODFLOWT transport model as part of the FS for the GWOU (DOE 2001b). This model assumed transport to the same points of exposure used in the MEPAS model (DOE 2005a).

Potential exposure of VOCs via VI will be considered in the RI/FS. The RI/FS Report will include information collected as part of the C-400 Vapor Intrusion Study (DOE 2018b). See also Section 6.1.

6.2.4 Release Potential from Contaminant Sources

The CSMs presented in Figures 6.1 and 6.2 identify the potential sources, primary and secondary exposure media, release/transport mechanisms, and potential receptor and exposure routes/pathways at the C-400 Complex to the potential human and ecological receptors. From the source, two primary exposure media are identified: (1) a probable pathway to the surface soils, and (2) a probable pathway to subsurface soils. From these pathways, three probable exposure media are identified with solid lines: (1) surface soil, (2) subsurface soil, and (3) groundwater. These probable exposure media will be the focus of the investigation activities.

The CSM for this investigation identified the following as the primary sources of contamination: past spills and releases from operations. Although specific information is not available regarding all past spills or releases, the CSM assumes that the C-400 Complex soils are contaminated. Contaminants found in soil are available for direct contact on-site through ingestion, inhalation, dermal exposure, or external exposure (for gamma-emitting radionuclides). Receptors potentially exposed to soil are industrial workers, recreational users, trespassers, and ecological receptors. Additionally, the residential scenario is included because the child resident screening levels will be used to determine COPCs.

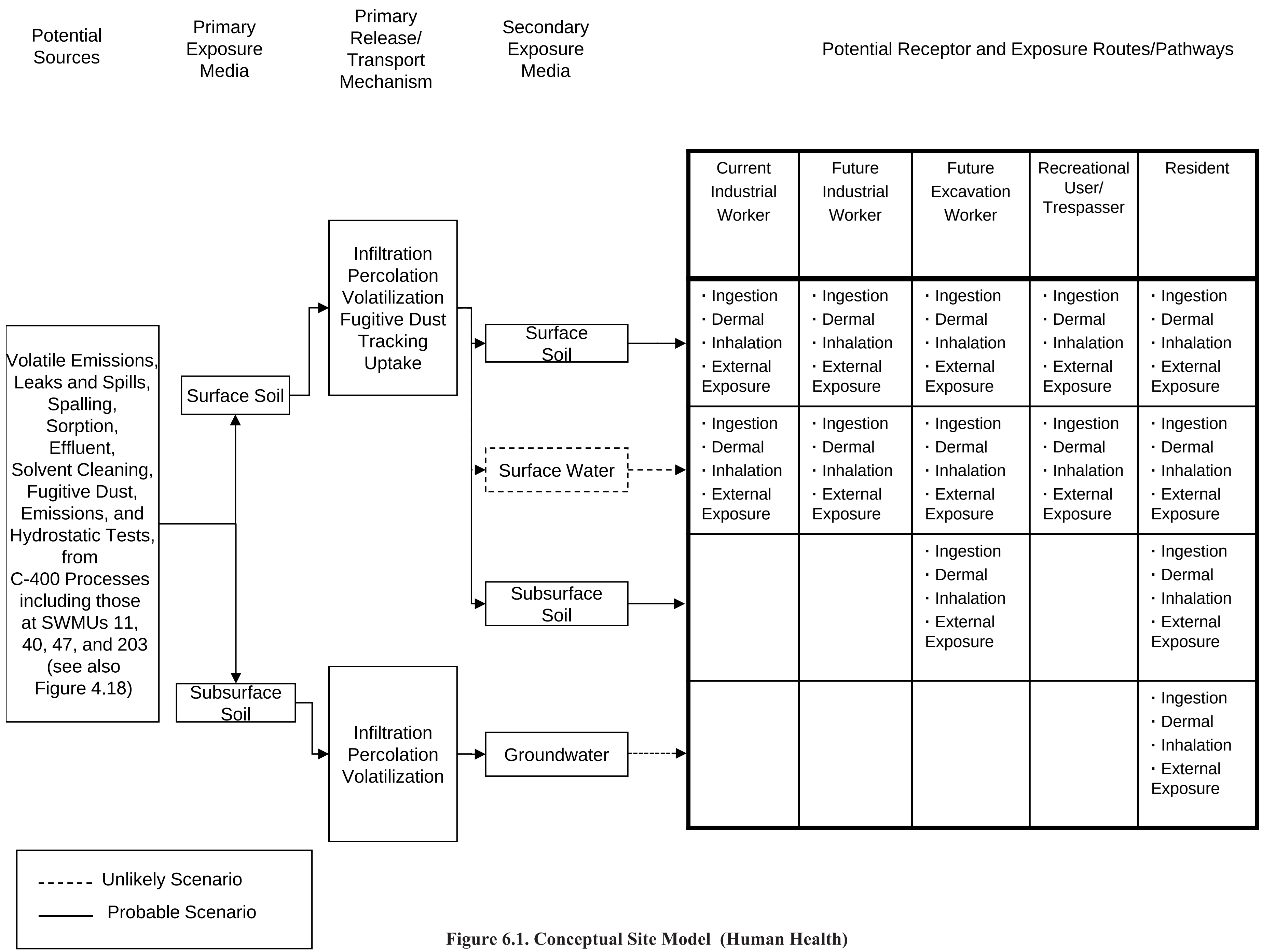

Figure 6.1. Conceptual Site Model (Human Health)

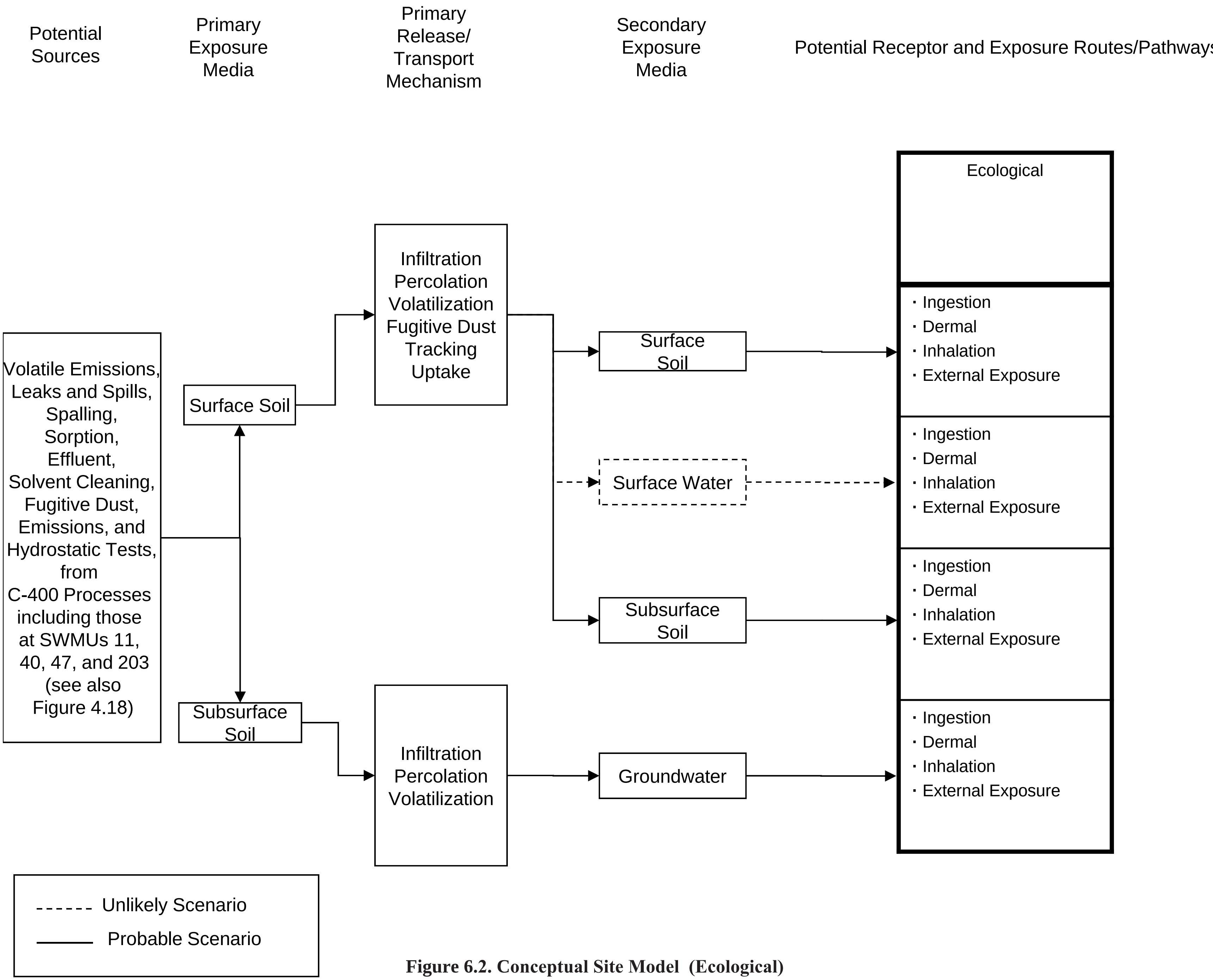

Figure 6.2. Conceptual Site Model (Ecological)

Ecological receptors on-site also may be exposed to contaminants through ingestion of biota that has taken up contamination from soil. The C-400 Complex RI/FS will complete a SERA in accordance with the RMD based on data collected. Exposure of ecological receptors through other media is evaluated in the appropriate OUs. The SWOU will include a sitewide BERA.

6.3 SAMPLING STRATEGY

The sampling strategy for this work plan is to identify data gaps and complete characterization of the nature and extent of contamination for the C-400 Complex. Evaluation of the adequacy and representativeness of information will be determined by the following criteria:

- Will existing data support C-400 Complex decision making; and

- Are data sufficient to support a risk evaluation. Specifically, there must be analytical data of sufficient and appropriate quality for the full set of COCs and COPCs to determine if there is a threat to the industrial worker.

If data were not adequate and representative, data gaps were identified, and additional sampling was planned to ensure adequate, sufficient, and representative data to support a final decision at the C-400 Complex. QA data considerations made to ensure that data quality requirements are met include sample point density, number of samples, analyses required, locations, depth of samples, and compositing methodology. Quality Control (QC) considerations include adherence to field and laboratory procedures/protocols and data validation/management procedures as described in the appropriate chapters.

The DQO process was used to focus the sampling strategy on site-specific media, contamination, and migration pathways. In addition, this process was used to identify the potential remedial action alternatives and RI/FS data requirements presented in Chapters 8 and 9 of this work plan. To facilitate this activity, existing data on the C-400 Complex process, waste management, releases, and environmental site conditions were gathered and presented in a briefing document entitled *Scoping Document for the C-400 Complex Remedial Investigation/Feasibility Study at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2424&D1 (DOE 2018a). This document, along with other information, was used during meetings held among all participating organizations between March and June 2018 to complete Steps 1 through 4 of the DQO process, as described in Chapter 1. Subsequent steps in the DQO process were completed by the project team later in 2018.

The results of the DQO process indicated that the sampling strategy of the C-400 Complex varies by sector and will be based on historical information used to inform sampling locations. Discussions of sector-specific sampling strategies are in Chapter 9. Sector sampling will follow the analyte list presented in Table 6.1.

Table 6.1. Planned Analyte List

Metals	VOCs	SVOCs	PCBs	Dioxins/Furans[d,e]	Radionuclides
Aluminum	Acrylonitrile	Acenaphthene	Total PCBs	2,3,7,8-TCDD	Actinium-227[a,e]
Antimony	Benzene	Acenaphthylene	Aroclor 1016	1,2,3,7,8-PeCDD	Americium-241
Arsenic	Bromodichloromethane	Anthracene	Aroclor 1221	1,2,3,4,7,8-HxCDD	Cesium-137
Barium	Carbon tetrachloride	Carbazole	Aroclor 1232	1,2,3,6,7,8-HxCDD	Cobalt-60[a,e]
Beryllium	Chloroform	Fluoranthene	Aroclor 1242	1,2,3,7,8,9-HxCDD	Lead-210[a,e]
Boron	1,1-Dichloroethene	Fluorene	Aroclor 1248	1,2,3,4,6,7,8-HpCDD	Neptunium-237
Cadmium	1,2-Dichloroethane	Hexachlorobenzene	Aroclor 1254	OCDD	Plutonium-238
Total Chromium	1,2-Dichloroethene	Naphthalene	Aroclor 1260	2,3,7,8-TCDF	Plutonium-239[b]
Cobalt	*trans*-1,2-Dichloroethene	2-Nitroaniline		1,2,3,7,8-PeCDF	Plutonium-240[b]
Copper	*cis*-1,2-Dichloroethene	N-Nitroso-di-n-propylamine		2,3,4,7,8-PeCDF	Protactinium-231[a,e]
Fluoride	1,4-Dioxane	Pentachlorophenol[c]		1,2,3,4,7,8-HxCDF	Radium-226[a,e]
Iron	Ethylbenzene	Phenanthrene		1,2,3,6.7,8-HxCDF	Strontium-90[a,e]
Lead	Tetrachloroethene	Pyrene		1,2,3,7,8,9-HxCDF	Technetium-99
Manganese	Toluene	Total Carcinogenic PAHs		2,3,4,6,7,8-HxCDF	Thorium-228[a,e]
Mercury	1,1,1-Trichloroethane	Benz(a)anthracene		1,2,3,4,6,7,8-HpCDF	Thorium-230
Molybdenum	1,1,2-Trichloroethane	Benzo(a)pyrene		1,2,3,4,7,8,9-HpCDF	Thorium-232[a,e]
Nickel	Trichloroethene	Benzo(b)fluoranthene		OCDF	Uranium-234
Selenium	Vinyl chloride	Benzo(k)fluoranthene		Total TCDD	Uranium-235
Silver	Xylenes (Mixture)	Chrysene		Total PeCDD	Uranium-238
Thallium	p-Xylene	Dibenz(a,h)anthracene		Total HxCDD	
Uranium	m-Xylene	Indeno(1,2,3-cd)pyrene		Total HpCDD	
Vanadium	o-Xylene			Total TCDF	
Zinc				Total PeCDF	
				Total HxCDF	
				Total HpCDF	

[a] Additional radionuclides analyzed only in designated locations.
[b] Reported as plutonium-239/240.
[c] Pentachlorophenol is analyzed in designated locations, as discussed during project scoping.
[d] Dioxins and furans are analyzed in designated locations, as discussed during project scoping.
[e] Solid (concrete), Soil Matrix will be sampled for analysis.

7. TREATABILITY STUDIES

Treatability studies involve testing technologies to assess their performance on specific materials or media. This section includes a discussion of the treatability study process. No treatability studies have been identified at this time for the C-400 Complex RI/FS; however, as the RI/FS is implemented and alternatives are evaluated, additional studies may be identified.

7.1 PREVIOUS C-400 AREA TREATABILITY STUDIES

Five treatability studies previously have been conducted to investigate methods for reducing or remediating the VOC contamination in the C-400 Complex. The first was conducted in 1994 at the southeast corner of the C-400 Complex using an existing RGA MW. Results are reported in *The In-Situ Decontamination of Sand and Gravel Aquifers by Chemically Enhanced Solubilization of Multiple-Component DNAPLs with Surfactant Solutions* (INTERA 1995). In the first study, researchers screened 99 surfactants in a laboratory and identified four surfactants that were good solubilizers of three common DNAPL components—TCE, tetrachloroethene, and carbon tetrachloride; one surfactant, a sorbitan monooleate, was selected for testing at the Paducah Site. The field test consisted of a push-pull (injection-extraction) test in MW156 to assess the efficacy of the surfactant to solubilize DNAPL. Extraction during the test was able to recover only one-third of the injected surfactant. (It is believed that the surfactant became sorbed to the aquifer matrix, precipitated, or formed a liquid crystal.) There was no enhancement of the concentration of TCE recovered from the well. The field test demonstrated that sorbitan monooleate is unsuitable for use as a solubilizer in the RGA.

The second and third studies were bench scale tests of RGA remediation conducted as part of the WAG 6 RI. The second study looked at other surfactants and co-solvents. Results were documented in *Surfactant Enhanced Subsurface Remediation Treatability Study Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1787&D1 (DOE 1999b). Through laboratory screening, the study identified two surfactant systems (a 5% Dowfax 8390 mixture and an 8% AMA-80 mixture) that would be effective in the RGA. The Dowfax 8390 system had greater surfactant recovery efficiency; the AMA-80 system was a more effective solubilizer. The study determined that surfactant-enhanced remediation had the potential to remove a high percentage of TCE mass from the RGA.

The third study evaluated chemical oxidation and reported the results in *Bench Scale In-Situ Chemical Oxidation Studies of Trichloroethene in Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1788&D1 (DOE 1999c). Thermal acceleration tests, batch tests, and column tests using RGA soil demonstrated that chemical oxidation of TCE-impacted WAG 6 soils and groundwater was achievable and should be investigated further for full-scale field implementation.

The fourth treatability study (conducted in 2003) was a test of full-scale deployment of ERH technology in the area adjacent to the southeast corner of the C-400 Cleaning Building. This study included the installation and operation of one SPH treatment array and a vapor recovery system. The SPH treatability study began on February 14, 2003, and was discontinued on September 6, 2003. A key operational criterion of the test was to raise the temperature of soil and groundwater within the treatment volume sufficient to transition groundwater and targeted contaminants into their vapor phases. During the test, a design/construction flaw prevented the two deepest electrodes from reaching target temperatures. The primary objective, as outlined in the *Treatability Study Work Plan for Six-Phase Heating, Groundwater Operable Unit, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1789&D2/R1 (DOE 2001a), was to demonstrate the implementability of the ERH technology in the unsaturated and saturated soils of the UCRS and in the groundwater of the underlying RGA. Comparison of pretreatment and posttreatment sample results was used to measure treatment efficacy. The SPH treatability study achieved a 98% reduction of TCE concentration in UCRS soils and a 99.1% reduction in TCE concentration in RGA groundwater, which met the removal efficiency criteria outlined in Six-Phase Heating Technology Assessment (GEO Consultants 2003).

The success of the SPH project lead to a 2005 ROD to implement ERH to remove additional volatile organics from the UCRS and RGA. ERH was implemented in two phases: Phase I and Phase II. An important objective of Phase I was to evaluate the heating performance of the base ERH design through the RGA down to the McNairy Formation interface. During Phase I, temperature goals were not attained in the lower RGA below 70 ft bgs [refer to Phase I Technical Performance Report, DOE/LX/07-1260&D1 (DOE 2011a)]. Because of the inability of ERH to reach target temperatures in the lower RGA, the FFA parties agreed to divide Phase II into Phase IIa (using ERH to address the UCRS and upper RGA to a depth of 60 ft bgs) and Phase IIb (using a technology to be decided to address the lower RGA). Phase IIa operations were completed in fall of 2014.

In 2013, a series of multiphase flow numerical simulations were performed to evaluate likely behavior of steam injection in the RGA at the C-400 area (Falta 2013). These numerical simulations bound the range of hydrogeologic and operational conditions that reasonably could be expected during steam injection in the RGA at PGDP. The numerical simulations indicated that injecting steam may be effective in evenly heating the base of the RGA, provided that the horizontal hydraulic conductivity is moderate and the horizontal-to-vertical anisotropy ratio is high.

The fifth treatability study, to test Phase IIb steam injection, followed in 2015 (April through June) to obtain data specific to understanding whether/how injected steam could heat the full thickness of the RGA, maintain target temperatures at the RGA/McNairy interface, and move the steam front effective distances from the injection wells (DOE 2016). Subsurface temperatures in the RGA were measured at various depths and distances from steam injection points throughout the duration of the treatability study to monitor the change in temperatures and the arrival of the steam front horizontally and vertically in the subsurface. Two nested steam injection wells allowed for steam injection at upper and lower screened intervals simultaneously, while maintaining the ability to isolate the upper and lower wells to focus steam injection to a single depth interval. The injection strategy was varied to assess the effects on steam front mobility, configuration, and heating effectiveness under varying steam injection conditions. Thermal modeling yielded simulations of a full-scale design. The treatability study concluded that the encountered site conditions are within the expected range, and that steam is technically implementable to heat the target zone to facilitate VOC remediation.

The following are three studies related to Tc-99 treatment in groundwater.

- *Treatability Studies Using Iron Filings to Remediate Trichloroethylene and Technetium,* KY/ER-51, February 1994;

- *A Field Trial of Novel Bifunctional Resins for Removing Pertechnetate (TcO_4^-) from Contaminated Groundwater*, ORNL/TM-13593, March 1998; and

- *Selective Anion Exchange Resins for the Removal of Perchlorate ClO_4^- from Groundwater*, ORNL/TM-13573, February 1999.

7.2 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 materials or media at the site. They 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 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 later phases of the RI/FS.

The identification of data needs for treatability studies is shown, conceptually, in Figure 7.1 and consists of the following four steps:

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

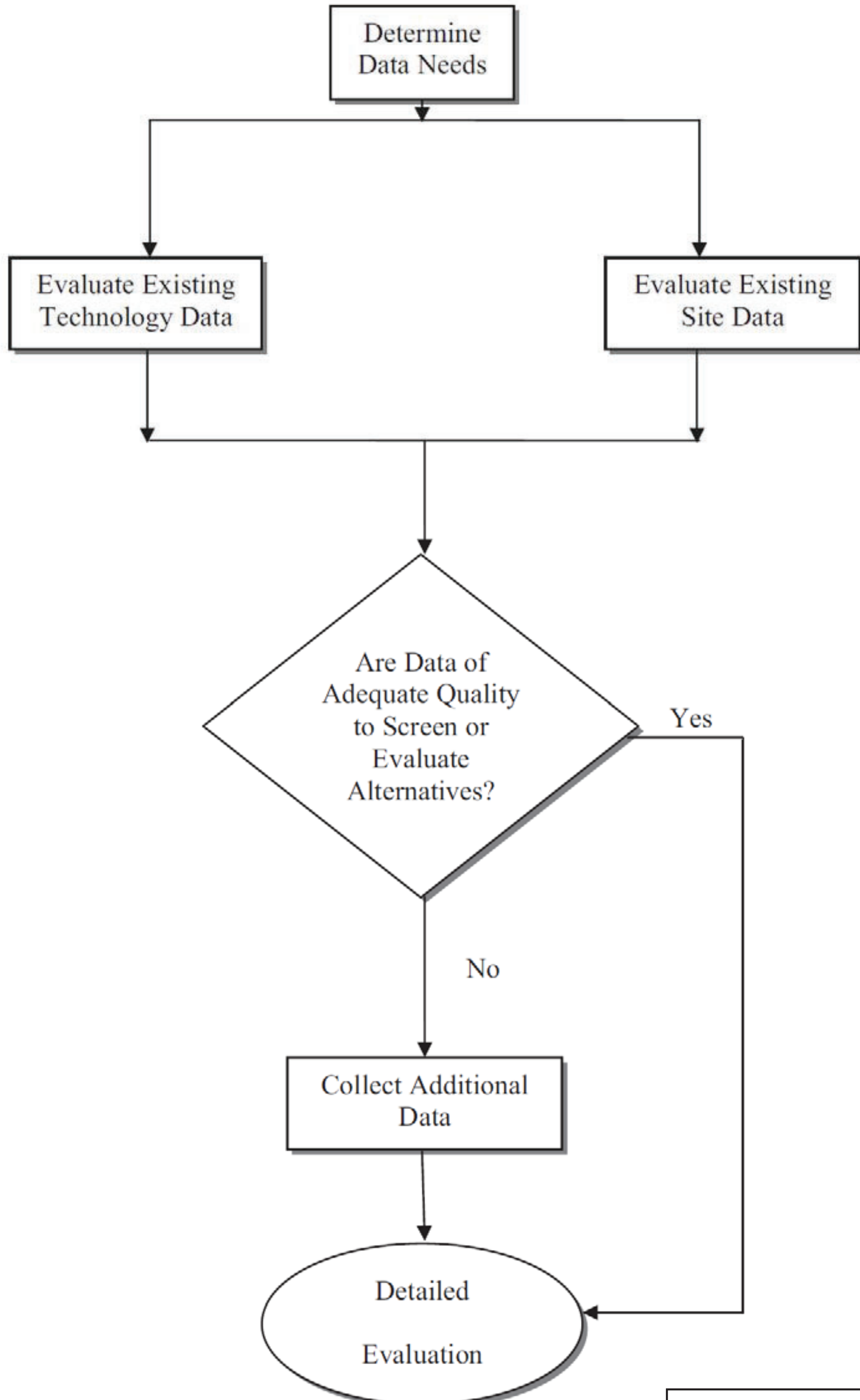

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Figure 7.1. Flowchart for Treatability Study Data Needs

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Frequently, technologies have not been demonstrated sufficiently, or characterization of the materials or media 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 materials or media. 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 materials or media than it would be to characterize the materials or media in sufficient detail to predict performance.

No treatability studies have been identified at this time for the C-400 Complex RI/FS; however, as the RI/FS is implemented and alternatives are evaluated, additional studies may be identified.

7.3 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.

7.4 ADDITIONAL SITE DATA NEEDED FOR STUDY OR EVALUATION

Before evaluation for remedy selection in the RI/FS, sufficient data must be available, or acceptable assumptions taken, 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 materials or media, 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 materials or media 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.

7.5 SCHEDULE FOR SUBMISSION OF TREATABILITY STUDY WORK PLAN

Should a need for a treatability study be identified during the planning and execution of the C-400 Complex RI/FS, the decision to undertake such a treatability study will be addressed in accordance with the FFA (EPA 1998).

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8. ALTERNATIVES DEVELOPMENT

This section explains the process that will be used to develop and evaluate alternatives during the C-400 Complex RI/FS. Topics addressed in this section of the work plan include the following:

- Description of the general approach to investigating and evaluating potential remedies;
- Overall objective of the study, a discussion of preliminary identification, general response actions, and remedial technologies;
- Remedial alternatives development and screening; and
- Detailed analysis of remedial alternatives.

A discussion of the format for the RI/FS that will be consistent with the Paducah FFA also is provided. The schedule for developing and submitting the RI/FS to the FFA parties will be consistent with the dates contained in the SMP, as amended (DOE 2019a).

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 that was completed for the C-400 Complex in June 2018. The RI/FS Report will identify remedial alternatives based on results of the RI. The alternatives undergo a detailed evaluation using the nine evaluation criteria outlined in 40 *CFR* § 300.430(e)(9)(iii).

Treatability studies may be performed, if necessary, to evaluate more adequately the potential alternative's effectiveness, as discussed in Chapter 7. Currently, no treatability studies are planned for implementation simultaneously with this RI/FS. Historically, a number of treatability studies have been performed in the area that composes the C-400 Complex; these support development of the RI/FS Report.

The process overview for developing the FS portion on the RI/FS Report can be viewed as occurring in three phases (EPA 1988):

- The *development* of alternatives,
- The *screening* of alternatives, and
- The *detailed* analysis of alternatives.

The first and second phases typically are developed and discussed simultaneously after the RAOs are developed. The detailed analysis of alternatives is performed last, prior to consolidation of the analyses into the RI/FS Report for review.

8.2 OVERALL OBJECTIVES OF THE FEASIBILITY STUDY

The primary objective of the RI/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 to provide protection of human health and the environment by recycling or treating waste or by eliminating, reducing, or controlling risks present.

8.3 PRELIMINARY REMEDIAL ACTION OBJECTIVES

As a result of previous RIs and baseline risk assessment(s) that have been performed at Paducah concerning the C-400 Complex, the following problem statement has been developed.

> Hazardous substances that historically have been present and/or migrated from the C-400 Complex and its SWMUs have been released to surrounding environmental media. These substances, in turn, have infiltrated into groundwater and been transported through subsurface pathways. The nature and extent of contamination have been defined adequately for some SWMUs, and areas and risk assessments have been prepared. For other SWMUs and areas, the nature and extent of contamination have not been defined adequately to assess whether potential contaminants pose unacceptable risks to human health and the environment at the C-400 Complex and at downgradient exposure points. Data gaps must be identified so that a comprehensive RI/FS Report can be prepared for the C-400 Complex.

At the C-400 Complex, TCE as free product likely exists in the UCRS, RGA, and potentially in the McNairy Formation. The mass of TCE in these location(s) must be reduced, removed, or contained to support National Contingency Plan expectations (40 *CFR* § 300.430(a)(1)(iii)(F)) to return groundwater back to its beneficial use wherever practicable.

Some of the areas inside the C-400 Complex have been identified where TCE occurs in the subsurface as free product. Potential remains for additional unknown source zones of free product-TCE to be present in the subsurface at the C-400 Complex (e.g., underneath the C-400 Building) that may pose unacceptable risks to human health and the environment at the C-400 Complex and downgradient. Also, potential remains for additional unknown source zones of other COCs to be present in the subsurface at the C-400 Complex (e.g., underneath the C-400 Building) that may pose unacceptable risks to human health and the environment at the C-400 Complex and downgradient. Additional data must be collected during fieldwork associated with the RI/FS Work Plan to define adequately these areas and/or other COCs. The remedial strategy to be selected must deal with these uncertainties.

In order to develop remedial alternative(s) that provide for the protection of human health and the environment, preliminary RAOs were developed based on the risks identified in the baseline risk assessment and the problem statement above. The C-400 Complex will employ the CERCLA remedial process to support accomplishing the overarching goals for OUs throughout the Paducah Site as summarized below:

- Prevent exposure to contaminated groundwater, soils, slab, and subsurface structures, including exposure to vapors from these environmental media and structures, by on-site industrial workers through institutional controls (e.g., excavation/penetration permit program);

- Address all sources of contamination within the C-400 Complex,[8] based on the results of the RI/FS, including, but not limited to, PTW (e.g., TCE DNAPL and high concentration TCE contamination) in

[8] Dissolved-phase groundwater contamination will be addressed as part of the Dissolved-Phase Plumes Remedial OU.

the UCRS, RGA, and upper McNairy Formation. TCE and Tc-99 are expected to be the primary COCs that will drive the remediation approach; and

- Return usable groundwater to beneficial use wherever practicable, within a time frame that is reasonable, given the particular circumstances of the site. If restoration of groundwater to beneficial use is not practicable inside the C-400 Complex, then prevent, reduce, or control contaminant sources contributing to groundwater contamination originating from inside the C-400 Complex.

RAOs are goals for protection of human health and the environment. RAOs provide a general description of what a CERCLA cleanup is designed to accomplish. The C-400 Complex RI/FS Report will utilize RI/FS information to develop, screen, and analyze potential remedial actions to protect human health and the environment from C-400 Complex contamination and addressing releases or potential releases from C-400 Complex source areas that may impact RGA groundwater. The preliminary RAOs that will be used in screening technologies and developing remedial alternatives are as follows.

- Contribute to the protection of groundwater by eliminating, reducing, or controlling sources of groundwater contamination;

- Prevent exposure to waste, groundwater, soils, slab, and subsurface structures, including exposure to vapors from these environmental media and structures, that present an unacceptable risk; and

- Treat or remove PTW wherever practicable, consistent with 40 *CFR* § 300.430(a)(1)(iii)(A).

These preliminary RAOs will be defined further in the RI/FS Report and finalized in the final action ROD.

The C-400 Complex is located within the fenced security area of the Paducah Site, and a reasonable future use of this area is expected to remain industrial, as discussed during scoping. The preliminary RAOs presented in this section are relative to future industrial worker and future excavation worker receptors only.

The final remedial action is expected to achieve the RAOs by addressing contamination (removing, preventing, reducing, and/or controlling contaminant sources) including, but not limited to, PTW (e.g., TCE DNAPL and high concentration TCE contamination) in the UCRS and RGA to include the upper McNairy contributing to groundwater contamination originating from inside the C-400 Complex (thereby decreasing the amount of mass available for off-site migration and the time frame that off-site contamination will remain above health-based levels) and maintaining C-400 IRA land use controls (LUCs), until LUCs are terminated by a subsequent decision.

As stated in the Land Use Control Implementation Plan for the C-400 IRA (DOE 2008c), the following LUC objectives are necessary to ensure the protectiveness of the selected remedy:

- Maintain the integrity of any current or future remedial or monitoring system;

- Prohibit the development and use of the C-400 Cleaning Building for residential housing, elementary and secondary schools, child care facilities, and playgrounds;

- Prevent exposure of current and future on-site industrial workers to groundwater and prevent use of the groundwater at the C-400 Cleaning Building area through institutional controls (e.g., the current excavation/penetration permit program) and through deed restrictions;

- Provide notice in property records regarding contamination and response actions at the C-400 Cleaning Building area.

Figure 8.1 shows the LUC Boundary for the C-400 Interim Remedial Action (DOE 2008c). The LUC Boundary (Figure 8.1) does not coincide completely with the C-400 Complex OU Area, as shown on Figure 1.2.

8.4 PRELIMINARY IDENTIFICATION OF GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

This section will summarize the identification of potential remedial technologies for the C-400 Complex. 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 sections of previous feasibility studies developed for the Paducah Site, including the *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1857&D2 (DOE 2001b); and the draft *Summary of Alternatives for Remediation of Offsite Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1991). Additionally, databases will be queried to identify additional technologies, such as the following:

- Electronic Encyclopedia of Remedial Action Options (https://frtr.gov/matrix2/appd_c/appd_c19.html) (FRTR 2018);

- Clu-in Remediation Technologies Data Base (EPA 2018); and

- Vendor Information Systems for Innovative Treatment Technologies.

Alternatives for remediation consideration will be developed to meet the RAOs. A technology or combinations of technologies will be applied to address contamination presenting unacceptable risks at the C-400 Complex. This process will consist of development of alternatives, screening of alternatives, and detailed analysis of alternatives.

8.5 REMEDIAL ALTERNATIVES DEVELOPMENT AND SCREENING

The alternatives will be developed 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 RI/FS Report.

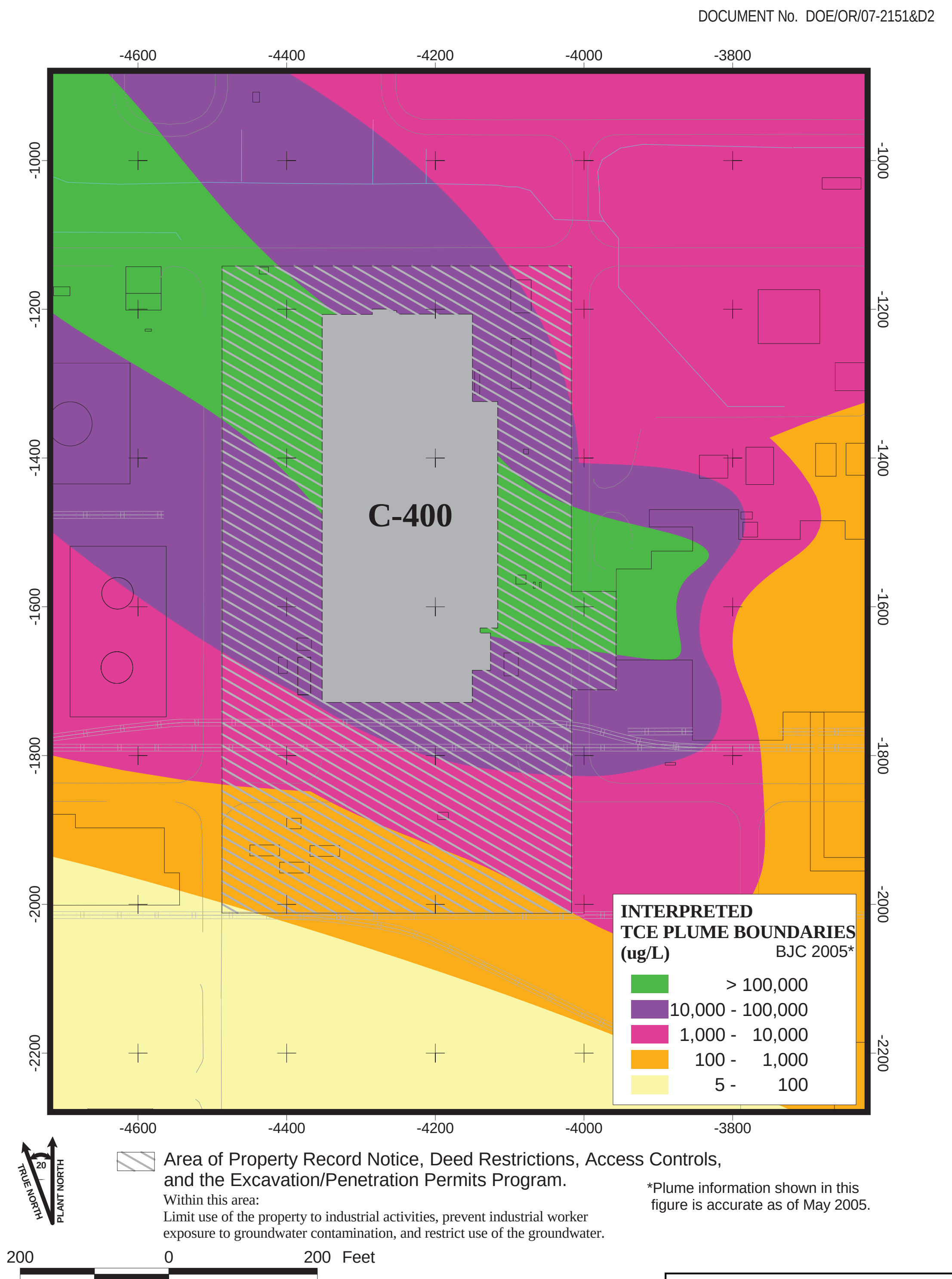

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Figure 8.1 LUC Boundary for the C-400 Area (DOE 2008)

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 the following six general steps.

(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. The preliminary RAOs for the C-400 Complex are as follows:

  a. Contribute to the protection of groundwater by eliminating, reducing, or controlling sources of groundwater contamination;

  b. Prevent exposure to waste, groundwater, soils, slab, and subsurface structures, including exposure to vapors from these environmental media and structures, that present an unacceptable risk; and

  c. Treat or remove PTW wherever practicable, consistent with 40 *CFR* § 300.430(a)(1)(iii)(A).

(2) **Development of general response actions.** Response actions will be identified to satisfy the preliminary RAOs for the C-400 Complex sites.

(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.

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 regulation [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 appraisal of implementability, and a cost evaluation [40 *CFR* § 300.430(e)(7)].

The alternatives remaining after screening is complete will undergo a detailed evaluation [40 *CFR* § 300.430(e)(9)].

8.6 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives involves evaluating each of the alternatives remaining after the screening described in Section 8.5, using the nine evaluation criteria [40 *CFR* § 300.430(e)(g)(iii)]. The alternatives then are compared. The results of the detailed analysis will allow an appropriate remedy to be recommended in a proposed plan and finally selected in a ROD.

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.

8.6.1 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)]. A discussion of ARARs for the C-400 Complex is presented in Appendix A.

8.6.2 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 residual 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)].

8.6.3 Modifying Criteria

These criteria allow for the influences of the community and the state. The modifying criteria are assessed following comment on the RI/FS Report and the proposed plan.

(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)].

The remedy selection process must follow the requirements of 40 *CFR* § 300.430(e), including the proposed plan, community involvement, and preparation of a ROD.

8.6.4 Potential Remedial Actions

As screened during project scoping, Table 8.1 contains examples of general remedial alternatives, technology types, and process options that can be implemented individually or in combination for the targeted media at the C-400 Complex. These potential remedial actions are subject to change, which may include the addition or deletion of specific actions as the CERCLA process proceeds.

During scoping discussions related to specific C-400 Complex sectors and SWMUs, the parties agreed to consider existing risk assessments and previously collected sample data to inform likely response actions and guide future sampling efforts. The FFA parties agreed to support a targeted sampling approach to support remedy screening and selection, not a random sampling approach to support completion of a new BHHRA and SERA.

8.7 FORMAT FOR THE FEASIBILITY STUDY REPORT

The content of the C-400 Complex RI/FS Report will be consistent with the FFA (EPA 1998). The RI/FS Report will incorporate NEPA values consistent with the DOE 1994 Secretarial Policy on NEPA (DOE 1994).

8.8 SCHEDULE/TIMING FOR CONDUCTING THE STUDY

Feasibility studies will be developed and submitted consistent with the dates included in SMP, as amended (DOE 2019a).

8.9 ABANDONED UTILITIES AND REMAINING INFRASTRUCTURE IN THE C-400 COMPLEX

As a part of C-400 Cleaning Building deactivation activities, all utilities will have been disconnected to isolate energy from the building.

All surface and subsurface infrastructure (including utilities, auxiliary systems, site infrastructure such as railroads, etc.) inside the C-400 Complex that remains following deactivation activities will be evaluated on a case-by-case basis to determine an appropriate response action. If feasible, the evaluation may consider if an AL [i.e., the lesser of the hazard-based value calculated using target HI of 3 and the

Table 8.1. Example General Remedial Alternatives, Technology Types, and Process Options

General Remedial Alternatives	Technology Types	Examples of Process Options
		Infrastructure*
Excavation/Removal	Other Technology	Scabbling, Excavation, Retrieval, Off-Site Disposal (off Paducah Site)/ on-site (e.g., C-746-U Landfill)
Ex Situ Treatment	Physical/Chemical Treatment (assumes excavation)	Chemical Extraction Chemical Reduction/Oxidation Separation Solidification/Stabilization
	Thermal Treatment (assumes excavation)	Thermal Desorption Thermal
	Air Emissions/Off-Gas Treatment (assumes excavation)	High Energy Destruction Oxidation Scrubbers Vapor Phase Carbon Adsorption
Containment	Containment	Asphalt Cover Soil Cover (e.g., Earthen Cover) Concrete Cover Physical Barriers (e.g., fixatives)
		Soil, Sediment, and Sludge
In Situ Treatment	Biological Treatment	Bioventing (unsaturated soil) Enhanced Bioremediation (saturated soil)
	Physical/Chemical Treatment	Chemical Oxidation (saturated soil) Soil Flushing Soil Vapor Extraction Solidification/Stabilization
	Thermal Treatment	Thermal Treatment
Ex Situ Treatment	Biological Treatment (assumes excavation)	Biopiles Composting (VOCs, to some extent SVOCs, Inorganics) Slurry Phase Biological Treatment
	Physical/Chemical Treatment (assuming excavation)	Chemical Extraction (radionuclides) Chemical Reduction/Oxidation Separation Soil Washing Solidification/Stabilization (metals)
	Thermal Treatment (assumes excavation)	Thermal Desorption (PAHs in surface soils, not recommended for TCE) Thermal
Containment	Containment	Landfill Cap Landfill Cap Enhancements/Alternatives Asphalt Cover Soil Cover
Excavation	Other Technology	Excavation, Retrieval, Off-Site Disposal (off Paducah Site)/on-site (e.g., C-746-U Landfill)

Table 8.1. Example General Remedial Alternatives, Technology Types, and Process Options (Continued)

General Remedial Alternatives	Technology Types	Examples of Process Options
Groundwater Sources (for water media, nonaqueous-phase liquid, and contaminants sorbed to soil)		
In Situ Treatment	Biological Treatment	Enhanced Bioremediation Monitored Natural Attenuation
	Physical/Chemical Treatment	Air Sparging Bioslurping Chemical Oxidation Directional Wells (Enhancement) Dual-Phase Extraction In-Well Air Stripping Passive/Reactive Treatment Walls
	Thermal Treatment (nonaqueous-phase liquid and soil)	Steam Enhanced Extraction ERH
Ex Situ Treatment	Biological Treatment (may assume pumping)	Bioreactors Constructed Wetlands
	Physical/Chemical Treatment (assumes pumping)	Adsorption/Absorption Advanced Oxidation Processes Air Stripping Groundwater Pumping/Pump-and-Treat Ion Exchange Separation Disposal: Reinjection or surface water discharge
	Air Emissions/Off-Gas Treatment	Biofiltration High Energy Destruction Oxidation Scrubbers Vapor Phase Carbon Adsorption
Containment	Containment	Physical Barriers

*Infrastructure consists of construction materials (such as concrete, brick, metal, paint, coatings, and caulk) and piping material. Material within pipelines is covered by the "Soil, Sediment, Sludge" and "Groundwater" sections.

cancer-based value calculated using target ELCR of 1E-04 when both are calculated (DOE 2019c)] is exceeded in any sample based on a realistic exposure scenario.

In addition to the risk-based values above, the evaluation would consider a combination of additional factors including, but not limited to, response to an immediate site threat to human health and the environment, rapidly achieving risk reduction, extent of contamination, accessibility, efficiency, cost effectiveness, building/site specific conditions, and forecasted timeline for final remedy decision and implementation. Surface and subsurface infrastructure that extends through the complex (i.e., supplying multiple facilities or not associated with the C-400 Cleaning Building at all) may remain in place or be rerouted, as appropriate. Surface and subsurface infrastructure designated to be left in place will be characterized (excluding the C-400 Building structure) based on sample analyses, evaluation of existing data, and/or process knowledge to ensure risks are mitigated properly. Surface and subsurface infrastructure that supply only the C-400 Cleaning Building and/or support structures inside the C-400 Complex may undergo one or more of the following actions:

- Air-gapped;
- Sealed (e.g., grouted);
- Excavated; and
- Addressed by other appropriate means.

The purpose of these actions would be to mitigate potential impacts to the RI/FS, remedial action, etc. One example of a potential impact would be void spaces beneath grade. The following information includes a listing of additional details of these surface and subsurface infrastructure components.

8.9.1 Presence of Aboveground and Subsurface Utilities in the C-400 Complex following C-400 Cleaning Building Deactivation Activities

The area that composes the C-400 Complex OU is crossed by a number of utilities. The expected locations of those utilities (combined) are shown in Figure 8.2. The following text describes the expected location, condition and future use, if any, of these utilities or other physical infrastructure.

8.9.1.1 Communication

The occurrence of communication utility in the C-400 Complex is the presence of underground cabling entering the southern end of the C-400 Cleaning Building (Figure 8.3). These communication cables are not expected to be an environmental hazard.

8.9.1.2 Sanitary, storm, acid, and discard waste lines

A large number of drain lines are located in and around the C-400 Complex (Figure 8.4). All of the lines that are present within the building will have been deactivated from their associated respective line portions located on the exterior of the building. A number of these lines are being inspected with video borescope technology prior to the RI/FS fieldwork (see Section 5.1.5.2 and Appendix D of the RI/FS Work Plan). Nature of contamination in inaccessible lines would be assumed to be consistent with other portions of line that were accessed (e.g., the contamination levels of an inaccessible portion of the acid drain line would be assumed to be consistent with contamination levels from the portions of the accessed acid drain lines).To secure the lines and prevent release of contaminants, it is anticipated the acid drain lines in the basement area(s) will be cut flush with grade and plugs installed as part of C-400 deactivation activities. Also, as apart of C-400 deactivation activities, the acid drain lines that traverse underneath the dip tanks to C-403 Neutralization Pit were grouted from an acid drain cleanout at grade surface, located approximately 24 ft from the northeast corner of the C-400 Building (refer to Appendix D, Figure 6,

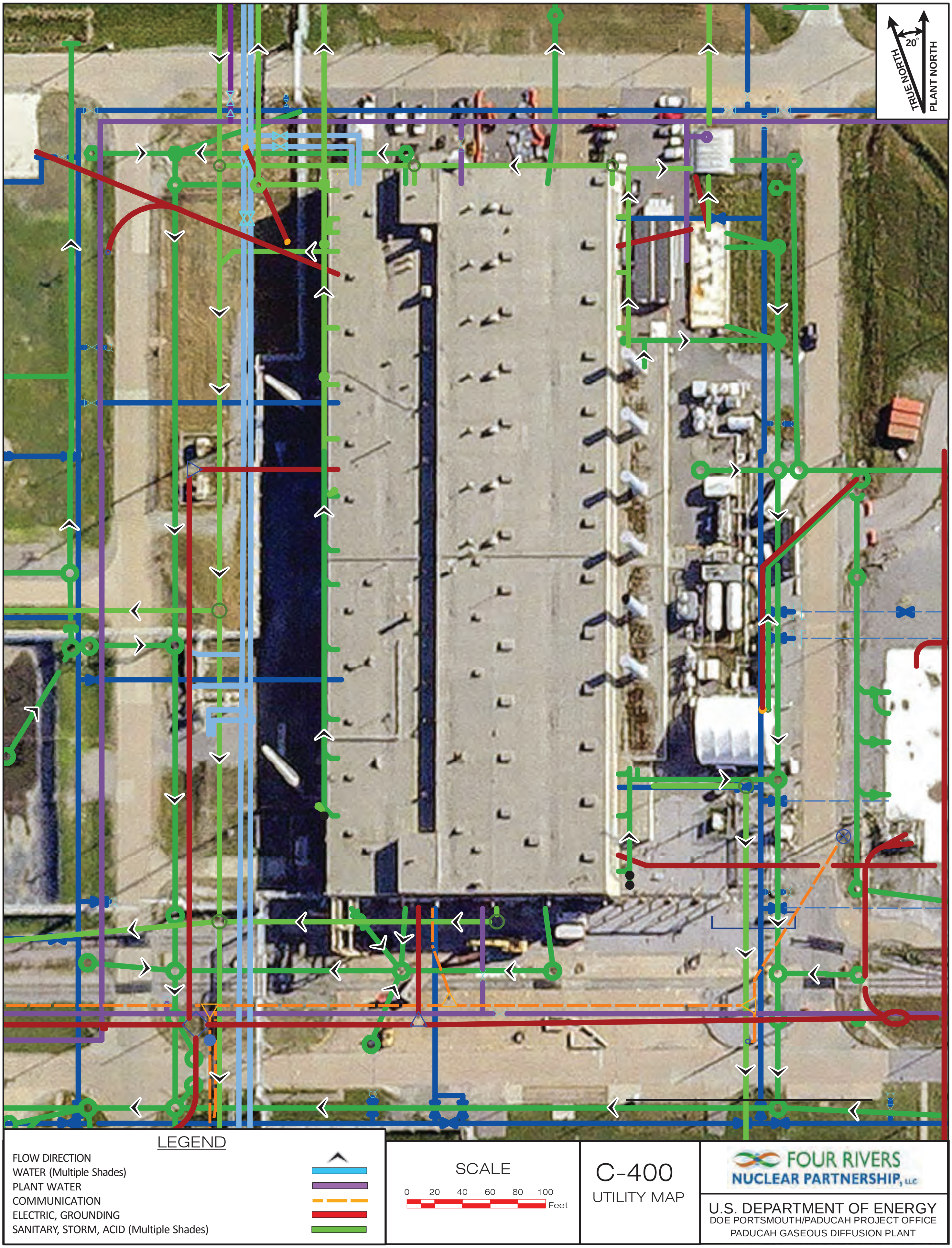

Figure 8.2. Utilities within the C-400 Complex and Adjacent to the C-400 Cleaning Building

Figure 8.3. Underground Communication Cabling within the C-400 Complex and Adjacent to the C-400 Cleaning Building

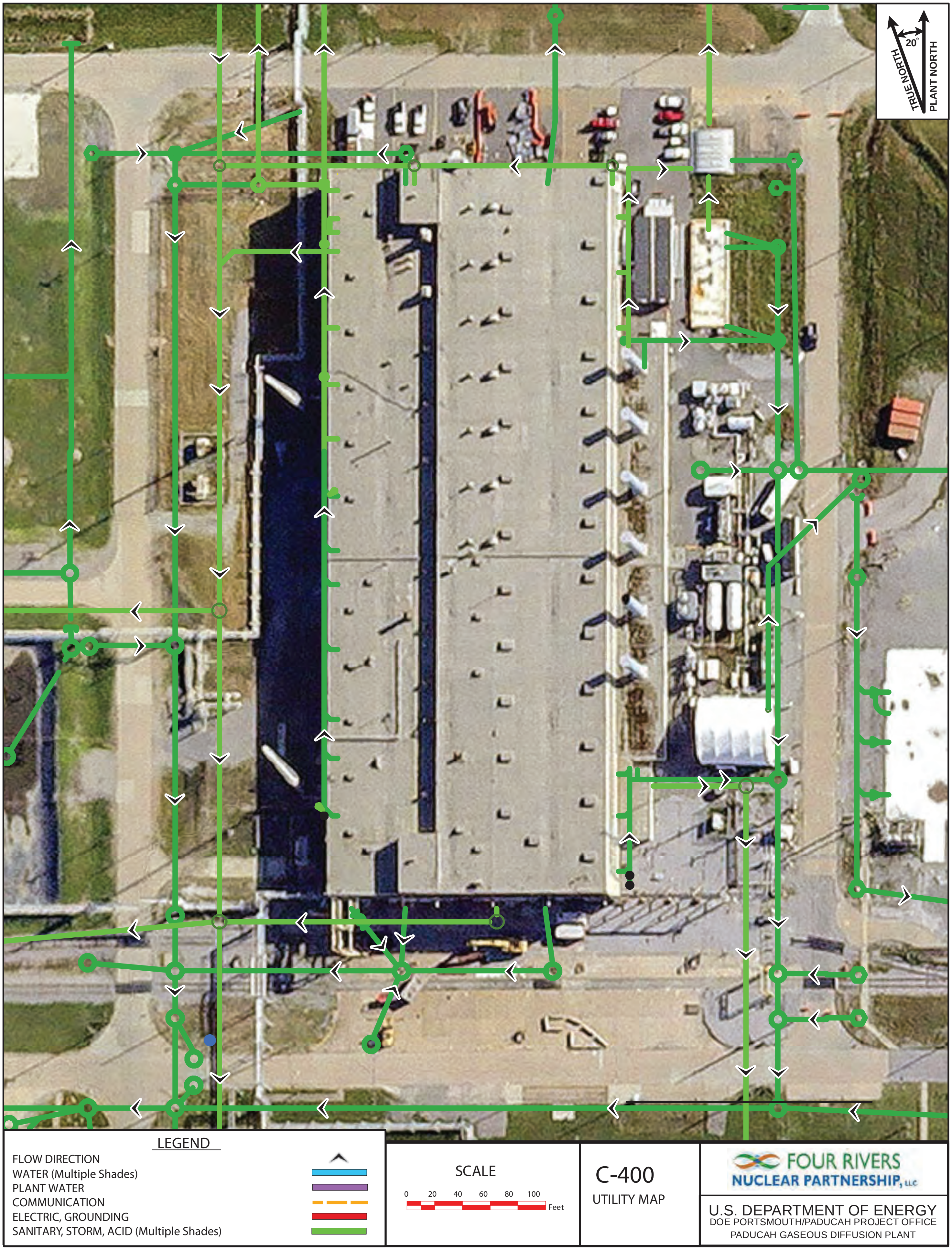

Figure 8.4. Underground Drain Lines within the C-400 Complex and Adjacent to the C-400 Cleaning Building

Video Borescope Locations #6, #32, and #33), to allow video borescoping of the acid drain lines and also to mitigate the potential for liquid from C-403 to back feed into the acid drain lines.

8.9.1.3 Water Supply Lines

All three forms of water supply lines (sanitary water, plant process water, recirculating cooling water) and steam were available in the C-400 Cleaning Building. Figure 8.5 shows the undifferentiated water supply lines going into the C-400 Cleaning Building. Sanitary water and plant process water both are being used at the Paducah Site. The recirculating cooling water no longer is in use for the enrichment process at the Paducah Site; however, the pipeline system still is being maintained and charged with water. The sanitary, plant process water, and steam transfer system would not be expected to contain or be the source of any contaminants in the area of the C-400 Complex. These systems still are being utilized across the Paducah Site.

The recirculating cooling water system lines, as indicated earlier, are not being utilized, but the system is being maintained. Because the system operation included using conditioning chemicals, the system could have released compounds associated with those conditioners. Due to the size of the system and its complexity, it may not be feasible to isolate, abandon, or remove the recirculating cooling lines that are located on the western edge of the C-400 Complex without a decision concerning impacts to the system sitewide.

Steam transfer lines are present at aboveground locations west of the C-400 Cleaning Building. These lines (or a portion thereof) will remain following C-400 Cleaning Building deactivation activities. The steam lines continue to provide steam to other plant locations and will remain in service for the foreseeable future. The portion of the aboveground lines that is located in the area of the C-400 Complex OU will be assessed similar to other water utilities.

8.9.1.4 Electric Power Supply Lines

Electric power is supplied to or from the C-400 Cleaning Building in five locations as shown by the red lines entering the building on Figure 8.6. The cabling associated with these five power access locations leads to electrical equipment located either within the C-400 Complex, but outside the C-400 Cleaning Building, or to equipment located completely outside the C-400 Complex. The power lines to the building will be air-gapped at a location before the cables enter the building and as part of C-400 Building deactivation activities. The portion of the cables that remains buried after building deactivation could remain in place if other reasons do not require their removal. During scoping, it was discussed that the electrical feeder line does not contain PCBs, per the engineering drawings.

Additionally, a number of electrical lines traverse the area that comprises the C-400 Complex. Some electrical equipment units (transformers, electric manholes, pull-boxes, etc.) also will remain in the C-400 Complex area after C-400 Cleaning Building deactivation because they supply other areas of the plant. These lines should remain in place unless reasons are identified that require them to be removed and or relocated.

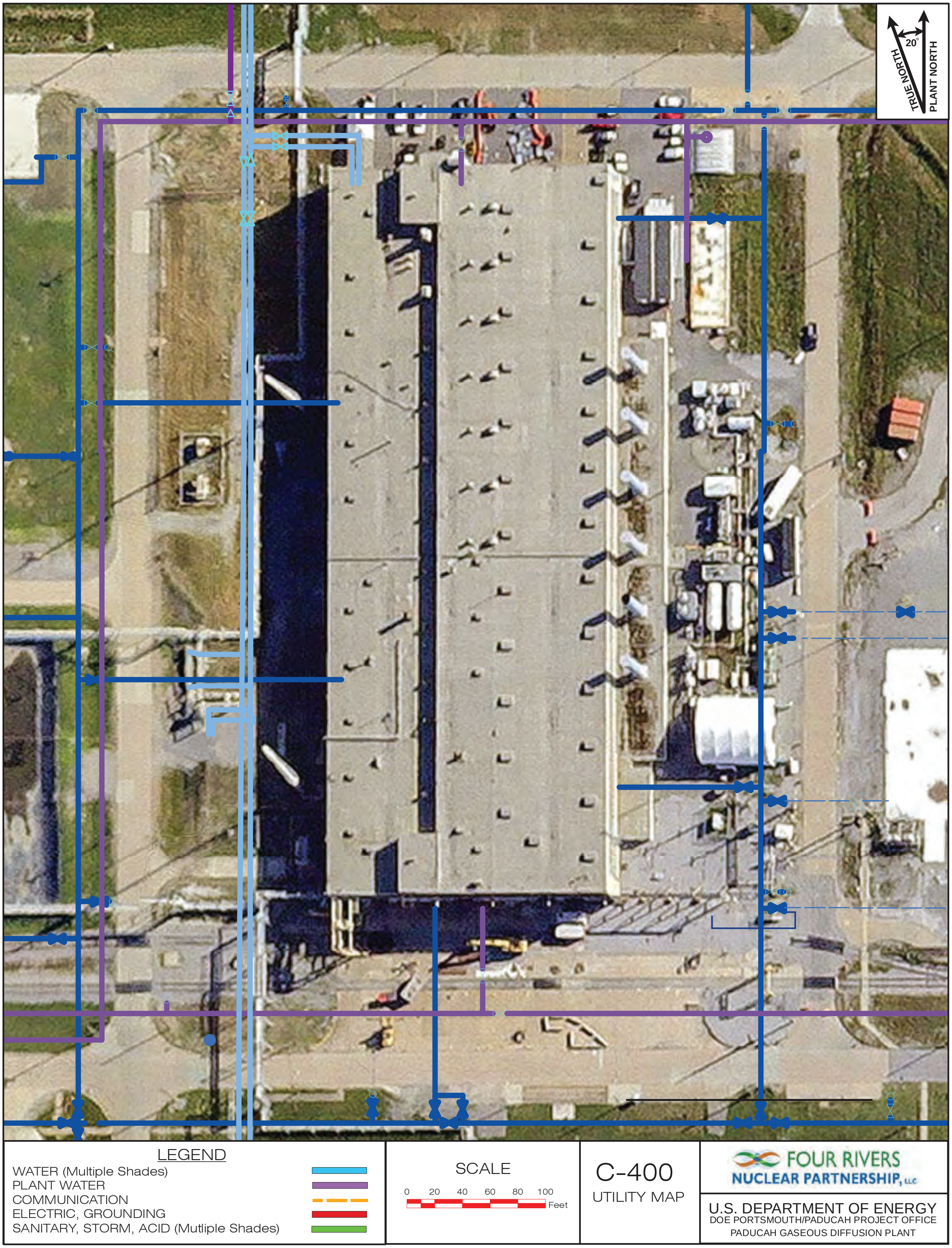

Figure 8.5. Water Supply Lines within the C-400 Complex and Adjacent to the C-400 Cleaning Building

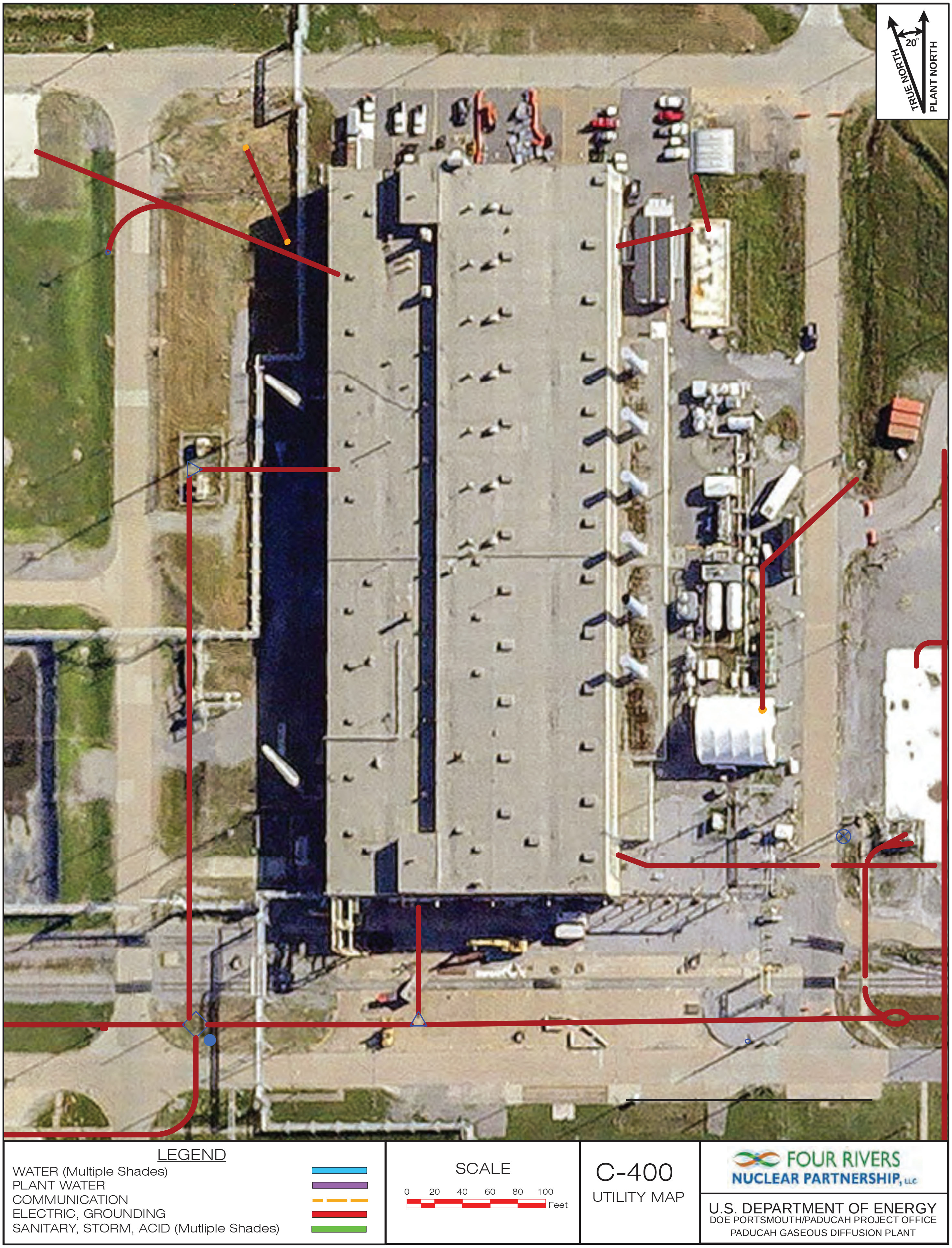

Figure 8.6. Electrical Supply Lines within the C-400 Complex and Adjacent to the C-400 Cleaning Building

8.9.2 Infrastructure and/or Utilities That Remain in the C-400 Complex following C-400 Cleaning Building Deactivation

After completion of building deactivation, some infrastructure items, in addition to utilities, may be present in the area that makes up the C-400 Complex. These items will be assessed as part of the RI/FS Report to see if they require removal, modification, relocation, etc., before or during the performance of any selected remedial action for the C-400 Complex. The assessment of infrastructure and/or utilities that remain in the C-400 Complex following building deactivation activities is discussed further in Section 8.9 and Section 8.9.3. The following are areas and items to be included.

- C-400 Cleaning Building floor and foundation(s)
- C-402 Lime House floor and foundation(s)
- Pavements and ground covers
  - Concrete
  - Asphalt
  - Tar and Chip
  - Gravel
- C-403 Neutralization Tank
- C-400 Acid Waste System
- C-400 Discard Waste System
- Waste heat recovery system equipment (west side)
- Electrical transformer station (west side)
- Utilities that supply other facilities

As discussed during scoping, the southern railroad track (Sectors 4 and 5) is expected to remain in place to support site operations.

8.9.3 Utility and Infrastructure Assessment

The presence of a utility or infrastructure within the C-400 Complex area could result in impacts to risk levels associated with the C-400 Complex. Furthermore, presence of the utility or infrastructure could prevent a selected remedial alternative from being deployed successfully or may require modification to the remedial design for successful implementation. For example, a delay in implementation of the removal action for the C-403 Neutralization Pit (SWMU 40) was determined to be necessary because a 30-inch water line located adjacent to SWMU 40 must be rerouted. The water line is critical to plant operations, and rerouting the water line will interfere with ongoing plant operations. The removal action for SWMU 40 will occur when the 30-inch water line no longer is required for plant operations.

The information developed from the assessment of the remaining utility or infrastructure will be provided in the completed RI/FS Report. Each remedial alternative will utilize this information to the degree necessary to complete the detailed alternative analysis.

9. FIELD SAMPLING PLAN

This Field Sampling Plan for the combined RI/FS for the C-400 Complex area includes an investigation of all remaining building structure(s) (e.g., slab and subsurface structures) and releases of any hazardous substances to soils and groundwater associated with the C-400 Complex area operations (including, but not limited to, TCE DNAPL and high concentration areas considered PTW). The RI/FS is intended (1) to define the full nature and extent of all contamination within the C-400 Complex, from the surface down through the RGA to include the upper McNairy Formation and (2) provide sufficient information to support alternatives development and evaluation of final remedial action(s) for all source areas and related COCs that require remediation for the entire C-400 Complex. This section was developed consistent with discussions held among the FFA parties throughout the RI/FS scoping process, as applicable. Locations shown in this section are general. Locations may be adjusted as field conditions warrant (refusal, unforeseen obstructions, etc.). Over and above the sampling identified in this work plan, additional sampling may be performed as determined by the project team. For example, additional samples may be taken in ongoing sample borings or a boring may be extended to a deeper depth based on observations by the project/field team [e.g., sandy layers with high photoionization detector (PID) readings in the McNairy Formation may result in a groundwater sample being collected at that sample depth], and/or additional borings may be placed. Any additional samples will be collected using the methods described in this section and throughout the work plan (e.g., Section 11) for the same matrix type.

The previous sampling efforts of the WAG 6 RI were targeted to known and expected releases of contaminants. To facilitate scoping of the RI/FS, this work plan has retained sector designations for the C-400 Complex similar to those in WAG 6. The C-400 Cleaning Building footprint is defined as Sector 1, which has been divided further into 4 subsectors (Sectors 1A-1D), based on general associations of process-related contaminants as identified in the C-400 Process and Structure Review (DOE 1995b). The area outside of the C-400 Cleaning Building footprint is divided into 6 sectors, Sectors 2-7 (Figure 9.1).

Sampling activities will focus on the soils and groundwater within the C-400 Complex to a depth of 50 ft into the McNairy Formation (approximately 140- to 150-ft depth). If TCE source zone contamination continuously extends deeper or beyond the boundaries of the C-400 Complex, the CSM is suspect, and FFA parties will evaluate the path forward. Non-TCE source zone contamination of soils and groundwater outside the C-400 Complex will be addressed under other appropriate Paducah Site OUs.

This RI/FS will use multiple sampling approaches to characterize nature and extent of contamination in the C-400 Complex. Because the UCRS is largely unsaturated and commonly has low hydraulic conductivity, soil samples are the primary means of identifying the contaminants present and the level of contamination. Where existing UCRS wells are present within the C-400 Cleaning Building OU and are capable of producing a sample, UCRS groundwater also will be sampled and analyzed. In addition, two shallow piezometers will be installed to monitor water levels in the sub-slab gravel of the C-400 Building. The two piezometers will be completed in the sub-slab gravel at locations in the north and south halves of the C-400 Building (Section 9.3.2 and Section 9.3.3 identify the specific locations). Each piezometer will be set with the screen at the base of the sub-slab gravel, presumably 8 to 11 ft below the C-400 slab. The piezometers will be outfitted with pressure transducers connected to data loggers for in-scope monitoring wells to document conditions during the RI field work. The sub-slab water level measurements are intended to support both understanding the significance of the analytical results from the planned water sample in the sub-slab gravel and assessing the significance of leakage from the roof drain system to the C-400 water budget. With regard to the significance of the analytical results from the planned water sample in the sub-slab gravel, the water level record will identify whether the analysis of the water applies to episodic pulses or a continuous contribution to the UCRS. Moreover, if the common condition is found to be several feet of saturated gravel, it can be anticipated that the sample represents

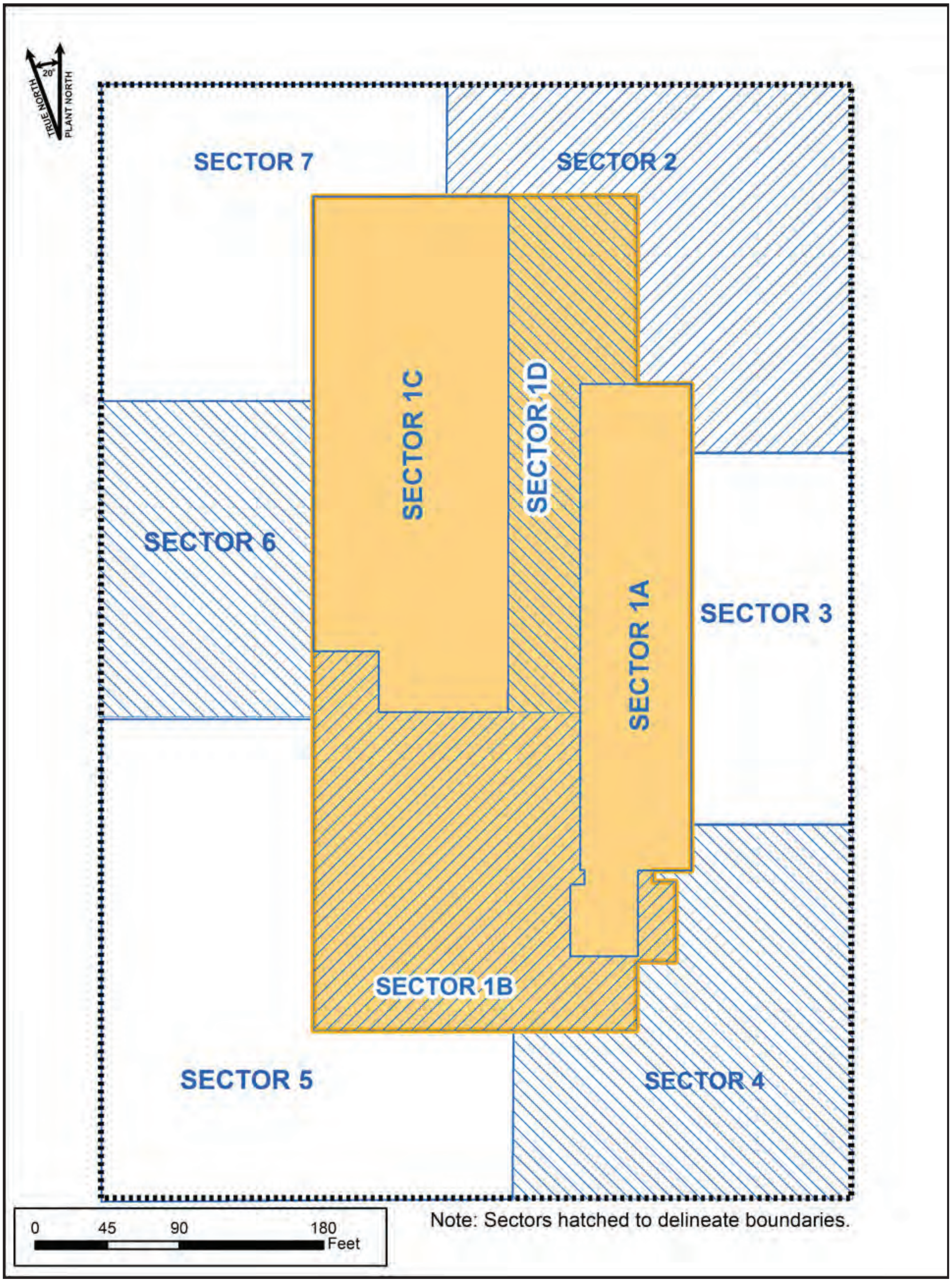

Figure 9.1 C-400 Complex Sectors for the RI/FS

conditions over a broader area because a pool of water would be a local integrator unit. With regard to the significance of leakage of the roof drain system, this input has long been anticipated as a primary component of the C-400 groundwater system. If the subslab water level fluctuates significantly with rainfall, pulses of contaminant contribution to the RGA can be anticipated (and help understand fluctuating contaminant levels in the MWs better). If several feet of water are present continually in the sub-slab gravel, some lateral migration of contaminants in the UCRS away from the C-400 Building can be anticipated (and help understand the extent of shallow contamination better). While the HU4 interval within the top of the RGA (Figure 4.14) is both saturated and hydraulically conductive, it has proven difficult to collect a grab water sample with minimal suspended sediment from the interval. Given that the fine sand matrix can be sampled and analyzed representatively by a laboratory, soil samples will be collected from the HU4[9] in all deep UCRS soil borings. The comparative greater density of deep UCRS/HU4 soil borings, compared to RGA HU5 sample borings, results in good distribution of analyses to characterize both source material and dissolved contamination migrating downward into the RGA.

It has proven difficult to collect grab groundwater samples in the RGA HU5 interval with minimal suspended sediment content. Given that the HU5 primarily has a gravelly sand texture that cannot be grab sampled and analyzed representatively by a laboratory, groundwater is the only medium available for characterization of contaminant levels (and the primary route of exposure to potential off-site recipients). RI/FS sampling to collect HU5 groundwater will incorporate an initial airlift pumping phase, or by other appropriate means, in the initial purge-and-development stage of groundwater grab sampling to expedite removal of suspended solids. To further address obtaining groundwater samples, several MW clusters will be installed, which is discussed further in Section 9.1.2.4. The RI/FS will sample and analyze groundwater in sample borings from up to three depths in the HU5 gravel interval. Three depths (upper, middle, and lower) will be sampled in the south half of the C-400 Complex, and two depths will be sampled in the north half of the complex (actual sample depths based on observed contaminant trends).

Like the UCRS, the McNairy Formation has a fine grained texture and relatively low hydraulic conductivity. Representative groundwater sampling in the McNairy Formation has proven difficult. Soil and groundwater samples will be used to characterize the McNairy Formation. Unlike sampling in the UCRS, the drill rods extending downward to the McNairy Formation will contain water, either introduced by the sampling system or derived from the RGA. Without additional effort, that water will flush through the McNairy Formation soil samples as the sampling equipment is recovered. To minimize the problem and to prevent cross-contamination between the RGA and the McNairy, the drill system used in the UCRS and RGA is intended to stop at the bottom of the Continental Deposits/top of the McNairy Formation. A dual-tube sampling system, a common direct push technology (DPT) approach, or other appropriate means will be used to sample the upper 50 ft of soil in the McNairy Formation through the main drill rods. Prior to extracting the McNairy Formation soil cores, an airlift pump or other appropriate means will be used to purge most of the water in the dual tube sample rods prior to retrieving the soil sample. The RI/FS will sample and analyze groundwater at depths of 10, 20, and 50 ft into the McNairy formation, at 13 preselected McNairy boring locations. RI/FS sampling to collect McNairy groundwater will incorporate an initial airlift pumping phase or by other appropriate means in the initial purge-and-development stage of groundwater grab sampling to expedite removal of suspended solids.

As suitable, the RI/FS will utilize MIP and DyeLIF tools to delineate VOCs and TCE DNAPL further in the soils and groundwater of the C-400 Complex. These tools offer continuous downhole profiles of dissolved TCE levels (MIP) and residual TCE DNAPL (DyeLIF).

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[9] The HU4 interval may be locally absent in the lithologic column. If the HU4 is missing, the base of the HU3 will be sampled.

Conceptually, the RI/FS field work may occur in multiple sectors throughout the complex at any given time and utilize a semiphased approach (using multiple drill rigs and/or multiple combinations of various RI/FS field work activities). Upon FFA approval of RI/FS Work Plan and likely prior to drilling activities, initial field activities may include the Gamma Walkover Surveys (Appendix C); collection of 5-point grid composite soil samples (Section 9.1.2.1); and/or maintenance/redevelopment of existing MWs around the C-400 complex (based on the results of the MW assessment discussed in Section 9.1.2.4), as applicable.

The tentative sequencing for drilling field activities is to begin concurrently with installation of the new MWs and the initial defined sampling locations. Installation of the new MWs will occur as soon as possible to allow installation, development, surface completions, etc., of the wells and initiate quarterly groundwater and colloidal borescope data collection. Drilling fieldwork for the defined sampling locations is anticipated to begin on the south end of the C-400 Complex (e.g., Sectors 4 and 5) and work northward through the entire C-400 Complex. As VOC analytical data from specific sector(s) become available from the lab (post receipt and verification/validation), the FFA parties will participate in review of analytical results from soil and groundwater samples to assist in locating and conducting the MIP and DyeLIF borings. It is anticipated that VOC analysis will be expedited from the laboratory to facilitate timely discussions on the MIP and DyeLIF borings, and these discussions may be broken into specific sector(s) as necessary.

Once MIP and DyeLIF borings are determined for sufficient sector(s) to allow for continuous field work, the MIP/DyeLIF drilling work may commence on the south end of the C-400 Complex (e.g., Sectors 4 and 5). It is anticipated that drilling to collect both analytical data from the initial defined sampling locations and MIP/DyeLIF data will be occurring at this time. As remaining analytical data (other than VOCs) from a specific sector(s) become available from the lab (post receipt and verification/validation) and the results from MIP/DyeLIF are available, then the FFA parties will participate in the review of the data to assist in locating and conducting the contingency borings. Discussions among the FFA parties would occur throughout the field work as specific information from applicable sector(s) becomes available.

During comment resolution meetings the FFA parties used the information in Appendix D of this work plan to agree that one additional sample from SWMU 98 is needed to finalize the work plan. If liquid and/or sludge are present in SWMU 98 during the RI/FS field work, then a sample(s) will be collected. Any additional samples will be collected using the methods described in this section and throughout the work plan (e.g., Section 11) for the same matrix type. This additional sample(s) will be used for a qualitative comparison of the liquid sample results taken after initially removing the sludge material in the sump as described in Appendix D of this work plan (e.g., does a potential source still exist in the sump, associated piping, and/or contamination potentially infiltrating in from the outside the sump).

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 radiological surveys) and intrusive media sampling (surface, shallow, and subsurface soil; concrete; and groundwater). Investigation activities will use industry practices that are consistent with EPA procedures and protocols. Section 11, QAPP Worksheet #21 includes a project sampling procedure references table.

9.1.1 Non-Intrusive Data Collection—Gamma Walkover Surveys

Walkover surveys of accessible areas will be performed for Sectors 2-7 using a Field Instrument for the Detection of Low Energy Radiation (FIDLER) or similar instrument coupled with a Global Positioning System (GPS) device. Examples of areas that are not accessible include structures that remain following deactivation activities (e.g., C-403 Neutralization Pit) and areas close to the C-400 Building structure that impact GPS surveying, etc. The intent of the radiological walkover of the surface soils is to delineate areas of high activity. Based on inflection point analysis of the Gamma Walkover Survey, one biased grab sample per sector will be collected for Sectors 2-7. These samples will be collected from 0-0.5 ft bgs and analyzed for the radionuclides listed in Table 6.1 (excluding those designated with footnote “a”). This approach is consistent with the Soils OU RI (DOE 2014). Appendix C of this document provides additional information regarding the Gamma Walkover Survey and determination of the sample location.

9.1.2 Intrusive Sampling

Various media samples will be collected to characterize C-400 Complex area locations, as discussed during scoping. The samples will be collected using DOE Prime Contractor procedures and will be submitted for analysis to a fixed-base, analytical laboratory.

9.1.2.1 Surface soil and shallow soil sampling

Sampling for each sector will include grid-based composite sampling [consistent with the Soils OU RI (DOE 2014)] unless otherwise noted. As discussed in Section 9.1.1 and Appendix C of this document, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7. The majority of intrusive sampling for surface soils and shallow soils will be comprised of composite samples. For compositing, equal volumes from each of the specified sampling locations are obtained. The volume of each sample typically is at least the amount required for a single sample. Samples then are thoroughly homogenized, and a subsample is collected for analysis. Prior to homogenization, sample portions for VOC analysis will be collected from the center of the five-point grid.

Surface soil and shallow soil samples will be collected as five-point composites from 50-ft × 50-ft grids. Collection of the five points for each composite will be as shown in Figure 9.2. Unless otherwise noted, one grab sample will be collected from the center of the grid. Four additional grab samples will be collected 20 ft from the center point in each cardinal direction (north, south, east, and west). On alternating grids, grab samples will be collected from the center of the grid and four additional grab samples will be collected 20 ft from the center point in each secondary direction (northeast, northwest, southeast, and southwest). Samples will be collected from the surface (0-1 ft bgs) and shallow subsurface (1-4 ft bgs) and composited separately (i.e., one composite sample for surface and one composite sample for shallow subsurface for each grid).

Surface soil and shallow soil samples will be collected as five-point composites from 50-ft long grids along the railroad in Sectors 4 and 5. Collection of the five points for each composite will be from random locations, as determined using Visual Sample Plan (PNNL 2018). These locations are shown in Subsections 9.3.7 and 9.3.8. Samples will be collected from the surface (0-1 ft bgs) and two sets of depths in the shallow subsurface (1-4 ft bgs and 4-7 ft bgs) and composited separately (i.e., one composite sample for surface and one composite sample for each of the shallow subsurface intervals for each grid).

Each composite sample will be analyzed for SVOCs, radionuclides, metals, and PCBs as listed in Table 6.1 (except the radionuclides for designated locations). Samples for VOC analysis will be collected from the center of the five-point grid (prior to obtaining the soil samples for homogenization). The 50-ft long grids along the railroad in Sectors 4 and 5 also will be analyzed for dioxins and furans and pentachlorophenol. The samples for additional analyses will include at least one sample for surface soil and one shallow subsurface soil representing each C-400 Complex sector being sampled. These samples for additional analyses will be selected randomly over all sample locations within the sector.

Each sample point in the 50-ft × 50-ft grids represents a 2,500 ft^2 area. Should any individual sample point within the grid be obstructed (such as by a concrete slab), then the nearest possible location will be substituted. If a suitable location (e.g., the entire quadrant of the grid) is not available, then the composite will consist of fewer than five points, as necessary.

Grids will be positioned so that as much of the sector boundary is covered as possible. By utilizing the alternating grid pattern as shown in Figure 9.2, the maximum unsampled area will be minimized for any sector requiring more than one grid. Additional grab sample points may be collected in the field to obtain biased sampling based on results obtained from radiological walkovers, as described in Section 9.1.1.

Composite sampling provides an average of the contamination over the grid. Although individual hot spots within the grid may not be evident, the overall benefit of the grid coverage is to provide a decrease in the uncertainty of concentrations in the area.

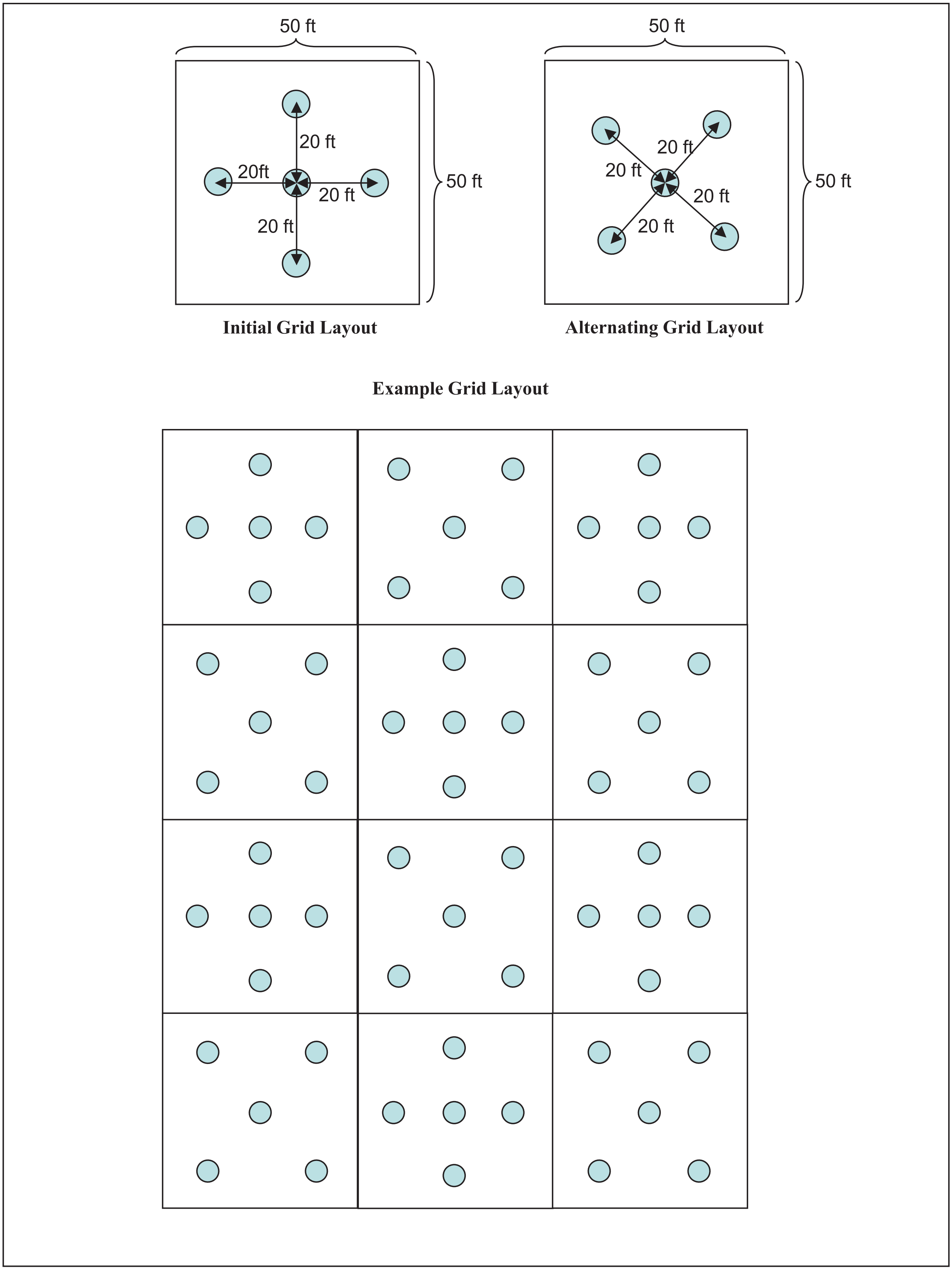

Figure 9.2. Grab Sample Locations within Each Composite Grid

The averaging of the soil concentrations potentially may lead to incorrectly omitting COPCs from the unit because chemicals or radionuclides elevated only slightly above background at one or two spots may not have a concentration in the composite sample that exceeds background. This is unlikely to affect the list of COCs that requires remedial action because selection of COCs is based on a significant contribution to risk and/or hazard at the site from the exposure concentration (which is generally a 95% UCL of the mean concentration).

9.1.2.2 Concrete sampling

Concrete media will be sampled based on two criteria: (1) defined areas to determine the presence and level of contaminants potentially in the concrete, and (2) evaluate if contamination in slab is a potential source to the underlying subsurface media. Each of the concrete samples will be analyzed for the following contaminant analytical groups.

- VOCs
- SVOCs
- Metals
- PCBs
- Radionuclides

A concrete coring machine, core barrel, drilling machine, or other appropriate means will be utilized to remove a sample of the remaining slab prior to subsurface drilling/sampling. The concrete samples will be size-reduced to fill sample containers. Two samples will be obtained from each concrete location. One sample will be obtained from the upper portion (thickness depends upon the amount of material necessary for analysis) and other sample will be collected from the lower portion (thickness depends upon the amount of material necessary for analysis) of the concrete sample location. The upper portion sample will provide indications of the presence of contaminants that may have been released where the sample was obtained. The lower portion sample is expected to provide an indication of whether contamination that was released could have permeated the concrete thickness and acted as a source of contamination to the soil beneath the slab. Additionally, the presence of contaminants in the lower portion sample will provide data to indicate the level of contamination in the volume of the slab. Accommodations will be made to demarcate the area to mitigate safety hazards to foot traffic once the concrete samples have been removed. In areas where multiple construction materials (e.g., multiple discreet concrete layers, acid brick lining) are located, an additional sample will be collected at each interface to support characterization of the slab.

Concrete samples (other than PCB analysis) will be collected in accordance with CP4-ES-2002, *Sampling of Structural Elements and Miscellaneous Surfaces*. For PCB sampling, concrete closely collocated with the non-PCB concrete cores will be collected consistent with the techniques contained in PCB sampling procedure, *Standard Operating Procedure for Sampling Porous Surfaces for Polychlorinated Biphenyls (PCBs)* (EPA 2011).

9.1.2.3 Subsurface soil sampling

Subsurface soil samples will be collected to represent each of the UCRS HUs (HU1 through HU3), the RGA HU4, and the upper 50 ft of the McNairy Formation (Figure 4.14). Soil samples will be collected in accordance with CP4-ES-2300, *Collection of Soil Samples*, or CP4-ER-1020, *Collection of Soil Samples with Direct Push Technology Sampling*, or other appropriate work controls may be developed if field conditions warrant. Field instruments will be used to screen soil cores collected from the HUs for VOCs and radiological contamination. Samples for VOCs and SVOCs will be collected from the soil core interval within the HU with highest VOC level as determined by field PID readings. Radionuclides and metals will be collected from the soil core interval with highest radiological activity. Radiological screening of the soil cores will be conducted in accordance with the procedures identified in Section 11, QAPP Worksheet #21.

Subsurface soil samples from soil borings will be collected in accordance with DOE Prime Contractor procedures. The specific sample equipment selected for utilization will be dependent on the drilling technology being used. Potential drilling methods for vertical borings include DPT, hollow stem auger (HSA), and rotary sonic. The intended drilling systems, drill casings sizes, sampling methods, etc., are described below. The actual drill rig, drill casing sizes, sampling methods, etc., used, however, may be different based on driller's recommendation and/or as field conditions warrant.

Contaminant analyses

For sampling in and through the RGA, the primary drill system intended for use is a rotary sonic rig and 4-/6-/8-inch diameter drill string assembly,[10] extruding the 4-inch diameter core in a plastic liner, in 10-ft-or-less lengths, to a target depth of 88 ft. (Commonly, the initial drill string advance is 8-ft depth, leaving a 2-ft stickup, and subsequent advances are 10-ft depth.) The target depth of 88 ft was the median depth of the top of the McNairy Formation in 14 deeper soil borings of the WAG 6 RI (DOE 1999a).

If the drill string has not reached the McNairy Formation at a depth of 88 ft, the drill crew will advance the drill string in 5-ft increments until the McNairy Formation is encountered (as identified by project geologists based on lithologic logging of the soil core).

Once the 4-/6-/8-inch drill string assembly has been advanced into the upper McNairy Formation (to a maximum depth of 5 ft), the 8-inch drill string will be set to a minimum depth of 5 ft below the top of the McNairy Formation. (Any advance of the 8-inch drill string below the 4-inch/6-inch assembly will be attempted without the addition of water and by down force only, if possible.) The 8-inch drill string will be used as a temporary isolation casing to prevent downward migration of pooled DNAPL into the McNairy Formation.

Field screening (visual identification, PID measurements of 300 ppm or greater, etc.,) will be used as an indicator of TCE DNAPL. If field screening indicates TCE DNAPL is migrating downward into the McNairy Formation as the sample borehole is being advanced, then the field crew will stop advancement of the borehole immediately and consult with the FFA parties. One option would be to plug and abandon the borehole. The following are indications of TCE DNAPL migration with the advance of the sample borehole.

- Occurrence of very high TCE levels (as indicated by high PID readings) only along the outside edge of the McNairy soil core (suggesting TCE DNAPL is entering inside the drill casing but has had insufficient time to penetrate the soil).

- Repeated occurrence of high TCE levels (as indicated by high PID readings) only at the bottom of the McNairy soil core (suggesting TCE DNAPL is migrating downward along the outside of the drill casing and is pooling in the bottom of the borehole).

- Where high TCE levels (as indicated by high PID readings) occur only at the bottom of the McNairy soil core intermittently and the bottom of the McNairy soil core is located in a transmissive zone (e.g.,

[10] Diameters are approximate.

sand lens) and the field geologist determines DNAPL is not being transported vertically down the borehole (e.g., where DNAPL had distributed as lenses), then sampling to target depth may continue.

Any decision to terminate a soil boring before reaching the target depth or continuing to the target sample depth where DNAPL is indicated will be a collaborative judgement of the project/field team and will be documented in the geologist's project notebook.

If flowing sand conditions in the McNairy Formation challenge the traditional sonic sampling approach, the sample team may attempt to sample to the target depth (without any further advancement of the 8-inch diameter drill string) using a 4-inch drill string with a split-barrel sampler assembly (and using the 6-inch drill string as overshot casing) or may attempt to use a DPT dual-tube sampling system.

VOC screening results of the soil core from PID measurements will be used to determine if additional sampling is required below the target depth.

Upon completion of sampling in a borehole, with the inner sample system removed, fill/sealing materials will be placed promptly in the borehole through the 6-inch drill string or DPT dual-tube casing. For borings that penetrate the McNairy Formation, a sufficient volume of 30%-solids bentonite grout will be placed in the bottom of the drill string to fill 110% of the calculated volume of the open borehole in the McNairy Formation. Afterward, the drill strings will be retracted to the depth of the top of the McNairy Formation. (The drill crew will measure depth to water inside the drill string as each section of the drill string is removed from the McNairy Formation to verify that the grout is flowing in the open borehole.) A sand basket or similar device may be set at the top of the McNairy Formation through the drill string to prevent overlying sand fill (yet to be placed) from displacing the bentonite grout in the McNairy Formation.

The drill crew will fill the borehole with 20-40 mesh well sand throughout the RGA interval and extend 2 ft up into the overlying HU3 silt/fine sand interval of the UCRS by placing the sand in the drill string and vibrating as the drill string is withdrawn. The intent is to fill the open borehole with sand throughout the RGA interval. (Site experience is that bentonite placed in an RGA borehole will bleed off into the aquifer.)

A 2- to 4-ft thick bentonite pellet seal will be placed on top of the sand column. (The hydraulic potential of the RGA/water level is higher than the top of the RGA; the RGA will hydrate the bentonite pellets.) The remainder of the borehole will be sealed with cement-bentonite slurry API Class A or B neat cement with no additives (or equivalent) through the drill string, as the drill string is recovered.

Upon collection, the soil core will be laid out in a top-to-bottom order on a table in a designated sample area in the vicinity of the drill rig. While the soil core still remains within the sample liner (if sampling by DPT or Sonic system) or the core remains in the sampling equipment (in the case of a HSA system), the sample liner or sampling equipment will be scanned radiologically with hand-held instruments to identify any occurrences of radiological contamination that require special handling. Instruments compliant with DOE Prime Contractor procedures will be used for this effort.

Upon release of the soil core by the radiological control technician (RCT) (still within the liner or sampling equipment), the total recovered core length for the sample interval will be measured and recorded, then the plastic soil core liner will be slit open or the core will be removed from the soil sampling equipment. With the exposed core on the table top, the soil core will be split length-wise to reveal the soil texture and provide a clean surface for radiological scans and sample collection; then one of the soil halves will be covered with aluminum foil sheeting. The soil core will be defined in 0.5 ft depth intervals[11] along the soil core length. The exposed soil core will be scanned immediately for gamma activity and beta activity at 1.0 ft depth intervals using the hand-held instruments, results documented, and any soil core that requires special handing identified.

Following radiological scans of the soil core, the covered soil core will be scanned for offgas VOCs levels at the 0.5-ft depth intervals by piercing the aluminum foil sheeting and underlying core with an awl and using a field PID with a 10.6 electron Volt (eV) lamp,[12] capable of detection of VOCs at ppb levels. The PID readings will be documented and the VOC sample area (intended as highest offgas VOC levels in the core) will be identified. A VOC sample will be collected immediately and stored in an iced cooler. In the case that VOC levels are consistent throughout the soil core, direct observation (discrete color, odor, or sand texture) may be used to determine the sample depth.

The depth interval of each HU will be assigned by observation of the soil core. VOC samples will be collected, initially, from each soil core. The complete HU interval may extend across several soil cores. A single VOC sample (based on the highest PID reading) will be retained for each HU and submitted for laboratory analysis: other VOC samples that were collected will be disposed of with the waste soils. Samples for SVOC analysis will be collected from the soil core adjacent to the VOC sample depth used for analysis and stored in an iced cooler. Samples will be collected for radionuclide analysis from the depth interval in each HU with highest alpha/beta activity (indicator of Tc-99). If a hotspot of gamma activity (indicator of uranium) is observed, a second sample for radionuclide analysis will be collected at that depth. Samples for metals analysis will be collected from the soil core adjacent to the radionuclides sample. If a gamma activity hotspot is present, the sample for metals analysis will be collected at that depth.

The readings from the VOC and radioactivity scans and any other criterion used to select the sample interval(s) will be documented in project log books. If no criterion is apparent to select samples in a UCRS HU or HU4, samples will be collected from the following default depths:

- HU1—10 ft
- HU2—20 ft
- HU3—35 ft
- HU4—(if present) 60 ft

In the McNairy Formation, soil samples will be collected for the full suite analyses at depths of 0, 10, and 20 ft below the base of the Continental Deposits (top of the McNairy Formation) in approximately half of the McNairy borings. In 17 defined McNairy boring locations, soil samples will be collected for analysis at depths of 0, 10, 20, 35, and 50 ft below the top of the McNairy Formation. At five[13] select locations, additional McNairy soil samples will be collected for VOC analysis at depths of 0, 1, 2, 3, 4, 6, 10, and 20 ft below the top of the McNairy Formation. The primary goal of these shallow McNairy samples is to characterize better the distribution of TCE in the uppermost McNairy Formation. These sample results

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[11] Sample and scan intervals will be identified by downhole depth. With the exception of obvious loss of core, depth intervals in the soil sleeve are corrected for length of soil core recovery by a multiplication factor that is derived as the total length of core recovered divided by the length of the downhole sample interval. For example, a sample sleeve containing 15 ft of recovery for a 10-ft sample interval would have a multiplication factor of 15/10 or 1.5. Scan intervals of 0.5-ft downhole depth would be spaced 0.5 ft × 1.5 (0.75 ft) apart.
[12] A 10.6 eV lamp is specified to be able to detect TCE (which has ionization energy of 9.47 eV and its anaerobic degradation products (DCE isomers and VC, with ionization energies of 9.65 to 9.99 eV).
[13] Four locations were determined during scoping, and these are included in the subsections that follow. The fifth location will be determined in the field.

and contingency samples, if applicable, in conjunction with MIP and DyeLIF surveys, will be used to assess TCE extent in the McNairy Formation. A description of the core will be developed following sampling.

MIP and DyeLIF

The RI/FS includes downhole profile surveys using MIP and DyeLIF tooling to provide additional characterization of VOCs in the dissolved-phase and as DNAPL, following receipt and assessment of analyses of the initial soil and groundwater samples. Both MIP and DyeLIF results require correlation to optimize the use of the data. To correlate the MIP and DyeLIF results, this RI/FS will characterize VOC levels in soil and groundwater in two sample borings from near land surface down to the upper 20 ft of the McNairy Formation (a depth of approximately 110 to 120 ft bgs). The two characterization sample borings will be located in areas of TCE DNAPL as interpreted from the analyses of the initial soil and groundwater samples. One of the characterization sample borings is expected to be located in the vicinity of sample location 400-S04-12 (Figure 9.15).

In the two sample borings, soil samples for VOC analysis will be collected at 2-ft intervals to the top of the HU5 gravel interval of the RGA and at 2-ft intervals in the underlying McNairy Formation. Groundwater samples will be collected in the HU5 gravel interval only, at intervals of 5 ft. An alternative approach will be to use laser-induced fluorescence (aboveground and with DyeLIF dye if needed) to identify VOC DNAPL in the soil cores and collect representative soil samples based on the induced fluorescence. The first MIP and DyeLIF surveys will be completed in close proximity (within 1 ft of the characterization sample borings if possible) to enable correlation of the fixed-base lab VOC results with the MIP and DyeLIF data. Additional correlation techniques may be utilized, as proposed by the vendor and based upon previous knowledge with these characterization tools.

The spatial variability of soil properties and the related dissolved phase and DNAPL occurrence may result in a poor quantitative comparison of MIP and DyeLIF results against the laboratory results for the characterization sample boring. The correlation analysis, therefore, will rely upon site experience to define appropriate subsets of the analytical, MIP, and DyeLIF data and statistical tendencies (e.g., median, minimum, or maximum of an interval) to optimize the calibration of the MIP and DyeLIF results.

MIP and DyeLIF borings may be advanced to the base of the RGA and up to 1-ft deep into the McNairy Formation without a temporary isolation casing. The electrical conductivity log of the MIP tool and the hydraulic profiling log of the DyeLIF tool can be used to identify the depth of the top of the McNairy Formation in the field.

Where the MIP or DyeLIF tooling will be advanced farther (greater than 1 ft into the McNairy Formation), the MIP/DyeLIF tooling will be retrieved, and a 3-inch/5-inch rotary sonic drill string assembly (or alternate casing assembly proposed by driller) will be advanced over the MIP hole to the depth of the top of the McNairy Formation. Beginning at the depth of the top of the McNairy Formation, the drill crew will advance the 5-inch diameter drill string, without the addition of water and by downforce only, if possible, for a minimum of 5 ft. The 5-inch drill string will be used as temporary isolation casing.

Following drilling, the drill crew will clean out the hole to the top of the McNairy Formation with the 3-inch drill string assembly and then extract the 3-inch tooling. The MIP tooling then will be set to the depth of the top of the McNairy Formation, through the 5-inch diameter sonic drill string, and advanced to the targeted depth of investigation or depth of refusal.

Upon completion of the MIP/DyeLIF survey, the MIP/DyeLIF tooling will be withdrawn, and the driller will seal/fill the borehole through the 5-inch diameter drill string following the same steps used for soil sampling.

Geotechnical and Geochemical Analyses

Locations designated for geotechnical sampling will require a pair of adjacent soil borings. The first soil boring at each location will be sampled for soil analyses as described in Subsection 9.1.2.3, "Subsurface Soil Sampling," and groundwater analyses as described in Subsection 9.1.2.4, "Groundwater sampling," and the soil stratigraphy will be documented. Geotechnical samples will be collected based on lithology defined in the initial split core for the designated location. The geotechnical samples will be collected whole (i.e., not split into two halves).

The second soil boring at each location will be sampled for geotechnical and geochemical parameters using sampling equipment appropriate to the test methods. Single soil samples will be collected for each of the appropriate geotechnical and geochemical analyses from each UCRS HU and the HU4, and two samples will be collected from the HU5 and from the McNairy Formation. The sample depths will be selected to represent the primary range of soil textures present in each HU. Table 9.1 summarizes the applicable geotechnical and geochemical analyses for the RI soil samples.

Archival

The RI/FS fieldwork must be completed prior to preparation of the RI/FS Report and its assessment of potential remedial actions. To partially address uncertainty of the completeness of geotechnical analyses in support of the remedial action(s), a 3-ft length of representative core may be collected and stored (refrigerated) for each UCRS HU, HU4, the upper, middle, and lower sections of HU5, and the McNairy Formation. If adequate storage space is identified, the cores will be archived; then these cores will be available for geotechnical and laboratory bench-scale analyses, if needed. If it is determined in the future [e.g., prior to implementing remedial action(s)] that these archived cores no longer are needed, waste will be dispositioned in accordance with Chapter 13 of this document.

Lithologic description

The description of the physical appearance of the soils being sampled is acquired from each new soil boring. Depth, color, grain sized, and texture facilitate development of 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. Continuous soil boring logs will be prepared for each deep UCRS and RGA/McNairy Formation soil boring core collected for the C-400 Complex RI/FS. The cores of each geotechnical soil boring will be photo documented.

9.1.2.4 Groundwater sampling

RGA and McNairy groundwater grab samples from boreholes will be analyzed for TCE, TCE degradation products, Tc-99, PCBs, and PAHs. Unfiltered groundwater samples will be collected for TCE and TCE degradation products. Both filtered and unfiltered groundwater samples will be collected for PCBs, PAHs (both used to identify source zone delineation–as a positive bias), and Tc-99 (used for source zone delineation). No metals or radionuclides (except Tc-99) will be analyzed in groundwater grab samples from boreholes.

- If turbidity of the groundwater sample > 100 NTUs, then results can be used qualitatively.
- If turbidity of the groundwater sample < 100 NTUs, then results can be used quantitatively.

Table 9.1. Geotechnical and Geochemical Analyses for Soils

ANALYSIS	METHOD(S)[a]	SIGNIFICANCE	APPLICABLE SAMPLES
Anion Exchange Capacity	To Be Determined (TBD)	Determining clay behavior and modeling chemical treatment of soil	HU1–HU3, HU4 & HU5
Cation Exchange Capacity	EPA Method 9081 American Society for Testing and Materials (ASTM) D7503-18	Determining clay behavior and modeling chemical treatment of soil	HU1–HU3, HU4, HU5, & McNairy Fm.
Clay Mineralogy	"Free Swell Ratio and Clay Mineralogy of Fine-Grained Soils," *Geotechnical Testing Journal*, Vol. 27, No. 2, 2004, pp. 220-225 X-Ray Diffraction	Dominant clay minerals present	HU1–HU3, HU4, HU5, & McNairy Fm.
Compaction–Standard Effort (12,400 ft-lb/ft^3)	ASTM D698-12e2	Engineering assessment of fill properties	HU1 & HU2
Compaction–Modified Effort (56,000ft-lb/ft^3)	ASTM D1557	Engineering assessment of fill properties	HU1 & HU2
Consolidation	ASTM D2435	Engineering assessment of fill properties	HU1–HU3, HU4 & HU5
Density of Soil	ASTM D7263–09(2018)e1	Engineering assessment of soil	HU1–HU3, HU4, HU5, & McNairy Fm.
Direct Shear	ASTM D3080-98	Friction angle of soil strength	HU1–HU3, HU4, HU5, & McNairy Fm.
Distribution Coefficients (K_d)	ASTM C1733-17a ASTM D4319	Mass transport modeling	HU1–HU3, HU4, HU5, & McNairy Fm.
Electrical Conductivity/Resistivity	"A Simple Methodology for Determining Electrical Conductivity of Soils," *Journal of ASTM International*, No. 5, 2204, pp. 1-11 ASTM G187-12a	Assessment/modeling of ERH	HU1–HU3, HU4, HU5, & McNairy Fm.
Fraction Organic Carbon	EPA Method 415.1 SW-846-9060, as modified for soil samples	Mass transport modeling	HU1–HU3, HU4, HU5, & McNairy Fm.
Grain Size	ASTM D1140 (Wet Sieving)	Clay/silt fraction (accurate assessment)–engineering assessment of soil properties	HU1–HU3, HU4, HU5, & McNairy Fm.
	ASTM 152H (Hydrometer Analysis)	Clay/silt fraction–engineering assessment of soil properties	HU1–HU3, HU4, HU5, & McNairy Fm.
	ASTM D6913M-17	Sand/gravel fraction–engineering assessment of soil properties	HU1–HU3, HU4, HU5, & McNairy Fm.
Hydraulic Conductivity of Unsaturated Soils	ASTM D7664-10	Analysis of water movement in unsaturated soil	HU1–HU3

Table 9.1. Geotechnical and Geochemical Analyses for Soils (Continued)

ANALYSIS	METHOD(S)[a]	SIGNIFICANCE	APPLICABLE SAMPLES
In Situ Water Content	ASTM D2216-10	Engineering assessment of soil properties	HU1–HU3, HU4, HU5, & McNairy Fm.
Index Properties	ASTM D4318-10	Engineering assessment of soil properties	HU1–HU3, HU4, & McNairy Fm.
Permanganate Natural Oxidant Demand	ASTM D7262-10(2016)e1	Assess the permanganate consumed by naturally occurring species.	HU4, HU5 & McNairy Fm.
Permeameter Testing	ASTM D5084-10	Vertical hydraulic conductivity of soil	HU1-HU4 & McNairy Fm.
pH	ASTM D4972-13	Assess the solubility of soil minerals and mobility of ions	HU1–HU3, HU4, HU5, & McNairy Fm.
Soil Matric and Total Potential	ASTM D5298-16	Free energy of pore-water in soil	HU1–HU4 & McNairy Fm.
Soil Water Characteristic Curve	"Determination of the Soil-Water Retention Curve and the Hydraulic Conductivity Function Using a Small Centrifuge," *Geotechnical Testing* Journal, Vol. 34, No. 5, 2011, pp. 457-466 ASTM D6836-16	Hydrological characterization of unsaturated soils/modeling of unsaturated water flow	HU1–HU3, HU4, HU5, & McNairy Fm.
Specific Gravity	ASTM D854-14	Required for assessment of degree of saturation of soil	HU1–HU3, HU4, HU5, & McNairy Fm.
Standard Penetration Test	ASTM D1586-11	In-place dynamic shear test for indication of density of cohesionless soils and strength of cohesive soils	HU1–HU3, HU4, HU5, & McNairy Fm.
Unconfined Compressive Strength	ASTM D2166-16	Compressive strength of soil	HU1–HU3, HU4, HU5, & McNairy Fm.
Unconfined Compressive Strength (lateral confinement)	ASTM D2850-15	Compressive strength of soil	HU1–HU3, HU4, HU5, & McNairy Fm.

[a] Alternate methods may be used, as necessary. If a laboratory cannot be located to complete a proposed or alternate method, then the analyses will not be performed.

The NTU criterion (100 NTUs) might be updated if additional information is brought forward. NOTE: the EPA field guidance uses 10 NTUs. Grab samples will be used in concert with other information in the RI/FS Report. The data will be used qualitatively to assess nature and extent, not for fate and transport modeling or for risk assessment. Groundwater grab sample data collected from boreholes will not be used for risk screening, regardless of turbidity. MW samples will be sampled for full suite of analyses. Risk screening will be performed only on MW data.

Soil borings will be used to collect grab groundwater samples within the RGA and the McNairy formation, at 13 defined locations. Groundwater samples will be collected in accordance with

CP4-ES-2101, *Groundwater Sampling*, (which requires groundwater samples to be collected directly into sample containers).

Three groundwater samples (upper, middle, and lower RGA) are being collected in specific sectors to characterize the anticipated location of TCE PTW. Two groundwater samples (middle and lower RGA) are being collected in other sectors to characterize the extent and magnitude of dissolved-phase contamination. Note, in all sectors, soils samples are being collected from the HU4 interval, where present, to characterize the contaminant contribution to the RGA. Where two samples are collected, they will be collected at depths of 15 ft below the top of the HU5 interval (middle RGA) and at the base of the HU5 interval (lower RGA). Where a third sample is collected, it will be collected at a depth of 5 ft below the top of the HU5 (upper RGA). Locations designated for two or three samples are discussed further in Section 9.3. The soil borings will be drilled using methods that allow collection of discrete-depth water samples with reduced vertical cross-contamination. Discrete RGA groundwater samples will be collected as each water sample depth is reached. A water-level indicator will be placed down the boring, and the water level will be monitored. Once the groundwater level stabilizes (or 15 minutes, whichever comes first), the sampling crew will purge the water column in the drill string with an airlift pump or by other appropriate means. With the recovery of the water level, the sample crew will successively purge the water column until the suspended solids content is noticeably reduced. If after five wetted drill volumes have been purged and suspended solids content is not noticeably reduced, then it will be documented, and documentation will be included with future use of the data. At that point, the airlift pump system (or other appropriate system) will be removed and a sampling pump will be lowered into the boring and the sample collection process will continue to purge the sample interval. A bladder pump, electric submersible pump, or inertial pump may be used to purge the boring and to collect water samples.

Discrete McNairy groundwater samples will be collected in 13 preselected boring locations at depths of 10, 20, and 50 ft into the McNairy Formation. A water-level indicator will be placed down the boring, and the water level will be monitored. Once the groundwater level stabilizes (or 15 minutes, whichever comes first), the sampling crew will purge the water column in the drill string with an airlift pump or by other appropriate means. With the recovery of the water level, the sample crew will purge the water column successively until the suspended solids content is noticeably reduced. If after five wetted drill volumes have been purged and suspended solids content is not noticeably reduced, then it will be documented, and documentation will be included with future use of the data. At that point, the airlift pump system (or other appropriate system) will be removed and a sampling pump will be lowered into the boring, and the sample collection process will continue to purge the sample interval. A bladder pump, electric submersible pump, or inertial pump may be used to purge the boring and to collect water samples.

Purging is required to eliminate the impact of the drilling fluid (potable water for rotary sonic or HSA drill systems) from the interval being sampled and to develop a natural gravel pack to minimize suspended solids. For the top HU5 sample, the minimum amount of water to be purged in each temporary boring prior to sampling will equal the volume of drilling fluid used to drill through the HU5 to the sample depth. For the bottom HU5 sample, the minimum amount of water to be purged in each temporary boring prior to sampling will equal the volume of drilling fluid used to drill below the upper sample depth. At both sample intervals, purging will continue, prior to sampling, until stabilization parameters meet the following criteria:

- 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.

The target turbidity for the final purge water is 10 NTUs or less and a stabilization criteria goal of ± 10% when turbidity is greater than 10 NTUs.

- If turbidity of the groundwater sample > 100 NTUs, then results can be used qualitatively.
- If turbidity of the groundwater sample < 100 NTUs, then results can be used quantitatively.

NTU values (100 NTUs) might be updated if additional information is brought forward. NOTE: the EPA field guidance uses 10 NTUs.

Grab samples will be used in concert with other information in the RI/FS Report. Qualitative use will be for nature and extent, not for fate and transport modeling or for risk assessment.

When the stabilization criteria are met, the flow rate of the pump will be adjusted to 200 mL/minute or less and the groundwater samples will be collected as soon as possible. During each sampling event, the field parameters of oxidation reduction potential (Eh) and dissolved oxygen also 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 procedures prior to its next use.

An alternative groundwater sampling collection method is the use of DPT-type water sampling probes within the RGA. The drive-point water sampling equipment is pushed or driven below the bottom of the drill string, permitting collection of a relatively undisturbed water sample with minimal cross-contamination. When the drive-point sampling equipment has reached the target depth, the purge/sampling pump is lowered into the drive point interval. Groundwater typically is pumped with an inertial pump. (The small inner diameter of the drive-point sampling equipment limits the types of pumps that can be used with this system.) A small amount of water, typically less than a gallon, is purged to reduce the initial turbidity of the water sample. Since sampling occurs below the drilled depth, there is no minimum purge volume. The water sample will be collected after sufficient water has been purged, to allow stabilization parameters (i.e., temperature, conductivity, and pH) to meet sampling criteria.

The UCRS is largely unsaturated beneath the C-400 Complex. No samples of UCRS groundwater will be collected for this RI/FS other than from existing UCRS MWs in the C-400 Complex that are able to provide sufficient water. If liquid is encountered in the gravel underlying the C-400 slabs, then one sample will be collected at a boring location near the building footers. During scoping, five preferred locations were identified for collection of this sample (refer to Tables 9.4–9.7 for specific locations). If no liquid is present in any of the five preferred locations, then other boring locations near building footers will be considered for collection of this sample. In addition, two shallow piezometers will be installed to monitor water levels in the sub-slab gravel of the C-400 Building. The two piezometers will be completed in the sub-slab gravel at locations in the north and south halves of the C-400 Building (Section 9.3.2 and Section 9.3.3 identify the specific locations). The two piezometers will be completed in the sub-slab gravel at locations in the north and south halves of the C-400 Building. Each piezometer would be set with the screen at the base of the sub-slab gravel, presumably 8 to 11 ft below the C-400 slab. The piezometers will be outfitted with pressure transducers connected to data loggers for in-scope MWs to document conditions during the RI field work.

The sub-slab water level measurements are intended to support both understanding the significance of the analytical results from the planned water sample in the sub-slab gravel and assessing the significance of leakage from the roof drain system to the C-400 water budget. With regard to the significance of the analytical results from the planned water sample in the sub-slab gravel, the water level record will identify whether the analysis of the water applies to episodic pulses or a continuous contribution to the

UCRS. Moreover, if the common condition is found to be several feet of saturated gravel, it can be anticipated that the sample represents conditions over a broader area because a pool of water would be a local integrator unit. With regard to the significance of leakage of the roof drain system, this input has long been anticipated as a primary component of the C-400 groundwater system. If the subslab water level fluctuates significantly with rainfall, pulses of contaminant contribution to the RGA can be anticipated (and help understand fluctuating contaminant levels in the MWs better). If several feet of water are present continually in the sub-slab gravel, some lateral migration of contaminants in the UCRS away from the C-400 Building can be anticipated (and help understand the extent of shallow contamination better).

Figure 9.3 and Table 9.2 summarize the location and construction of existing groundwater MWs within and adjacent to the C-400 Complex. The RI/FS will incorporate data from MWs located within 300 ft of the C-400 Complex boundary. These wells provide opportunity to collect groundwater samples of superior quality for inclusion in the RI/FS; however, some of the multi-port wells near the southeast corner of C-400 Cleaning Building have experienced mechanical failure. An initial task of the RI/FS will be to assess these sampling ports to determine which ports can be sampled as part of the RI/FS.

The RI/FS will install new RGA well clusters (with well screens in the upper, middle and lower HU5) in five locations (MW557–MW559, MW560–MW562, MW563–MW565, MW566–MW568, and MW569-MW571) within and adjacent to the footprint of the C-400 Cleaning Building (See Figure 9.4. and Table 9.3). In addition, the RI/FS will install a lower-RGA-screened well adjacent to both MW175 (west side of the C-400 Cleaning Building footprint) and MW178 (northeast corner of the C-400 Complex) and an upper HU5-screened well adjacent to the MW425 well nest. The new wells will be constructed with 4-inch diameter, stainless steel casing and 5-ft length screen. These existing and new wells will be sampled quarterly, for up to four quarters, during the course of the RI/FS, as possible, for the RI/FS groundwater parameters as a baseline of groundwater quality for comparison to the groundwater grab samples.

The new MW locations were chosen considering areas of higher contamination and to form a triangulated irregular network under the C-400 Building using existing MWs where available, and the focus was on the south end of the building, where TCE DNAPL is anticipated in the RGA.

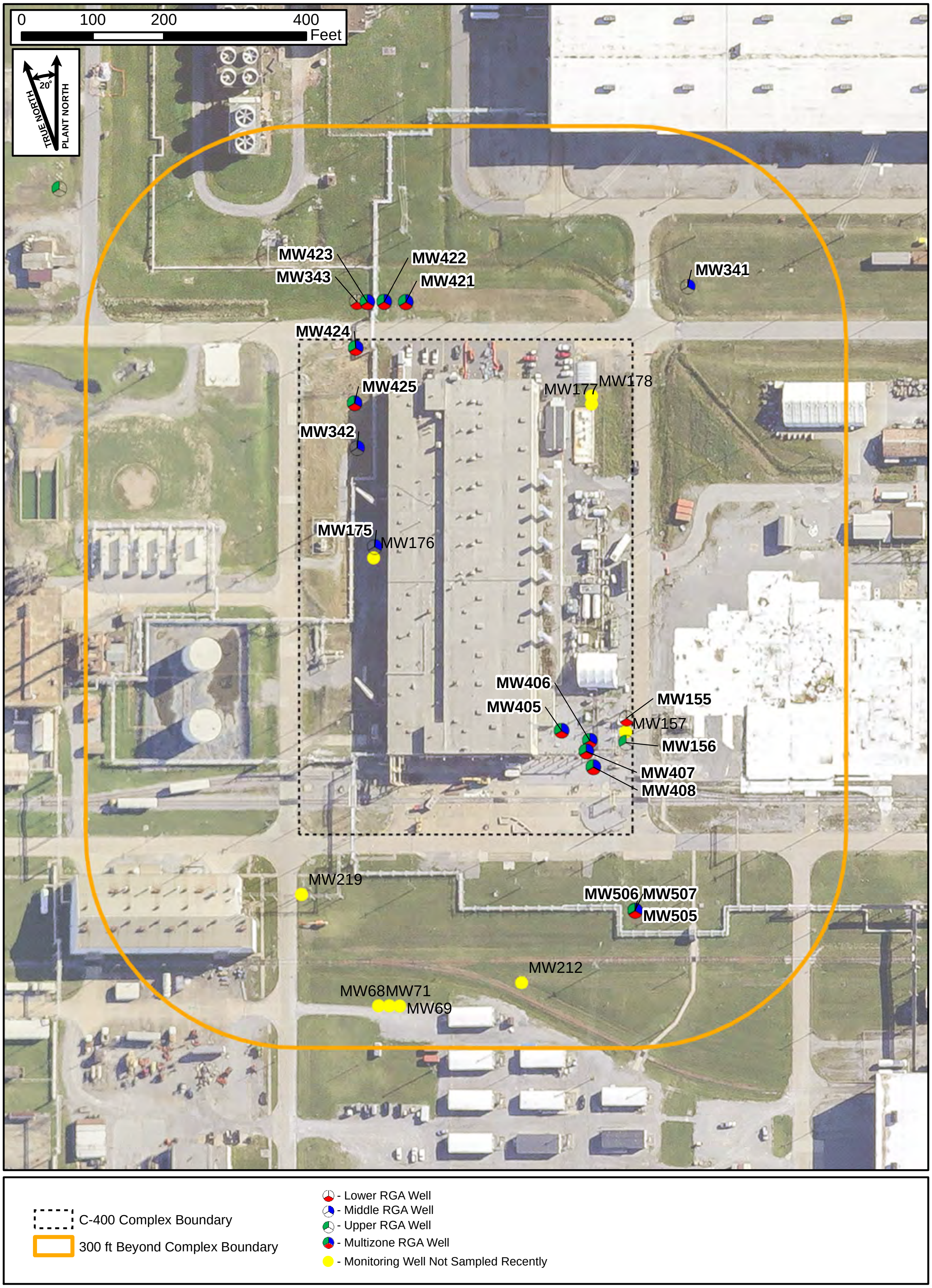

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Figure 9.3. Existing Monitoring Wells at C-400 Complex

Table 9.2. Existing Monitoring Well Construction and Location

Well ID	AKGWA Number	Screened Zone	Year Installed	Riser & Screen Material[1]	Riser & Screen Diam[2]	Screen Top Depth[3]	Screen Bottom Depth	Monument Elev[4]	Datum Elev	Datum	Plant Coordinates	
											X	Y
MW68[5]	8000-5217	LRGA	1986	SLS	2	97.40	102.40	377.00	379.01	TOC	-4343.18	-2074.93
MW69	8000-5218	UCRS	1986	SLS	2	33.30	38.30	376.99	379.05	TOC	-4358.03	-2074.79
MW71	8000-5220	URGA	1986	SLS	2	67.10	72.10	376.92	378.94	TOC	-4372.93	-2074.55
MW155	8000-5149	LRGA	1990	SLS	2	87.00	92.00	379.164	381.57	TOC	-4024.48	-1668.56
MW156	8000-5150	URGA	1990	SLS	2	63.00	70.00	379.564	382.41	TOC	-4025.25	-1702.98
MW157	8000-5151	UCRS	1990	SLS	2	30.00	35.00	378.95	382.05	TOC	-4025.32	-1687.62
MW175	8000-5169	MRGA	1991	SLS	2	75.00	80.00	378.49	381.46	TOC	-4378.81	-1428.36
MW176	8000-5170	UCRS	1991	SLS	2	32.50	37.50	378.75	381.59	TOC	-4379.63	-1444.18
MW177	8000-5171	UCRS	1991	SLS	2	39.50	44.50	377.00	380.08	TOC	-4073.43	-1226.62
MW178	8000-5172	URGA	1991	SLS	2	62.50	67.50	376.60	379.14	TOC	-4073.27	-1215.33
MW212	8000-5193	UCRS	1992	PVC	2	35.86	45.86	375.80	379.31	TOC	-4170.11	-2041.47
MW219	8000-5200	UCRS	1992	PVC	2	36.78	46.78	377.05	379.76	TOC	-4481.29	-1916.74
MW341	8003-3482	MRGA	1998	SLS	2	75.50	85.50	377.95	380.52	TOC	-3938.29	-1061.29
MW342	8003-3483	MRGA	1998	SLS	2	75.40	85.10	376.91	380.07	TOC	-4404.36	-1290.10
MW343	8003-3484	LRGA	1998	SLS	2	75.40	85.10	374.909	377.409	TOC	-4403.93	-1084.09
MW405-PRT1[6]	8004-3861	UCRS	2002	SLS	ML	36.00	38.00	379.47	379.43	TOC	-4115.67	-1686.59
MW405-PRT2[6]	8004-3861	URGA	2002	SLS	ML	60.00	62.00	379.47	379.43	TOC	-4115.67	-1686.59
MW405-PRT3[6]	8004-3861	URGA	2002	SLS	ML	66.00	68.00	379.47	379.43	TOC	-4115.67	-1686.59
MW405-PRT4[6]	8004-3861	URGA	2002	SLS	ML	72.00	74.00	379.47	379.43	TOC	-4115.67	-1686.59
MW405-PRT5	8004-3861	MRGA	2002	SLS	ML	80.00	82.00	379.47	379.43	TOC	-4115.67	-1686.59
MW405-PRT6[6]	8004-3861	LRGA	2002	SLS	ML	86.00	88.00	379.47	379.43	TOC	-4115.67	-1686.59
MW405-PRT7[6]	8004-3861	McNairy	2002	SLS	ML	106.00	108.00	379.47	379.43	TOC	-4115.67	-1686.59
MW406-PRT1[6]	8004-3863	UCRS	2002	SLS	ML	36.00	38.00	379.24	379.18	TOC	-4075.87	-1700.81
MW406-PRT2[6]	8004-3863	URGA	2002	SLS	ML	60.00	62.00	379.24	379.18	TOC	-4075.87	-1700.81
MW406-PRT3[6]	8004-3863	URGA	2002	SLS	ML	66.00	68.00	379.24	379.18	TOC	-4075.87	-1700.81
MW406-PRT4[6]	8004-3863	URGA	2002	SLS	ML	72.00	74.00	379.24	379.18	TOC	-4075.87	-1700.81
MW406-PRT5	8004-3863	MRGA	2002	SLS	ML	80.00	82.00	379.24	379.18	TOC	-4075.87	-1700.81
MW406-PRT6[6]	8004-3863	LRGA	2002	SLS	ML	86.00	88.00	379.24	379.18	TOC	-4075.87	-1700.81
MW406-PRT7[6]	8004-3863	McNairy	2002	SLS	ML	106.00	108.00	379.24	379.18	TOC	-4075.87	-1700.81

Table 9.2. Existing Monitoring Well Construction and Location (Continued)

Well ID	AKGWA Number	Screened Zone	Year Installed	Riser & Screen Material[1]	Riser & Screen Diam[2]	Screen Top Depth[3]	Screen Bottom Depth	Monument Elev[4]	Datum Elev	Datum	Plant Coordinates	
											X	Y
MW407-PRT1[6]	8004-3865	UCRS	2002	SLS	ML	36.00	38.00	379.47	379.37	TOC	-4081.17	-1716.24
MW407-PRT2[6]	8004-3865	URGA	2002	SLS	ML	60.00	62.00	379.47	379.37	TOC	-4081.17	-1716.24
MW407-PRT3[6]	8004-3865	URGA	2002	SLS	ML	66.00	68.00	379.47	379.37	TOC	-4081.17	-1716.24
MW407-PRT4	8004-3865	URGA	2002	SLS	ML	72.00	74.00	379.47	379.37	TOC	-4081.17	-1716.24
MW407-PRT5[6]	8004-3865	MRGA	2002	SLS	ML	80.00	82.00	379.47	379.37	TOC	-4081.17	-1716.24
MW407-PRT6[6]	8004-3865	LRGA	2002	SLS	ML	86.00	88.00	379.47	379.37	TOC	-4081.17	-1716.24
MW407-PRT7[6]	8004-3865	McNairy	2002	SLS	ML	106.00	108.00	379.47	379.37	TOC	-4081.17	-1716.24
MW408-PRT1[6]	8004-3868	UCRS	2002	SLS	ML	34.00	36.00	378.99	379.83	TOC	-4071.06	-1737.78
MW408-PRT2[6]	8004-3868	URGA	2002	SLS	ML	58.00	60.00	378.99	379.83	TOC	-4071.06	-1737.78
MW408-PRT3[6]	8004-3868	URGA	2002	SLS	ML	64.00	66.00	378.99	379.83	TOC	-4071.06	-1737.78
MW408-PRT4[6]	8004-3868	URGA	2002	SLS	ML	70.00	72.00	378.99	379.83	TOC	-4071.06	-1737.78
MW408-PRT5	8004-3868	MRGA	2002	SLS	ML	78.00	80.00	378.99	379.83	TOC	-4071.06	-1737.78
MW408-PRT6[6]	8004-3868	LRGA	2002	SLS	ML	84.00	86.00	378.99	379.83	TOC	-4071.06	-1737.78
MW408-PRT7[6]	8004-3868	McNairy	2002	SLS	ML	104.00	106.00	378.99	379.83	TOC	-4071.06	-1737.78
MW421-PRT1	8005-6385	MRGA	2009	PVC	2	71.00	73.00	375.64	378.88	TOC	-4334.78	-1084.32
MW421-PRT2	8002-3016	MRGA	2009	PVC	2	79.00	81.00	375.64	378.88	TOC	-4334.78	-1084.32
MW421-PRT3	8002-3017	LRGA	2009	PVC	2	83.00	85.00	375.64	378.88	TOC	-4334.78	-1084.32
MW422-PRT1	8005-6386	MRGA	2009	PVC	2	71.00	73.00	375.25	378.44	TOC	-4365.09	-1083.97
MW422-PRT2	8002-3019	MRGA	2009	PVC	2	79.00	81.00	375.25	378.44	TOC	-4365.09	-1083.97
MW422-PRT3	8002-3018	LRGA	2009	PVC	2	83.00	85.00	375.25	378.44	TOC	-4365.09	-1083.97
MW423-PRT1	8005-6387	MRGA	2009	PVC	2	70.83	72.83	375.02	378.21	TOC	-4388.84	-1084.16
MW423-PRT2	8002-3020	MRGA	2009	PVC	2	78.83	80.83	375.02	378.21	TOC	-4388.84	-1084.16
MW423-PRT3	8002-3021	LRGA	2009	PVC	2	82.83	84.83	375.02	378.21	TOC	-4388.84	-1084.16
MW424-PRT1	8005-6388	MRGA	2009	PVC	2	71.00	73.00	376.79	379.71	TOC	-4405.03	-1148.60
MW424-PRT2	8002-3022	MRGA	2009	PVC	2	79.00	81.00	376.79	379.71	TOC	-4405.03	-1148.60
MW424-PRT3	8002-3023	LRGA	2009	PVC	2	83.00	85.00	376.79	379.71	TOC	-4405.03	-1148.60
MW425-PRT1	8005-6389	URGA	2009	PVC	2	71.00	73.00	376.96	380.27	TOC	-4406.70	-1226.33
MW425-PRT2	8002-3024	MRGA	2009	PVC	2	79.00	81.00	376.96	380.27	TOC	-4406.70	-1226.33
MW425-PRT3	8002-3025	LRGA	2009	PVC	2	83.00	85.00	376.96	380.27	TOC	-4406.70	-1226.33

Table 9.2. Existing Monitoring Well Construction and Location (Continued)

Well ID	AKGWA Number	Screened Zone	Year Installed	Riser & Screen Material[1]	Riser & Screen Diam[2]	Screen Top Depth[3]	Screen Bottom Depth	Monument Elev[4]	Datum Elev	Datum	Plant Coordinates	
											X	Y
MW505	8005-8898	URGA	2011	SLS	2	65.00	70.00	378.55	381.80	TOC	-4013.02	-1938.54
MW506	8005-8899	MRGA	2011	SLS	2	77.00	82.00	378.57	381.80	TOC	-4011.90	-1939.69
MW507	8005-8900	LRGA	2011	SLS	2	90.00	95.00	378.52	381.80	TOC	-4013.88	-1940.36

[1] SLS = stainless steel. PVC = polyvinyl chloride, [2] Diameter in inches. ML= multi- level construction, [3] Depths are in feet below grade. [4] Monument elevation is approximate ground surface.
[5] Gray shading identifies MWs located outside of the C-400 Complex, but within a 300-ft buffer. [6] Port currently is not sampled and may not be operational.

Figure 9.4. Monitoring Wells to be Installed by the C-400 RI/FS

Table 9.3. New Monitoring Well Construction and Location

Well ID	Targeted Screened Zone	Area	Riser & Screen Material[1]	Riser & Screen Diam[2]	Approx. Screen Top Depth[3]	Approx. Screen Bottom Depth
MW557	URGA	South central C-400 Building	SLS	4	65	70
MW558	MRGA				76	81
MW559	LRGA				87	92
MW560	URGA	Southwest C-400 Complex			65	70
MW561	MRGA				76	81
MW562	LRGA				87	92
MW563	URGA	Mid- central C-400 Building			65	70
MW564	MRGA				75	80
MW565	LRGA				85	90
MW566	URGA	Mid-east C-400 Complex			66	71
MW567	MRGA				73	78
MW568	LRGA				80	85
MW569	URGA	North-central C-400 Building			66	71
MW570	MRGA				73	78
MW571	LRGA				80	85
MW572	LRGA	Adjacent to MW175 & MW176			80	85
MW573	LRGA	Adjacent to MW177 & MW178			80	85
MW574	URGA	Adjacent to MW425			63	68

[1] SLS = stainless steel [2] Diameter in inches [3] Depths in ft

Colloidal borescope data collection

The existing (Figure 9.3) and new MWs (Figure 9.4) define 9 discrete areas within the C-400 Complex as shown in Figure 9.5. Additional details for existing and new MWs are found in Tables 9.2 and 9.3. By equipping the MWs with pressure transducer/data logger assemblies, the sets of three adjacent wells will be used to accurately measure RGA hydraulic gradient throughout the field effort of the RI/FS. Colloidal borescopes periodically placed in each screened interval of a three-point matrix will be used to measure in-well velocity and direction which can be compared to the area-defined gradient(s). Placement of existing and new MWs allows a "three-point-problem" assessment of hydraulic gradient, which can be compared to in-well measurements of groundwater flow direction as measured by a colloidal borescope. The well depths were selected to provide independent measures of both hydraulic gradient and flow direction in the upper, middle, and lower RGA in most locations. A close alignment of the flow direction observed in the well with the groundwater flow direction defined by the gradient between sets of three adjacent wells would indicate near-homogeneous aquifer properties around the well(s). A poor alignment would indicate either faulty well construction and development (factors that the RI/FS can control) or significant heterogeneity within the aquifer [and a relative measure of the direction and magnitude of the more transmissive zone(s)]. The colloidal borescope data collection is anticipated to be performed outside of normal working hours (e.g., nights, weekends) and not as the same time as other drilling field work to mitigate impacts to the colloidal borescope measurements.

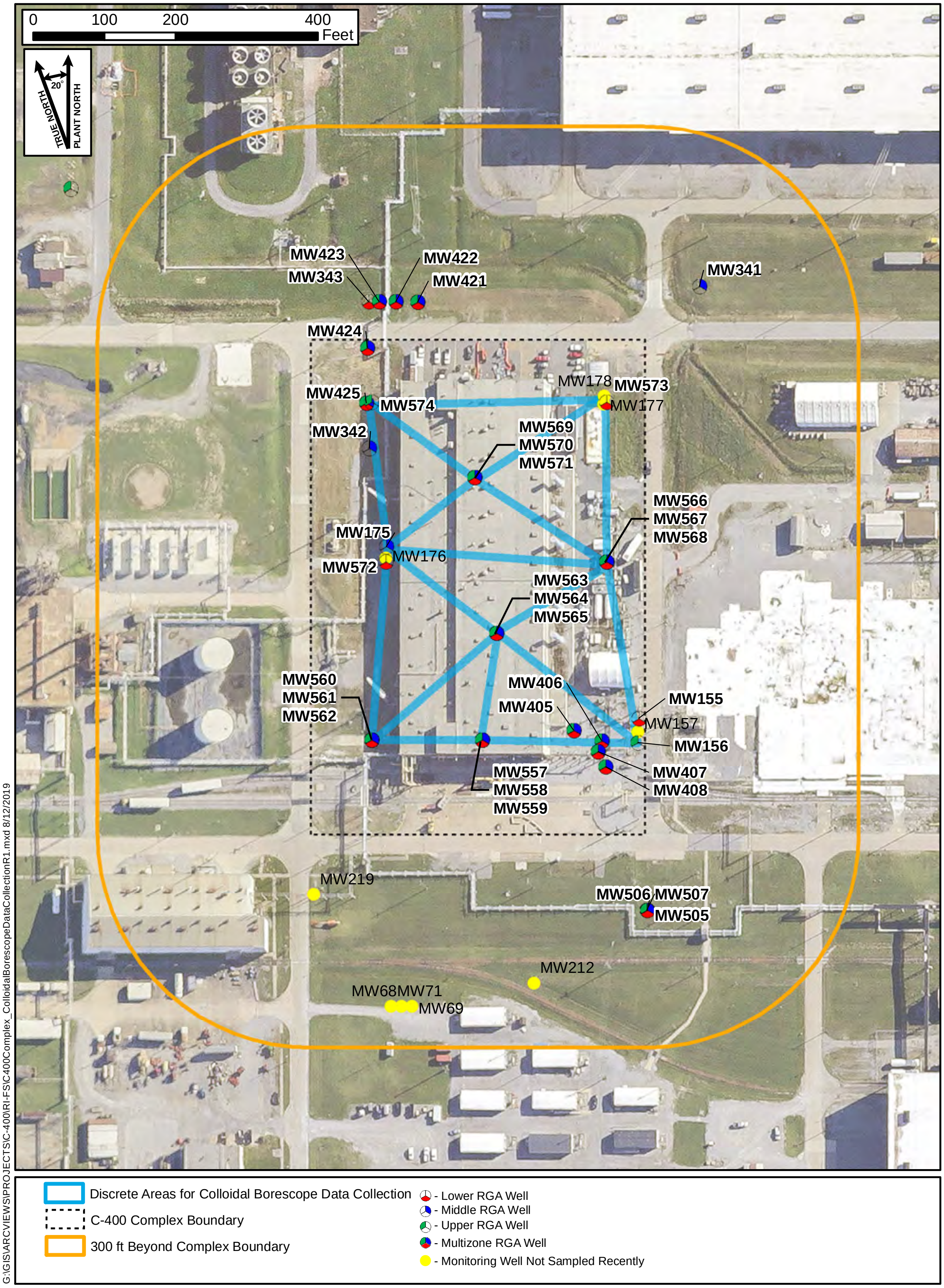

Figure 9.5. Colloidal Borescope Data Collection Areas from Both the Existing and C-400 RI/FS Installed Monitoring Wells

The hydraulic assessment of the Northeast Plume Optimization extraction wells has demonstrated that the extraction wells can control the RGA hydraulic gradient in the C-400 Complex area. By forcing the gradient to be directed toward the Northeast Plume extraction wells and measuring the gradient and intra-well flow velocity during two distinctly different pumping rates, the measurements of gradient and intra-well flow velocity allow for the determination of the hydraulic conductivity of the RGA in the vicinity of each MW.

By Darcy's Law:

$Q = -KiA$ Where, Q = inflow or outflow rate K = hydraulic conductivity i = gradient A = cross-sectional area through which "Q" occurs	Equation 9.1

Dividing both sides of the equation by cross-sectional area "A":

$Q/A = -Ki = \nu$ Where, ν = specific discharge	Equation 9.2

Specific discharge "ν" is directly related to "i."

"ν" also is directly related to the in-well flow velocity observed by the colloidal borescope, by a well-specific factor:

$\nu = V_B \times F_c$ Where, V_B = in-well flow velocity F_C = well-specific factor	Equation 9.3

Under two pumping rates, the change (Δ) in "ν" is directly proportional to the change in "i."

$\Delta\nu\ (v_1 - v_2) = n \times \Delta i\ (i_1 - i_2)$	Equation 9.4

Assuming the well-specific factor "F_c" is constant (at least, near constant) for the range of pumping rates and gradients that are likely to be produced, "F_c" is the proportionality constant.

$F_C \times (V_{B1}/V_{B2}) = (i_1/i_2)$	Equation 9.5

The RI/FS will collect measurements that allow the derivation of both "V_{B1}/V_{B2}" and "i_1/i_2." The derivation of "F_c" is straightforward.

Knowing "F_c," then "ν" (using Equation 9.3) and then "K" (using Equation 9.2) can be calculated with a set of field measurements.

In addition to measuring the hydraulic conductivity of the RGA beneath the C-400 Complex, the MWs can be used to delineate source zone areas inside the C-400 Complex further and to assess the impacts of the Northeast Plume Optimization extraction wells upon the C-400 area.

Geochemical Analyses

Anion and cation analyses for UCRS and RGA groundwater sample (as applicable), as well as the field-measured parameters, dissolved oxygen, Eh, and pH, will delineate the major water chemistry. In addition, up to 25% of the RGA samples will be analyzed for chemical oxygen demand (Method EPA 410.4) and microbial population (by quantitative polymerase chain reaction method).[14] The microbial population analyses will be limited to samples with 10,000 µg/L TCE or less (higher TCE levels are toxic to microbial populations).

9.2 SAMPLE ANALYSES

Sample analysis for this remedial investigation consists of analysis of groundwater samples; analysis of concrete cores; and analysis of surface and subsurface soil samples. Specific analytical requirements, methods, and procedures are described in the 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/or the ASTM will be used. A fixed-base laboratory will perform laboratory analyses. Table 6.1 identifies the analytes for this RI/FS.

9.3 SITE-SPECIFIC SAMPLING PLANS

Sampling within each sector is described in the following subsections. The following are types of samples proposed.

- Concrete samples

- Surface Soil Samples

  — As discussed during scoping meetings, for surface soil locations at focused sampling locations outside of the building (i.e., Sectors 2-7) where concrete, asphalt, etc., are present, the concrete, asphalt, etc., will be cored, removed, etc., to allow collection of the surface soil sample and to support subsurface sampling at that location. Once soil is encountered under the concrete, asphalt, etc., the soil sample will be collected, and this sample depth will be considered the surface soil sample.

- UCRS Soil Samples
  — HU 1 (~10 ft bgs) (if HU 1 is present)
  — HU 2 (~20 ft bgs)
  — HU 3 (~35 ft bgs)

- UCRS Water Samples (existing wells) (if water is present)

- RGA Soil Sample
  — HU 4 (~ 60 ft bgs)

[14] The addition of the microbial population analysis is contingent upon identification of a laboratory that has a license for handling radioactive materials and is capable of performing the microbial analysis.

- RGA Water Sample
  - HU 5 (~ 65, 75, and 85 ft bgs)

- McNairy Soil Samples
  - HU 5/McNairy Interface
  - Interface + 1 ft depth*
  - Interface + 2 ft depth*
  - Interface + 3 ft depth*
  - Interface + 4 ft depth*
  - Interface + 6 ft depth*
  - Interface + 10 ft depth
  - Interface + 20 ft depth
  - Interface + 35 ft depth**
  - Interface +50 ft depth**

*Limited to 5 soil borings in the vicinity of DNAPL.
**Limited to 17 defined soil borings as agreed upon by the FFA parties during comment resolution meetings.

- McNairy Water Samples*
  - Interface + 10-ft depth
  - Interface + 20-ft depth
  - Interface + 50-ft depth

*Limited to 13 defined soil borings as agreed upon by the FFA parties during comment resolution meetings.

9.3.1 Sector 1A

Sampling in Sector 1A is summarized in Table 9.4.

Following is rationale for focused sampling.

- 400-S1A-03 and 400-S1A-23: Provide information for a TCE transect and provide information near the degreaser, etc.

During comment resolution meetings the FFA parties used the information in Appendix D of this work plan to agree that one additional sample from SWMU 98 was needed to finalize the work plan. If liquid and/or sludge are present in SWMU 98 during the RI/FS field work, then a sample(s) will be collected. Any additional samples will be collected using the methods described in this section and throughout the work plan (e.g., Section 11) for the same matrix type. This additional sample(s) will be used for a qualitative comparison of the liquid sample results taken after initially removing the sludge material in the sump as described in Appendix D of this work plan (e.g., does a potential source still exist in the sump, associated piping, and/or contamination potentially infiltrating in from the outside the sump).

Table 9.4. Summary of Sector 1A Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)[a]			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1[d]	HU2	HU3	HU4[b]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S1A																								
-03			X[a,d]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	14	7[a]
-23	X[c]		X[d]	X	X	X																	4	0

X indicates sample will be collected.

[a] If liquid is present in the gravel at Location 400-S1A-03, one sample will be collected per scoping discussions. If no liquid is present at Location 400-S1A-03, other locations near building footers in the basement (400-S1B-04, 400-S1B-22, 400-S1C-29) will be utilized for sample collection, if liquid is present. If no liquid is present, a sample will not be collected; however, other boring locations near building footers will be considered for collection of this sample

[b] If HU4 is not present, sample will be collected at the HU3/HU5 interface.

[c] Two samples will be obtained from each concrete location. One sample will be obtained from the upper portion, and the other sample will be collected from the lower portion of the concrete sample location, as discussed in Section 9.1.2.2.

[d] Gravel is anticipated to exist in the HU1 interval beneath the grade slab. If soil is encountered in this interval, then a soil sample will be collected.

Figure 9.6 shows the Sector 1A sampling locations.

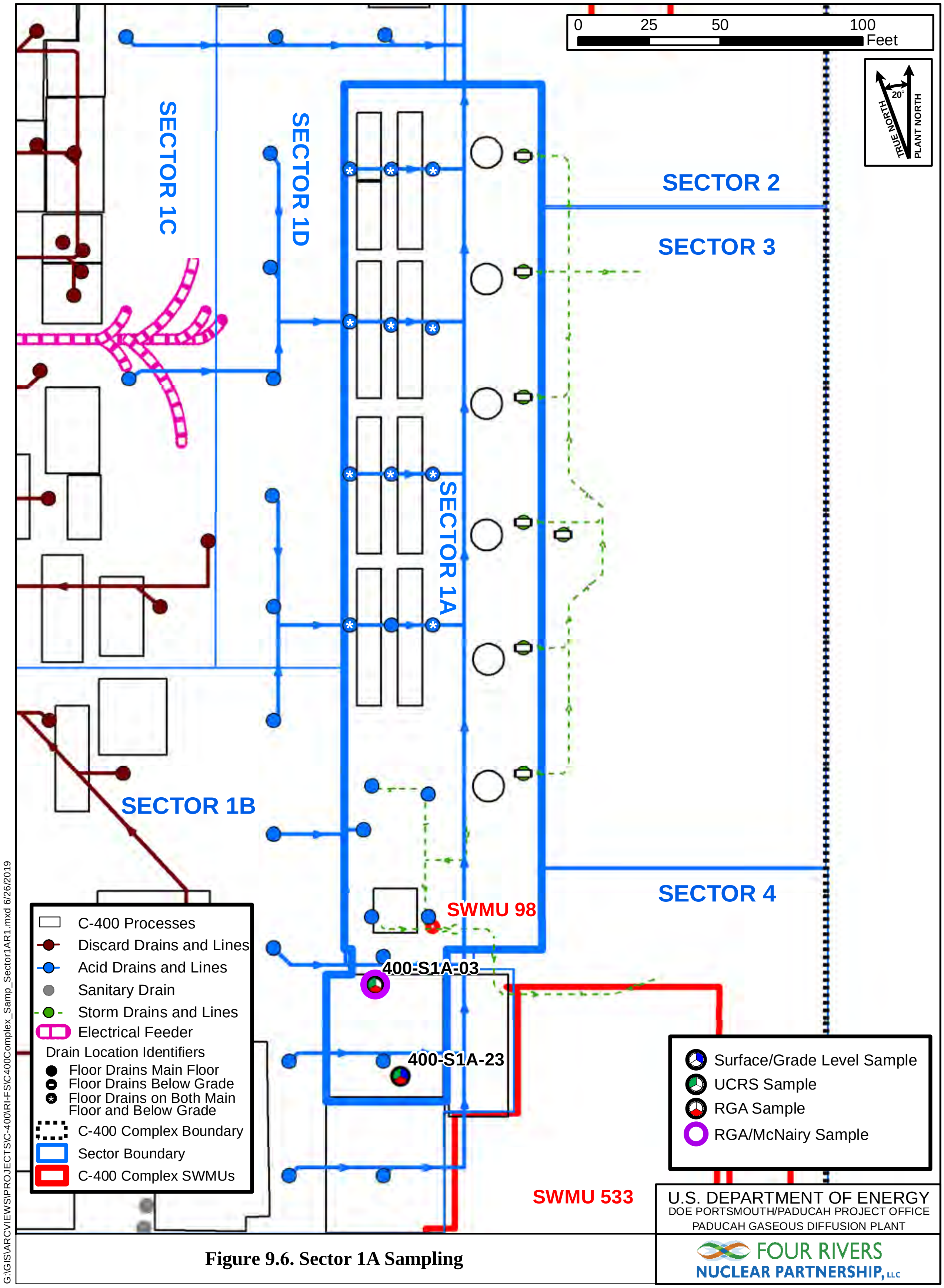

Figure 9.6. Sector 1A Sampling

9.3.2 Sector 1B

Sampling in Sector 1B is summarized in Table 9.5.

The following are rationale for focused sampling.

- 400-S1B-02: Provide information for a TCE transect and on the cylinder disassembly pit.
- 400-S1B-04: Provide information for a TCE transect and provide information near the degreaser, etc.
- 400-S1B-05: Provide information on the dip tanks and locations are near floor drains.
- 400-S1B-09: Provide information for a first line of transects for the Phase IIb area (Figure 4.2).
- 400-S1B-21 and 400-S1B-22: Provide information for a TCE transect and provide information near the degreaser, acid waste lines, etc.
    - — During abandonment of the sample boring 400-S1B-21, a shallow piezometer to monitor water levels in the sub-slab gravel of the C-400 Building will be installed as discussed in Section 9.1.2.4.
- 400-S1B-24: Provide information for a TCE transect and provide information near the degreaser, acid waste lines, etc.
- 400-S1B-25: Provide information for a TCE transect.
- 400-S1B-26: Provide information for a TCE transect and discard waste lines.
- 400-S1B-27: Provide information on discard waste line, near spray booth tanks, alumina dissolver, etc.
- 400-S1B-28: Provide information on the spray booth.
- 400-S1B-41: Provide information on the hand table and discard waste line. This area previously was used for disassembly and decontamination.
- 400-S1B-42: Provide information on the Blakeslee Degreaser and discard waste line. This area previously was used for disassembly and decontamination.
- 400-S1B-43: Provide information on the Blakeslee Degreaser, seal disassembly, and alumina dissolver. This area previously was used for disassembly and decontamination.
- 400-S1B-44: Provide information on the seal disassembly, receiving booth, and discard waste line. This area previously was used for disassembly and decontamination.
- 400-S1B-45 and 400-S1B-46: Provide information on the cylinder disassembly pit.

The Sector 1B sampling locations are shown on Figure 9.7.

Table 9.5. Summary of Sector 1B Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1[g]	HU2	HU3	HU4[c]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S1B																								
-02			X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	9	6
-04[d]			X[a]	X	X	X																	4	0[a]
-05			X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	9	6
-09			X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	9	6
-21	X[e]		X	X	X	X																	4	0
-22	X[e]		X[f]	X	X	X																	4	0[f]
-24[d]	X[e]		X	X	X	X	X	X	X	X						X	X						7	3
-25	X[e]		X	X	X	X																	4	0
-26	X[e]		X	X	X	X																	4	0
-27	X[a,e]		X	X	X	X																	4	0
-28	X[e]		X	X	X	X		X	X	X	X	X	X	X	X	X	X						12	2
-41	X[e]		X	X	X	X																	4	0
-42	X[a,e]		X[b]	X[b]	X	X		X	X	X						X	X	X	X	X	X	X	9	5
-43	X[e]		X	X	X	X																	4	0
-44	X[e]		X	X	X	X																	4	0
-45			X	X	X	X																	4	0
-46			X	X	X	X																	4	0

X indicates sample will be collected.
[a] Samples will be collected and analyzed for additional radionuclides (see Table 6.1).
[b] Samples will be collected and analyzed additionally for dioxins and furans (see Table 6.1).
[c] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[d] Geotechnical samples also will be collected from a collocated boring.

Table 9.5 Summary of Sector 1B Sampling (Continued)

[e] Two samples will be obtained from each concrete location. One sample will be obtained from the upper portion, and the other sample will be collected from the lower portion of the concrete sample location, as discussed in Section 9.1.2.2.
[f] If liquid is present in the gravel at Location 400-S1A-03, one sample will be collected per scoping discussions. If no liquid is present at Location 400-S1A-03, other locations near building footers in the basement (400-S1B-04, 400-S1B-22, 400-S1C-29) will be utilized for sample collection, if liquid is present. If no liquid is present, a sample will not be collected; however, other boring locations near building footers will be considered for collection of this sample.
[g] Gravel is anticipated to exist in the HU1 interval beneath the grade slab. If soil is encountered in this interval, then a soil sample will be collected.

Geotechnical samples also will be collected from locations 400-S1B-04 and 400-S1B-24.

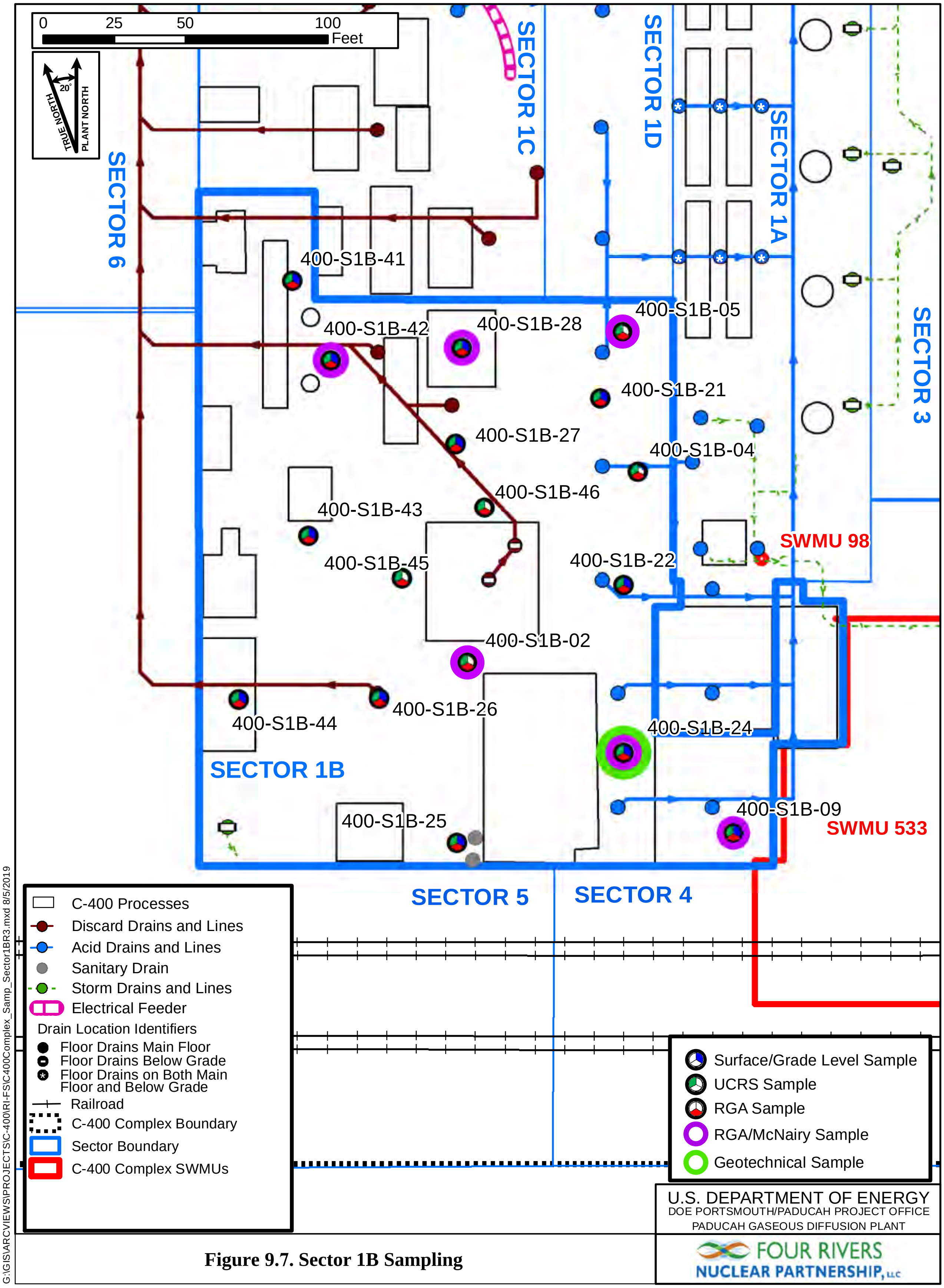

Figure 9.7. Sector 1B Sampling

9.3.3 Sector 1C

Sampling in Sector 1C is summarized in Table 9.6.

The following are rationale for focused sampling.

- 400-S1C-01: Provide information on North Basement Furnace Room.
- 400-S1C-35: Provide information on Laundry Area.
- 400-S1C-29: Provide information on the #5 Dissolver storage tanks and a discard waste line.
- 400-S1C-30: Provide information on uranium solution storage tanks, acidifying tanks, and an acid waste line and drain.
- 400-S1C-31: Provide information on the test loop and discard waste lines.
- 400-S1C-32: Provide information on the Uranium Oxide Calciner, an area covered in concrete due to severely eroded floor and contamination, and discard waste lines.
- 400-S1C-33: Provide information on the test loop and an acid waste line.
    - During abandonment of the sample boring 400-S1C-33, a shallow piezometer to monitor water levels in the sub-slab gravel of the C-400 Building will be installed as discussed in Section 9.1.2.4.
- 400-S1C-34: Provide information for a Tc-99 transect and to provide information on cubicles and an acid discard line.
- 400-S1C-35: Provide information on Laundry Area.
- 400-S1C-36: Provide information on safety equipment cleaning area and waste discard line.
- 400-S1C-37: Provide information on a discard waste line, the #4 Dissolver, the gold dissolver, and the gold furnace.
- 400-S1C-38 and 400-S1C-39: Provide information on the uranium recovery area and the discard waste line.
- 400-S1C-40: Provide information on the uranium recovery area, the #5 Dissolver, and discard waste line.

Figure 9.8 shows the Sector 1C sampling locations.

Table 9.6. Summary of Sector 1C Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1[e]	HU2	HU3	HU4[a]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S1C																								
-01			X	X	X	X																	4	0
-29	X[c]		X[d]	X	X	X																	4	0[d]
-30[b]	X[c]		X	X	X	X		X	X	X						X	X	X	X				9	2
-31	X[c]		X	X	X	X																	4	0
-32	X[c]		X	X	X	X		X	X	X						X	X	X	X	X	X	X	9	5
-33	X[c]		X	X	X	X																	4	0
-34[b]	X[c]		X	X	X	X		X	X	X						X	X						7	2
-35	X[c]		X	X	X	X																	4	0
-36	X[c]		X	X	X	X																	4	0
-37	X[c]		X	X	X	X																	4	0
-38	X[c]		X	X	X	X																	4	0
-39	X[c]		X	X	X	X																	4	0
-40	X[c]		X	X	X	X																	4	0

X indicates sample will be collected.
[a] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[b] Geotechnical samples also will be collected from a collocated boring.
[c] Two samples will be obtained from each concrete location. One sample will be obtained from the upper portion, and the other sample will be collected from the lower portion of the concrete sample location, as discussed in Section 9.1.2.2.
[d] If liquid is present in the gravel at Location 400-S1A-03, one sample will be collected per scoping discussions. If no liquid is present at Location 400-S1A-03, other locations near building footers in the basement (400-S1B-04, 400-S1B-22, 400-S1C-29) will be utilized for sample collection, if liquid is present. If no liquid is present, a sample will not be collected; however, other boring locations near building footers will be considered for collection of this sample.
[e] Gravel is anticipated to exist in the HU1 interval beneath the grade slab. If soil is encountered in this interval, then a soil sample will be collected.

Geotechnical samples also will be collected from locations 400-S1C-30 and 400-S1C-34.

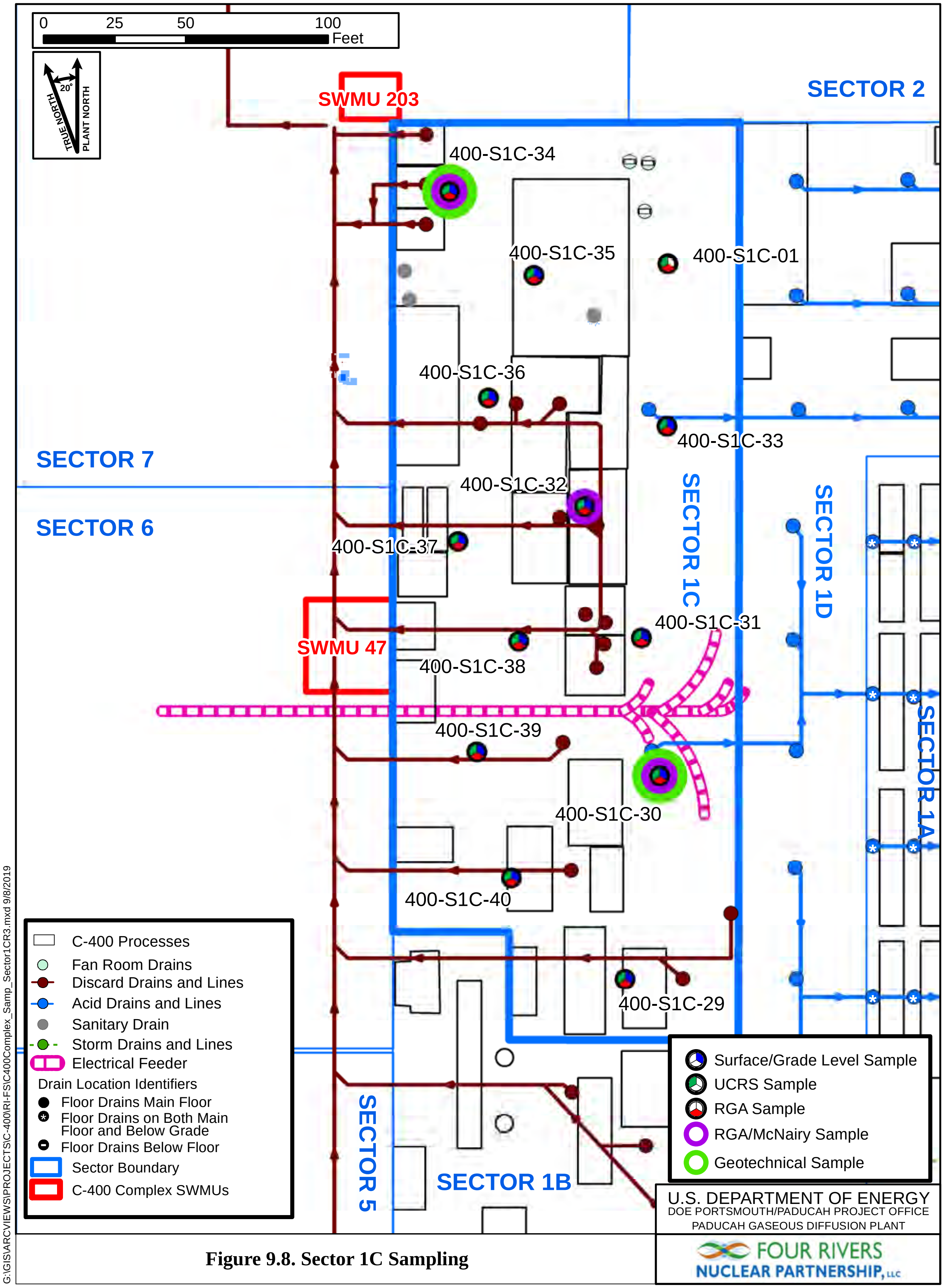

Figure 9.8. Sector 1C Sampling

9.3.4 Sector 1D

Sampling in Sector 1D is summarized in Table 9.7.

The following are rationale for focused sampling.

- 400-S1D-06—400-S1D-08: Provide information on the dip tanks and locations are near floor drains.
- 400-S1D-14: Provide information on the acid waste drain and the UF_6 pulverizer.
- 400-S1D-15: Provide information for a Tc-99 transect, acid waste drain, and the UF_6 pulverizer.
- 400-S1D-16—400-S1D-20: Provide information on the acid waste line and to bound contamination in the dip tank area.

Table 9.7. Summary of Sector 1D Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)											McNairy Samples (Water)			Total Soil Samples	Total Water[e] Samples
			HU1[d]	HU2	HU3	HU4[b]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft		~ 10 ft	~ 20 ft	~ 50 ft		
400-S1D																									
-06			X[d]	X	X	X																		4	0
-07			X[d]	X	X	X																		4	0
-08			X[d]	X	X	X																		4	0
-14	X[c]		X	X	X	X																		4	0
-15	X[a,c]		X	X	X	X		X	X	X						X	X	X	X					9	2
-16	X[c]		X	X	X	X																		4	0
-17	X[c]		X	X	X	X																		4	0
-18	X[c]		X	X	X	X																		4	0
-19	X[c]		X	X	X	X																		4	0
-20	X[c]		X	X	X	X																		4	0

X indicates sample will be collected.
[a] Samples will be collected and analyzed for additional radionuclides (see Table 6.1).
[b] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[c] Two samples will be obtained from each concrete location. One sample will be obtained from the upper portion, and the other sample will be collected from the lower portion of the concrete sample location, as discussed in Section 9.1.2.2.
[d] Gravel is anticipated to exist in the HU1 interval beneath the grade slab. If soil is encountered in this interval, then a soil sample will be collected.
[e] If liquid is present in the gravel at Location 400-S1A-03, one sample will be collected per scoping discussions. If no liquid is present at Location 400-S1A-03, other locations near building footers in the basement (400-S1B-04, 400-S1B-22, 400-S1C-29) will be utilized for sample collection, if liquid is present. If no liquid is present, a sample will not be collected; however, other boring locations near building footers will be considered for collection of this sample.

The Sector 1D sampling locations are shown on Figure 9.9.

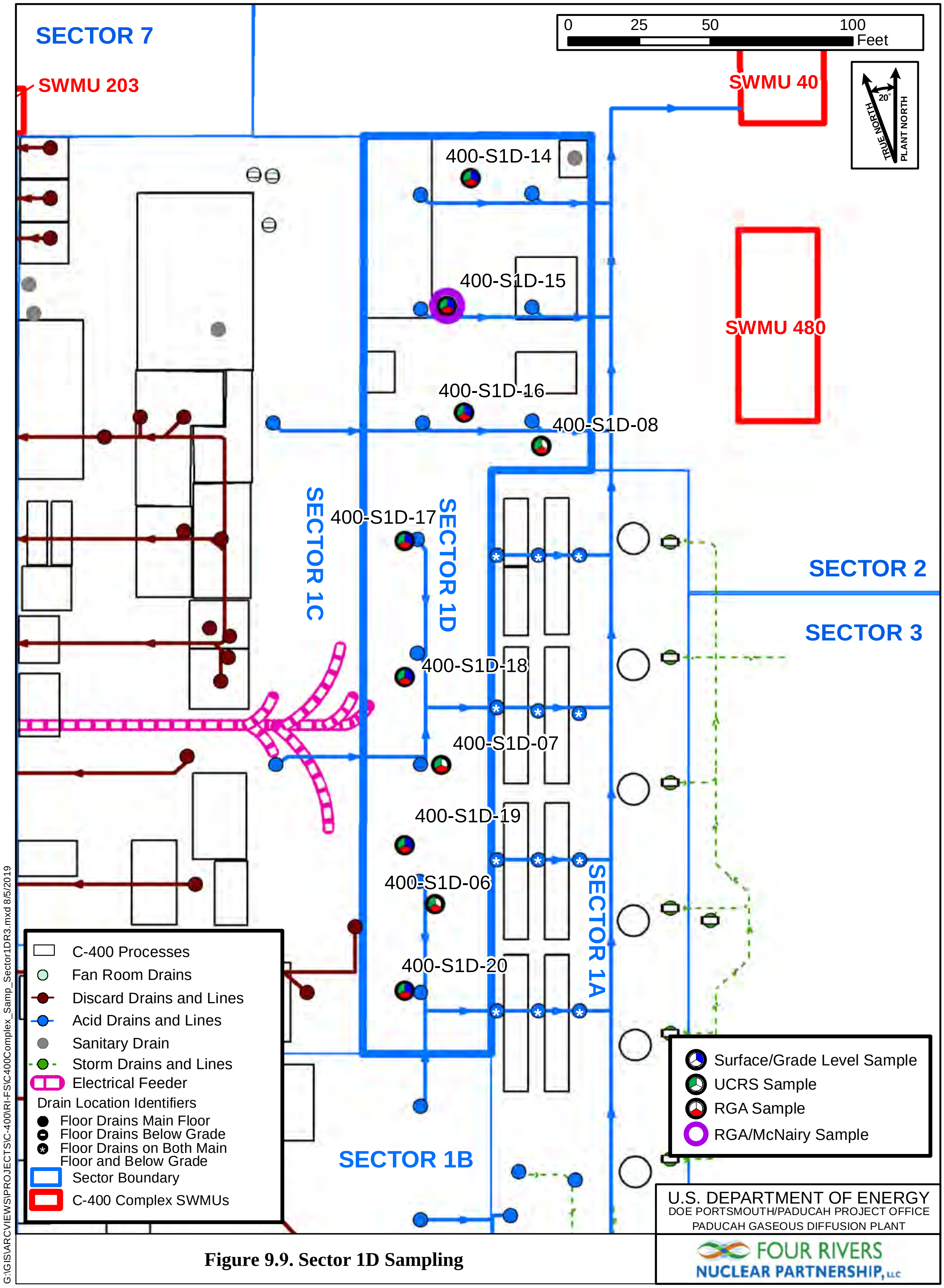

Figure 9.9. Sector 1D Sampling

9.3.5 Sector 2

Sampling in Sector 2 is summarized in Table 9.8.

The following are rationale for focused sampling.

- 400-S02-01 and 400-S02-14: Confirm WAG 6 data.
- 400-S02-02 and 400-S02-03: Bound contamination from the acid waste line to C-403 and to confirm WAG 6 data.
- 400-S02-04: Provide information on C-403 and C-402 surrounding soil. Location also is near a storm drain line.
- 400-S02-05: Provide information on the C-403 Neutralization Pit discharge line to the C-401 Transfer Line (and subsequent discharge line to the NSDD) and bound potential contamination associated with the C-403 Neutralization Pit.
- 400-S02-06 400-S02-07 and 400-S02-12: Provide information on the transfer line to the C-410-B Lagoon. 400-S02-07 also is near a storm drain.
- 400-S02-08 and 400-S02-10: Provide information on C-402 underlying soils.
- 400-S02-09: Provide information on the acid waste line to C-403 and to confirm WAG 6 data (PAHs near surface).
- 400-S02-11: Provide information on C-402 surrounding soil and storm drains.
- 400-S02-13 and 400-S02-14: Provide information on a nearby storm drain.

Additionally, 5-point composite samples from the grids will be collected as described in Section 9.1.2.1 from two grids of approximately 50-ft by 50-ft within Sector 2, as shown in Figure 9.10.

- 400-S02G01 and 400-S02G02: Provide information on exposed surface soil.

Figure 9.11 shows the Sector 2 sampling locations.

Table 9.8. Summary of Sector 2 Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[a]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S02																								
G01		X	X																				2	0
G02		X	X																				2	0
-01		X	X	X	X	X																	5	0
-02		X	X	X	X	X																	5	0
-03[b]		X	X	X	X	X																	5	0
-04		X	X	X	X	X																	5	0
-05		X	X	X	X	X																	5	0
-06		X	X	X	X	X		X	X	X						X	X						8	2
-07		X	X	X	X	X																	5	0
-08		X	X	X	X	X		X	X	X						X	X						8	2
-09		X	X	X	X	X																	5	0
-10		X	X	X	X	X																	5	0
-11		X	X	X	X	X																	5	0
-12		X	X	X	X	X																	5	0
-13		X	X	X	X	X																	5	0
-14		X	X	X	X	X		X	X	X						X	X						8	2
GS1[c]		X																					1	

X indicates sample will be collected.
[a] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[b] Geotechnical samples also will be collected from a collocated boring.
[c] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7 and analyzed for radionuclides in Table 6.1.

Geotechnical samples also will be collected from location 400-S02-03.

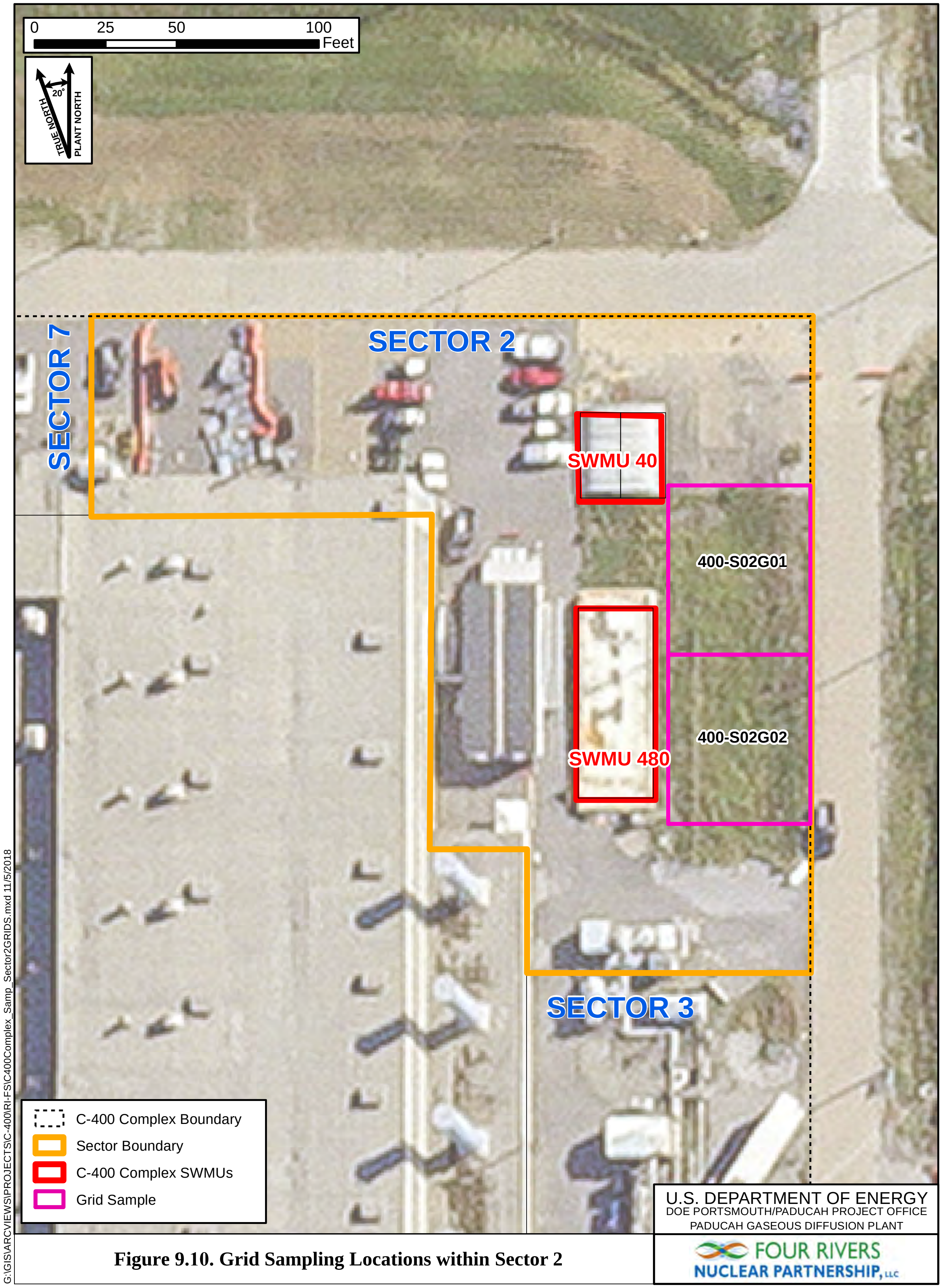

Figure 9.10. Grid Sampling Locations within Sector 2

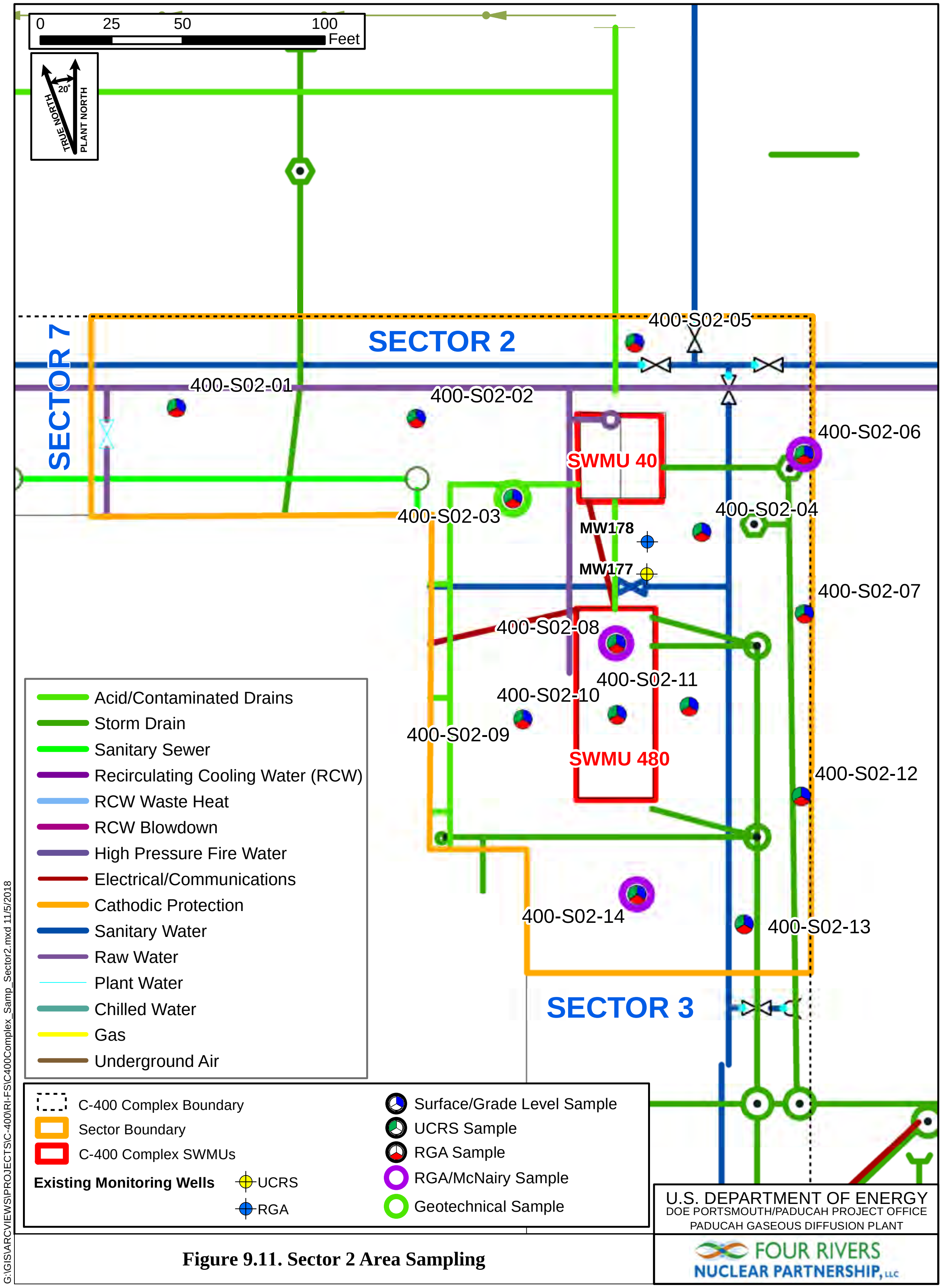

Figure 9.11. Sector 2 Area Sampling

9.3.6 Sector 3

Sampling in Sector 3 is summarized in Table 9.9.

The following are rationale for focused sampling.

- 400-S03-01: Provide information on a nearby storm drain (depression) and a transfer line to the C-410-B Lagoon. Due to the existing storm drain depression, the surface sample will be collected near storm drain; however, the remaining subsurface samples will be collected in close proximity to the storm drain depression to allow a stable surface for drilling operations.

- 400-S03-02, 400-S03-03, and 400-S03-04: Provide information on a nearby storm drain and to confirm WAG 6 data.

- 400-S03-05 and 400-S03-06: Provide information on an acid waste line to C-403 and to bound contamination found in WAG 6 data (i.e., location 400-011).

- 400-S03-07: Confirm WAG 6 data.

- 400-S03-08: Confirm WAG 6 data.

Additionally, 5-point composite samples from grids will be collected, as described in Section 9.1.2.1, from two grids of approximately 50-ft by 50-ft within Sector 3, as shown in Figure 9.12.

- 400-S03G01 and 400-S03G02: Provide information on exposed surface soil.

Table 9.9. Summary of Sector 3 Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[b]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S03																								
G01		X	X																				2	0
G02		X	X																				2	0
-01		X	X	X	X	X																	5	0
-02		X	X	X	X	X		X	X	X						X	X						8	2
-03		X	X	X	X	X																	5	0
-04		X	X	X	X	X																	5	0
-05		X	X	X	X	X		X	X	X						X	X	X	X	X	X	X	10	5
-06		X	X	X	X	X																	5	0
-07[c]		X[a]	X[a]	X	X	X		X	X	X						X	X						8	2
-08		X	X	X	X	X																	5	0
GS1[d]		X																					1	

X indicates sample will be collected.
[a] Samples will be collected and analyzed additionally for dioxins and furans (see Table 6.1).
[b] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[c] Geotechnical samples also will be collected from a collocated boring.
[d] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7 and analyzed for radionuclides in Table 6.1.

Geotechnical samples also will be collected from location 400-S03-07.

The Sector 3 sampling locations are shown on Figure 9.13.

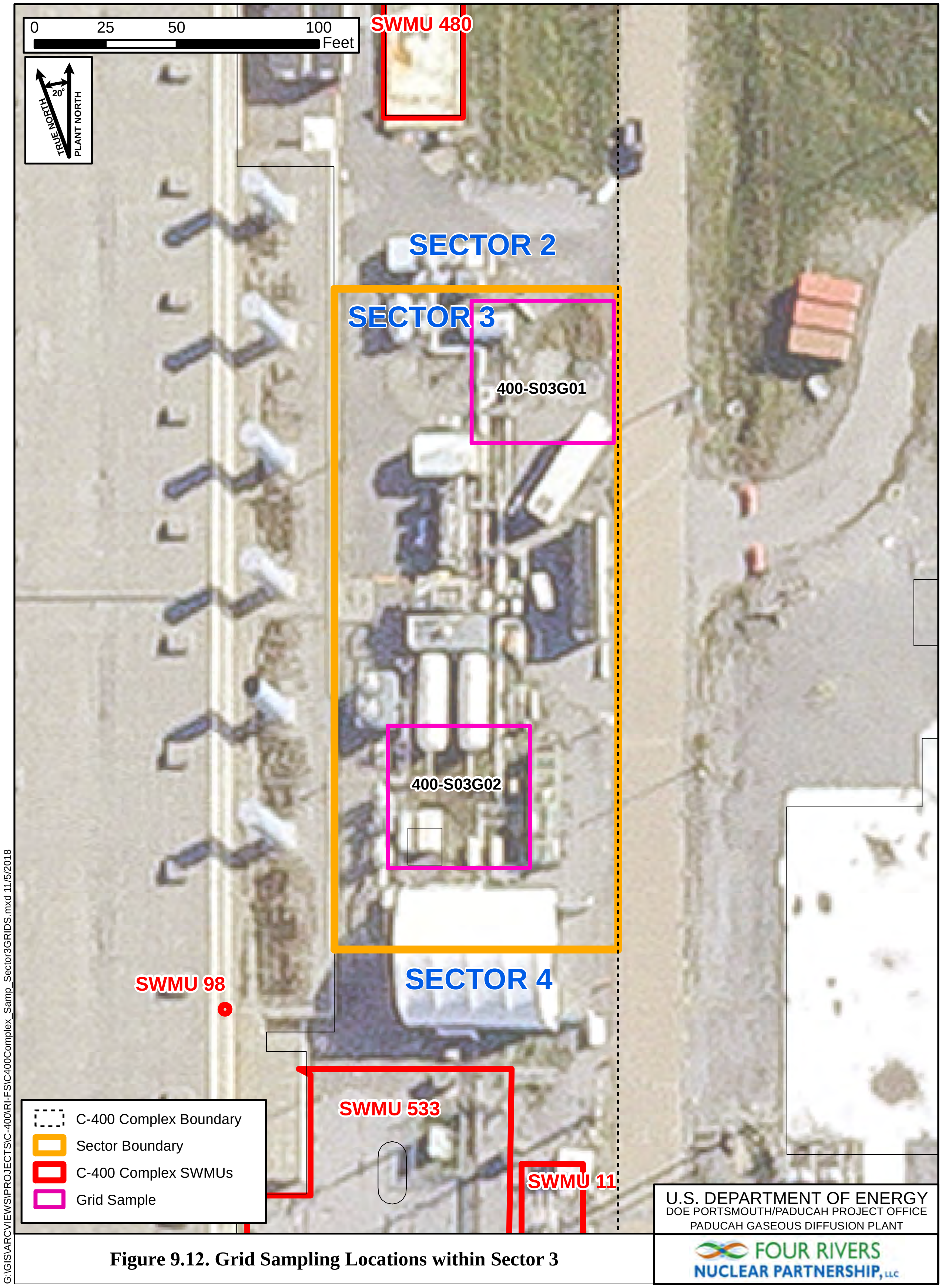

Figure 9.12. Grid Sampling Locations within Sector 3

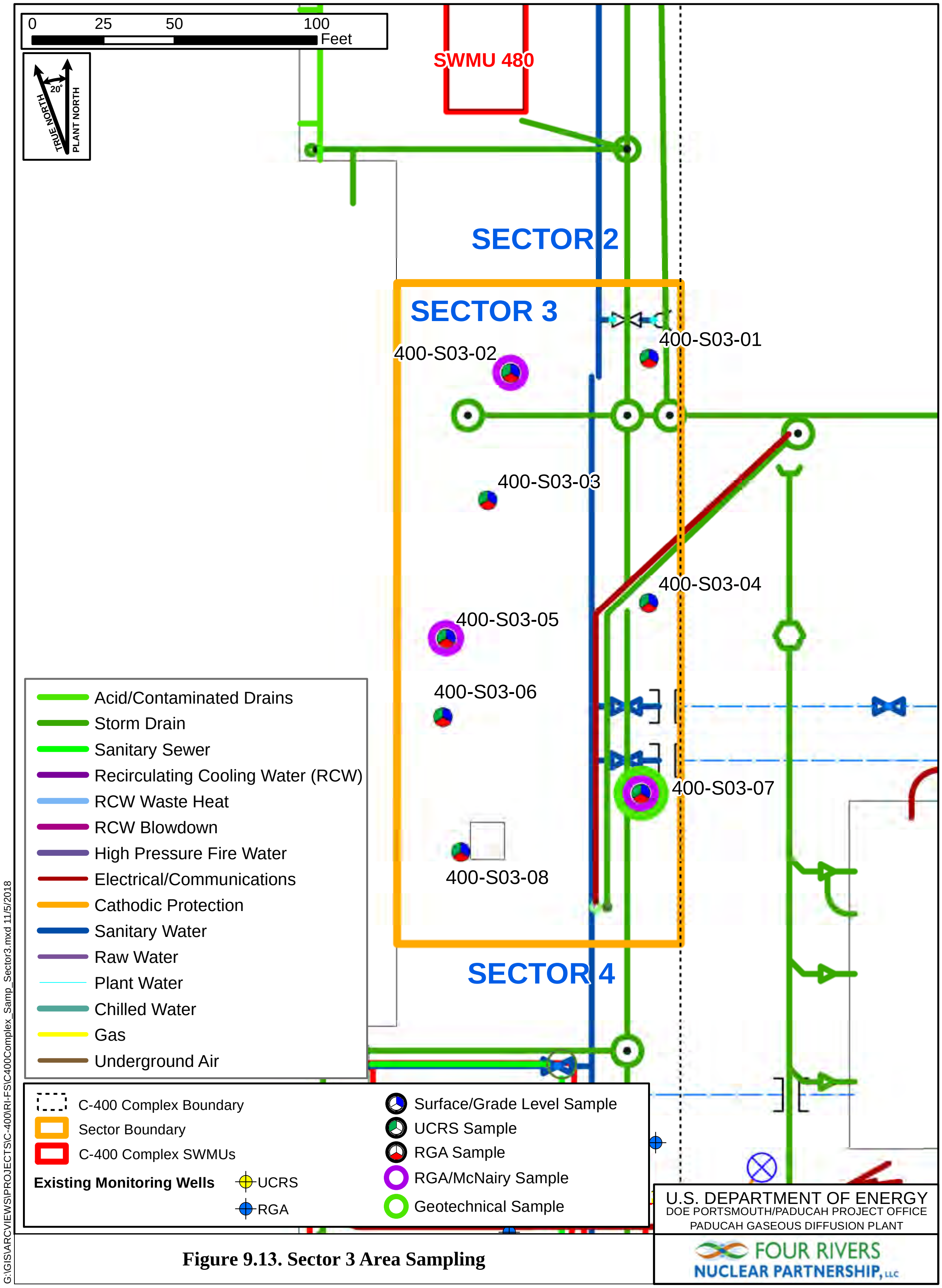

Figure 9.13. Sector 3 Area Sampling

9.3.7 Sector 4

Sampling in Sector 4 is summarized in Table 9.10.

The following are rationale for focused sampling.

- 400-S04-01 and 400-S04-05: Provide information on a nearby storm drain and to confirm WAG 6 data.
- 400-S04-02, 400-S04-08, and 400-S04-13: Confirm WAG 6 data and/or IRA data. Additionally, 400-S04-08 and 400-S04-13 are near a storm drain.
- 400-S04-03: Bound contamination from potential building source(s) and near a storm drain.
- 400-S04-04, 400-S04-07, and 400-S04-14: Provide information for a first line of transects for the Phase IIb area (Figure 4.2).
- 400-S04-06, 400-S04-11 and 400-S04-15: Determine whether contamination is contained within the C-400 Complex.
- 400-S04-12: Confirm previously determined Phase IIb area (Figure 4.2).
- 400-S04-10, 400-S04-16 and 400-S04-17: Determine whether contamination from the Phase IIb area is contained within the C-400 Complex.
- 400-S04-18: (1) reinvestigate the contamination found at WAG 6 sample location 400-092 and to collect samples at deeper depths than the 400-092 location; (2) further investigate the anomalous TCE concentrations in MW505/506/507 since 2015; and, (3) support the consideration of the validity of the CSM and determine the need for contingency samples as described in Sections 9.3.11 and 9.3.12.

Additionally, 5-point composite samples from grids will be collected, as described in Section 9.1.2.1, from eight grids of approximately 50-ft length from along the railroad within Sector 4, as shown in Figure 9.14.

- 400-S04G01 through 400-S04G08: Provide information on railroads.

Figure 9.15 shows the Sector 4 sampling locations.

Table 9.10. Summary of Sector 4 Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[a]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S04																								
G01[c]		X	X																				3[c]	0
G02[c]		X	X																				3[c]	0
G03[c]		X	X																				3[c]	0
G04[c]		X	X																				3[c]	0
G05[c]		X	X																				3[c]	0
G06[c]		X	X																				3[c]	0
G07[c]		X	X																				3[c]	0
G08[c]		X	X																				3[c]	0
-01		X	X	X	X	X																	5	0
-02		X	X	X	X	X																	5	0
-03		X	X	X	X	X																	5	0
-04		X	X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	10	6
-05		X	X	X	X	X	X	X	X	X						X	X						8	3
-06		X	X	X	X	X	X	X	X	X						X	X						8	3
-07		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						13	3
-08		X	X	X	X	X																	5	0
-10		X	X	X	X	X	X	X	X	X						X	X						8	3
-11		X	X	X	X	X																	5	0
-12		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	15	6
-13		X	X	X	X	X																	5	0

Table 9.10. Summary of Sector 4 Sampling (Continued)

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[a]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
-14		X	X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	10	6
-15		X	X	X	X	X																	5	0
-16		X	X	X	X	X	X	X	X	X						X	X						8	3
-17[b]		X	X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	10	6
-18[e]			X	X	X	X		X	X	X						X	X						7	2
GS1[d]		X																					1	

X indicates sample will be collected.
[a] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[b] Geotechnical samples also will be collected from a collocated boring.
[c] Samples will be collected and analyzed additionally for dioxins and furans and pentachlorophenol (see Table 6.1). Samples will be collected at 0-1 ft (if present), 1-4 ft and 4-7 ft. As discussed during scoping, soil is not anticipated to be present in the 0-1 ft interval at the railroad locations. Once soil is encountered the soil sample will be collected and this sample depth will be documented.
[d] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7 and analyzed for radionuclides in Table 6.1.
[e] As discussed during the comment resolution meetings, one defined sample location was added in the vicinity of 400-092 (collected during the WAG 6 investigation) and will be analyzed only for TCE and degradation.

Geotechnical samples also will be collected from location 400-S04-17.

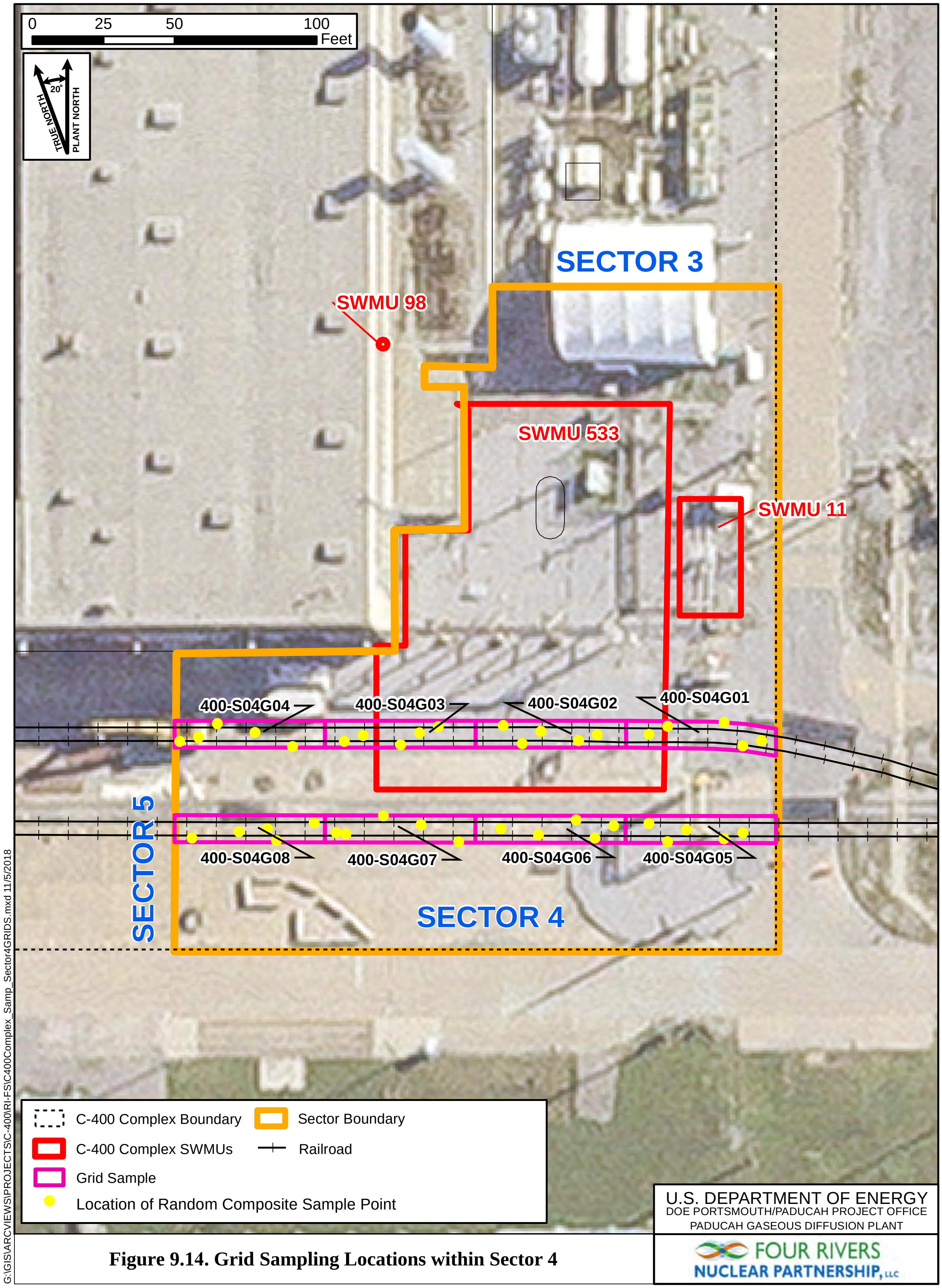

Figure 9.14. Grid Sampling Locations within Sector 4

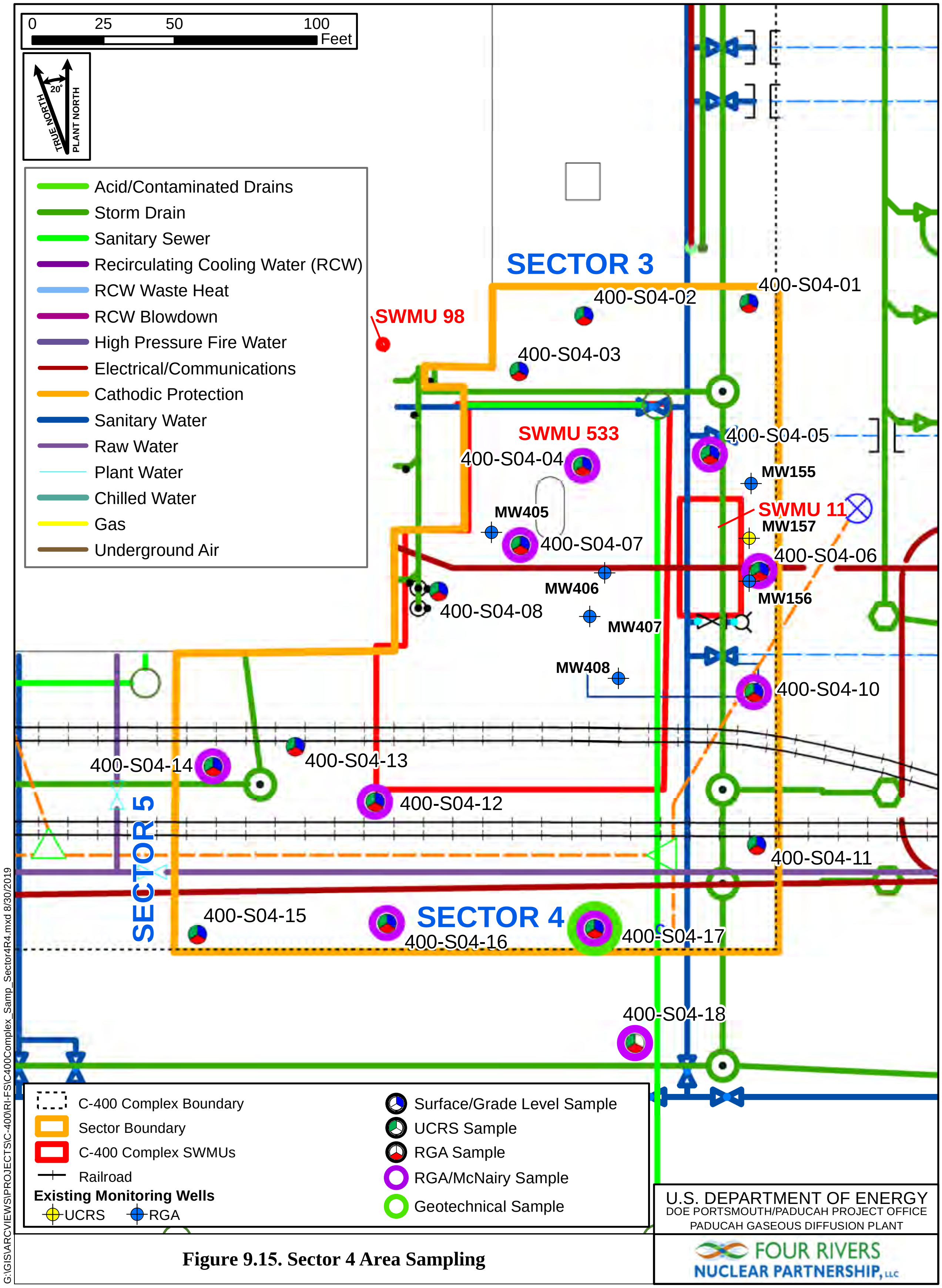

Figure 9.15. Sector 4 Area Sampling

9.3.8 Sector 5

Sampling in Sector 5 is summarized in Table 9.11.

The following are rationale for focused sampling.

- 400-S05-01: Provide information on the discard waste line.

- 400-S05-02, 400-S05-03, 400-S05-06, and 400-S05-10: Provide information on utilities and to confirm WAG 6 data.

- 400-S05-04: Provide information on the discard waste line and to confirm WAG 6 data.

- 400-S05-05 and 400-S05-12: Confirm WAG 6 data.

- 400-S05-07: Bound contamination in the Phase I SW area (Figure 4.2).

- 400-S05-08 and 400-S05-09: Provide information on utilities, confirm WAG 6 data, and bound contamination in the Phase I SW area (Figure 4.2).

- 400-S05-11: Provide information on a nearby storm drain, confirm WAG 6 area, and bound contamination in the Phase I SW area (Figure 4.2).

- 400-S05-13: Confirm WAG 6 data.

Additionally, 5-point composite samples from grids will be collected, as described in Section 9.1.2.1, from seven grids of approximately 50-ft by 50-ft within Sector 5 and from ten grids of approximately 50-ft length from along the railroad, as shown in Figure 9.16.

- 400-S05G01 through 400-S05G10: Provide information on railroads.
- 400-S05G11 through 400-S05G17: Provide information on exposed surface soil.

The Sector 5 sampling locations are shown on Figure 9.17.

Table 9.11. Summary of Sector 5 Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[c]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S05																								
G01[b]		X	X																				3[b]	0
G02[b]		X	X																				3[b]	0
G03[b]		X	X																				3[b]	0
G04[b]		X	X																				3[b]	0
G05[b]		X	X																				3[b]	0
G06[b]		X	X																				3[b]	0
G07[b]		X	X																				3[b]	0
G08[b]		X	X																				3[b]	0
G09[b]		X	X																				3[b]	0
G10[b]		X	X																				3[b]	0
G11		X	X																				2	0
G12		X	X																				2	0
G13		X	X																				2	0
G14		X	X																				2	0
G15		X	X																				2	0
G16		X	X																				2	0
G17		X	X																				2	0
-01		X[a]	X	X	X	X																	5	0
-02		X	X	X	X	X																	5	0
-03[d]		X	X	X	X	X	X	X	X	X						X	X						8	3
-04		X	X	X	X	X																	5	0
-05		X	X	X	X	X																	5	0
-06		X	X	X	X	X																	5	0

Table 9.11. Summary of Sector 5 Sampling (Continued)

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[c]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
-07		X	X	X	X	X																	5	0
-08		X	X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	10	6
-09		X	X	X	X	X																	5	0
-10		X	X	X	X	X																	5	0
-11		X	X	X	X	X																	5	0
-12		X	X	X	X	X																	5	0
-13		X	X	X	X	X	X	X	X	X						X	X	X	X	X	X	X	10	6
GS1[e]		X																					1	

X indicates sample will be collected.
[a] Samples will be collected and analyzed for additional radionuclides (see Table 6.1).
[b] Samples will be collected and analyzed additionally for dioxins and furans and pentachlorophenol (see Table 6.1). Samples will be collected at 0-1 ft (if present), 1-4 ft and 4-7 ft. As discussed during scoping,, soil is not anticipated to be present in the 0-1 ft interval at the railroad locations. Once soil is encountered, the soil sample will be collected, and this sample depth will be documented.
[c] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[d] Geotechnical samples also will be collected from a collocated boring.
[e] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7 and analyzed for radionuclides in Table 6.1.

Geotechnical samples also will be collected from location 400-S05-03.

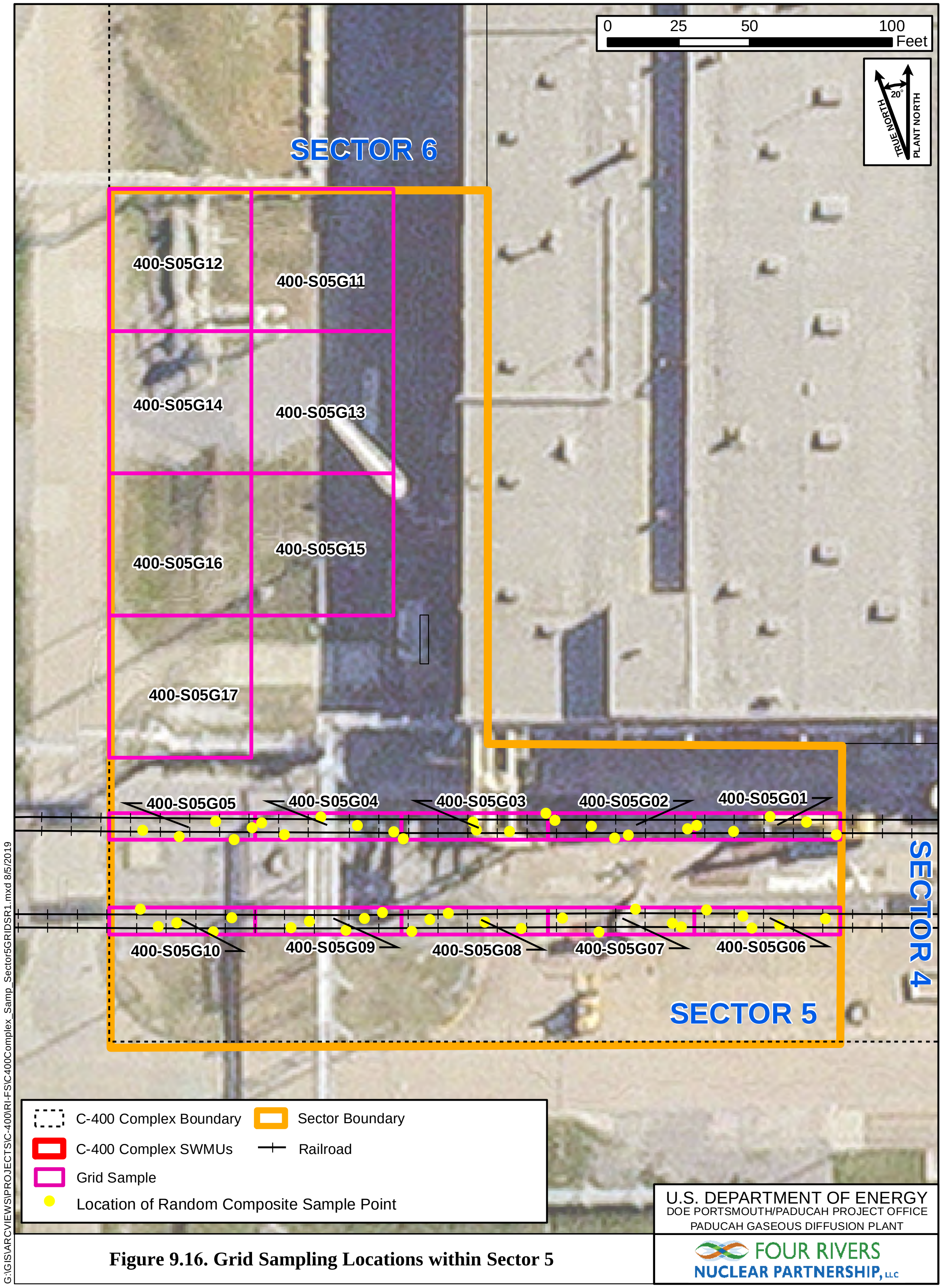

Figure 9.16. Grid Sampling Locations within Sector 5

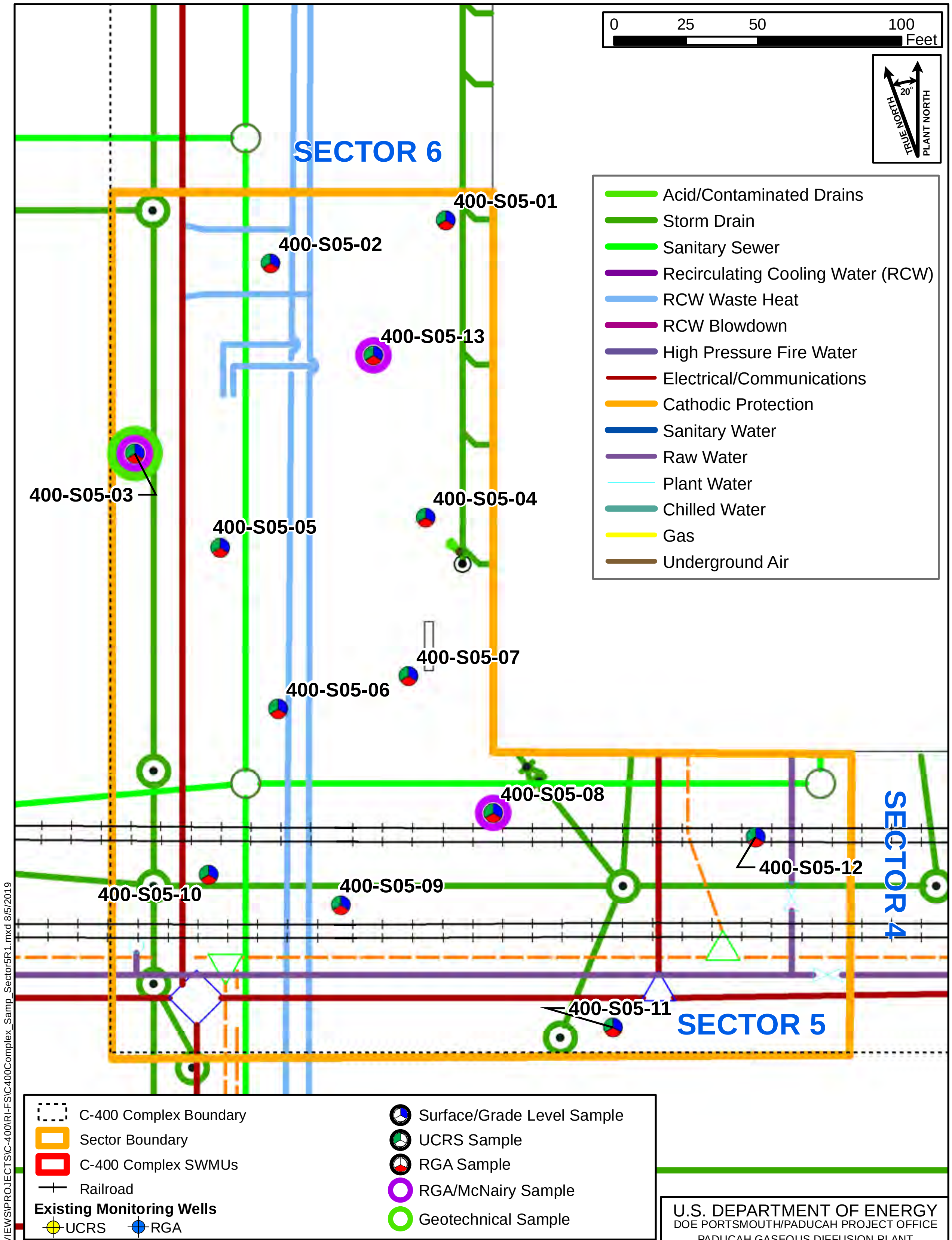

Figure 9.17. Sector 5 Area Sampling

9.3.9 Sector 6

Sampling in Sector 6 is summarized in Table 9.12.

The following are rationale for focused sampling.

- 400-S06-01, 400-S06-03, and 400-S06-05: Provide information on the area of the former Technetium Storage Tank underlying soils (SWMU 47) and on a discard waste line. Additionally, 400-S06-01 will provide information for a Tc-99 transect.

- 400-S06-02: Provide information on utilities.

- 400-S06-04 and 400-S06-06: Provide information on utilities and confirm WAG 6 data.

- 400-S06-07: Target an area of unknown contamination.

- 400-S06-08: Provide information on a discard waste line.

Additionally, 5-point composite samples from grids will be collected, as described in Section 9.1.2.1, from eight grids of approximately 50-ft by 50-ft within Sector 6, as shown in Figure 9.18.

- 400-S06G01 through 400-S06G08: Provide information on exposed surface soil.

Figure 9.19 shows the Sector 6 sampling locations.

Table 9.12. Summary of Sector 6 Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[a]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S06																								
G01		X	X																				2	0
G02		X	X																				2	0
G03		X	X																				2	0
G04		X	X																				2	0
G05		X	X																				2	0
G06		X	X																				2	0
G07		X	X																				2	0
G08		X	X																				2	0
-01		X	X	X	X	X	X	X	X	X						X	X						8	3
-02[b]		X	X	X	X	X	X	X	X	X						X	X						8	3
-03		X	X	X	X	X																	5	0
-04		X	X	X	X	X																	5	0
-05		X	X	X	X	X																	5	0
-06		X	X	X	X	X																	5	0
-07		X	X	X	X	X																	5	0
-08		X	X	X	X	X																	5	0
GS1[c]		X																					1	

X indicates sample will be collected.
[a] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[b] Geotechnical samples also will be collected from a collocated boring.
[c] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7 and analyzed for radionuclides in Table 6.1.

Geotechnical samples also will be collected from location 400-S06-02.

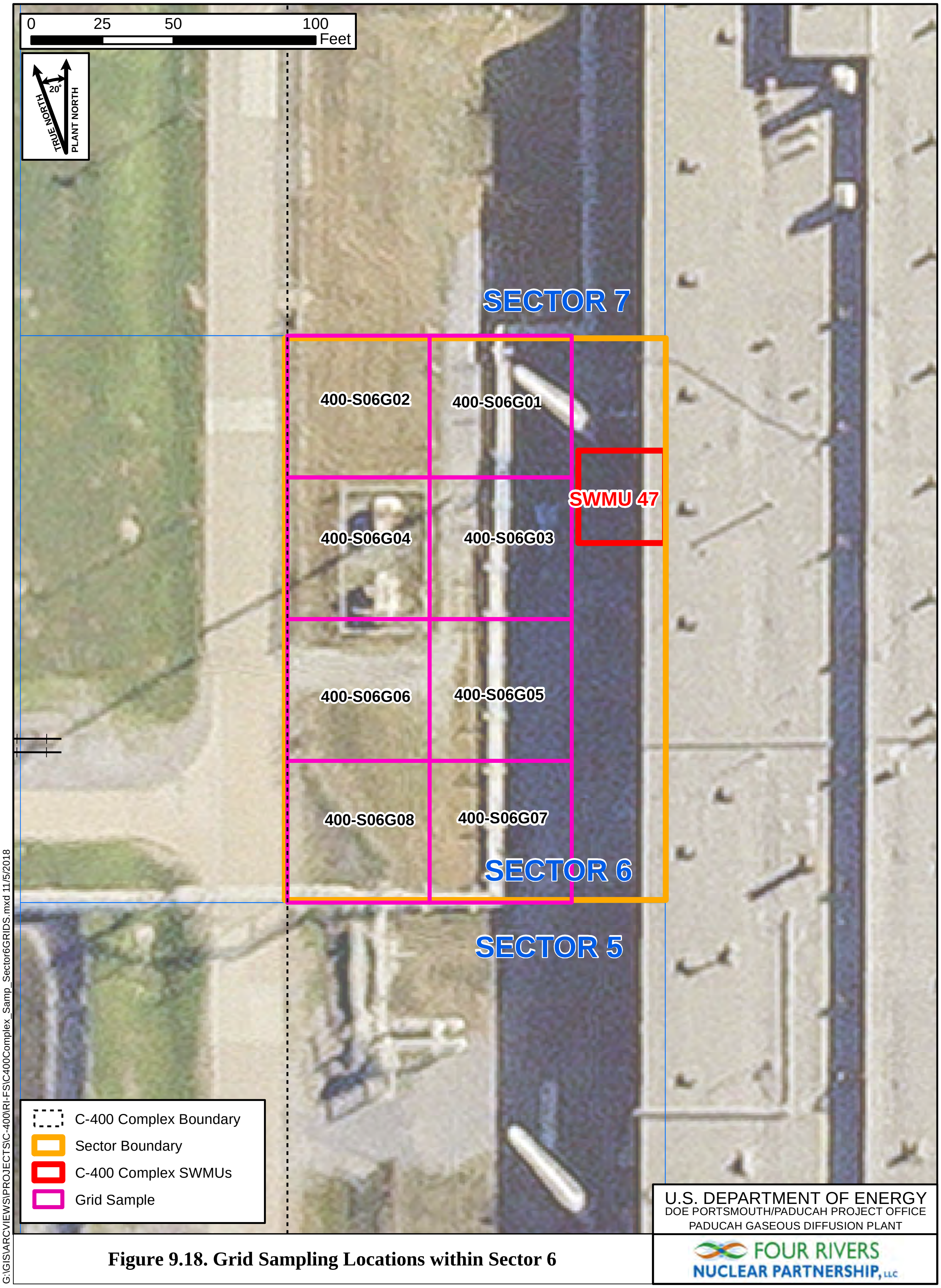

Figure 9.18. Grid Sampling Locations within Sector 6

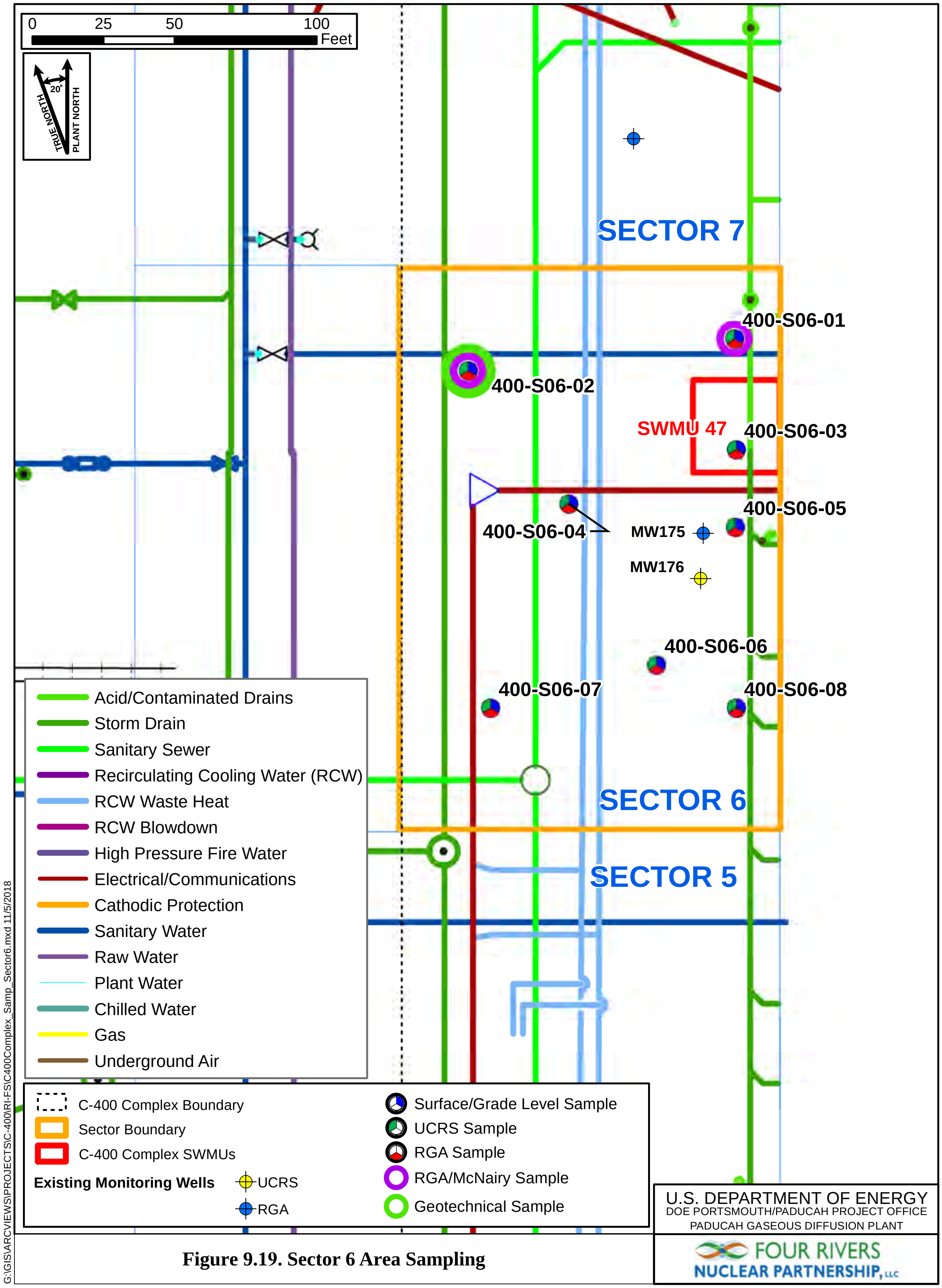

Figure 9.19. Sector 6 Area Sampling

9.3.10 Sector 7

Sampling in Sector 7 is summarized in Table 9.13.

The following are rationale for focused sampling.

- 400-S07-01: Provide information on discard waste line from the C-400 Discard Waste System (SWMU 203) and confirm WAG 6 data.
- 400-S07-02: Provide information on storm drain and other utilities.
- 400-S07-03: Provide information on the C-400 Discard Waste System (SWMU 203) underlying soils, discard waste line, and storm sewer.
- 400-S07-04: Confirm WAG 6 data.
- 400-S07-05: Provide information on discard waste line and the C-400 Discard Waste System (SWMU 203) underlying soils.
- 400-S07-06, 400-S07-07, and 400-S07-08: Provide information on utilities and confirm WAG 6 data.
- 400-S07-09: Provide information for a Tc-99 transect, storm drain, and confirm WAG 6 data.
- 400-S07-10: Provide information for a Tc-99 transect and on discard waste line.

Additionally, 5-point composite samples from grids will be collected, as described in Section 9.1.2.1, from eight grids of approximately 50-ft by 50-ft within Sector 7, as shown in Figure 9.20.

- 400-S07G01 through 400-S07G08: Provide information on exposed surface soil.

The Sector 7 sampling locations are shown on Figure 9.21.

Table 9.13. Summary of Sector 7 Sampling

Sample Point Location	Concrete Samples	Surface Soil Samples	UCRS Samples (Soil)			RGA Sample (Soil)	RGA Samples (Water)			McNairy Samples (Soil)										McNairy Samples (Water)			Total Soil Samples	Total Water Samples
			HU1	HU2	HU3	HU4[c]	HU5 (1)	HU5 (2)	HU5 (3)	Interface	~ 1 ft	~ 2 ft	~ 3 ft	~ 4 ft	~ 6 ft	~ 10 ft	~ 20 ft	~ 35 ft	~ 50 ft	~ 10 ft	~ 20 ft	~ 50 ft		
400-S07																								
G01		X	X																				2	0
G02		X	X																				2	0
G03		X	X																				2	0
G04		X	X																				2	0
G05		X	X																				2	0
G06		X	X																				2	0
G07		X	X																				2	0
G08		X	X																				2	0
-01		X	X	X	X	X																	5	0
-02[d]		X	X	X	X	X		X	X	X						X	X						8	2
-03		X[a,b]	X[b]	X	X	X																	5	0
-04		X	X	X	X	X																	5	0
-05		X	X	X	X	X																	5	0
-06		X	X	X	X	X																	5	0
-07		X	X	X	X	X																	5	0
-08		X	X	X	X	X																	5	0
-09		X	X	X	X	X		X	X	X						X	X	X	X				10	2
-10		X	X	X	X	X		X	X	X						X	X	X	X				10	2
GS1[e]		X																					1	

X indicates sample will be collected.
[a] Samples will be collected and analyzed for additional radionuclides (see Table 6.1).
[b] Samples will be collected and analyzed additionally for dioxins and furans (see Table 6.1).
[c] If HU4 is not present, sample will be collected at the HU3/HU5 interface.
[d] Geotechnical samples also will be collected from a collocated boring.

Table 9.13. Summary of Sector 7 Sampling (Continued)

[e] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected based on inflection point analysis for Sectors 2-7 and analyzed for radionuclides in Table 6.1.

Geotechnical samples also will be collected from location 400-S07-02.

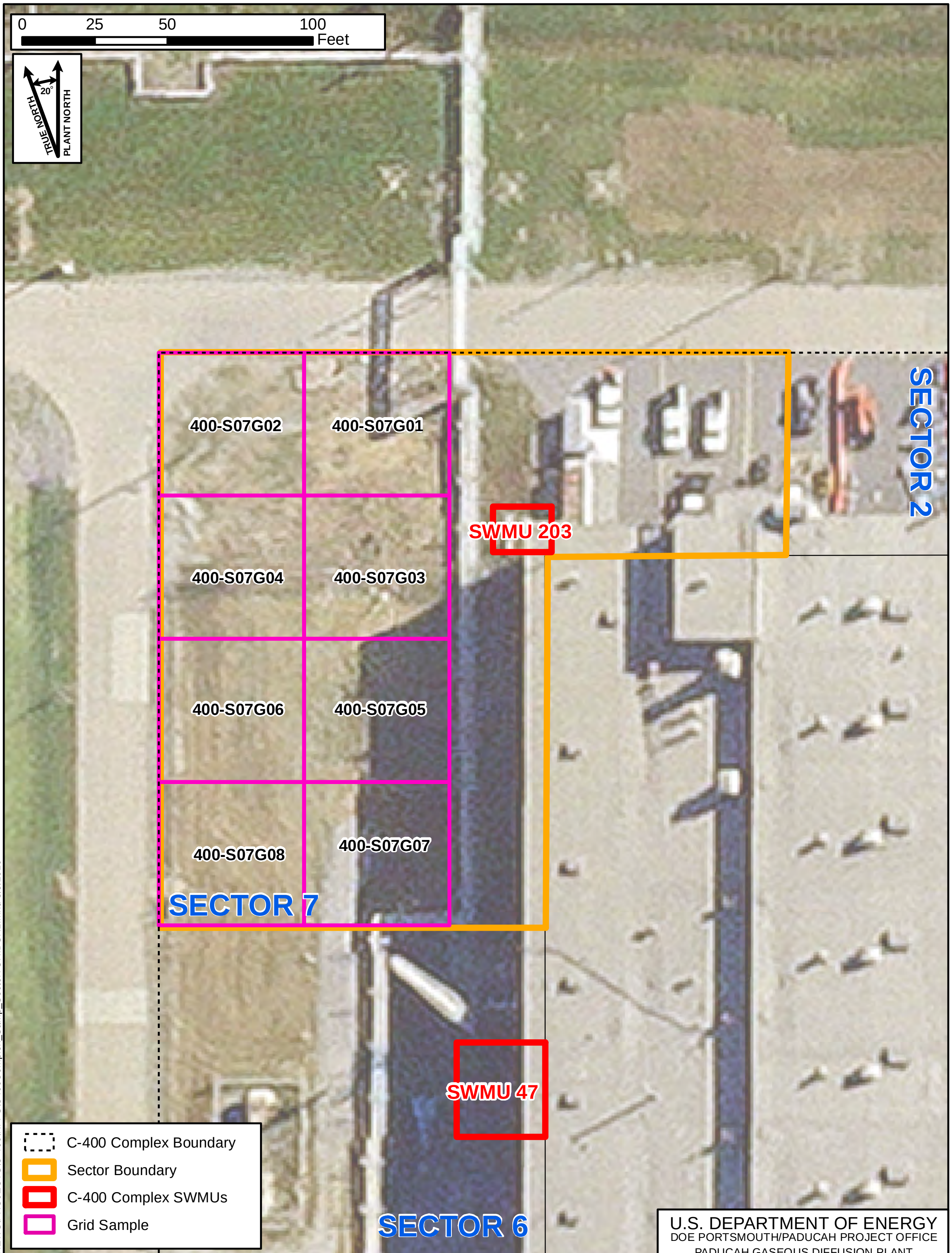

Figure 9.20. Grid Sampling Locations within Sector 7

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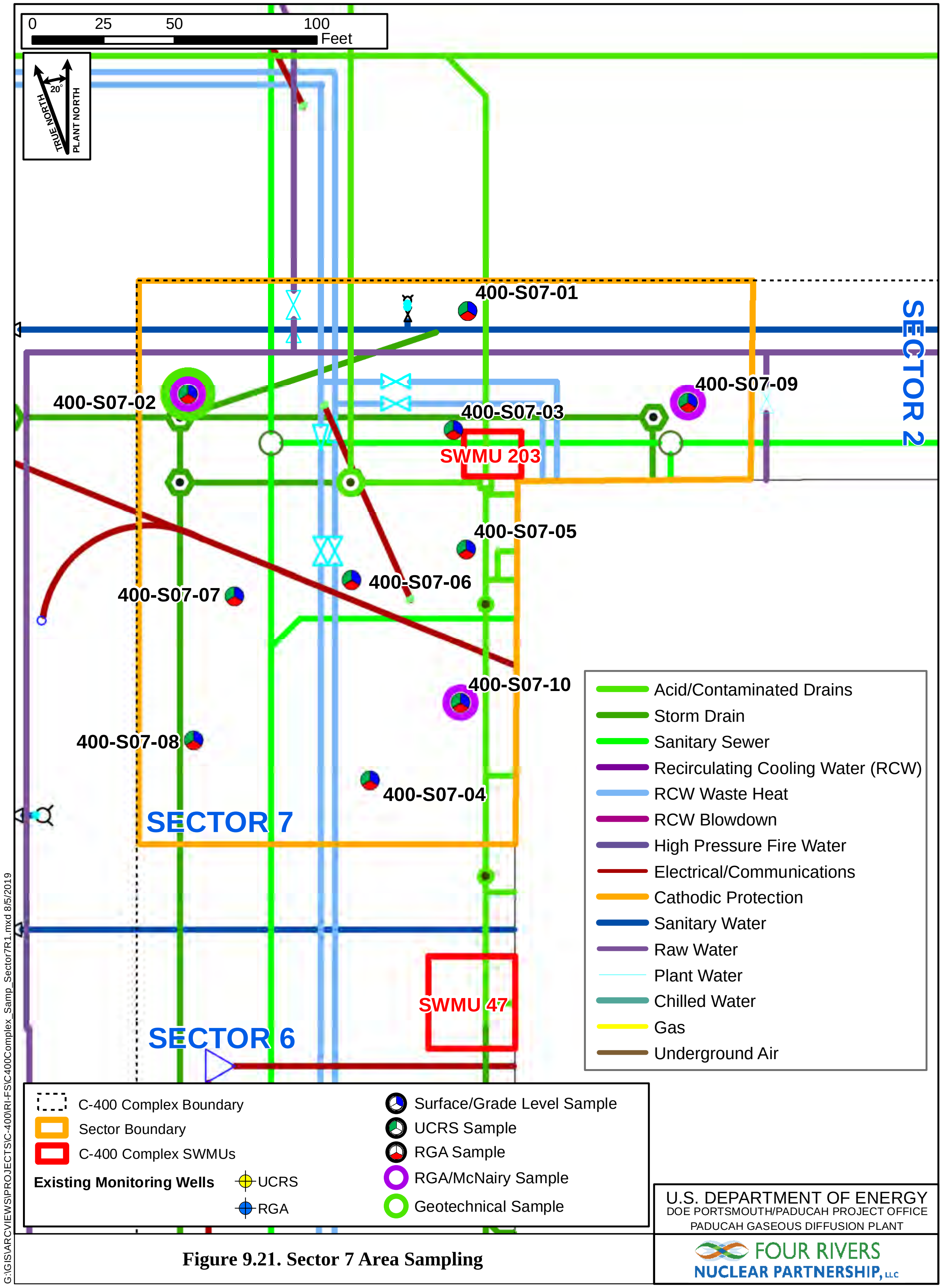


Figure 9.21. Sector 7 Area Sampling

9.3.11 MIP and DyeLIF

A combined total of up to 50 MIP and DyeLIF borings are proposed to be conducted as necessary to address data gaps and provide additional characterization for the DNAPL TCE source area. The following details how the MIP and DyeLIF borings will be conducted.

- The locations and depths of the MIP and DyeLIF borings will be based on the evaluation of results of the soil and groundwater analyses from the sample borings and/or other available information.

- The MIP and DyeLIF borings may begin before completion of the proposed +100 sample borings; however, the MIP and DyeLIF borings will begin after the results of sufficient soil and groundwater analyses have been evaluated for a given area.

- Initially, up to 20 MIP borings will be conducted to provide additional source area delineation data. The number and locations of additional MIP borings will be determined based on the results of these 20 MIP borings and the soil and groundwater data. It is anticipated that between 10 and 20 additional MIP borings may be necessary to enhance delineation of the source area; thus, a total of between 30 and 40 MIP borings will be conducted.

Between 10 and 20 DyeLIF borings will be conducted to characterize the DNAPL TCE source area further. The number and locations of the DyeLIF borings will be based on the results of the soil and groundwater samples collected from the sample borings and the data collected from the MIP borings. The DyeLIF borings will be conducted concurrent with or after the completion of the MIP borings.

DOE will propose MIP and DyeLIF boring locations, and the FFA parties will participate in the review of analytical results from soil and groundwater samples to assist in locating and conducting the MIP and/or DyeLIF borings. In the event the FFA parties cannot reach consensus in locating and conducting the MIP and/or DyeLIF borings, and if delays associated with reaching consensus would impact the ongoing progress of field work, then DOE will make the final determination about locating and conducting the MIP and/or DyeLIF borings (taking into consideration the recommendations from both EPA and KDEP). The MIP and DyeLIF values and other criteria to determine termination depth and identification of potential impacts of the proposed boring locations will be discussed by the FFA parties during locating and conducting the MIP and/or DyeLIF borings. The southern side of Tennessee Avenue will be considered the southern edge of the investigation area for MIP, DyeLIF, and/or contingency borings. If analytical, MIP, and/or DyeLIF results indicate TCE source zone contamination south of Tennessee Avenue, then the CSM is suspect, and the FFA parties will discuss the path forward.

9.3.12 Contingency Sampling

The FFA parties, through the scoping process, agreed to an initial 112 boring locations from which 810 soil and groundwater samples will be collected. Figure 9.22 shows a summary of the C-400 Complex RI/FS sampling (i.e. Sectors 1-7 combined), as discussed above. During the investigation, the results of the analyses conducted on soil and groundwater samples collected from these borings will be plotted in a visual Geographic Information Service (GIS) for all contaminants of interest. The GIS plots will include contours of dissolved TCE that will begin at a concentration of approximately 1% of solubility (11,000 µg/L) and at 50,000 µg/L increments. Contingency sampling for other contaminants of interest also will be put into a visualization program. Contour intervals will be based on MCLs, and other contour intervals will be determined at that time. Two dimensional cross sections also will be included in the RI/FS Report.

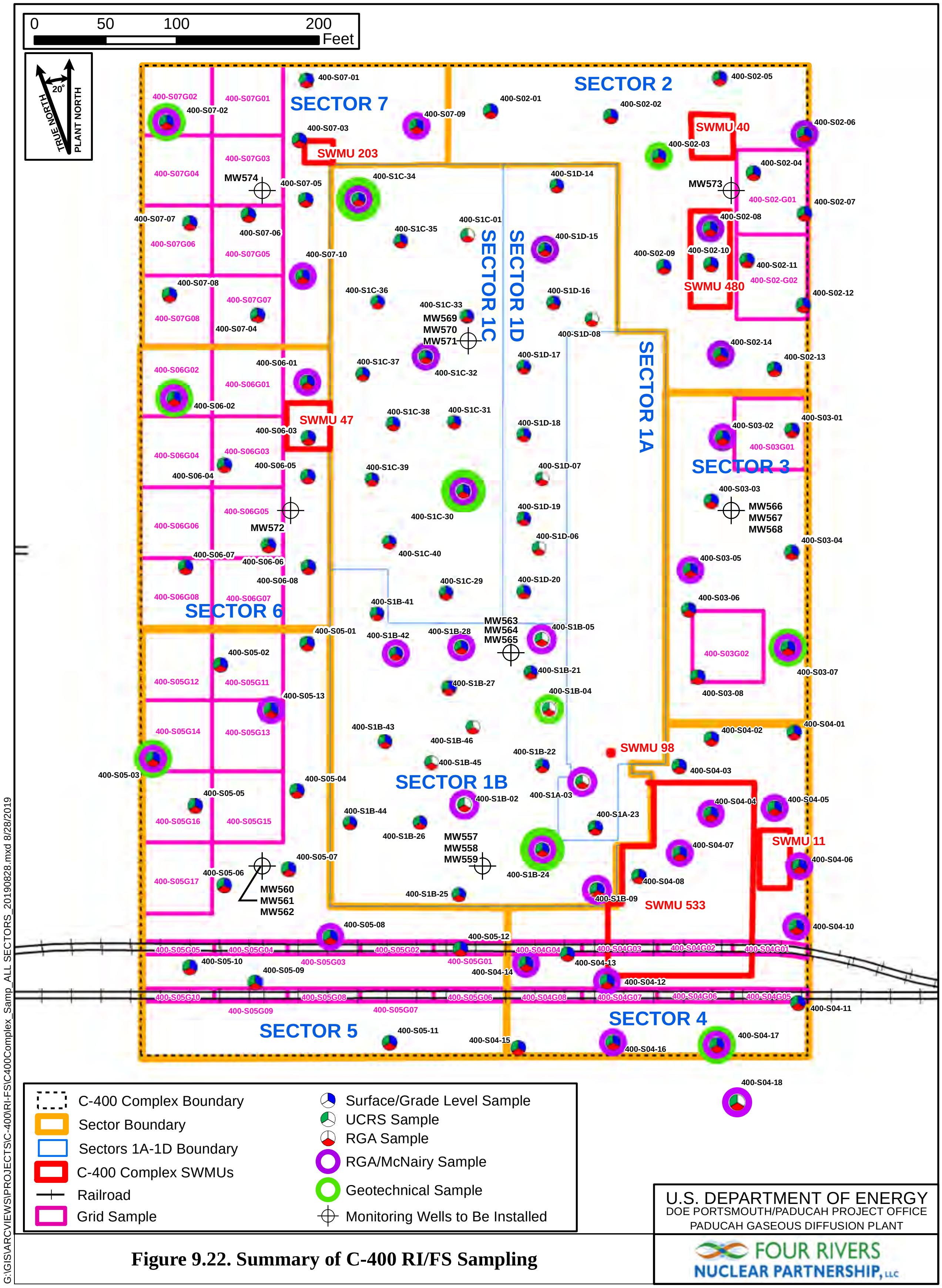


Figure 9.22. Summary of C-400 RI/FS Sampling

Contingent samples and data determined to be useable in the work plan will be used to delineate all potential source areas further. The RI/FS includes a contingency of up to 20% of the borings or up to 10% samples; thus, up to 22 (20%) borings will be conducted to address potential data gaps. Up to 81 (10%) soil and/or groundwater samples will be collected from the contingency boring locations. Contingency soil boring locations and sample media, depth, and analyses will be determined upon evaluations of the data collected from the initial 112 borings and other data determined to be useable in the work plan. The contingent boring locations and depths and sample collection intervals will be determined based upon the results of the soil and groundwater samples collected from the initial sample borings, results of the MIP borings and the DyeLIF borings, and other data determined to be useable in the work plan. The contingent sample borings may be conducted concurrent with the MIP and DyeLIF borings after sufficient MIP and/or DyeLIF data are available in a given area or after completion of all of the MIP and DyeLIF borings. In addition, results of MIP and DyeLIF borings may be used to locate contingency borings and determine sample media, depth, and analyses.

DOE will propose contingency boring locations, and the FFA parties will participate in the review of analytical results from soil and groundwater samples to assist in locating and conducting contingency borings. In the event the FFA parties cannot reach consensus in locating and conducting the contingency borings, and if delays associated with reaching consensus would impact the ongoing progress of field work, then DOE will make the final determination about locating and conducting the contingency borings (taking into consideration the recommendations from both EPA and KDEP). The information needed from contingency borings (contaminants to be analyzed, termination depths, etc.), as well as potential impacts of the proposed boring locations, will be discussed by the FFA parties locating and conducting the contingency borings The southern side of Tennessee Avenue will be considered the southern edge of the investigation area for MIP, DyeLIF, and/or contingency borings. If analytical, MIP, and/or DyeLIF results indicate TCE source zone contamination south of Tennessee Avenue, then the CSM is suspect, and the FFA parties will discuss the path forward.

9.4. SAMPLING PROCEDURES

Fieldwork and sampling at the Paducah Site will be conducted in accordance with DOE Prime Contractor medium-specific work instructions or procedures consistent with *Environmental Investigation Standard Operating Procedure and Quality Assurance Manual*, EPA Region 4, November 2001. The DOE Prime Contractor will document changes on Field Change Request forms as detailed in the QAPP. Table 9.14 provides an example list of investigation activities that may require work instructions or procedures.

9.5 DOCUMENTATION

Field documentation will be maintained throughout the RI/FS in various types of documents and formats, including the field logbooks, sample labels, chain-of-custody forms, and sample data forms. Additional information is contained in the DMIP (Chapter 12). Documentation will be conducted in accordance with DOE Prime Contractor procedures.

Table 9.14. Example RI/FS Activities Requiring Work Instructions or Procedures

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

9.5.1 Field Logbooks

The primary purpose of the logbook is to document each day's field activities; the personnel on each field 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.

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 logbooks will be numbered sequentially or otherwise controlled. A designated field team member will record field activities and pertinent information.

9.5.2 Sample Data Forms

A sample data form will contain sample-specific information for each field sample collected, including field QC samples.

9.5.3 Field Information

Field information will be maintained, as appropriate. Examples may include the following:

- Soil boring logs,
- MW construction logs,
- Well development logs,
- Well purging logs,
- Groundwater sampling logs,
- Instrument calibration logs,
- Temperature monitoring sheets,
- VOC characterization from the PID, and
- Radiological values recorded for each sample collected.

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 sample data forms are not used, information will be recorded manually in the field logbook.

9.5.4 Sample Chain-of-Custody

A sample chain-of-custody form will contain sample-specific information for each field sample collected, including field QC samples. Generally, sample chain-of-custody forms will be preprinted from the Paducah PEMS. If preprinted sample chain-of-custody forms are not used, information will be recorded manually.

9.5.5 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. Whenever new personnel join the field team, they will be briefed on the appropriate work controls. Additional planning meetings may be held if the scope of work changes significantly.

9.5.6 Field Readiness

Before implementation of the field program, the appropriate readiness review process will be conducted in accordance with DOE Prime Contractor procedures.

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 painting, 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. 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 RI/FS project team 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. 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 Project Environmental Measurements System (PEMS) and will be transferred with the station’s ready-to-load (RTL) file to Paducah OREIS.

10. HEALTH AND SAFETY

10.1 PURPOSE

The purpose of this site-specific Health and Safety Plan (HASP) for the C-400 Complex RI/FS is to identify the potential hazards associated with the activities that support DOE and to outline proper control methods to protect the workers, the public, and the environment from potential harm in accordance with CP2-SM-1000, *Activity Level Work Planning and Control Program for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*.

The RI/FS tasks will be performed in accordance with the Hazardous Waste Site Operations and Emergency Response (HAZWOPER) regulation 29 *CFR* § 1910.120, as applicable. The HASP has been developed to meet the requirements of the DOE Prime Contractor procedures. The HASP also is to be used in conjunction with CP2-HS-2000, *Worker Safety and Health Program for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*; CP2-RP-0001, *Radiation Protection Program for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*; CP2-HS-1000, *Integrated Safety Management System Description for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*; and any applicable DOE Prime Contractor procedures.

10.2 INTEGRATED SAFETY MANAGEMENT/ENVIRONMENTAL MANAGEMENT

The C-400 Complex RI/FS project is committed to implementing an ISMS) and an Environmental Management System (EMS that integrate personnel and environmental safety into management and work practices at all levels so that missions are accomplished while protecting the public, the workers, and the environment. The concepts of the ISMS/EMS will be utilized to provide a formal, organized process to ensure the safe performance of work. The *Integrated Safety Management System Description for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, CP2-HS-1000, integrates EMS and identifies the methodologies that will be used to address previously recognized hazards and how the hazards are mitigated using the DOE Prime Contractor-accepted HSS&Q practices.

The core functions and guiding principles of ISMS/EMS will be implemented by incorporating applicable programs, policies, technical specifications, and procedures from the DOE, U.S. Occupational Safety and Health Administration (OSHA), EPA, the DOE Prime Contractor, and other applicable regulatory guidance. Brief descriptions of the five ISMS/EMS core functions are provided below.

10.2.1 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 project team will participate in discussions conducted to understand the scope and contribute to the planning of the work. The project team will meet to ensure that everyone understands the scope of work and the technical and safety issues involved. These meetings are conducted to ensure all parties of the project team are in agreement on the scope and approach to complete the work.

10.2.2 Analyze Hazards

In the course of planning the work, the project team will identify hazards, including personnel safety and environmental risks associated with the performance of the work. Hazards may be identified and assessed by performing a site visit, reviewing lessons learned, and reviewing project plans or historical data. The hazard assessment process is described in procedure CP3-HS-2004, *Job Hazard Analysis*.

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 JHAs or work instructions. These measures provide a control mechanism for all work activities. JHAs are detailed, activity-specific evaluations that address the hazards associated with the tasks and/or activities that will be performed. The JHA development process is a detailed evaluation of each task to identify specific activities or operations required to successfully complete the scope of work and define 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 personal protective equipment (PPE). The project team is responsible for the preparation, revision, and implementation of JHAs and hazard controls.

Applicable JHAs and hazard controls will be reviewed with assigned personnel who will perform the work. Participants in this review will sign and date the JHA or applicable work control to signify that they understand all hazards, controls, and requirements in the work control/JHAs. Copies of the work control documents/JHAs with appropriate signatures shall be maintained and readily accessible.

10.2.3 Develop and Implement Hazard Controls

Project-specific plans and technical procedures are the primary mechanisms used to flow down ISMS/EMS controls to the project team. Other mechanisms include program/project management systems, employee training, communication, work site inspections, independent assessments, and audits. These mechanisms are communicated in the following:

- Pre-job meetings
- Training
- Plan-of-the-day/pre-job briefings
- JHAs
- Radiological work permits (RWP)

The plan-of-the-day/pre-job briefing incorporates the principles of ISMS/EMS. The specific steps within ISMS/EMS are emphasized to each employee. It is emphasized that no employee will be directed or forced to perform any task that he/she believes is unsafe, puts his/her and/or coworker's health at risk, or that could endanger the public or the environment. One of the key elements of ISMS/EMS is that all personnel have "stop work authority" and are encouraged to use this authority whenever they perceive the safety of workers, the public, or the environment to be at risk.

Employee involvement is emphasized in training sessions and in briefings/meetings. Employees are encouraged to participate in the selection, development, and presentation of training/meeting topics and their full and constructive input is encouraged in all communication sessions.

10.2.4 Perform Work

After the project team has been given approval to proceed, the project-specific plans will be implemented. The C-400 Complex project team will verify that all applicable plans, forms, and work control is in place prior to execution of work. Actions that will be taken during the performance of the work to incorporate ISMS/EMS principles include the following:

- Plan-of-the-day/pre-job briefings
- Project safety meetings
- HSS&Q oversight/inspections
- Safety inspections
- Equipment inspection
- Stop work authority

10.2.5 Feedback/Improvement

Feedback and improvement are accomplished through several channels, including ISMS/EMS audits, self-assessments, employee suggestions, lessons learned, and post-job briefings.

The DOE Prime Contractor project management will encourage employees to freely submit suggestions that offer opportunities for improvement and constructive criticism on the program. Project management will conduct periodic inspections in accordance with CP3-OP-0050, *Performance Observations,* and meetings with project personnel at the work site to discuss safety/environmental issues and/or concerns as well as other relevant topics.

During field activities, meetings and briefings will provide opportunities for project personnel to communicate the following:

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

10.3 FLOW DOWN TO SUBCONTRACTORS

The DOE Prime Contractor's approach to HSS&Q ensures that personnel, including subcontractors, are aware of their roles, responsibilities, and authorities for worker/public safety and protection of the environment. DOE Prime Contractor subcontractors will be responsible for compliance with the DOE Prime Contractor's Worker Safety and Health Program. Personnel will have the appropriate health and safety training required by OSHA 29 *CFR* § 1910.120, HAZWOPER, but also will undergo site-specific pre-job training including safety and environmental topics to ensure that HSS&Q issues related to the activities to be performed or specific to the work site are understood clearly. Documentation of personnel training and qualifications will be available for review prior to starting work.

10.4 SUSPENDING/STOPPING WORK

In accordance with procedure CP2-HS-1000, *Integrated Safety Management System Description for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, employees and subcontractors have suspend/stop-work authority and responsibility. This process is defined and governed by procedure CP3-HS-2009, *Stop/Suspend Work*. Individuals involved in any aspect of the project have the authority and responsibility to suspend or stop work for any perceived threat to the safety and health of the workers, other personnel, or to the environment. Concerns shall be brought to the attention of the Frontline Supervisor and/or Industrial Safety/Industrial Hygiene (IS/IH) specialist, they will be evaluated by project management personnel, and actions will be taken to rectify or control the situation. In the case of imminent danger or emergency situations, personnel should halt activities immediately and instruct other affected workers to pull back from the hazardous area. The Frontline Supervisor and/or IS/IH specialist should be notified immediately, at which time plant shift superintendent (PSS) and/or emergency responders will be notified.

10.5 HEALTH AND SAFETY BRIEFINGS

Plan-of-the-day/pre-job briefings detailing the specific hazards of the work to be performed and safety precautions and procedures specific for the job shall be conducted by the subcontractor, Frontline Supervisor, and/or IS/IH specialist at the beginning of each shift. During these briefings, work tasks and the associated hazards (personnel safety and environmental risks) and mitigating controls will be discussed using task-specific work control documents, JHAs, and/or lessons learned as guidance.

Prior to performing work on the site, personnel shall be required to read, or be briefed, on the DOE Prime Contractor's Worker Safety and Health Program, this HASP, applicable JHAs, the work package, and other applicable work control and project related documents. This shall be documented on acknowledgement forms, briefing sheets, or as required reading. Visitors also will be oriented to the applicable plans and potential hazards that they may encounter.

10.6 SITE BACKGROUND/SCOPE OF WORK

Site background and scope of work information can be found in Sections 1, 4, 5, and 9 of this document.

10.7 KEY PROJECT PERSONNEL AND RESPONSIBILITIES

One of the primary underlying principles of a successful project organization is the establishment of clearly defined roles and responsibilities and effective lines of communication among DOE Prime Contractor employees at the Paducah Site, subcontractors, and other organizations. Ensuring that personnel fully understand their roles and responsibilities and that they have a thorough understanding of the scope of work and other project requirements will provide the foundation for successful and safe completion of the project. Individuals and responsibilities will be identified for the various project tasks in the applicable work packages/instructions and communicated to personnel prior to work.

Section 2.1 identifies the roles and responsibilities of key personnel associated with the implementation of the HASP. Each team member shares the responsibility of accomplishing the scope of work; achieving required quality; participating in work planning and JHA development; and maintaining compliance with laws, regulations, and DOE Orders and Directives in a safe working environment. In general, it is the responsibility of every DOE Prime Contractor employee and subcontractor to ensure that work performed is accomplished in a safe and professional manner.

Examples of additional support personnel who fall under the HSS&Q Director (key personnel identified in Section 2.1) and who may support the project are included below.

10.7.1 DOE Prime Contractor Industrial Safety/Industrial Hygiene Specialist

The IS/IH specialist is a representative from the IS or IH groups and is responsible for the following:

- Identifies standards and provides oversight of safety and health compliance and training.

- Provides independent oversight for S&H.

- Assists the Frontline Supervisor in verification of employee suitability for work based on the employee's training and physician's recommendation.

- Advises personnel of potential exposures and consequences.

- Assists in hazard analysis and ensures that JHAs are developed and maintained properly.

- Conducts inspections, as necessary, to verify proper implementation of the Worker Safety and Health Program.

- Notifies the PSS, Frontline Supervisor, and site personnel as required in the Worker Safety and Health Program, DOE Prime Contractor's procedures and this HASP.

- Completes all IS/IH specialist documents and records as required by the DOE Prime Contractor's plans and procedures.

- Participates in accident/incident investigations.

10.7.2 DOE Prime Contractor Quality Assurance Specialist

The QA specialists may be responsible for certain aspects of program implementation and/or assisting project and functional management in the implementation of the QA Program requirements within his/her area of responsibility. Other activities include, but are not limited to, the following:

- Reviews work control documents, applicable plans and procedures, as needed for QA requirements.

- Performs and documents scheduled QA independent assessments and/or surveillances to evaluate the adequacy of project, functional, and subcontractor organizations implementation of QA Program and Implementation Plan requirements.

- Participates in readiness/operational reviews of projects and activities.

- Tracks and trends identified issues and corrective actions in issues management database.

- Identifies problems to management that hinder organizational effectiveness or contract performance.

- Reviews nonconformance documentation and submits the documentation for nonconforming or suspect/counterfeit items for entry into the DOE nonconformance tracking system database.

- Provides support as required for reportable occurrences, as requested by the organizations responsible for the events.

- Assists line organizations in problem identification, causal analysis, and lessons learned development.

- Implements procedure governing the identification, evaluation (screening), and reporting of potential Price-Anderson Amendments Act (PAAA) noncompliance.

- Assists in the development and revision of issues management reports for nonconforming items.

10.8 GENERAL PROJECT HAZARDS

10.8.1 Operation of Project Vehicles and Equipment

All field personnel operating vehicles shall have a valid operator's license and authorization for the type of vehicle being operated, drive responsibly, and comply with posted speed limits. All vehicle occupants shall use seat belts, where available, while project vehicles are in operation and drivers also shall comply with project-specific training requirements. The use of cellular phones or other potentially distracting activities while driving on company business is prohibited. Operators shall walk around the vehicle and check for obstacles and material prior to backing up. Use of a spotter is recommended when backing vehicles as well.

Large vehicles and heavy equipment, such as excavators, cranes, and forklifts, have blind spots and the potential for pinch and crush hazards. Drill rigs also include the hazard of rotating equipment during operations. Heavy equipment shall have a functioning backup alarm or a spotter will be required when the vehicle is backing up in congested areas. The spotter shall not stand directly behind the equipment while backing.

Equipment operations will be in accordance with the DOE Prime Contractor procedure CP3-SM-0020, *Administrative Controls for Powered Industrial Trucks.*

10.8.2 Tools and Equipment

Tools and equipment shall be inspected visually prior to each use to ensure that the devices are in good working order. All guards and safety devices (e.g., power tools) shall be in place when the equipment is in use. The individual conducting an inspection should look for signs of wearing (e.g., frayed power cords, loose parts), missing components (e.g., lock pins, guards), and any indication of a potentially unsafe condition. Deficiencies affecting safe operation of project equipment shall cause the equipment to be taken out of service until properly repaired. The DOE Prime Contractor's field equipment and tools shall be operated only by knowledgeable personnel with appropriate work experience and awareness of the hazards and safe operating procedures of the devices, as applicable. This determination is to be made by the Frontline Supervisor, IS/IH specialist, or his/her designee.

10.8.3 Material and Drum Handling

Material handling will be accomplished using safe lifting procedures. Mechanical lifts and/or carts will be used whenever possible. Whenever moving or lifting objects, travel paths and actions should be considered prior to initiating the work. Drum-handling activities include the general handling, transport, and opening and closing of drums along with the storage of wastes within the drums. These activities shall be performed in accordance with CP3-WM-1017, *Safe Handling and Opening of Sealed Containers* and only by individuals who are knowledgeable in the use of appropriate techniques, drum-handling equipment, and safety devices. Drums/containers will be handled as to avoid spills or releases, such as using spotters when using forklifts to pick-up or move containers and place containers with liquids in/on secondary containment when not in transit.

Drums containing wastes or material could become pressurized and must be inspected prior to handling or opening and periodically, as required. If the container/drum appears to have a swollen lid, side, or bottom and/or emits a hissing sound, consider the container to be pressurized. Do not touch, move, or disturb the container and report it to the Frontline Supervisor and/or IS/IH specialist immediately for appropriate actions. Empty drums also must be inspected prior to opening, since they may be pressurized if subjected to changing temperatures. Drum webs or other restraining device should be used when opening any container suspected of containing pressure to prevent injury from flying lids and or closure rings.

10.8.4 Electrical Service

DOE Prime Contractor personnel using portable generators shall ensure that the units are grounded, as required, prior to use. To provide additional worker protection, ground-fault circuit interrupters will be used at the primary power distribution location whenever portable electrical equipment powered by 120-volt alternating current is used. Whenever possible, electrical cords will be routed out of traffic areas or adequately shielded. As with other field equipment, all cords should be inspected before use, and any damaged equipment shall be removed from service and a defective equipment tag attached until replaced or repaired. Personnel will adhere to requirements set forth by National Fire Protection Association 70E and CP3-SM-0019, *Electrical Safety Guidelines.*

CP3-HS-2010, *Instructions for Lockout/Tagout* establishes the requirements for the lockout/tagout (LOTO) of energy sources and the use of LOTO Work Permits at the Paducah Site. This program applies to all energy sources including electrical, mechanical, hydraulic, pneumatic, chemical, thermal or other sources in machines and equipment that can be hazardous to workers. During the servicing and maintenance of machines and equipment, the unexpected startup or release of stored energy could cause injury to employees. LOTO permitting will be used for the protection of personnel, be established for planned or anticipated maintenance/support activities and required if unexpected operation or energizing could cause injury.

10.8.5 Fire Safety

Refueling equipment can present a significant fire/explosion hazard if subjected to sparks, static electricity, or other ignition sources. Subcontract personnel who handle/transfer containers with flammable liquids to another container shall be bonded appropriately prior to use. Only safety containers approved by the Factory Mutual Research, Underwriters Laboratories, or U.S. Department of Transportation (DOT) will be used to transport and store these liquids. Site personnel are to ensure that the equipment used to transfer the liquids is approved for the material being handled and personnel should take precautions to prevent overfilling and spill/drips. Safety cans shall be labeled as to their contents and properly secured during transport. When applicable, equipment should be given adequate time to cool down before refueling. During refueling operations, a 20-B:C rated fire extinguisher will be within 50 ft of the operation.

Smoking is not allowed in the work area or radiologically controlled areas. Smoking will be allowed in designated areas and cigarette butts properly discarded as not to create litter or pose a fire risk. Personnel shall adhere to CP2-FP-2002, *Control of Flammable/Combustible Liquids.*

10.8.6 Housekeeping

Good housekeeping, including routine site cleanup and waste management, shall be practiced at all times to improve the general safety of the site activities. Housekeeping efforts may include eliminating or minimizing slip, trip, and fall hazards. Sanitary trash shall be containerized and disposed of periodically. Supplies, materials, and ancillary equipment should be properly stowed when not in use, and walk areas shall be kept free of obstructions.

10.8.7 Slips, Trips, and Falls

The work locations, especially excavations, rough terrain, as well as surface obstructions, may pose hazards causing slips, trips, and/or falls. Care should be taken when working around uneven terrain, and obstructions should be kept out of walkways. Slipping hazards, such as grease, oil, water, or other liquids, shall be cleaned up immediately or addressed in work areas and packaged appropriately after cleanup as warranted.

10.8.8 Head, Eye, Hand, and Foot Hazards

Work activities have potential hazards that may result in injuries to the head, eyes, hands, or feet. The use of engineering controls (such as ensuring that appropriate machine guarding is in place) or administrative controls (such as restricting personnel from encroaching in machine operating areas) have limited applications for these hazards. The use of PPE may be necessary to adequately address these hazards. Where these hazards exist, the task-specific JHA, work instruction, and/or RWP will specify the use of appropriate PPE, including American National Standards Institute (ANSI)-approved hard hats, safety eye protection, gloves (as required), and safety-toed footwear or composite safety shoes.

10.8.9 Elevated Work

Mobilization, demobilization, and routine maintenance of equipment will require elevated work for assembling the equipment. Fall protection shall be used for elevated work, and operators of man lifts shall be trained and follow manufacturers procedures for their operation. All elevated work activities will follow CP3-HS-2036, *Aerial Devices*, and CP3-HS-2014, *Fall Prevention and Protection*.

10.8.10 Kinetic Energy

All kinetic hazards must be protected against any harm to personnel. Kinetic energy associated with motion or the potential for motion. Motion hazards are most commonly linked to mechanical energy but other forms of movement are hazards as well.

10.9 SUSPECTED CHEMICAL AND RADIOLOGICAL HAZARDS

TCE. As previously mentioned, the primary groundwater COC is TCE. This contaminant is a halogenated organic compound used by industry in the past for a variety of purposes. It mainly was used as a degreasing and cleaning agent on-site. EPA has set the MCL for drinking water at 5 ppb and the American Conference of Governmental Industrial Hygienists (ACGIH) has the 8-hour time weighted average at 10 ppm. TCE is a nonflammable, colorless liquid that has a sweet odor and a sweet burning taste. Historically, TCE was used as a solvent to clean equipment. It is heavier than water and has low solubility (up to one part TCE per thousand parts of water at room temperature). TCE in high concentrations may take on a liquid form commonly referred to as DNAPL and in the presence of water forms a separate phase from the water. These qualities make TCE a difficult contaminant to remediate. When present in groundwater, TCE tends to settle into a layer at the bottom of the aquifer and then continuously dissolves into the groundwater. This has resulted in varying levels of TCE in the aquifer for years after the release of TCE at the Paducah Site. TCE no longer is used in processes at the Paducah Site.

Breathing small amounts of TCE may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Breathing large amounts of TCE may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage. Drinking large amounts of TCE may cause nausea, liver damage, unconsciousness, impaired heart function, or death. Drinking small amounts of TCE for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear. Skin contact with TCE for short periods may cause skin rashes. In its 12th Edition of the Report on Carcinogens, the National Toxicology Program determined that TCE is "reasonably anticipated to be a human carcinogen." The International Agency for Research on Cancer has determined that TCE is a "probably carcinogenic to humans (Group 2A)."

1,2-Dichloroethene, *cis*- and *trans*-. 1,2- DCE is a degradation product of TCE. It exists in two isomeric forms, *cis*-1,2-DCE and *trans*-1,2-DCE. Although not utilized extensively in industry, 1,2-DCE is used both in the production of other chlorinated solvents and as a solvent. Humans are exposed to 1,2-DCE primarily by inhalation, but exposure also can occur by oral and dermal routes. Information on the toxicity of 1,2-DCE in humans and animals is limited. Studies suggest that the liver is the primary target organ. EPA does not classify 1,2-DCE as a human carcinogen.

Vinyl Chloride. Vinyl chloride (VC) is a degradation product of TCE. It is also a halogenated organic compound and is used in industry as an intermediary of polyvinyl chloride (PVC) and other chlorinated compounds. VC has not been used in the PGDP manufacturing processes. Exposure to VC has been associated with narcosis and anesthesia (at very high concentrations), liver damage, skin disorders, vascular and blood disorders, and abnormalities in central nervous system and lung function. Liver cancer is the most common type of cancer linked with VC, a known human carcinogen. Other cancers related to exposure include those of the lung, brain, blood, and digestive tract.

1,1-DCE. 1,1-DCE is used primarily in the production of PVC copolymers and as an intermediate for synthesis of organic chemicals. Acute exposure to 1,1-DCE has been associated with central nervous system depression, which may progress to unconsciousness. 1,1-DCE is irritating when applied to the skin, and prolonged contact can cause first-degree burns. Direct contact with the eyes may cause conjunctivitis and transient corneal injury. EPA has classified 1,1-DCE as a possible human carcinogen.

PCB. PCBs are synthetic organic chemicals comprising 209 individual chlorinated biphenyl compounds (known as congeners). Exposure to each of these compounds is associated with different levels of risk for harmful effects. Potential for overexposure to PCBs is believed to be low for the field activities because the expected amount of PCBs that may be present in the soil and/or water samples is, for the most part, well defined and the routes of entry are limited for personnel exposure. If PCB levels are unknown and/or expected to be elevated above action limits, personnel will be notified and proper controls put in place in the JHA/work control to protect personnel.

Uranium-234, -235 and -238. Uranium-234, -235 and -238 (collectively) may be the most abundant radionuclides at the Paducah Site and pose a potential for worker exposure when performing invasive work and in radiologically controlled areas. Uranium isotopes undergo radioactive decay by emission of an alpha particle and weak gamma radiation. Workers may be exposed to uranium by inhaling contaminated dust in the air, ingesting contaminated water and food, or if not properly protected through cuts in the skin. Uranium may be harmful to people as a chemical toxin, as well as radioactive substance, and once inside the body is linked to cancer and especially kidney damage.

Tc-99. Technetium-99 is a fission product and is a long-lived, low-energy beta-emitting radionuclide and is one of the major COCs, especially in the groundwater plume. Tc-99 is a light element that is very mobile and bonds to protein and usually cannot be easily removed, especially from hair. Like most radionuclides, it is harmful if taken internally although the beta particles it emits are very weak. The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs and JHAs.

Cesium-137. Cesium-137 is a fission product and is a long-lived gamma emitting radionuclide. Cesium-137 generally is considered to have limited mobility in the environment. The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs and JHAs.

Thorium-230. Thorium-230 is a naturally occurring decay product of uranium-238, and it was chemically separated at the Paducah Site. Thorium poses a potential for worker exposure when performing invasive work and in radiological controlled areas. Thorium undergoes radioactive decay by emission of an alpha particle. Workers may be exposed to thorium by inhaling contaminated dust in the air, ingesting contaminated water or food, or if not properly protected though cuts in the skin. Thorium is a radioactive substance, and once inside the body is linked to cancer. The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs, and JHAs.

Plutonium-239. Plutonium-239 is a man-made element created during the fission process in nuclear reactors, and it was sent to Paducah as reprocessed fuel. Plutonium poses a potential for worker exposure when performing invasive work and in radiological controlled areas. Plutonium undergoes radioactive decay by emission of high energy alpha particle and low energy gamma/X-rays. It has a shorter half-life as compared to uranium with higher potential of internal exposure. Workers may be exposed to plutonium by inhaling contaminated dust in the air, ingesting contaminated water or food, or if not properly protected though cuts in the skin. Plutonium is a radioactive substance, and once inside the body is linked to cancer and especially in lung, liver and bone. The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs, and JHAs.

Neptunium-237. Neptunium-237 is a man-made element created during the fission process in nuclear reactors, and it was sent to Paducah as reprocessed fuel. Neptunium poses a potential for worker exposure when performing invasive work and in radiological controlled areas. Neptunium undergoes radioactive decay by emission of high energy alpha particle and low energy gamma/x-rays. It has a shorter half-life as compared to uranium with higher potential for internal exposure. Workers may be exposed to Neptunium by inhaling contaminated dust in the air, ingesting contaminated water or food, or if not properly protected though cuts in the skin. Neptunium is a radioactive substance, and once inside the body is linked to cancer and especially in lung, liver and bone. The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs, and JHAs.

Americium-241. Americium-241 is a man-made element created during the fission process in nuclear reactors, and it was sent to Paducah as reprocessed fuel. Americium poses a potential for worker exposure when performing invasive work and in radiological controlled areas. Americium undergoes radioactive decay by emission of high energy alpha particle and low energy gamma/x-rays. It has a shorter half-life as compared to uranium with higher potential for internal exposure. Workers may be exposed to Americium by inhaling contaminated dust in the air, ingesting contaminated water or food, or if not properly protected though cuts in the skin. Americium is a radioactive substance, and once inside the body is linked to cancer and especially in lung, liver and bone. The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs, and JHAs.

UF_6 Cylinders. UF_6 cylinders emit a low level external gamma radiation field (less than 5 mrem/hr) and a very low level external neutron radiation field range (0.2 mrem/hr). The potential for personnel exposure is limited and controls are implemented through the procedures, work instructions, RWPs, and JHAs.

Asbestos. Asbestos is a group of naturally occurring minerals that are resistant to heat and corrosion. Asbestos has been used in products, such as insulation for pipes (steam lines for example), floor tiles, building materials, and in vehicle brakes and clutches. Asbestos includes the mineral fibers chrysotile, amosite, crocidolite, tremolite, anthophyllite, actinolite. Asbestos is well recognized as a health hazard, and its use now is highly regulated by both OSHA and EPA. Asbestos fibers associated with these health risks are too small to be seen with the naked eye. Breathing asbestos fibers can cause a buildup of scar-like tissue in the lungs called asbestosis and result in loss of lung function that often progresses to disability and death. Asbestos also causes cancer of the lung and other diseases such as mesothelioma of the pleura, which is a fatal malignant tumor of the membrane lining the cavity of the lung or stomach.

There is a potential of exposure to other materials as part of site operations. These material descriptions and permissible exposure limits (PELs) are listed in Table 10.1.

10.10 SUSPECTED BIOLOGICAL HAZARDS

Biological hazards that may be present at the site include snakes; insects such as ticks; and poisonous plants, such as poison ivy, oak, or sumac. Personnel should be aware of the presence of potential hazards and prevent insects and ticks with repellant and avoid hazards as much as possible. Personnel who are or may be hypersensitive to plants and insects stings should report their condition to the Frontline Supervisor, Field Team Leader, or designee and IS/IH specialist.

10.11 SUSPECTED PHYSICAL/CONSTRUCTION HAZARDS

The physical hazards discussed in the sections that follow have been identified as potential hazards for activities and/or tasks that will be required during the work activities. Strict adherence to standard work practices and the DOE Prime Contractor's procedures will aid in the elimination or control of these hazards.

10.11.1 Noise

Saws, generators, compressors, and other equipment may produce noise exceeding 85 decibels. Sound levels will be assessed and/or measurements will be taken for specific equipment and tasks, and project personnel will be made aware of the hearing protection requirements. Noise assessment, prevention, and protection will be in accordance with procedure CP2-HS-2002, *Occupational Noise Exposure and Hearing Conservation Program.*

Table 10.1. Chemical Exposure and Hazard Information

Substance	Odor	PEL	Route	Symptoms of Exposure	Treatment
Carbon monoxide	Odorless	25 ppm	Inhalation	Headache; nausea, weakness; dizziness; confusion; hallucinations; angina; coma; death	Eye: Immediate medical attention Skin: Immediate medical attention Breath: Respiratory support
TCE	Characteristic aromatic	10 ppm	Inhalation Ingestion Contact	Eye, skin, and mucous membrane irritation; dermatitis; headache, fatigue, dizziness, confusion	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention

Table 10.1. Chemical Exposure and Hazard Information (Continued)

Substance	Odor	PEL	Route	Symptoms of Exposure	Treatment
1,2-DCE (*cis-*, *trans-)*	Acrid, chloroform	200 ppm	Inhalation Ingestion Contact	Eye, skin, and throat irritation; headache, fatigue, central nervous system depression; liver and kidney damage	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention
1,1-DCE	Mild, sweet, chloroform	5 ppm	Inhalation Ingestion Contact	Eye, skin and throat irritation; dizziness; headache; fatigue; central nervous system depression; liver and kidney damage	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention
VC	Pleasant- at high concentration	1 ppm	Inhalation Ingestion Contact	Eye, skin and throat irritation; dizziness; headache; fatigue; central nervous system depression; liver and kidney damage	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention
Compressed nitrogen (simple asphyxiant)	Gas	N/A	Inhalation Contact	Headache; nausea, weakness; dizziness; confusion; difficulty breathing	Breath: Respiratory support, oxygen, immediate medical attention
Diesel fuel	Oily	100 mg/m³	Inhalation Ingestion Contact	burning sensation in chest; headache, nausea, weakness, restlessness; incoherence, confusion, drowsiness; diarrhea; dermatitis	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention
Diesel exhaust (carcinogenic)	Varies upon exhaust components	CO 25 ppm	Inhalation	Eye irritation; pulmonary function changes	Breath: Respiratory support

Table 10.1. Chemical Exposure and Hazard Information (Continued)

Substance	Odor	PEL	Route	Symptoms of Exposure	Treatment
Gasoline (carcinogenic, benzene)	Characteristic aromatic	300 ppm	Inhalation Ingestion Contact	Eye, skin, and mucous membrane irritation; dermatitis; headache, fatigue, dizziness, confusion	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention
Silica, crystalline (as respirable dust)	Colorless, odorless solid	0.025 mg/m³	Inhalation Ingestion Contact	Cough; breathing difficulty; wheezing; decreased pulmonary function; progressive respiratory symptoms (silicosis); irritation eyes	Eye: Irrigate immediately Skin: Soap wash daily Breath: Respiratory support Swallow: Immediate medical attention
PCB (in soil, stains, paint, or caulk)	Dust visible Oily stains	0.5 mg/m³	Inhalation, Ingestion Contact	Irritated eyes, nose and throat, dermatitis;	Eye: Irrigate immediately Skin: Soap flush promptly Breathing: Respiratory support
Hydrochloric Acid Sulfuric Acid Nitric acid	Vapors	5 ppm 0.2 mg/m³ 2 ppm	Inhalation, Ingestion Contact	Irritated eyes, nose and throat, larynx; cough, choking; dermatitis; skin burns; pulmonary edema	Eye: Irrigate immediately Skin: Soap wash immediately Breath: Respiratory support Swallow: Immediate medical attention
Uranium	Dust visible	0.2 mg/m³	Inhalation Ingestion Contact	Irritated eyes, nose and throat, dermatitis; skin burns; nausea; jaundice	Eye: Irrigate immediately Skin: Soap flush promptly Breathing: Respiratory support Swallow: Medical attention immediately
Technetium-99	N/A	Set by 10 *CFR* § 835	Inhalation Ingestion	Cancer	If contact suspected, notify RADCON immediately

Table 10.1. Chemical Exposure and Hazard Information (Continued)

Substance	Odor	PEL	Route	Symptoms of Exposure	Treatment
Cesium 137	N/A	Set by 10 *CFR* § 835	Inhalation Ingestion Direct exposure	Cancer	If contact suspected, notify RADCON immediately
Thorium -230	N/A	Set by 10 *CFR* § 835	Inhalation Ingestion	Cancer	If contact suspected, notify RADCON immediately
Plutonium -239	N/A	Set by 10 *CFR* § 835	Inhalation Ingestion	Cancer	If contact suspected, notify RADCON immediately
Americium -241	N/A	Set by 10 *CFR* § 835	Inhalation Ingestion	Cancer	If contact suspected, notify RADCON immediately
Neptunium -237	N/A	Set by 10 *CFR* § 835	Inhalation Ingestion	Cancer	If contact suspected, notify RADCON immediately
Asbestos	Odorless Dust (visual or not)	0.1 f/cc	Inhalation Ingestion Contact	Cancer	Skin: Soap flush promptly; Breathing: Respiratory support; Swallow: Medical attention immediately
UF_6 Cylinder	N/A	Set by 10 *CFR* § 835	External	Cancer	Use time, distance, and shielding to reduce external exposure

10.11.2 Pinch/Compression Points

Pinch and compression points associated with drilling, sampling, and other equipment may result in injury to personnel. All equipment must be maintained in proper working order, with all protective shields or guards in place. Any equipment found to be lacking in these areas will be removed from service per procedure CP3-HS-2008, *Accident Prevention/Equipment Control Tags*. Any activity with the potential for pinch/compression point hazards will be identified during work planning and work controls will be put in place to mitigate those hazards.

10.11.3 Traffic and Heavy Equipment

The work locations will be at or near roads, fueling stations, building entrances, deactivation contractor work areas, and cylinder storage areas. These locations may be heavily traveled by plant traffic and cylinder haulers, which pose hazards to personnel working in and around the work area. Coordination with other DOE subcontractors and the DOE Prime Contractor as well as special precautions should be taken to reduce the amount of traffic around the work zone. If the DOE Prime Contractor is performing work in close vicinity of the work area with equipment, DOE Prime Contractor personnel shall pause work until the area is clear. These conditions pose hazards to personnel and must be respected; personnel must remember that cylinder haulers have the right-of-way on plant roads. Personnel working in the area of traffic and/or heavy equipment shall wear a high visibility shirt, vest, or jacket. Also, personnel walking on the plant site shall only walk on designated sidewalks. Many areas of the plant have limited sidewalks so personnel shall be diligent to identify pathways that pose the least hazard.

10.11.4 Steam and High-Pressure Cleaning Equipment

Decontamination of equipment may require the use of steam and high-pressure cleaning. Project personnel performing decontamination activities will do so in accordance with CP4-ER-2701, *Large Equipment Decontamination*, the task-specific JHA, and/or work control documents. Personnel will be knowledgeable of the use and hazards associated with the equipment and utilize appropriate PPE. Personnel using this equipment will, at a minimum, wear the following PPE: ANSI-approved safety glasses, face shield, hard hat, steel-toe boots, and disposable latex or nitrile gloves. Additional PPE may be required for radiological protection. Any proposed variation from the prescribed PPE requirements must be approved by the IS/IH specialist and Frontline Supervisor, Field Team Leader, or designee before implementing the change. Personnel should be aware that PPE and decontamination solutions may present an environmental hazard and should be managed in a manner to prevent mixing with other wastes/materials.

10.11.5 Repetitive Motion

Activities involving potential hazards associated with repetitive motion, such as shoveling or sampling activities, will be addressed in task-specific JHAs and/or work control documents. Awareness and controls, such as taking frequent breaks, utilizing worker rotation, and position modification, will be covered with affected personnel during pre-job and daily meetings as needed.

10.12 NUCLEAR CRITICALITY SAFETY HAZARDS

Nuclear criticality safety (NCS) hazards are evaluated in accordance with the DOE Prime Contractor's procedure CP2-NS-1000, *Nuclear Criticality Safety Program Description Document at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. NCS controls must be implemented for all items that contain or potentially contain fissile material in order to prevent the occurrence of an inadvertent nuclear criticality. An accidental criticality is an extremely rare event, usually of very short time duration, and normally is self-limiting. Even though the time duration of a criticality is short, the radiation produced can be very intense. Criticalities are detected through the use of a criticality accident alarm system (CAAS). When a CAAS alarm is activated, all personnel are to flee the immediate evacuation zone via the most direct route and report to the closest plant assembly point.

10.13 ENVIRONMENTAL MANAGEMENT SYSTEM HAZARDS

The EMS hazards discussed in the sections that follow have been identified as potential impact for activities and/or tasks that will be required during the work activities. Strict adherence to standard work practices and the DOE Prime Contractor's procedures will aid in the elimination or control of these hazards.

10.13.1 Waste Generation/Waste Minimization

Personnel will minimize the wastes generated during drilling and sampling activities. They will segregate, store, manage, and recycle/dispose of wastes properly, as provided in CP2-WM-0001, *Four Rivers*

Nuclear Partnership, LLC, Remediation and Deactivation Project Waste Management Plan, and CP2-ES-0005, *Pollution Prevention/Waste Minimization Plan for the Deactivation and Remediation Project, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*.

10.13.2 Spills/Releases to the Environment

Personnel will use caution when drilling to prevent the uncontrolled release of drill cutting and contaminated groundwater to the environment. Care should be taken during handling samples, preservatives, and other hazardous materials/contaminants to prevent spills/releases to the environment and provide timely response if a spill/release should occur. Work controls (applicable JHAs, the work package, and other applicable work control and project-related documents) will be developed identifying hazards and mitigation controls.

10.14 TRAINING

As a requirement for work on this project, workers entering the exclusion zone (EZ) or contamination reduction zone (CRZ) will be required to take appropriate HAZWOPER training associated with the tasks and ongoing activities. This training must cover the requirements in 29 *CFR* § 1910.120. In addition, workers must receive annual 8-hour refresher training (if applicable) and 3-day on-site supervision under a trained, experienced supervisor. Supervisory personnel shall receive additional 8-hour training in hazardous waste operations supervision. Workers and visitors entering the EZ or CRZ will be briefed in the provisions of this HASP and be required to sign the HASP Acknowledgment Form (or equivalent documentation). Workers entering radiological posted work areas also will be required to complete Radiological Worker Training in accordance with CP3-RP-1104, *Radiological Area Entry Control*, and comply with requirements of work control documents.

An example set of core training requirements can be found in Table 10.2. Specific training requirements will be identified by the project team during work planning.

Table 10.2. Core Training Requirements

GENERAL EMPLOYEE TRAINING
RAD WORKER II
HAZWOPER 40-HOUR (24-HOUR, AS APPROPRIATE)
CURRENT HAZWOPER MEDICAL
HAZWOPER 8-HOUR REFRESHER
3-DAY HAZWOPER SUPERVISED FIELD EXPERIENCE
WORKER SAFETY AND HEALTH PROGRAM ORIENTATION
TEMPERATURE EXTREMES
ENVIRONMENTAL MANAGEMENT SYSTEM AWARENESS
CONSOLIDATED ANNUAL TRAINING
EMPLOYEE CONDUCT TRAINING (DOE PRIME CONTRACTOR EMPLOYEES ONLY)

10.15 PERSONAL PROTECTIVE EQUIPMENT

The use of appropriate PPE is required for personnel involved in operations where exposure to hazardous conditions exist and cannot be eliminated by engineering controls or where such equipment is needed to reduce hazards. PPE will be selected and used in accordance with OSHA standards and the requirements of the DOE Prime Contractor procedures. PPE selection will be determined by IS/IH specialist and

RADCON to ensure protection of the workers from site-specific hazards posed by the task and work location.

PPE will be utilized as follows.

- It is not possible and/or feasible to implement engineering controls and work practices that will unequivocally ensure the safety and health of workers.

- It is necessary to reduce and maintain employee exposure less than the applicable PELs in 29 *CFR* § 1910, Subparts G and Z, and/or less than the applicable reduction zone threshold limit values (TLVs) established by the ACGIH, or in the absence of PELs or TLVs, less than the applicable recommended exposure limits published by the National Institute for Occupational Safety and Health

- Radiological materials/contamination may be present in excess of levels established by site RADCON criteria.

- Workers may be exposed to chemical contamination through skin absorption.

Existing or potential physical hazards may pose a threat to worker safety and health. Because potential hazards will vary with individual field activities, PPE may be modified for specific tasks. The PPE for each task will be listed on applicable JHAs, work instructions and/or RWPs.

Initial entry to work areas will include PPE appropriate for the predicted hazards in the work area based on preliminary data. The PPE requirement for subsequent entries into a specific zone will be based upon the information gathered during the initial entries.

Selection of the most appropriate level of protection and combinations of respiratory protection is based on the following:

- Level of knowledge of on-site chemical, biological, and radiological hazards;

- Properties, such as toxicity, radioactivity, route of exposure, and matrix of the contaminants known or suspected of being present;

- Type and measured concentrations of the contaminants that are known or suspected of being present;

- Potential for exposure to contaminants in air, liquids, soils, or by direct contact with hazardous materials;

- Physical hazards; and

- Temperature extremes.

Personnel entering the work zone are required to undergo training for the use of PPE. For routine work, Level D PPE or modified Level D is required. Where the scope of work requires a higher level of PPE, specific training will be provided.

PPE requirements will be identified in the JHA/RWP(s) and/or work instructions and discussed with site workers prior to the start of work. Employees will be trained and approved following baseline medical examinations for the use of prescribed PPE. Radiological PPE requirements will be integrated with those established for potential non radiological contaminants to ensure compatibility prior to the start of work.

The following sequential steps must be followed to facilitate the selection of PPE for hazardous waste site operations.

- Identify work area and job-specific hazard potential (e.g., chemical, radiological, physical, mechanical).
- Determine type of exposure for the work areas and specific work activities.
- Determine level of respiratory protection for the work areas and specific work activities, including cartridge selection, if appropriate.
- Evaluate the chemical resistant characteristics needed for the potential exposures and select clothing with the appropriate protection factor, evaluate potential physical hazards associated with the work areas and specific work activities (e.g., walking/working surfaces, electrical installations/lines, noise exposure), and select PPE to mitigate identified hazards.
- Consider climatic conditions and select PPE to accommodate the conditions (e.g., cooling units, insulated clothing/footwear).
- Evaluate potential biological hazards (e.g., snakes, insects) and select PPE to mitigate identified hazards.
- Evaluate type and level of work (e.g., heavy, moderate, light) and select PPE for the work.
- Evaluate PPE for both chemical and radiological hazards when mixed waste is involved.

The specific levels of PPE and necessary components for each level are divided into four categories according to the degree of protection afforded. These are general guidelines to use to identify level of PPE.

Level A: Worn when the highest level of respiratory, skin, and eye protection is needed.

Level B: Worn when the highest level of respiratory protection is needed, but a lesser level of skin protection is needed.

Level C: Worn when the criteria for using air-purifying respirators are met, but a lesser level of skin protection is needed, and oxygen concentrations are between 19.5% and 23%.

Level D: Refers to work conducted without respiratory protection. This level should be used only when the atmosphere contains no known or suspected airborne chemical or radiological contaminants and oxygen concentrations are between 19.5% and 23%.

Health and Safety Supplies and Equipment. A sufficient quantity of drinking water or replacement fluids shall be maintained at the site. In addition, a hand-wash area will be made available and all personnel are encouraged to wash their hands prior to eating, drinking, tobacco use, and at the conclusion of each day’s work activities.

Eyewash stations will be available as necessary and will operate in accordance with manufacturer specifications. An eyewash solution with an antimicrobial agent will be used in accordance with the schedule specified by the manufacturer.

Safety equipment shall be inspected for serviceability by the DOE Prime Contractor's project personnel, initially at the start of the project and periodically thereafter. Any defective equipment will be immediately taken out of service, tagged, and replaced. In addition to periodic inspections, the presence of compliant, operable extinguisher and first aid kit shall be verified by field personnel prior to the start of work and inspected in accordance with procedures and regulations. Safety equipment inspections shall be documented on equipment tags or in the project records.

10.16 MEDICAL SURVEILLANCE

The medical surveillance program provides for baseline, annual, and termination medical examinations for site employees in accordance with 29 *CFR* § 1910.120, *Hazardous Waste Operations and Emergency Response*, and DOE Prime Contractor procedure CP3-HS-4002, *Implementation of the Occupational Medicine Program*.

Personnel performing HAZWOPER activities on this project must complete an annual HAZWOPER physical. The examining physician will document the worker's fitness for work and ability to wear a respirator, as applicable.

Radiation workers, working under an RWP, may be required to submit a baseline bioassay, periodic bioassay during the project, and exit bioassay at the end of the project. Detailed explanation of the radiation worker requirements are described in CP2-RP-0001, *Radiation Protection Program for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky.*

10.17 EXPOSURE MONITORING

Exposure monitoring at the worksite shall be done in accordance with CP4-HS-2000, *Industrial Hygiene Sampling*, and applicable subcontract requirements. This will be done to evaluate the effectiveness of engineered controls, to confirm appropriate PPE/respirator selection, and to assess employee exposures. Exposure monitoring shall be conducted pursuant to requirements of 29 *CFR* § 1910.120. Requirements for radiological monitoring are contained in the DOE Prime Contractor Radiation Protection Program. All equipment will be maintained and calibrated per the manufacturer instructions.

Worker exposure monitoring and sampling shall be determined by industrial hygiene on a case-by-case basis. Information gathered during initial assessments shall be used to determine the PPE requirements. Information gathered in subsequent assessments shall be used to modify exposure monitoring as necessary to ensure worker safety and health and protection of the environment. General monitoring criteria are defined in the following subsections.

10.17.1 Employee Nonradiological Exposure Monitoring

Depending on the work activities being performed, real-time and/or integrated personal exposure sampling will be performed where there is a potential for employees to be over exposed. Exposure action levels for contaminants to which employees may reasonably be exposed shall be established. These action levels shall be developed based on regulatory drivers, industry standards, and sound industrial hygiene practice. Exposure monitoring data may be used to evaluate the effectiveness of engineering and administrative controls as well as to upgrade or downgrade PPE requirements.

The monitoring frequency and coverage may be increased should monitoring data indicate the potential for exposure to higher concentrations of chemicals than initially anticipated or if changes in the scope of work involve potential exposure to particularly toxic chemicals.

10.17.2 Environmental Air Monitoring

The expectation of significant contaminants becoming airborne and potentially dispersing is minimal. IH may initiate project boundary or perimeter monitoring as necessary to ensure protection of the public and the environment. The goal of such monitoring will be to determine whether any airborne contaminants are dispersing off the designated work area and to obtain data that would identify the need for corrective action in the work area.

10.18 TEMPERATURE EXTREMES

Typically, one of the most common types of stress that affect field personnel is from heat and cold. Heat stress and cold stress are serious hazards to workers at waste sites. Personnel will be familiarized on the symptoms of heat and cold stress during training or in the plan-of-the-day/pre-job briefing. Activities related to heat and cold stress and work rest activities will be in accordance with the DOE Prime Contractor’s procedure CP3-HS-2000, *Temperature Extremes*.

Cool water and disposable drinking cups or bottled water will be provided in a rest area and/or break trailer. Workers shall use safe work practices, including drinking plenty of fluids, such as water, taking rest breaks as necessary, and using the “buddy system” to monitor each other and watch for heat or cold stress symptoms.

10.18.1 Heat Stress

Heat stress is a condition that arises from a variety of factors, among the most important of these is ambient temperature, the relative humidity, the level of effort required by the job, and the clothing being worn by an exposed individual. An individual who is experiencing heat stress will tend to exhibit an array of measurable symptoms that can include an increased pulse rate, a greater rate of perspiration (except for heat stroke), and an increase in the individual’s body temperature.

Heat-related disorders generally are classified as one of the following four basic categories.

- Heat Rash—Caused by continuous exposure to heat or humid air and can be recognized by the occurrence of small red pimples on the skin. Typically found in sensitive areas of the body where the potential for rubbing can occur (e.g., underarm, groin area).

- Heat Cramps—Caused by heavy sweating and inadequate electrolyte replacement. Signs to look for include muscle spasms and pain in the extremities, such as hands and feet, and in the abdomen.

- Heat Exhaustion—Caused by increased stress on various parts of the body, including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs to look for include these:

    - Pale, cool, moist skin
    - Heavy sweating
    - Dizziness
    - Nausea
    - Fainting

- Heat Stroke—This is the most serious of all temperature related disorders or conditions since temperature regulation fails and the body temperature rises to critical levels. Immediate action should be taken to cool the body before serious injury or death occurs. Competent medical help should be obtained. Signs to look for include these:

    - Red, hot, usually dry skin
    - Lack of or reduced perspiration
    - Nausea
    - Dizziness and confusion
    - Coma, in extreme situations

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

- Acclimate employees to working conditions by increasing workloads slowly over extended periods of time. Do not initiate site work activities with tasks having 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 water and/or electrolytes and encourage them to drink it throughout the work shift; discourage the use of alcohol and caffeine during nonworking hours as these contribute to dehydration. It is essential that fluids lost through perspiration be replenished.

- During hot periods, rotate out employees wearing impervious clothing.

- Provide cooling devices, as appropriate. Mobile showers and/or hose-down facilities, powered air purifying respirators, and ice vests all have proven effective in helping prevent heat stress.

- Provide shade, hats, and sunscreen, when possible. Sunburn reduces the skin's ability to release excess heat, making the body more susceptible to heat-related illness. Repeated overexposure to sunlight also leads to skin cancer.

10.18.2 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 for frostbite and hypothermia are provided below.

Frostbite can occur, in absence of hypothermia, when the extremities do not receive sufficient heat from central body stores. This can occur because of inadequate circulation and/or insulation. Frostbite occurs when there is freezing of fluids around the cells of the body tissues due to extremely low temperatures. Damage may result, including loss of tissue around the areas of the nose, cheeks, ears, fingers, and toes. This damage can be serious enough to require amputation or result in permanent loss of movement.

Hypothermia is described as when the temperature of the body drops. The first symptoms of this condition are uncontrollable shivering and the sensation of cold, irregular heartbeat, weakened pulse, and change in blood pressure. Severe shaking of rigid muscles may be caused by a burst of body energy and changes in the body's chemistry. Vague or slow, slurred speech, memory lapses, incoherence, and drowsiness are some of the additional symptoms. Symptoms noticed before complete collapse are cool skin, slow and irregular breathing, low blood pressure, apparent exhaustion, and fatigue even after rest. As the core body temperature drops, the victim may become listless and confused, and may make little or no attempt to keep warm. Pain in the extremities can be the first warning of dangerous exposure to cold. If the body core temperature drops to about 85°F, a significant and dangerous drop in the blood pressure, pulse rate, and respiration can occur. In extreme cases, death will occur.

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, fluids as well as soups, should be readily available. The skin should NOT be exposed continuously to subzero temperatures.

10.19 SITE CONTROL

10.19.1 Background

The site control program at hazardous waste sites is used to control the activities and movement of people and equipment in order to minimize the potential for worker exposure to hazardous substances. The provisions of 29 *CFR* § 1910.120(d) require that an appropriate site control program be developed prior to the implementation of cleanup operations.

Site control for field activities will be determined by the Frontline Supervisor, Field Team Leader, or designee, IS/IH specialist, and RADCON and will be communicated to the workers through pre-job briefings. Site control may be modified as new information becomes available based on the types of hazards that are found.

During the performance of this project, a Radiological Area generally will equate to an EZ (hot zone), a Radiological Buffer Area generally will equate to a CRZ (warm zone), and a Controlled or Clean Area generally will equate to a support zone (SZ) (cold zone).

The overall objective of the site control component of this HASP is to specify procedures to minimize employee exposure and protect the public from hazardous substances and to prevent unauthorized access to the site.

10.19.2 Visitors

Visitors requesting to observe work conducted in the work area must wear appropriate PPE prior to entry into the area. Visitors are non-workers who are on the site only occasionally, for a specific or limited task such as observing work activities. Visitors who wish to enter a HAZWOPER EZ must produce evidence that they have had medical clearance, which includes complete physical examination for hazardous waste operations, appropriate HAZWOPER training, and subsequent 8-hour refresher training. Visitors also must have received the required training for the tasks being performed and entry must be approved by the Frontline Supervisor, Field Team Leader, designee, IS/IH specialist, and/or RADCON.

10.19.3 Zone Delineation

During the C-400 RI/FS field execution, areas where activities involve contact with uncharacterized material or performance of activities that may pose a risk of overexposure above the established action levels will be considered the EZ. The Boundary Control Station areas, as applicable, will be considered the CRZ, and areas outside of the work area will be the SZ.

10.19.4 Using the Buddy System

When performing activities in remote areas, workers must use the "buddy system" to ensure that rapid assistance can be provided in the event of an emergency. The buddy system is an approach used to organize work groups so that each worker is observed by at least one other worker. All personnel are responsible for ensuring that the buddy system is incorporated.

As part of the buddy system, workers should remain in close proximity and maintain visual contact with each other to provide assistance in the event of an emergency. The responsibilities of workers utilizing the buddy system include the following:

- Providing his/her partner with assistance,
- Observing his or her partner for signs of chemical or heat exposure,
- Periodically checking the integrity of his or her partner's PPE, and
- Notifying the frontline supervisor or other site personnel if emergency assistance is needed.

10.19.5 Communication Network

Communication systems shall be established for both internal and external communication. Internal communication refers to communication among workers operating within the individual work areas of the site. Routine checks to verify proper operation should be addressed.

External communication refers to communication between on-site and off-site personnel. The primary means of external communication are cellular telephone and radio. An external communication system should be maintained in order to accomplish the following:

- Coordinate emergency response efforts with off-site responders,
- Report progress or problems to management, and
- Maintain contact with essential off-site personnel.

10.19.6 Worker Safety Procedures

As part of site control, procedures have been established to ensure worker safety. Safe work practices are incorporated into standard operating procedures and work control documents, such as work packages, work instructions, and JHAs. Engineering controls and safe work practices will be implemented to attempt to reduce and maintain employee exposure levels at or below the PELs and published exposure limits for those hazardous substances at the site. PPE will be used to protect employees against possible exposure to hazardous substances when engineering controls and safe work practices are insufficient to maintain worker exposure at levels below established action levels.

10.20 DECONTAMINATION

Contamination of personnel, equipment, and/or material can occur from contact with radiological and/or hazardous material. When decontamination is required, appropriate procedures shall be followed to ensure effective decontamination is achieved and to minimize generation of mixed waste.

- The overall objectives of decontamination are these:
- To determine and implement the decontamination methods for personnel and equipment that are effective for the specific hazardous/radioactive substance(s) present;
- To ensure the decontamination procedure itself does not pose any additional safety or health hazards;
- To provide pertinent information on the locations and layouts of decontamination stations and equipment;
- To establish procedures for the collection, storage, and disposal of clothing and equipment that has not been completely decontaminated; and
- To provide for periodic evaluation of the effectiveness of decontamination methods.

10.20.1 General Consideration

It is assumed that some of contamination concerns from the field activities will be radiological in nature. Disposable PPE and one-time use items may undergo radiological surveys prior to release for disposal as nonradioactive waste. Reusable equipment may be required to undergo a radiological survey prior to release from a radiological area. If hazardous waste is encountered, IS/IH specialist and RADCON will assist project management in determining additional methods of decontamination. If clothing or equipment is contaminated with both radiological and hazardous material, mixed waste may be generated. Special precautions shall be taken to ensure this waste is handled, treated, stored, and disposed of properly.

10.20.2 Personnel Decontamination Methods

Personnel decontamination will be conducted in accordance with procedure CP4-RP-1103, *Personnel and Personal Effects Decontamination*. In the event of a chemical exposure, decontamination will be performed according to the available Safety Data Sheet or as directed by IS/IH specialist. After the initial field decontamination, the potentially exposed employee will be transported to the appropriate medical facility for exposure assessment, if deemed necessary by IS/IH specialist.

10.20.3 Collection, Storage, and Disposal Procedures

All items (including clothing, equipment, liquids) that cannot be completely decontaminated shall be considered radioactive, hazardous, or mixed waste, as appropriate. Clothing and equipment shall be collected, treated, stored, and disposed of based on the type and level of contamination according to applicable federal, state, and local regulations. Drainage and/or collection systems for contaminated liquids shall be established and approved containers shall be used. Wash water shall be collected for proper disposal. Waste minimization will be encouraged; however, worker safety and health will take precedence.

10.21 EMERGENCY RESPONSE

This HASP applies to hazards expected to be encountered during work associated with the C-400 Complex RI/FS that will be conducted at the Paducah Site and personnel need to be familiar with the appropriate action in case an emergency occurs on-site. The DOE Prime Contractor and subcontractor employees are subject to certain requirements of the Paducah Site Emergency Plan and emergency implementing procedures, maintained by the deactivation contractor, in addition to requirements identified in CP3-EP-1023, *Security Emergencies*. Emergency response at the Paducah Site is controlled by the deactivation contractor PSS and appropriate notifications must be made in accordance with the plans and protocols. The following information is guidance in the responsibilities and protocols to follow in case of an emergency at the Paducah Site. Local emergency shelters and assembly points for specific work areas will be identified in work packages/JHAs and communicated to affected personnel.

10.21.1 Responsibilities

The Frontline Supervisor, Field Team Leader, or designee and IS/IH specialist are responsible for the emergency response and communications to appropriate responders.

DOE Prime Contractor project personnel are responsible for reporting emergencies immediately and ensuring that the appropriate emergency response equipment is readily available at the work site and in proper working order. Depending on the activities and hazards, the following are equipment and supplies to be maintained.

- First-aid kit
- Absorbents for spill control
- Emergency eyewash station/emergency shower
- Fire extinguisher

10.21.2 Reporting an Emergency

10.21.2.1 Discovery

The person who discovers an emergency immediately should attempt to establish control ONLY if the incident is minor in magnitude (e.g., using a fire extinguisher to put out an incipient fire if trained to do so and extinguishment can be accomplished in a safe manner). Where such measures obviously are inadequate or not successful in controlling the incident or for emergency conditions, personal injuries, or other unusual events with potential for causing personal injury, environmental releases, or property damage, the employee will notify the following appropriate emergency response personnel.

- DOE Prime Contractor response personnel
- The PSS

10.21.2.2 Emergency contacts

Fire: Fire alarm pull box, plant telephone Bell System 333, or plant radio channel 16
Medical: Plant telephone Bell System 333 or plant radio channel 16
Security: Plant telephone Bell System 6246 or plant radio channel 16
PSS: Plant telephone Bell System 6211 or plant radio channel 16.

If using a cell phone: 270-441-6333 for emergency; use 270-441-6211 for nonemergency calls.

10.21.2.3 Initial emergency response

When an emergency occurs, someone must assume responsibility for the management of the scene and the protection of personnel. Personnel are to be evacuated from the immediate danger area, as appropriate. Initially, this is the person who discovers the emergency, until the arrival of emergency response personnel. For personnel injury or illness, the DOE Prime Contractor will ensure that at least one person with current training in first aid and cardiopulmonary resuscitation is present on-site during all field activities. This individual will provide minor first aid until other emergency personnel arrive and assume emergency response duties or it is determined to transport the injured to the hospital or the DOE Prime Contractor's medical provider. Determinations and incident reporting will be made according to DOE Prime Contractor procedure, CP3-OP-2024, *Initial Incident/Event Reporting*.

10.21.2.4 Emergency response

Fire: Fire response is provided by the DOE Prime Contractor fire services (or successors) as first responder. The Paducah Site also has mutual aid agreements with additional fire departments, if needed.

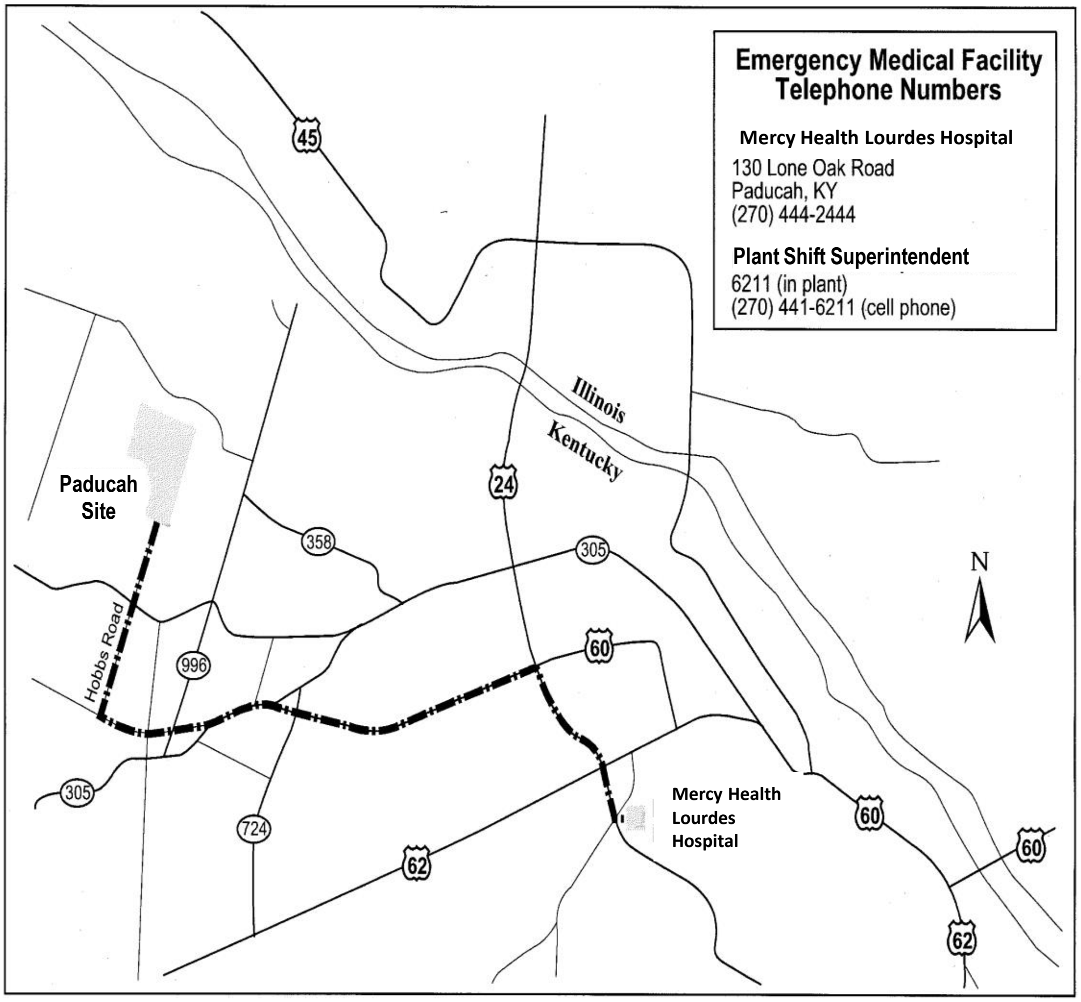
Medical: DOE Prime Contractor medical service (or successors) is the primary responder in all life threatening and/or potentially serious injuries. Minor injuries should be monitored by first aid or first responder trained personnel and the injured taken to the local hospitals or the DOE Prime Contractor's medical provider. Maps to both of the local hospitals are provided in Figures 10.1 and 10.2.

Security: The DOE Prime Contractor's security organization/department is responsible to ensure that order is maintained. Agreements exist among the local law enforcement agencies in situations where mutual aid and services may be rendered on the DOE Reservation.

10.21.2.5 Paducah Gaseous Diffusion Plant alarms

The alarms can be heard by calling 6161 on a Bell phone. Alarms include the following:

Radiation Emergency/CAAS:	Continuous blast on a high-pitched air whistle or electronic horn ACTION: Evacuate area immediately and stay away from effected building. Report to an assigned plant assembly point. If work area is outside the affected areas, personnel should pause work and listen for plant announcement.
Attack Warning/Tornado Warning:	Intermittent 2-second blast on plant horns ACTION: Take cover.



The primary emergency medical facility inside the plant is the C-102 Medical Facility (connected to the C-100 Building).

DIRECTIONS TO MERCY HEALTH LOURDES HOSPITAL

1530 Lone Oak Road, Paducah, Kentucky 42003 (270) 444-2444

From the site go to Highway 60 and travel east into Paducah to I-24. Take I-24 west to Exit 7. Proceed through one traffic light (Hwy. 62) and turn left (going north) at the traffic light onto Hwy. 45. Proceed north approximately 0.25 mile and turn right into Lourdes Hospital. The emergency room is located 0.10 mile (approximately) on the right side.

Figure 10.1. Map to Mercy Health Lourdes Hospital

DIRECTIONS TO BAPTIST HEALTH PADUCAH

2501 Kentucky Avenue, Paducah, KY 42003 (270) 575-2100

Start out going south on Hobbs Rd/Hwy. 1154. Turn left onto Hwy. 60 east, go 11.1 miles, then turn right in front of Bob Noble Park onto Hwy. 60/Joe Clifton Drive. Continue to follow Hwy. 60/Joe Clifton Drive approximately 0.9 miles then turn left onto Washington St/Hwy. 45 BR. Continue approximately 0.2 miles to hospital on left.

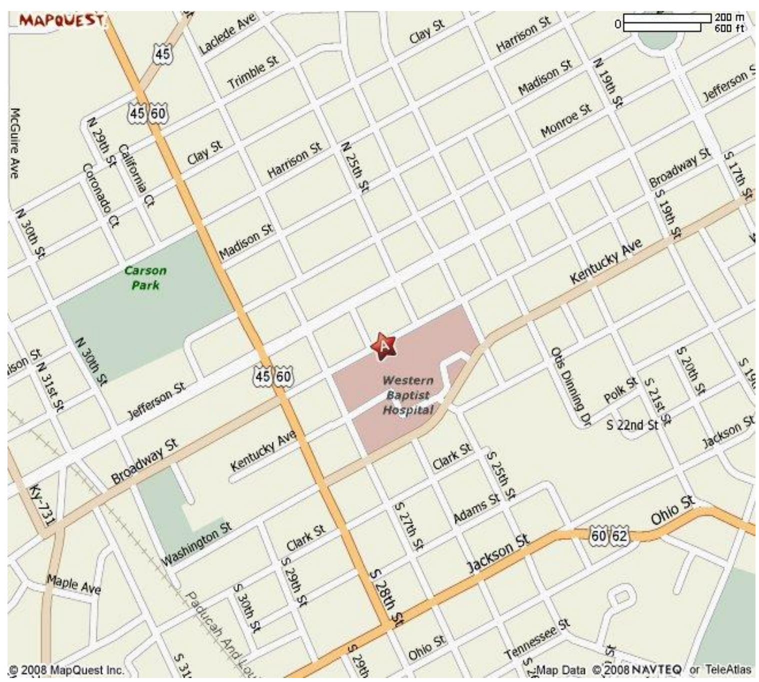


Figure 10.2. Map to Baptist Health Paducah

Evacuate Signal:	Continuous blast on plant horns ACTION: Evacuate building and report to an assigned plant assembly point. If work area is outside the affected areas, personnel should pause work and listen for plant announcement.
Plant Emergency:	Hi-lo tones ACTION: Listen to plant public address (PA) system/radio for instructions
Cascade Buildings:	Three blasts on building horns or howlers ACTION: Call area control room.
Other Buildings:	One 10-second blast on building horns or sirens ACTION: Follow local emergency procedures.

10.21.3 Fire

10.21.3.1 Definitions

Incipient Stage Fire. A fire that is in the initial or beginning stage and that can be controlled or extinguished by a portable fire extinguisher, Class II stand pipe, or small hose systems without the need for protective clothing or breathing apparatus.

Hostile Fire. An unwanted or destructive fire.

10.21.3.2 Reporting a fire

Persons observing a hostile fire should report it immediately by pulling the nearest fire alarm box, phoning Bell 333, or using channel 16 on the radio.

Persons reporting a fire should remain near the area to direct emergency responders if it is safe to do so. Persons reporting the fire should also ensure the areas near the fire have been evacuated and that all personnel have been directed to a remote location upwind of the fire.

Use fire extinguishers to put out an incipient fire if trained to do so and if extinguishment can be accomplished in a safe manner.

10.21.3.3 Protective actions for fire

Personnel should evacuate the area and proceed to the designated assembly points.

Listen for an announcement or emergency instructions from the DOE Prime Contractor incident commander or other emergency response officials. Depending on the nature and extent of the emergency, an assembly point may be provided in the emergency instructions.

For local accountability purposes, report to the Frontline Supervisor, Field Team Leader, designee, or IS/IH specialist who then will contact the DOE Prime Contractor’s project management.

The Frontline Supervisor, Field Team Leader, designee, and IS/IH specialist organization have the following responsibilities:

- Checking their assigned areas, if it is safe to do so, to assist with the evacuation and ensure the areas are clear.
- Reporting to the designated assembly point and begin organizing the local accountability.
- Sizing up the fire.
- Ensuring the alarm has been reported to the PSS.
- Using fire extinguishers to put out an incipient fire if trained to do so and if extinguishment can be accomplished in a safe manner.

10.21.4 Tornado/Severe Weather

10.21.4.1 Definitions

Tornadoes. A tornado is formed by winds rotating at very high speeds in a counterclockwise direction. A typical tornado in the PGDP area, with wind speeds of 73 to 112 mph, moves from the southwest to the northeast following the parent thunderstorm. A tornado can move in any direction and can change direction at any time. Tornadoes travel at various speeds, usually between 25 and 45 mph, and are usually on the ground less than 10 minutes. The largest tornadoes can produce wind speeds of up to 380 mph and follow a path 1,000-miles long and 10-miles wide.

Severe Thunderstorm. A severe thunderstorm produces wind speeds of up to at least 58 mph or hailstones of up to three-quarters of an inch or larger in diameter. They may produce lightning and, during downbursts, produce straight-line winds of 150 mph or faster.

Lightning. Lightning strikes the earth 40 million times each year. Lightning's return stroke of 50,000°F is hotter than the surface of the sun. Lightning kills more people each year than tornadoes.

Thunderstorm Warning. Issued by the National Weather Service (NWS) to inform residents of a specific area that a severe thunderstorm is moving toward their location.

Thunderstorm Watch. Issued by the NWS to identify a relatively large area in which conditions are favorable for severe storms.

Tornado Warning. A warning issued by the NWS to inform residents of a specific area when a tornado sighting has been confirmed or indicated by radar and is moving toward their location.

Tornado Watch. A watch issued by the NWS to identify a relatively large area in which conditions are favorable for the formation of a tornado.

10.21.4.2 Inclement weather

All field activities shall be paused during thunderstorms or high wind conditions. Personnel will secure equipment and materials in a safe condition and move to the designated assembly point. Plant evacuation assembly points are presented in Facility Emergency Action Plans and will be covered with all personnel as part of the initial site-specific briefing and reviewed, as necessary, during plan-of-the-day/pre-job briefings.

10.21.4.3 Reporting severe weather

Immediately report the sighting of a tornado, local flooding, or damage from a storm to the PSS by phoning Bell 333 or channel 16 on the radio.

10.21.4.4 Receiving a severe weather report

Thunderstorm or Tornado Watch. The PSS sounds the hi-lo tone alarm and make a PA announcement of the watch.

Thunderstorm Warning. The DOE Prime Contractor PSS sounds the hi-lo tone alarm, make a PA announcement of the thunderstorm warning, and instruct all personnel in mobile office structures to relocate to a permanent structure.

Tornado Warning. The DOE Prime Contractor PSS sounds the hi-lo tone alarm, make a PA announcement of the tornado warning, and sound the take cover signal over the PA system.

10.21.4.5 Protective actions for severe weather

Thunderstorm or Tornado Watch. No protective action is required. This is merely a caution that conditions may deteriorate. All personnel should stay alert for further updates or warnings.

Thunderstorm Warning**.** Upon receiving a thunderstorm warning, personnel working in mobile office trailers will be directed to relocate in permanent facilities. Personnel conducting field activities must immediately perform those tasks necessary to stabilize the worksite and proceed to a stable building or relocate to a storm shelter. All personnel should take lightning precautions and expect high winds and damaging hail. The Frontline Supervisor, Field Team Leader, or designee and IS/IH specialist will be responsible for accounting for all project personnel and immediately notifying the PM of any unaccounted-for personnel.

Tornado Warning. Upon receiving a tornado warning, all personnel should take cover in the nearest take cover area.

- **Indoors.** Personnel should take cover in the designated tornado shelter for your locations. Automobiles, trailers, and other mobile structures should be vacated.

- **Outdoors.** If time permits, proceed immediately to a safe shelter. If unable to find shelter, lie flat in the nearest ditch or depression. Stay out of mobile structures, automobiles, or trailers.

10.21.4.6 After a tornado strike

The following actions should be taken following a tornado strike.

- The Frontline Supervisor, Field Team Leader, or designee and IS/IH specialist will take charge of the area.

- After the tornado has passed, the local emergency director should check for personnel injury, look for fires or fire hazards, and be aware of any chemical leaks or releases.

- Take only the emergency action for which you are trained, as directed by procedure.

- Be alert for such dangers as loose electrical and high-voltage wires; damaged structures; or broken or cracked gas lines that may be releasing flammable, toxic, or inert gas. De-energize nonessential electrical equipment to ensure continued operations.

- Stay in the designated assembly area until instructed otherwise.

- Do not reenter any building; there may be damage.

The following are the responsibilities of the Frontline Supervisor and IS/IH specialist.

- Upon receiving direction to relocate, assist by directing local population in their area on relocation areas and desired routes to travel. Assist in organizing the group as they relocate.

- Upon receiving a take cover alarm, the Frontline Supervisor, Field Team Leader, designee, or IS/IH specialist will assist the crew by directing them to the appropriate take cover area. They will assist in organizing the group, maintaining an orderly response action, and keeping the group together.

- After a tornado strike, take charge of the local area, check for personnel injury, look for fires or fire hazards and be aware of any chemical leaks or releases, and initiate the local accountability.

- Look for such dangers as loose electrical or high-voltage wires; damaged structures; or broken or cracked gas lines that may be releasing flammable, toxic, or inert gas. De-energize nonessential electrical equipment to ensure continued operations.

10.21.5 Earthquake

10.21.5.1 Definitions

New Madrid Earthquake Zone. The Paducah Site lies within the New Madrid earthquake zone. Rift zones such as this produce large but infrequent earthquakes. The zone is active and produces thousands of micro earthquakes each year. Persons in the New Madrid earthquake zone can expect earthquakes ranging from minor ground shaking to a catastrophic earthquake. Something in the mid-range can be expected in the next 20 years.

Earthquake. An earthquake is a sudden release of energy that occurs when rock abruptly shifts along a break in the earth's crust.

Aftershocks. Additional shock waves follow the main shock wave of an earthquake. They may be minor or nearly as strong as the initial shock.

10.21.5.2 Reporting an earthquake

There is no need to report a substantial earthquake; everyone will know. Slight ground shaking should be reported to the PSS by phoning Bell 333.

10.21.5.3 Receiving an earthquake alarm

The first alarm you receive concerning an earthquake will be the ground shaking. There is no alarm that can warn you of an approaching earthquake.

10.21.5.4 Protective actions

During the quake

(1) **Indoors.** If indoors, be alert for falling objects such as light fixtures, plaster, bookcases, and falling cabinets. Immediately crawl under a desk or table located in a strong corner away from windows or move to a strong doorway. Do not attempt to rush outside; stairways may be unsafe, and exits may be jammed. When the shaking stops, evacuate immediately if you feel that the trailer/facility is unsafe.

(2) **Outdoors.** If outside, avoid walls, power poles, and other tall objects. Do not run through streets. If driving an automobile, stop in the safest place possible. Move to a safer and open area.

After the Quake

- Check for any personal injury and fires or fire hazards.
- Assist the injured to the best of your ability.
- Report for accountability to ensure that everyone is safe and accounted.
- Do not reenter the trailer/facility until a competent person examines it.

The Frontline Supervisor and IS/IH specialist have the following responsibilities.

After the earthquake, evaluate reports to ensure building safety for occupancy (consider aftershocks).

- If the building/trailer is damaged but occupants can continue safely, direct nonessential personnel to exit the building, and report to local assembly point unless otherwise directed by the PSS.

- Check for personnel injury; look for fires or fire hazards; observe utility lines and equipment for damage. Follow applicable procedures for shutting down equipment.

- If damage is determined too extensive for continued occupancy, direct complete evacuation of the building/trailer.

- If building/trailer/area is evacuated, initiate personnel accountability at local point unless otherwise directed by the PSS.

10.21.6 Chemical/Hazardous Material Release

10.21.6.1 Definitions

Downwind of a Chemical Release. Persons in facilities downwind of chemical releases may be in danger. Immediate protective actions by persons downwind can significantly reduce the safety and health risks from an approaching chemical plume.

Shelter-in-Place. This term means to go indoors, close all windows and doors, and turn off all sources of outside ventilation.

10.21.6.2 Reporting an approaching chemical plume

Persons observing a chemical plume should warn other nearby persons verbally and, after taking protective action, report the emergency to the PSS by phoning Bell 333 or using radio Channel 16.

10.21.6.3 Receiving warning of an approaching chemical plume

Warning of an approaching chemical plume typically will come from the Paducah Site incident commander via the PA system accompanied by an order to either evacuate or to shelter-in-place. The first warning of an approaching chemical plume could be direct observation of the approaching plume by local personnel who verbally sound an alarm.

10.21.6.4 Protective actions for an approaching chemical plume

Evacuation. Upon receiving an order to evacuate, personnel should evacuate immediately per the directions given in the PA message or direct order. If no specific directions are given, personnel should evacuate at a 90 angle to the plume path and report to the appropriate off-site assembly point. Outside the plant security fence the assembly point is at the C-103 DOE office building.

Once at the off-site assembly area, personnel should report to their supervisor or other point of contact for accountability purposes and for other emergency information.

Shelter-in-Place. Upon receiving orders to shelter-in-place, persons should go inside, close all windows and doors, shut off all sources of outside ventilation, and remain there until the shelter-in-place order is lifted.

The following are the responsibilities of the Frontline Supervisor and IS/IH specialist.

- Assist the crew with evacuation.
- If building/trailer/area is evacuated, initiate personnel accountability at local assembly point unless otherwise directed by the PSS.
- Assist the crew with sheltering-in-place.
- Ensure windows, doors, and sources of outside ventilation are closed.
- Conduct a local accountability to ensure people who should be sheltered are sheltered.

10.21.7 Contingency Plan for Spills

10.21.7.1 Definitions

Spill. An unidentified or unanticipated release of a substance(s) to air, surface water, groundwater, soil, pavement, or other location where the substance presents a potential hazard or environmental impact.

10.21.7.2 Reporting a spill

When a spill is discovered, the Frontline Supervisor, Field Team Leader, designee, or IS/IH specialist will contact the PSS immediately and convey as much information as possible (e.g., material involved, estimated quantity spilled/affected, location, affected personnel, other hazardous conditions).

10.21.7.3 Protective actions for spill

An effort will be made to stop the release and contain the spill using materials in the on-site spill response kit, only if it is safe to do so and if no unprotected exposures occur. A telephone contact list will be available for emergency notification.

In the event that personnel are exposed to hazardous chemicals or radioactive materials, appropriate emergency response action will be taken to remove the contaminated clothing. An emergency shower and eyewash station will be used to flush exposed skin and eyes, respectively. This emergency equipment will be maintained in a readily accessible location adjacent to the active work area.

If an acute exposure to airborne chemicals occurs or is suspected and the affected personnel are unable to escape the work zone, the Frontline Supervisor, Field Team Leader, designee, or IS/IH specialist will contact PSS immediately for assistance. Rescue operations will not be performed unless the rescuers are dressed in the appropriate protective equipment.

The DOE Prime Contractor's project management will be responsible for ensuring all spills of hazardous materials are cleaned up and disposed of properly, including any material generated from the spill, unless otherwise directed.

The following are the responsibilities of the Frontline Supervisor, Field Team Leader, designee, or IS/HI specialist.

- Ensure that spill containment is performed safely
- Provide all known information to PSS to ensure proper response
- Ensure that decontamination measures for exposed personnel are conducted safely and promptly, and
- Ensure that, if personnel are exposed to airborne chemicals and are unable to escape the work zone, rescue is not attempted unless rescue personnel are dressed in the appropriate protective equipment.

10.21.8 Bomb Threat or Device

WARNING: Do Not Use Radios or cell phones

Radio transmissions could cause a blasting cap (electronic initiator) to detonate prematurely. The use of radios or telephones near suspected devices or inside search areas could result in premature detonation of the explosive device.

10.21.8.1 Definitions

Bomb Threat. A communication by telephone, personnel contact, writing, or discovery through physical evidence that a hazard may exist involving an explosive device.

Explosive. A substance that, through chemical reactions, violently changes to a gaseous form and releases pressure and heat equally in all directions.

10.21.8.2 Bomb threat or device discovery response

Telephone Bomb Threat

Obtain as much and as accurate information as possible and have as many people as possible listen to the telephone call.

Immediately notify the PSS by phoning Bell 333, building operator, and your immediate supervisor.

Attempt to keep the caller talking. Try to determine the following:

- Location of the suspected item
- Time of detonation
- Size, type, and arming device
- Who planted the device, why, and how
- Where, when, and under what circumstances device was planted
- Who gave this information to the caller
- Background noises, music, televisions, aircraft noise, etc.

Written Bomb Threat

Protect and preserve the written communication. Do not handle the communication excessively. Immediately notify your immediate supervisor.

Personal Contact

Obtain as much and as accurate information as possible from the person to whom you are talking.

Immediately notify the PSS by phoning Bell 333, the building operator, and DOE Prime Contractor Management.

Discovering an Explosive Device

Ensure that the object is not disturbed or moved.

Immediately notify the Paducah Site PSS by phoning Bell 333, the building operator, and the DOE Prime Contractor management.

Control access to the area.

10.21.8.3 Contractor accountability/assessment drills

The DOE Prime Contractor will participate in all Paducah Site accountability/assembly drills by sending all on-site project personnel to the appropriate assembly station for accountability if inside the plant. The Frontline Supervisor, Field Team Leader, designee, or IS/IH specialist will be responsible for accounting for all field personnel (including sub tier subcontractor personnel) and reporting any unaccounted-for personnel to the emergency coordinator directing the drill.

10.22 CONFINED SPACE ENTRY

All confined space entries shall be in accordance with OSHA 29 *CFR* § 1910.146; CP3-HS-2055, *Confined Space*; and the following requirements. The requirements provided below are not intended to be all-inclusive.

A confined space is considered to be any space that is large enough and so configured that it can be bodily entered to perform work, has limited or restricted means of entry or exit, and is not designed for continuous employee occupancy. Entry into a confined space will be considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space.

Permit-required confined spaces are those spaces that have one or more of the following characteristics:

- Contain or have the potential to contain a hazardous atmosphere;
- Contain a material that has the potential for engulfing an entrant;
- Have internal configurations such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section; and
- Contain any other serious safety or health hazards.

10.23 SPILL CONTAINMENT

The intent of this section of the HASP is to meet the requirements of 29 *CFR* § 1910.120 (b)(4)(ii)(j). The spill containment program shall address all hazardous substance spill scenarios that are likely to occur at the site. In addition, the spill containment program also shall provide procedures to contain and isolate the entire volume of any hazardous substance spilled in the course of a transfer, accident, or on-site release. Response to such an incident is specified in Section 10.21.7.3.

In order to implement successful spill containment during operations, an assessment shall be conducted of the site conditions, current operations, and planned activities. The assessment shall carefully examine all hazardous materials on-site to determine the following about the materials:

- Where and how materials are stored (e.g., location, type of container);
- How material are handled (e.g., processed, used, transferred); and
- How materials are transported (e.g., mode, routes).

As part of the assessment, each area or activity shall be analyzed for potential accidental releases or spills. The following are examples of situations that have potential for spill or release:

- Bulging or corroded containers;
- Transfer line connections (e.g., leaking seals, misaligned connections);
- Metal fatigue of storage tanks;
- Leaking or inoperable valves; and
- Poor housekeeping (e.g., drums improperly staged).

Many potential spills can be avoided through application of proper engineering controls to hazards identified in the assessment. In areas where storage, handling, and transportation activities occur, preplanning to contain the largest volume of material that could be released in the area will minimize worker exposure. The containment measure shall be appropriate to the hazardous material(s) identified and shall be installed in the area or located nearby. The following examples are measures that are most frequently used:

- Salvage containers (e.g., overpack drums);
- Bermed, lined pads;
- Concrete pad and dike;
- Inflatable containment (e.g., "kiddie" pools, bladders); and
- Associated equipment (e.g., pumps, hoses, shovels, hoists).

Spill containment equipment and fixtures shall be maintained and replaced properly, as necessary.

10.24 RECORDKEEPING

Proper safety recordkeeping is essential in the implementation of the HASP. The forms associated with the recordkeeping must be completed in an accurate, timely fashion. Completed forms will be kept and maintained by the project.

10.24.1 Records and Logs

The Frontline Supervisor and IS/IH specialist will maintain a record of each day's activities and work. Other relevant data and field information will be recorded on separate forms for air monitoring, sampling, equipment calibration, inspections, and incident reporting. An EZ entry log will be maintained that will provide a project record of the following information for each work shift's activities:

- Worker's name
- Work area
- Level of protection
- Time in/time out

Personnel will be required to log in and out of the EZ and radiological controlled area.

10.24.2 Safety Inspections

Safety inspections are required by various tiers of the management structure. Each safety inspection is to be documented. Management and independent assessments shall be conducted in accordance with the DOE Prime Contractor's procedure CP3-QA-1003, *Management and Self Assessments*. These activities are conducted in accordance with CP3-OP-0050, *Performance Observations*. The primary responsibilities of the assessor include the following:

- Interviewing employees with regard to IS/IH specialist recommendations and how they might be integrated into the performance of work,

- Observing and correcting unsafe conditions and acts, and

- Verifying that corrective actions have been assigned to a responsible employee and implemented.

Positive safety observations and safety issues also should be documented. A list of corrective action items will be maintained showing the corrective action, responsible person, and the date action is to be completed. Completed reports are to be given to DOE Prime Contractor's management.

10.24.3 Accident/Incident Reporting and Investigation

Personnel should report all accidents and incidents, no matter how minor, to the Frontline Supervisor and/or IS/IH specialist as soon as possible. The Frontline Supervisor shall immediately notify PSS of any event or condition that adversely affects or may adversely affect DOE, the DOE Prime Contractor, the DOE Prime Contractor's subcontractors, the public, or government property. These events may include any accident/incident that results in employee injury/illness, accident precursor that could result in injury/illness or damage to government equipment and facilities, potential PAAA noncompliance, or any other unplanned event that may be a violation of a regulatory requirement or that may be viewed negatively by the public or DOE. In situations where an accident or incident has occurred, the scene may not be altered without PSS concurrence, unless alteration is necessary to protect human life, mitigate an immediate hazard, or stop a spill in progress.

PSS will investigate and report each accident or incident involving employee injury/illness, damage to government property (including vehicles), or any precursor incident that has the potential to result in these undesired outcomes. For personnel illness/injury or safety and health related issues, a Safety Notification Report shall be completed in a timely manner after the event as well as if environmental issues are involved and proper notifications will be made. If radiological/contamination control issues are involved, a Radiological Anomalous Condition Report shall be initiated. Such reports shall provide a description of the incident, direct and contributing causes, immediate corrective actions taken, and planned measures that will be taken to prevent recurrence of similar incidents. The DOE Prime Contractor's Occupational Medicine provider shall maintain an injury log listing occupational injuries/illness involving DOE Prime Contractor, DOE Prime Contractor subcontractor employees, or anyone else injured as a result of work performed under this contract. Investigation and reporting shall be conducted in accordance with the DOE Prime Contractor's procedure, CP3-OP-2024, *Initial Incident/Event Reporting*.

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11. QUALITY ASSURANCE PROJECT PLAN

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LIST OF QAPP WORKSHEETS

QAPP Worksheets #1 and #2. Title and Approval Page

Site Name/Project Name: *Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*
Site Location: Paducah, Kentucky
Site Number/Code: KY8890008982
Contractor Name: Four Rivers Nuclear Partnership, LLC (FRNP)
Contractor Number: Contract No. DE-EM0004895
Contract Title: Paducah Gaseous Diffusion Plant Paducah Deactivation and Remediation Project
Work Assignment Number: Not applicable

Document Title: *Quality Assurance Project Plan for Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit*

Lead Organization: U.S. Department of Energy (DOE)

Preparer's Name and Organizational Affiliation: Kenneth Davis, FRNP

Preparer's Address, Telephone Number, and E-mail Address: 5511 Hobbs Rd, Kevil, KY 42053, Phone (270) 441-5049, kenneth.davis@pad.pppo.gov

Preparation Date (Month/Year): November 2018

Document Control Number: DOE/LX/07-2433&D2

FRNP Environmental Services Director	Signature David Hutchison	Date: 9/9/19
FRNP C-400 RI/FS Project Manager	Signature Todd Powers	Date: 9/9/19
FRNP Environmental Monitoring and Sample Management Office Project Manager	Signature Lisa Crabtree	Date: 9/9/19
FRNP Quality Assurance Manager	Signature Jennie Freels	Date: 9/9/19

QAPP Worksheets #1 and #2. Title and Approval Page (Continued)

1. Identify guidance used to prepare Quality Assurance Project Plan (QAPP):

   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Implementing Environmental Quality Systems*, Version 2.0.
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 1 UFP QAPP Manual*, Version 1.0 (DTIC ADA 427785 or EPA-505-B-04-900A).
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 2A UFP QAPP Worksheets*, Version 1.0.
   - Intergovernmental Data Quality Task Force, March 2005. The *Uniform Federal Policy for Quality Assurance Project Plans: Part 2B Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities*, Version 1.0.
   - Intergovernmental Data Quality Task Force, March 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Optimized UFP QAPP Worksheets*.
   - *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Volume* 1. *Human Health,* DOE/LX/07-0107&D2/R9/V1.
   - *Paducah Gaseous Diffusion Plant Programmatic Quality Assurance Project,* DOE/LX/07-2421&D1.

2. Identify regulatory program: Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1707 (FFA)

3. Identify approval entities: DOE, U.S. Environmental Protection Agency (EPA) Region 4, and Kentucky Department for Environmental Protection (KDEP)

4. Indicate whether the QAPP is a generic or a project-specific QAPP (circle one).

5. List dates of scoping sessions that were held: Scoping sessions for Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex OU held 3/13/2018–6/21/2018

QAPP Worksheets #1 and #2. Title and Approval Page (Continued)

6. List dates and titles of QAPP documents written for previous site work, if applicable:

Title:	**Approval Date(s):**
C-400 Vapor Intrusion Study Work Plan to Support the Additional Actions for the CERCLA Five-Year Review at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2403&D2/R1 Errata	8/2017
Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan, DOE/LX/07-2430&D1	7/2018 (DOE Approval)
Appendix D, *Paducah Gaseous Diffusion Plan C-400 Basement Slab and Subsurface Structures Data Summary Report*, DOE/LX/07-2442&D1	N/A (Work performed outside the FFA)

7. List organizational partners (stakeholders) and connection with lead organization:
EPA Region 4 (FFA member), KDEP (FFA member)

8. List data users: DOE, FRNP, subcontractors, EPA Region 4, KDEP, stakeholders

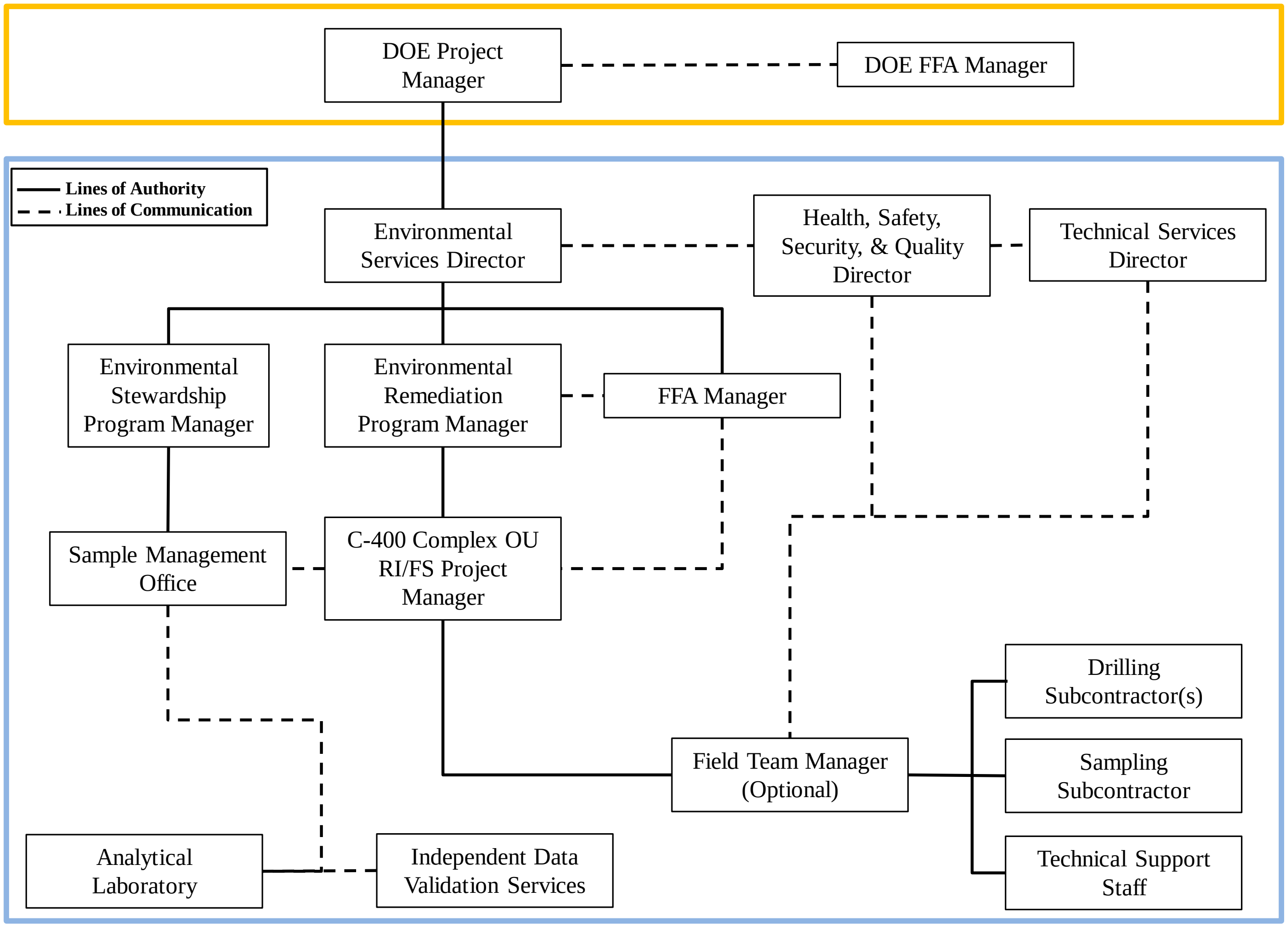
9. Table 1 provides a crosswalk of required QAPP elements.

This QAPP includes all 28 combined worksheets that are required based on UFP-QAPP guidance, as updated by the optimized worksheet guidance (37 total worksheets). Each of these worksheets has been reviewed to ensure the accuracy of the information presented in this QAPP.

Table 1. Crosswalk: UFP-QAPP Workbook to 2106-G-05-QAPP

Optimized UFP-QAPP Worksheets		CIO 2106-G-05 QAPP Guidance Section	
1 & 2	Title and Approval Page	2.2.1	Title, Version, and Approval/Sign-Off
3 & 5	Project Organization and QAPP Distribution	2.2.3	Distribution List
		2.2.4	Project Organization and Schedule
4, 7, & 8	Personnel Qualifications and Sign-off Sheet	2.2.1	Title, Version, and Approval/Sign-Off
		2.2.7	Special Training Requirements and Certification
6	Communication Pathways	2.2.4	Project Organization and Schedule
9	Project Planning Session Summary	2.2.5	Project Background, Overview, and Intended Use of Data
10	Conceptual Site Model	2.2.5	Project Background, Overview, and Intended Use of Data
11	Project/Data Quality Objectives	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
12	Measurement Performance Criteria	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
13	Secondary Data Uses and Limitations	Chapter 3	QAPP Elements for Evaluating Existing Data
14 & 16	Project Tasks and Schedule	2.2.4	Project Organization and Schedule
15	Project Action Limits and Laboratory-Specific Detection/Quantitation Limits	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
17	Sampling Design and Rationale	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
18	Sampling Locations and Methods	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
		2.3.2	Sampling Procedures and Requirements
19 & 30	Sample Containers, Preservation, and Hold Times	2.3.2	Sampling Procedures and Requirements
20	Field Quality Control (QC)	2.3.5	QC Requirements
21	Field Standard Operating Procedures (SOPs)	2.3.2	Sampling Procedures and Requirements
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
23	Analytical SOPs	2.3.4	Analytical Methods Requirements and Task Description
24	Analytical Instrument Calibration	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Require
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration and Maintenance Requirements, Supplies and Consumables
26 & 27	Sample Handling, Custody, and Disposal	2.3.3	Sample Handling, Custody Procedures, and Documentation
28	Analytical Quality Control and Corrective Action	2.3.5	QC Requirements
29	Project Documents and Records	2.2.8	Documentation and Records Requirements
31, 32, & 33	Assessments and Corrective Action	2.4	Assessment and Data Review (Check)
		2.5.5	Reports to Management
34	Data Verification and Validation Inputs	2.5.1	Data Verification and Validation Targets and Methods
35	Data Verification Procedures	2.5.1	Data Verification and Validation Targets and Methods
36	Data Validation Procedures	2.5.1	Data Verification and Validation Targets and Methods
37	Data Usability Assessment	2.5.2	Quantitative and Qualitative Evaluations of Usability
		2.5.3	Potential Limitations on Data Interpretation
		2.5.4	Reconciliation with Project Requirements

QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution



Note: DOE personnel are in Orange Box, and DOE Prime Contractor personnel are in Blue Box.

QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution (Continued)

Distribution is based on the position title. A change in the individual within an organization will not trigger a resubmittal of the QAPP. DOE may choose to update this worksheet and submit page changes to the document holders. This change will not require a review by FFA stakeholders because it is not a substantive change. Alternatively, as with other changes to the approved project-specific QAPP, personnel changes may be tracked and included as an attachment to the QAPP. Managers are responsible for distribution to their staffs.

Controlled copies of the C-400 Complex Remedial Investigation/Feasibility Study (RI/FS) QAPP will be distributed according to the distribution list below. This list will be updated, as needed, and kept by the FRNP Records Management Department. Each person receiving a controlled copy also will receive updates/revisions. If uncontrolled copies are distributed, it will be the responsibility of the person distributing the uncontrolled copy to provide updates/revisions.

Position Title	Organization	QAPP Recipients	Current Telephone Number	Current E-mail Address	Document Control Number
Paducah Site Lead	DOE	Jennifer Woodard	(270) 441-6820	jennifer.woodard@pppo.gov	1
FFA Manager	DOE	Tracey Duncan	(270) 441-6862	tracey.duncan@pppo.gov	2
Project Manager (PM)	DOE	David Dollins	(270) 441-6819	dave.dollins@pppo.gov	3
Environmental Services Director	FRNP	David Hutchison	(270) 441-5929	dave.hutchison@pad.pppo.gov	4
Environmental Remediation Program Manager	FRNP	Bruce Ford	(270) 441-5357	bruce.ford@pad.pppo.gov	5
Environmental Stewardship Program Manager	FRNP	Kelly Layne	(270) 441-6726	kelly.layne@pad.pppo.gov	6
C-400 Complex RI/FS PM	FRNP	Todd Powers	(270) 441-5791	todd.powers@pad.pppo.gov	7
FFA Manager	KDEP	Brian Begley	(502) 564-6716	brian.begley@ky.gov	8
PM	KDEP	Chris Jung	502-782-6391	christopher.jung@ky.gov	9
FFA Manager and PM	EPA	Julie Corkran	(404) 562-8547	corkran.julie@epa.gov	10
FFA Manager	FRNP	Jana White	(270) 441-5185	jana.white@pad.pppo.gov	11
Quality Assurance Manager	FRNP	Jennie Freels	(270) 441-5407	jennie.freels@pad.pppo.gov	12
Environmental Monitoring and Sample Management Office (SMO) PM	FRNP	Lisa Crabtree	(270) 441-5135	lisa.crabtree@pad.pppo.gov	13
Health, Safety, Security, and Quality (HSS&Q) Director	FRNP	Bob Macfarlane	(270) 441-6920	bob.Macfarlane@pad.pppo.gov	14

QAPP Worksheets #3 and #5. Project Organization and QAPP Distribution (Continued)

Position Title	Organization	QAPP Recipients	Current Telephone Number	Current E-mail Address	Document Control Number
SMO	FRNP	Jaime Morrow	(270) 441-5508	jaime.morrow@pad.pppo.gov	13
Technical Services Director	FRNP	James Miller	(270) 441-5068	james.miller@pad.pppo.gov	14
Field Team Leader	FRNP	TBD	TBD	TBD	15
Contract Laboratory PM	TBD	TBD	TBD	TBD	16
Subcontractor PM (Sampling)	TBD	TBD	TBD	TBD	17
Subcontractor PM (Drilling)	TBD	TBD	TBD	TBD	TBD

*TBD = to be determined

QAPP Worksheets #4, #7, and #8. Personnel Qualifications and Sign-off Sheet

ORGANIZATION: DOE Prime Contractor

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date*
David Hutchison	Environmental Services Director, FRNP	> 4 years relevant work experience	No specialized training or certification. See Training Position Description (TPD).	
Todd Powers	C-400 Complex RI/FS PM, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Lisa Crabtree	Environmental Monitoring and SMO PM, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
Jaime Morrow	SMO, FRNP	> 4 years relevant work experience	No specialized training or certification. See TPD.	
TBD	Sample Team Leader, TBD	> 4 years relevant work experience	No specialized training or certification. See TPD.	
TBD	Drilling Contract PM, TBD	> 4 years relevant work experience	No specialized training or certification. See TPD.	

*Signature indicates personnel have read and agree to implement this QAPP as written and approved.

QAPP Worksheet #6. Communication Pathways

NOTE: Formal communication across company or regulatory boundaries occurs via letter. Other forms of communication, such as e-mail, telephone calls, meetings, etc., will occur throughout the project. Regular project communication among DOE, the Prime Contractor, and the regulatory agencies concerning project progress is expected. Deviations from the work plan/QAPP will be communicated upward through the chain of command to regulatory agencies using communication tools commensurate with the issue.

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
Regulatory agency interface	DOE, EPA, KDEP	DOE Project Manager: David Dollins, EPA Remedial Project Manager: Julie Corkran, KDEP FFA Manager: Brian Begley	dave.dollins@pppo.gov corkran.julie@epa.gov brian.begley@ky.gov	Formal communication among DOE, EPA, and KDEP.
Field progress reports	FRNP	FRNP Environmental Services Director: David Hutchison	dave.hutchison@pad.pppo.gov	Formal communication among the project staff, the site lead, and the DOE PM.
Stop work due to safety issues	FRNP	FRNP Environmental Services Director: David Hutchison and FRNP HSS&Q: Bob Macfarlane	dave.hutchison@pad.pppo.gov bob.Macfarlane@pad.pppo.gov	FRNP will communicate work stoppages to DOE PM as required by procedure.
QAPP changes during project execution	FRNP	FRNP Environmental Services Director: David Hutchison and FRNP QA Manager: Jennie Freels	dave.hutchison@pad.pppo.gov jennie.freels@pad.pppo.gov	Obtain approval from DOE PM. Submit QAPP amendments to DOE and EPA.

QAPP Worksheet #6. Communication Pathways (Continued)

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
Field corrective actions	FRNP	FRNP Environmental Services Director: David Hutchison	dave.hutchison@pad.pppo.gov	Field corrective actions will need to be approved by FRNP Project Director and communicated to the DOE, EPA, and KDEP PMs.
Analytical laboratory interface	FRNP	FRNP Environmental Monitoring and SMO PM: Lisa Crabtree	lisa.crabtree@pad.pppo.gov	Communication between FRNP and analytical laboratory.
Laboratory quality control variances	Contracted Laboratory	Laboratory PM	TBD	Notify FRNP Sample Management Office. SMO will notify FRNP PM to determine corrective actions.
Analytical corrective actions	Contracted Laboratory, FRNP	Laboratory PM, FRNP Environmental Monitoring and SMO PM: Lisa Crabtree	Laboratory PM TBD, lisa.crabtree@pad.pppo.gov	Notify FRNP Sample Management Office. SMO will notify FRNP PM to determine corrective actions and notify DOE.
Data verification issues (e.g., incomplete records)	Wastren Advantage, Inc., FRNP	Wastren Advantage, Inc.; Veolia Nuclear Solutions Federal Services; FRNP	TBD lisa.crabtree@pad.pppo.gov	Data verification issues will be reported to the FRNP SMO.
Data validation issues (e.g., noncompliance with procedures)	Wastren Advantage, Inc., FRNP	Wastren Advantage, Inc.; Veolia Nuclear Solutions Federal Services; FRNP	TBD lisa.crabtree@pad.pppo.gov	Issues with data quality will be reported to the FRNP SMO.

NOTE: This QAPP is position-based with names of the current positions presented. In the event the contractor changes and the position titles change, DOE will notify the appropriate parties of the change.

QAPP Worksheet #9. Project Scoping Session Participant Sheet

Project scoping is the key to the success of any project and is part of the systematic planning process. The preparation of this QAPP included review of past documents produced and planning meetings to establish the objectives of the project. The worksheet below was completed as part of the scoping of the C-400 Complex RI/FS prior to developing the SAP and QAPP. The following tables include details about these meetings.

Name of Project: C-400 Complex RI/FS Sampling
Date of Session: March 13–15, 2018
Scoping Session Purpose: DOE and its contractors, EPA and its contractors, and KDEP met to scope the C-400 Complex OU RI/FS and develop DQOs.

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Project Manager	DOE	Dollins, David	270-441-6819	dave.dollins@pppo.gov	Project management
Project Manager	FRNP	Powers, Todd	270-441-5791	todd.powers@pad.pppo.gov	Project management
FFA Manager and Project Manager	EPA	Corkran, Julie	404-562-8547	corkran.julie@epa.gov	Project management
FFA Manager	KDEP	Begley, Brian	502-782-6317	brian.begley@ky.gov	Project management
Project Manager	KDEP	Brewer, Gaye	270-898-8468	gaye.brewer@ky.gov	Technical support
Technical advisor	EPA	Ahsanuzzaman, Noman		ahsanuzzaman.noman@epa.gov	Technical support
Technical support	FRNP	Baker, Cheryl	270-441-6288	cheryl.baker@pad.pppo.gov	Technical support
Technical support	EPA	Bentkowski, Ben	404-562-8507	bentkowski.Ben@epa.gov	Technical support
Technical support	DOE	Bonczek, Richard	859-219-4051	richard.bonczek@pppo.gov	Technical support
Technical support	CHFS	Brock, Stephanie	502-564-8390	stephaniec.brock@ky.gov	Technical support
Technical support	Pro2Serve	Butterworth, George	270-441-6803	george.butterworthIII@pppo.gov	Technical support
Technical support	SMSI	Clauberg, Martin		martin.clauberg@pppo.gov	Technical support
Technical support	FRNP	Clayton, Brian	270-441-5412	brian.clayton@pad.pppo.gov	Technical support
Technical support	EPA	Davis, Eva	580-436-8548	davis.eva@epa.gov	Technical support
Technical support	FRNP	Davis, Ken	270-441-5049	ken.davis@pad.pppo.gov	Technical support
Technical support	TechLaw	Dawson, Jana	703-627-0821	jdawson@techlawinc.com	Technical support
Technical support	DOE	Dollins, David	270-441-6819	dave.dollins@pppo.gov	Technical support
Technical support	FRNP	Flynn, Robert	270-441-5171	robert.flynn@pad.pppo.gov	Technical support
Technical support	FRNP	Ford, Bruce	270-441-5357	bruce.ford@pad.pppo.gov	Technical support
Technical support	FRNP	Fountain, Stefanie	270-441-5722	stefanie.fountain@pad.pppo.gov	Technical support
Technical support	FRNP	Garner, LeAnne	270-441-5436	leanne.garner@pad.pppo.gov	Technical support
Technical support	CHFS	Garner, Nathan	502-564-8390	nathan.garner@ky.gov	Technical support

CHFS = Cabinet for Health and Family Services (CHFS)

QAPP Worksheet #9. Project Scoping Session Participant Sheet (Continued)

Position Title	Affiliation	Name	Phone #	E-mail Address	Project Role
Technical support	KDEP	Guffey, Mike	502-330-4454	mike.guffey@ky.gov	Technical support
Technical support	KDEP	Higginbotham, Jeri		jeri.higginbotham@ky.gov	Technical support
Technical support	KDEP	Jung, Christopher	502-782-6391	christopher.jung@ky.gov	Technical support
Technical support	Sapere	Kytola, Kevin	509-524-2343	kkytola@sapereconsulting.com	Technical support
Technical support	DOE	Ladd, April	270-441-6843	ladd.april@pppo.gov	Technical support
Technical support	KDEP	Lainhart, Brian	270-898-8468	brian.lainhart@ky.gov	Technical support
Technical support	FRNP	Layne, Kelly	270-441-5206	kelly.layne@pad.pppo.gov	Technical support
Technical support	TechLaw	McRae, Mac	678-493-1247	mmcrae@techlawinc.com	Technical support
Technical support	FRNP	Morgan, John	270-441-5206	john.morgan@pad.pppo.gov	Technical support
Technical support	KDEP	Newton, Aaron	502-523-8023	aaron.newton@ky.gov	Technical support
Technical support	SMSI	Nourse, Bobette		bobette.nourse@lex.doe.gov	Technical support
Technical support	Sapere	Parsons, Christopher	509-524-2345	cparsons@sapereconsulting.com	Technical support
Technical support	FRNP	Powers, Todd	270-441-5206	todd.powers@pad.pppo.gov	Technical support
Technical support	TechLaw	Rapal, Kristen	312-345-8929	kristen.rapal@techlawinc.com	Technical support
Technical support	Pro2Serve	Taylor, Tracy	270-441-6866	tracy.taylor@pppo.gov	Technical support
Technical support	FRNP	Walker, Curt	270-441-5226	curt.walker@pad.pppo.gov	Technical support
Technical support	FRNP	White, Jana	270-441-5206	jana.white@pad.pppo.gov	Technical support

CHFS = Cabinet for Health and Family Services
SMSI = Strategic Management Solutions, LLC
Notes/comments:

Consensus decisions made:

- One hundred nine boring locations agreed upon by FFA parties.
- Analytical compounds chosen by the FFA parties.
- During the scoping process, progress was made in defining sample locations, clarifying concepts and identifying data needs, exchanging ideas on investigation methods, and identifying and resolving concerns/issues related to the RI/FS Work Plan development.

Action items:
Action items were identified and resolved during scoping activities by the FFA parties and incorporated into the work plan as appropriate.

QAPP Worksheet #10. Conceptual Site Model

See Section 4.10 of this work plan.

QAPP Worksheet #11. Project Quality Objectives/Systematic Planning Process Statements

Step 1. State the Problem:

Hazardous substances that historically have been present and/or migrated from the C-400 Complex and its SWMUs have been released to surrounding environmental media. These substances, in turn, have infiltrated into groundwater and been transported through subsurface pathways. The nature and extent of contamination have been defined adequately for some SWMUs and areas, and risk assessments have been prepared. For other SWMUs and areas, the nature and extent of contamination have not been defined adequately to assess whether potential contaminants pose unacceptable risks to human health and the environment at the C-400 Complex and at downgradient exposure points. Data gaps must be identified so that a comprehensive RI/FS report can be prepared for the C-400 Complex.

Problem Description: Within the C-400 Complex area, there have been 22 SWMUs identified. Of the SWMUs present, 15 have been identified as requiring no further action. The remaining seven SWMUs requiring action include, SWMUs 11, 40, 47, 98, 203, 480, and 533. In addition numerous potential and known spill areas (stained areas) have been identified requiring further investigation. The chemicals or radionuclides of potential concern (COPCs) included radionuclides, metals, inorganic compounds, volatile organic compounds, semivolatile compounds, and PCBs. The C-400 Complex area is also the suspected source zone for trichloroethene (TCE) contamination associated with the Northeast and Northwest Groundwater Plumes and likely the source zone for technetium-99 (Tc-99) contamination associated with the Northwest Groundwater Plume.

Problem Approach: The planning team determined that it will be best to divide the C-400 Complex into seven sectors: six of these sectors surround the C-400 Cleaning Building; and the seventh sector is the C-400 Cleaning Building, which is further divided into four subsectors. The sampling strategy for the C-400 Complex will focus on concrete slabs, surface soils, subsurface soils, and groundwater.

Planning Team: FFA parties, FRNP

- Conceptual Model: See Section 4.10 of this work plan.
- Determine Resources:
  - Schedule: See Worksheets #14 and 16
  - Budget: Based upon final scope of work
  - Personnel: FRNP

QAPP Worksheet #11. Project Quality Objectives/Systematic Planning Process Statements (Continued)

Step 2: Identify the Goals of the Study

- Characterize nature of source zone(s).
- Define extent of source and contamination in soil and remaining structures in the OU area.
- Evaluate potential for surface and subsurface transport mechanisms and pathways.
- Complete a risk assessment for the C-400 Complex.
- Identify, develop, and evaluate remedial alternatives.

Step 3. Identify Information Inputs:

Concrete, soil, and groundwater sample results for quantitative use in determining contamination contained within the footprint of the C-400 Complex area.

Step 4. Identify the Boundaries of the Study:

Boundary of the study area is defined by the outer edges of the surrounding roadways (Virginia Street to the north, 11th Street to the east, Tennessee Street to the south, and 10th Street to the west) which encompass the C-400 Cleaning Building footprint.

Step 5. Develop the Analytical Approach:

- The samples will undergo chemical analysis at a contract laboratory, consistent with the contract protocols.

Step 6. Specify Performance or Acceptance Criteria:

- Analytical sample results must successfully undergo assessment and validation to be used to support the C-400 Complex RI/FS and in support of CERCLA analysis.

Step 7. Develop the Detailed Plan for Obtaining Data:

- The process of obtaining the data has been laid out in the SAP section.

QAPP Worksheet #12-A. Measurement Performance Criteria (VOCs)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Volatile Organic Compounds (GC/MS)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-8260 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-B. Measurement Performance Criteria (Metals)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc)
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-6020/6010 See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

GC/MS = gas chromatography/mass spectrometry; PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-C. Measurement Performance Criteria (Mercury)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Metals (mercury)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-7471 See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-D. Measurement Performance Criteria (PCBs)

Matrix	Solid (Concrete), soil				
Analytical Group[1]	PCBs (GC/ECD)				
Concentration Level	Low				
Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-8082 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 35%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual column analysis	A
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

GC/ECD = gas chromatography/electron capture detector; PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-E. Measurement Performance Criteria (Radionuclides)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Radionuclides (uranium-234, uranium-235, uranium-238)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-F. Measurement Performance Criteria (Radionuclides)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, thorium-230 thorium-228, thorium-232)
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.

[1] If information varies within an analytical group, separate by individual analyte.

[2] Reference number from QAPP Worksheet #21.

[3] Reference number from QAPP Worksheet #23.

[4] The most current version of the method will be used.

[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-G. Measurement Performance Criteria (Radionuclides)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Radionuclides (cesium-137, actinium-227, cobalt-60, lead-210, protactinium-231)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Gamma spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-H. Measurement Performance Criteria (Strontium-90)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Strontium-90
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	EPA-905.0-M See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-I. Measurement Performance Criteria (Radium-226)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Radium-226
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	EPA-903.1-M See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-J. Measurement Performance Criteria (Radionuclides)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Radionuclides (technetium-99)
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Liquid scintillation See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 50%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-K. Measurement Performance Criteria (SVOCs)

Matrix	Solid (Concrete), soil
Analytical Group[1]	Semivolatile Organic Compounds (GC/MS)
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8270 See Worksheet #23	Precision—Lab	RPD—< 25%	Laboratory Duplicates	A
		Precision	RPD—< 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	N/A
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-L. Measurement Performance Criteria (Dioxins and Furans)

Matrix	Soil
Analytical Group[1]	Dioxins and Furans (HRGC/HRMS)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-8290 See Worksheet #23	Precision—Lab	RPD—< 25%	Laboratory Duplicates	A
		Precision	RPD—< 35%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	N/A
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-M. Measurement Performance Criteria (VOCs)

Matrix	Groundwater
Analytical Group[1]	Volatile Organic Compounds (GC/MS)
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-8260 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-N. Measurement Performance Criteria (Metals)

Matrix	Groundwater
Analytical Group[1]	Metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-6020/6010 See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-O. Measurement Performance Criteria (Mercury)

Matrix	Groundwater
Analytical Group[1]	Metals (mercury)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-7470 See Worksheet #23	Precision—Lab	RPD—≤ 20%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-P. Measurement Performance Criteria (PCBs)

Matrix	Groundwater
Analytical Group[1]	PCBs (GC/ECD)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-8082 See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy	RPD—≤ 40%	Dual column analysis	A
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-Q. Measurement Performance Criteria (Radionuclides)

Matrix	Groundwater
Analytical Group[1]	Radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, thorium-230, uranium-234, uranium-235, uranium-238)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Alpha spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-R. Measurement Performance Criteria (Radionuclides)

Matrix	Groundwater
Analytical Group[1]	Radionuclides (cesium-137)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	Gamma spectroscopy See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.

QAPP Worksheet #12-S. Measurement Performance Criteria (Radionuclides)

Matrix	Groundwater
Analytical Group[1]	Radionuclides (technetium-99)
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	Liquid scintillation See Worksheet #23	Precision—Lab	RPD—≤ 25%	Laboratory Duplicates	A
		Precision	RPD—≤ 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > MDA	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > MDA	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > MDA	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

MDA = minimum detectable activity; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-T. Measurement Performance Criteria (SVOCs)

Matrix	Groundwater
Analytical Group[1]	Semivolatile Organic Compounds (GC/MS)
Concentration Level	Low

Sampling Procedure[2]	**Analytical Method/SOP**[3, 4]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria (MPC)**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)**
See Worksheet #21	SW-846-8270 See Worksheet #23	Precision—Lab	RPD—< 25%	Laboratory Duplicates	A
		Precision	RPD—< 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	N/A
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-U. Measurement Performance Criteria (Inorganics)

Matrix	Solid (Concrete), Soil
Analytical Group[1]	Fluoride
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-9056 See Worksheet #23	Precision—Lab	RPD–< 25%	Laboratory Duplicates	A
		Precision	RPD–< 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	N/A
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #12-V. Measurement Performance Criteria (Inorganics)

Matrix	Groundwater
Analytical Group[1]	Fluoride
Concentration Level	Low

Sampling Procedure[2]	Analytical Method/SOP[3, 4]	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPC)	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
See Worksheet #21	SW-846-9056 See Worksheet #23	Precision—Lab	RPD–< 25%	Laboratory Duplicates	A
		Precision	RPD–< 25%	Field Duplicates	S
		Accuracy/Bias	% recovery[6]	Laboratory Sample Spikes	A
		Accuracy/Bias Contamination	No target compounds > PQL	Method Blanks/Instrument Blanks	A
		Accuracy/Bias Contamination	No target compounds > PQL	Field Blanks	S
		Accuracy/Bias Contamination	No target compounds > PQL	Trip Blanks	N/A
		Accuracy/Bias Contamination	No target compounds > PQL	Equipment Rinseates	S
		Completeness[5]	90%	Data Completeness Check	S&A

PQL = practical quantitation limit; RPD = relative percent difference.
[1] If information varies within an analytical group, separate by individual analyte.
[2] Reference number from QAPP Worksheet #21.
[3] Reference number from QAPP Worksheet #23.
[4] The most current version of the method will be used.
[5] Completeness is calculated as the number of valid analytical results reported divided by the number of analytical results requested, multiplied by 100 to obtain the percentage.
[6] Percent recovery is laboratory-specific, calculated from studies performed every six months. Percent recovery ranges will be provided in the laboratory data packages based on the most current study.

QAPP Worksheet #13. Secondary Data Criteria and Limitations Table

Secondary Data Type	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/Collection Dates)	How Data Will Be Used	Factors Affecting Reliability and Limitations on Data Use
OREIS Database	Various	Various	Data will be used to determine whether the concrete slab is a potential secondary source of contamination. The data will be used in conjunction with RI/FS data to be collected at a later date.	Data have been verified, assessed, and validated (if validation is required). Rejected data will not be used.
Historical Documentation	CH2M HILL 1992. *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/Sub/ 13B-97777C P03/1991/1. DOE 1995b. *C-400 Process and Structure Review*, KY/ERWM-38, U.S. Department of Energy, Paducah, KY, May. DOE 1999. *Remedial Investigation Report for Waste Area Grouping 6 (C-400) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1727&D2.	DOE contractors, soil and aqueous, 1992–1999 Various	Information will be used in conjunction with newly collected data to determine chemical or radionuclide of potential concern are present in the concrete slabs. Information will be used as guidance on related project work.	Data have been verified, assessed, and validated (if validation required). Rejected data will not be used. Information from historical documents will be limited to the available documentation as it relates to a specific project. Use of historical data may be limited based on how long ago the data were collected and whether site conditions have changed since data collection.

NOTE: Oak Ridge Environmental Information System (OREIS) is the repository for environmental and waste characterization analytical results. OREIS is a limited access database. Most of the results in OREIS are downloaded to Portsmouth/Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS) periodically (usually on a quarterly basis). The general public can access data in PEGASIS.

QAPP Worksheets #14 and #16. Project Tasks & Schedule

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Mobilization/demobilization	FRNP	February 2020	April 2021	Field notes	August 2021
Sample collection	FRNP	February 2020	April 2021	Field notes	August 2021
Analysis	Contract Lab	March 2020	August 2021	Report of analysis	August 2021
Validation	Wastren Advantage, Inc.; Veolia Nuclear Solutions Federal Services	April 2020	August 2021	Validation summary	August 2021
Data Report	Project Team	April 2020	October 2021	Data report	October 2021

QAPP Worksheet #15-A. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Groundwater)

Matrix: Groundwater
Analytical Group: VOCs

VOC	Chemical Abstracts Service (CAS) Number	Project Action Limit/NAL (µg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/L)	MDL[e] (µg/L)
Acrylonitrile	107-13-1	0.052/0.0523	Tap water[d]/NAL	Yes	5[a]	1.5[a]
Benzene	71-43-2	5.0/0.455	MCL/NAL	Yes	1[a]	0.3
Bromodichloromethane	75-27-4	80/0.134	MCL[f]/NAL	Yes	1[a]	0.3[a]
Carbon tetrachloride	56-23-5	5.0/0.455	MCL/NAL	Yes	1[a]	0.3
Chloroform	67-66-3	80/0.221	MCL[f]/NAL	Yes	1[a]	0.3[a]
1,1-Dichloroethene	75-35-4	7.0/28.5	MCL/NAL	Yes	1	0.3
1, 2-Dichloroethane	107-06-2	5.0/0.171	MCL/NAL	Yes	1	0.3
1,2-Dichloroethene (mixed)	540-59-0	70/16.3	MCL/NAL	Yes	4	0.3
cis-1,2-Dichloroethene	156-59-2	70/3.61	MCL/NAL	Yes	1	0.3
trans-1,2-Dichloroethene	156-60-5	100/9.29	MCL/NAL	Yes	1	0.3
1, 4-Dioxane	123-91-1	0.046/-	Tap water[d] /-	No	50	15
1,1,1 Trichloroethane	71-55-6	200/801	MCL/NAL	Yes	1	0.3
1,1,2-Trichloroethane	79-00-5	5.0/0.0415	MCL/NAL	Yes	1	0.3
Ethylbenzene	100-41-4	700/1.50	MCL/NAL	Yes	1	0.3
Toluene	108-88-3	1,000/110	MCL/NAL	Yes	1	0.3
Tetrachloroethene	127-18-4	5.0/4.06	MCL/NAL	Yes	1	0.3
Trichloroethene	79-01-6	5.0/0.283	MCL/NAL	Yes	1[a]	0.3[a]
Vinyl Chloride	75-01-4	2.0/0.0188	MCL/NAL	Yes	1[a]	0.3[a]
Total Xylenes	1330-20-7	10,000/19.3	MCL/NAL	Yes	3	0.3
o-Xylene	95-47-6	19/19.3	Tap water/NAL	Yes	1	0.3
m,p-Xylene	179601-23-1	19/19.3	Tap water/NAL	Yes	2	0.3

CAS = Chemical Abstracts Service. COPC = chemical (or radionuclide) of potential concern. MCL = maximum contaminant level. MDL = method detection limit. NAL = no action level for the child resident scenario taken from the RMD (DOE 2019c). PQL = practical quantitation limit. VOC = volatile organic compound.

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.
NOTE: Additional VOCs in suite will be reported.

[a] This QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] Tap water—Source: EPA regional screening levels, Tap water Supporting Table (Target Risk = 1E-6, Hazard Quotient = 0.1) November 2017 (EPA 2017a).

QAPP Worksheet #15-A. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (VOCs, Groundwater) (Continued)

[e] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[f] As Total trihalomethanes.

QAPP Worksheet #15-B. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (SVOCs, Groundwater)

Matrix: Groundwater
Analytical Group: SVOCs

SVOC	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL[c,h] (µg/L)	MDL[e] (µg/L)
Acenaphthene	83-32-9	53/53.5	Tap water[d]/NAL	Yes	1	0.3
Acenaphthylene[f]	208-96-8	53.5	NAL	Yes	1	0.3
Anthracene	210-12-7	180/177	Tap water/NAL	Yes	1	0.3
Carbazole	86-74-8	2.03	NAL	Yes	1	0.3
Fluoranthene	206-44-0	80/80.2	Tap water/NAL	Yes	1	0.3
Fluorene	86-73-7	29/29.4	Tap water/NAL	Yes	1	0.3
Hexachlorobenzene	118-74-1	1.0/0.00976	MCL/NAL	Yes	10[a]	3[a]
Naphthalene	91-20-3	0.17/0.165	Tap water/NAL	Yes	1[a]	0.3[a]
2-Nitroaniline	88-74-4	19/18.9	Tap water/NAL	Yes	10	3
N-nitroso-di-n-propylamine	621-64-7	0.011/0.0108	Tap water/NAL	Yes	10[a]	3[a]
Pentachlorophenol	87-86-5	1.0/0.0413	MCL/NAL	Yes	TBD	TBD
Phenanthrene[f]	85-01-8	53.5	NAL	Yes	1	0.3
Pyrene	129-00-0	12/12.1	Tap water/NAL	Yes	1	0.3
Total PAHs (carcinogenic)[g]						
~Benz[a]anthracene	56-55-3	0.0298	NAL	Yes	1[a]	0.3[a]
~Benzo[a]pyrene	50-32-8	0.20/0.0251	MCL/NAL	Yes	1[a]	0.3[a]
~Benzo[b]fluoranthene	205-99-2	0.251	NAL	Yes	1[a]	0.3[a]
~Benzo[k]fluoranthene	207-08-9	2.51	NAL	Yes	1	0.3
~Chrysene	218-01-9	25.1	NAL	Yes	1	0.3
~Dibenz[a,h]anthracene	53-70-3	0.0251	NAL	Yes	1[a]	0.3[a]
~Indeno[1,2,3-cd]pyrene	193-39-5	0.251	NAL	Yes	1[a]	0.3[a]

NOTE: Worksheet #15 will be prepared with preliminary target laboratory-specific PQLs and MDLs to be used to procure the laboratory.
NOTE: Additional SVOCs in the method suite will be reported.
CAS = Chemical Abstracts Service; COPC = chemical (or radionuclide) of potential concern; MCL = maximum contaminant level; MDL = method detection limit; NAL = no action level for child resident scenario from the RMD; PAH = polycyclic aromatic hydrocarbon; PQL = practical quantitation limit; SVOC = semivolatile organic compound; TBD = to be determined
[a] This QAPP references the MCLs (or EPA screening level for Tap water if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD and MCLs reproduced in the RMD. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] Tap water—Source: EPA regional screening levels, Tap water Supporting Table (Target Risk = 1E-6, Hazard Quotient = 0.1) November 2017.
[e] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[f] Acenaphthylene and phenanthrene use NALs for acenaphthene.
[g] Total PAHs uses MCL for benzo(a)pyrene.
[h] Nonstandard laboratory method may be necessary to meet PQL.

QAPP Worksheet #15-C. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Metals, Groundwater)

Matrix: Groundwater
Analytical Group: Metals

Metal	CAS Number	Project Action Limit/NAL (mg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/L)	MDL[e] (mg/L)
Aluminum	7429-90-5	2.0/2.00	Tap water[d]/NAL	Yes	0.05	0.015
Antimony	7440-36-0	0.0060/0.000779	MCL/NAL	Yes	0.003[a]	0.001[a]
Arsenic	7440-38-2	0.010/0.0000517	MCL/NAL	Yes	0.005[a]	0.0017[a]
Barium	7440-39-3	2.0/0.377	MCL/NAL	Yes	0.002	0.0006
Beryllium	7440-41-7	0.0040/0.00246	MCL/NAL	Yes	0.0005	0.0002
Boron	7440-42-8	0.40/0.399	Tap water/NAL	Yes	0.015	0.004
Cadmium	7440-43-9	0.0050/0.000922	MCL/NAL	Yes	0.001	0.00011
Chromium (Total)	7440-47-3	0.10/2.25[f]	MCL/NAL	Yes	0.01	0.002
Cobalt	7440-48-4	0.0006/0.000601	Tap water/NAL	Yes	0.001[a]	0.0001
Copper	7440-50-8	1.3/0.0799	MCL/NAL	Yes	0.001	0.00035
Fluoride	16984-48-8	4,000/79.9	MCL/NAL	Yes	TBD	TBD
Iron	7439-89-6	1.4/1.40	Tap water/NAL	Yes	0.1	0.033
Lead	7439-92-1	0.015/0.015	MCL[g]/NAL	Yes	0.002	0.0005
Manganese	7439-96-5	0.043/0.0434	Tap water/NAL	Yes	0.005	0.001

QAPP Worksheet #15-C. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Metals, Groundwater) (Continued)

Matrix: Groundwater
Analytical Group: Metals

Metal	CAS Number	Project Action Limit/ NAL (mg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c] PQL (mg/L)	Laboratory-Specific[c] MDL[e] (mg/L)
Mercury	7439-97-6[g]	0.0020[h]/0.000566[h]	MCL/NAL	Yes	0.0002	0.000067
Molybdenum	7439-98-7	0.010/0.00998	Tap water/NAL	Yes	0.0005	0.000165
Nickel	7440-02-0[g]	0.039[h]/0.0392[h]	Tap water/NAL	Yes	0.002	0.0005
Selenium	7782-49-2	0.050/0.00998	MCL/NAL	Yes	0.005	0.0015
Silver	7440-22-4	0.0094/0.00941	Tap water/NAL	Yes	0.001	0.0002
Thallium	7440-28-0	0.0020/0.000020	MCL/NAL	Yes	0.002[a]	0.00045[a]
Uranium[h]	7440-61-1	0.030/0.000399	MCL/NAL	Yes	0.0002	0.000067
Vanadium	7440-62-2	0.0086/0.00864	Tap water/NAL	Yes	0.01[a]	0.003
Zinc	7440-66-6	0.60/0.600	Tap water/NAL	Yes	0.01	0.0035

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MCL = maximum contaminant level
MDL = method detection limit
NAL = no action level for child resident scenario from the RMD
PQL = practical quantitation limit

[a] This QAPP references the MCLs (or EPA screening level for Tap water if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD and MCLs reproduced in the RMD for the child resident scenario. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the MDL, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] Tap water—Source: EPA regional screening levels, Tap water Supporting Table (Target Risk = 1E-6, Hazard Quotient = 0.1) November 2017.
[e] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[f] An NAL is not available for chromium (total); therefore, the NAL for chromium III was used.
[g] The MCL established by the EPA for lead is based on a treatment technique action level of 0.015 mg/L.
[h] The PAL/NAL values (for metals identified as salts) were derived for metal salts; the CAS number is presented for the elemental form.

QAPP Worksheet #15-D. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (PCBs, Groundwater)

Matrix: Groundwater
Analytical Group: PCBs

PCB	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/L)	MDL[d] (µg/L)
Aroclor 1016	12674-11-2	0.50[e]/0.140	MCL/NAL	Yes	0.1	0.0333
Aroclor 1221	11104-28-2	0.50[e]/0.00471	MCL/NAL	Yes	0.1[a]	0.0333[a]
Aroclor 1232	11141-16-5	0.50[e]/0.00471	MCL/NAL	Yes	0.1[a]	0.0333[a]
Aroclor 1242	53469-21-9	0.50[e]/0.00785	MCL/NAL	Yes	0.1[a]	0.0333[a]
Aroclor 1248	12672-29-6	0.50[e]/0.00785	MCL/NAL	Yes	0.1[a]	0.0333[a]
Aroclor 1254	11097-69-1	0.50[e]/0.00785	MCL/NAL	Yes	0.1[a]	0.0333[a]
Aroclor 1260	11096-82-5	0.50[e]/0.00785	MCL/NAL	Yes	0.1[a]	0.0333[a]
Total PCBs	1336-36-3	0.50[e]/0.0436	MCL/NAL	Yes	0.1[a]	0.0333

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDL = method detection limit
NAL = no action level for child resident scenario from the RMD
PCBs = polychlorinated biphenyls
PQL = practical quantitation limit

[a] This QAPP references the MCLs (or EPA screening level for Tap water if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD and MCLs reproduced in the RMD. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process. This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the MDL, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] MCL for Total PCBs.

QAPP Worksheet #15-E. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits (Radionuclides, Groundwater)

Matrix: Groundwater

Analytical Group: Radionuclides

Radionuclide	CAS Number	Project Action Limit (pCi/L)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c] MDA[d] (pCi//L)
Americium-241	14596-10-2	0.504	NAL	Yes	1[a]
Cesium-137	10045-97-3	1.71	NAL	Yes	10[a]
Neptunium-237	13994-20-2	0.763	NAL	Yes	1[a]
Plutonium-238	13981-16-3	0.398	NAL	Yes	1[a]
Plutonium-239/240	15117-48-3/14119-33-6	0.387	NAL	Yes	1[a]
Technetium-99	14133-76-7	4 mrem/year-dose,[e] 900/19.0	MCL/NAL	Yes	25[a]
Thorium-230	14269-63-7	0.572	NAL	Yes	1[a]
Uranium-234	13966-29-5	10.24/0.739	MCL[f]/NAL	Yes	1[a]
Uranium-235	15117-96-1	0.466/0.728	MCL[f]/NAL	Yes	1[a]
Uranium-238	24678-82-8	9.99/0.601	MCL[f]/NAL	Yes	1[a]

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDA = minimum detectable activity
NAL = no action level for child resident scenario from the RMD

[a] This QAPP references the MCLs (or EPA screening level for Tap water if no MCL) to support project planning and identify whether lower reporting limits may be needed for some constituents. The worksheet also lists the NALs established by the RMD and MCLs reproduced in the RMD. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDAs identified in the worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] The value derived by the EPA from the 4 mrem/yr MCL for Tc-99 is 900 pCi/L (see http://www.epa.gov/reg-flex/radionuclides-drinking-water-small-entity-compliance-guide-february-2002). An alternate value derived by the EPA from the 4 mrem/yr MCL is 3,790 pCi/L and was proposed in the July 18, 1991, *Federal Register*, http://nepis.epa.gov (document number 570-Z-91-049).
[f] Based on RMD (DOE 2019c).

QAPP Worksheet #15-F. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Metals, Solid (Concrete), Soil]

Matrix: Solid (Concrete), Soil
Analytical Group: Metals

Metal	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/kg)	MDL[d] (mg/kg)
Aluminum	7429-90-5	7,740	NAL	Yes	10	3
Antimony	7440-36-0	3.13	NAL	Yes	1	0.33
Arsenic	7440-38-2	0.356	NAL	Yes	1[a]	0.2
Barium	7440-39-3	1,530	NAL	Yes	0.4	0.1
Beryllium	7440-41-7	15.6	NAL	Yes	0.1	0.02
Boron	7440-42-8	1,560	NAL	Yes	3	0.8
Cadmium	7440-43-9	5.28	NAL	Yes	0.2	0.02
Chromium (Total)	7440-47-3	11,700[e]	NAL	Yes	0.6	0.2
Cobalt	7440-48-4	2.34	NAL	Yes	0.2	0.06
Copper	7440-50-8	313	NAL	Yes	0.2	0.066
Fluoride	16984-48-8	313	NAL	Yes	TBD	TBD
Iron	7439-89-6	5,480	NAL	Yes	20	6.6
Lead	7439-92-1	400	NAL	Yes	0.4	0.1
Manganese	7439-96-5	183	NAL	Yes	1	0.2
Mercury	7439-97-6	2.35	NAL	Yes	0.01	0.004
Molybdenum	7439-98-7	39.1	NAL	Yes	0.2	0.06
Nickel[f]	7440-02-0	155	NAL	Yes	0.4	0.1
Selenium	7782-49-2	39.1	NAL	Yes	1	0.33
Silver	7440-22-4	39.1	NAL	Yes	0.5	0.1
Thallium[f]	7440-28-0	0.0782	NAL	Yes	0.4[a]	0.06
Uranium[f]	7440-61-1	1.56	NAL	Yes	0.04	0.013
Vanadium	7440-62-2	39.3	NAL	Yes	0.5	0.1
Zinc	7440-66-6	2,350	NAL	Yes	2	0.4

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDL = method detection limit
NAL = no action level for child resident scenario from the RMD
PCB = polychlorinated biphenyl
PQL = practical quantitation limit

QAPP Worksheet #15-F. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Metals, Solid (Concrete), Soil] (Continued)

NOTE: Worksheet #15 will be prepared with preliminary target laboratory-specific PQLs and MDLs to be used to procure the laboratory.

[a] This QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] An NAL is not available for chromium (total); therefore, the NAL for chromium III was used. The NAL for Chromium VI (0.301 mg/kg) would be a more appropriate action limit where Chromium VI was known to be used.
[f] The PAL/NAL values (for metals identified as salts) were derived for metal salts; the CAS number is presented for the elemental form.

QAPP Worksheet #15-G. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [PCBs, Solid (Concrete) Soil]

Matrix: Solid (Concrete), Soil
Analytical Group: PCBs

PCB	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (mg/kg)	MDL[d] (mg/kg)
Aroclor 1016	12674-11-2	0.206	NAL	Yes	0.0033	0.001099
Aroclor 1221	11104-28-2	0.0752	NAL	Yes	0.0033	0.001099
Aroclor 1232	11141-16-5	0.0708	NAL	Yes	0.0033	0.001099
Aroclor 1242	53469-21-9	0.0791	NAL	Yes	0.0033	0.001099
Aroclor 1248	12672-29-6	0.0792	NAL	Yes	0.0033	0.001099
Aroclor 1254	11097-69-1	0.0588	NAL	Yes	0.0033	0.001099
Aroclor 1260	11096-82-5	0.0803	NAL	Yes	0.0033	0.001099
Total PCBs	1336-36-3	0.0788	NAL	Yes	0.0033	0.001099

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDL = method detection limit
NAL = no action level for child resident scenario from the RMD
PQL = practical quantitation limit
PCBs = polychlorinated biphenyls

[a] This QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.

QAPP Worksheet #15-H. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Radionuclides, Solid (Concrete), Soil]

Matrix: Solid (Concrete), Soil
Analytical Group: Radionuclides

Radionuclide	CAS Number	Project Action Limit (pCi/g)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]
					MDA[d] (pCi/g)
Actinium-227	7440-34-8	TBD	TBD	No	TBD
Americium-241	14596-10-2	1.75	NAL	Yes	1
Cesium-137	10045-97-3	0.0402	NAL	Yes	0.1[a]
Cobalt-60	10198-40-0	TBD	TBD	No	TBD
Lead-210	14255-04-0	TBD	TBD	No	TBD
Neptunium-237	13994-20-2	0.0911	NAL	Yes	1[a]
Plutonium-238	13981-16-3	4.27	NAL	Yes	1
Plutonium-239/240	15117-48-3/ 14119-33-6	3.77/3.80	NAL	Yes	1
Protactinium-231	7440-13-3	TBD	TBD	No	TBD
Radium-226	7440-14-4	TBD	TBD	No	TBD
Strontium-90	7440-24-6	TBD	TBD	No	TBD
Technetium-99	14133-76-7	110	NAL	Yes	5
Thorium-228	14274-82-9	TBD	TBD	No	TBD
Thorium-230	14269-63-7	4.93	NAL	Yes	1
Thorium-232	7440-29-1	TBD	TBD	No	TBD
Uranium-234	13966-29-5	5.77	NAL	Yes	1
Uranium-235	15117-96-1	0.148	NAL	Yes	1[a]
Uranium-238	24678-82-8	0.556	NAL	Yes	1[a]

NOTE: For consistency at a programmatic level, these worksheets will be reviewed and updated for project-specific QAPPs. Worksheet #15 of each project-specific QAPP will have a Project QL column that will be related to action levels deemed appropriate for the specific analytes as a result of three-party project scoping.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDA = minimum detectable activity
NAL = no action level for child resident scenario from the RMD

QAPP Worksheet #15-H. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Radionuclides, Solid (Concrete), Soil] (Continued)

[a] This programmatic QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process within the project-specific QAPP.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COC in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the MDA is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.

QAPP Worksheet #15-I. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [VOCs, Solid (Concrete), Soil]

Matrix: Solid (Concrete), Soil
Analytical Group: VOCs

VOC	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL (µg/kg)	MDL[d] (µg/kg)
1,1-Dichloroethene	75-35-4	22,700	NAL	Yes	1	0.33
1, 2-Dichloroethane	107-06-2	464	NAL	Yes	1	0.33
1,2-Dichloroethene (mixed)	540-59-0	70,400	NAL	Yes	2	0.33
cis-1,2-Dichloroethene	156-59-2	15,600	NAL	Yes	1	0.33
trans-1,2-Dichloroethene	156-60-5	10,200	NAL	Yes	1	0.33
1,1,1 Trichloroethane	71-55-6	815,000	NAL	Yes	1	0.33
Bromodichloromethane	75-27-4	293	NAL	YES	1	0.33
1, 4-Dioxane	123-91-1	-	-	No	50	16.67
Acrylonitrile	107-13-1	255	NAL	Yes	5	1.7
Benzene	71-43-2	1,160	NAL	Yes	1	0.33
Carbon Tetrachloride	56-23-5	653	NAL	Yes	1	0.33
Chloroform	67-66-3	316	NAL	Yes	1	0.33
Ethylbenzene	100-41-4	5,780	NAL	Yes	1	0.33
Toluene	108-88-3	489,000	NAL	Yes	1	0.33
Tetrachloroethene	127-18-4	8,100	NAL	Yes	1	0.33
Trichloroethene	79-01-6	412	NAL	Yes	1	0.33
Vinyl chloride	75-01-4	59.2	NAL	Yes	1	0.33
Total Xylenes	1330-20-7	57,600	NAL	Yes	3	1
m,p-xylene	179601-23-1	55,100/56,100	NAL	Yes	2	0.67
o-xylene	95-47-6	64,500	NAL	Yes	1	0.33

NOTE: Worksheet #15 will be prepared with preliminary target laboratory-specific PQLs and MDLs to be used to procure the laboratory. Once selected, the PQL/MDL information will be updated.
NOTE: Additional VOCs in suite will be reported.

CAS = Chemical Abstracts Service. COPC = chemical (or radionuclide) of potential concern. MDL = method detection limit. NAL = no action level for child resident scenario from the RMD
PQL = practical quantitation limit.

[a] This QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process within the project-specific QAPP.
[b] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.

QAPP Worksheet #15-I. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [VOCs, Solid (Concrete), Soil] (Continued)

[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.

[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.

QAPP Worksheet #15-J. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [SVOCs, Solid (Concrete), Soil]

Matrix: Solid (Concrete), Soil
Analytical Group: SVOCs

SVOC	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference[a]	Site COPC?[b]	Laboratory-Specific[c]	
					PQL[d] (µg/kg)	MDL[d] (µg/kg)
Acenaphthene	83-32-9	185,000	NAL	Yes	33.3	10
Acenaphthylene	208-96-8	185,000[e]	NAL	Yes	33.3	10
Anthracene	210-12-7	923,000	NAL	Yes	33.3	10
Carbazole	86-74-8	10,400	NAL	Yes	33.3	10
Fluoranthene	206-44-0	123,000	NAL	Yes	33.3	10
Fluorene	86-73-7	123,000	NAL	Yes	33.3	10
Hexachlorobenzene	118-74-1	212	NAL	Yes	333[a]	100
Naphthalene	91-20-3	3,830	NAL	Yes	33.3	10
2-Nitroaniline	88-74-4	35,600	NAL	Yes	333	110
N-nitroso-di-n-propylamine	621-64-7	29.7	NAL	Yes	333[a]	100[a]
Pentachlorophenol	87-86-5	254	NAL	Yes	333	100
Phenanthrene	85-01-8	185,000[e]	NAL	Yes	33.3	10
Pyrene	129-00-0	92,300	NAL	Yes	33.3	10
Total PAHs (carcinogenic)						
~Benz[a]anthracene	56-55-3	475	NAL	Yes	33.3	9.99
~Benzo[a]pyrene	50-32-8	47.8	NAL	Yes	33.3	9.99
~Benzo[b]fluoranthene	205-99-2	478	NAL	Yes	33.3	9.99
~Benzo[k]fluoranthene	207-08-9	4,780	NAL	Yes	33.3	9.99
~Chrysene	218-01-9	47,800	NAL	Yes	33.3	9.99
~Dibenz[a,h]anthracene	53-70-3	47.8	NAL	Yes	33.3	9.99
~Indeno[1,2,3-cd]pyrene	193-39-5	478	NAL	Yes	33.3	9.99

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.
NOTE: Additional SVOCs in suite will be reported.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDL = method detection limit
N/A = not applicable
NAL = no action level for child resident scenario from the RMD
PAH = polycyclic aromatic hydrocarbon
PQL = practical quantitation limit
SVOC = semivolatile organic compound

QAPP Worksheet #15-J. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [SVOCs, Solid (Concrete), Soil] (Continued)

[a] This QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[b] Analytes marked with COPC are from Table 2.1 of the RMD (DOE 2019c) and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[c] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[d] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs and this information will be appended to the QAPP.
[e] Acenaphthylene and phenanthrene use values for acenaphthene.

QAPP Worksheet #15-K. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Dioxins and Furans, Solid (Concrete), Soil]

Matrix: Solid (Concrete), Soil
Analytical Group: Dioxins and Furans

Dioxins and Furans[i]	CAS Number	Project Action Limit (mg/kg)	Project Action Limit Reference[e]	Site COPC?[f]	Laboratory-Specific[g]	
					PQL (mg/kg)	MDL[h] (mg/kg)
2,3,7,8-TCDD	1746-01-6	3.08E-06	NAL	Yes	TBD	TBD
1,2,3,7,8-PeCDD	40321-76-4	3.14E-06[a]	NAL	Yes	TBD	TBD
1,2,3,4,7,8-HxCDD	39227-28-6	3.14E-05[b]	NAL	Yes	TBD	TBD
1,2,3,6,7,8-HxCDD	57653-85-7	3.14E-05[b]	NAL	Yes	TBD	TBD
1,2,3,7,8,9-HxCDD	19408-74-3	3.14E-05[b]	NAL	Yes	TBD	TBD
1,2,3,4,6,7,8-HpCDD	35822-39-4	3.09E-04[c]	NAL	Yes	TBD	TBD
OCDD	3268-87-9	1.05E-02	NAL	Yes	TBD	TBD
Total TCDD	41903-57-5	3.08E-06[d]	NAL	Yes	TBD	TBD
2,3,7,8-TCDF	5127-31-9	3.09E-05	NAL	Yes	TBD	TBD
1,2,3,7,8-PeCDF	57117-41-6	1.05E-04	NAL	Yes	TBD	TBD
2,3,4,7,8-PeCDF	57117-31-4	1.05E-05	NAL	Yes	TBD	TBD
1,2,3,4,7,8-HxCDF	70648-26-9	N/A	NAL	No	TBD	TBD
1,2,3,6.7,8-HxCDF	57117-44-9	N/A	NAL	No	TBD	TBD
1,2,3,7,8,9-HxCDF	72918-21-9	N/A	NAL	No	TBD	TBD
2,3,4,6,7,8-HxCDF	60851-34-5	N/A	NAL	No	TBD	TBD
1,2,3,4,6,7,8-HpCDF	67562-39-4	N/A	NAL	No	TBD	TBD
1,2,3,4,7,8,9-HpCDF	55673-89-7	N/A	NAL	No	TBD	TBD
OCDF	39001-02-0	1.05E-02	NAL	Yes	TBD	TBD
Total PeCDD	36088-22-9	3.14E-06[a]	NAL	Yes	TBD	TBD
Total HxCDD	34465-46-8	3.14E-05[b]	NAL	Yes	TBD	TBD
Total HpCDD	37871-00-4	3.09E-04[c]	NAL	Yes	TBD	TBD
Total TCDF	30402-14-3	3.09E-05 [j]	NAL	No	TBD	TBD
Total PeCDF	30402-15-4	N/A	-	No	TBD	TBD
Total HxCDF	55684-94-1	3.14E-05[k]	NAL	No	TBD	TBD
Total HpCDF	38998-75-3	3.12E-04	NAL	Yes	TBD	TBD

NOTE: Worksheet #15 will be prepared with preliminary target laboratory specific PQLs and MDLs to be used to procure the laboratory.

CAS = Chemical Abstracts Service
COPC = chemical (or radionuclide) of potential concern
MDL = method detection limit
NAL = no action level for child resident scenario from the RMD
PQL = practical quantitation limit

QAPP Worksheet #15-K. Project Action Limits and Laboratory-Specific Detection/Quantitation Limits [Dioxins and Furans, Solid (Concrete), Soil] (Continued)

[a] Child resident NAL for PeCDD, 2,3,7,8- used for project action limit.
[b] Child resident NAL for HxCDD used for project action limit.
[c] Child resident NAL for HpCDD, 2,3,7,8- used for project action limit.
[d] Child resident NAL for TCDD, 2,3,7,8- used for project action limit.
[e] This QAPP references the NALs established by the RMD and MCLs reproduced in the RMD to support project planning and identify whether lower reporting limits may be needed for some constituents. In some cases, the laboratories may not be able to reach detection limits below the NAL. In these cases, the project team will address this issue in the decision process.
[f] Analytes marked with COPC are from Table 2.1 of the RMD and represent the list of chemicals, compounds, and radionuclides compiled from COPCs retained as COCs in risk assessments previously performed at PGDP.
[g] The analytical laboratory may not be able to meet the NALs established by the RMD and MCLs reproduced in the RMD. For cases where the PQL is above the PAL/NAL, FRNP will have the laboratory report to the method detection limit, qualifying the result as estimated. Standard practices for qualifying data will apply for any result reported below the laboratory PQL.
[h] This QAPP will be used to solicit laboratories to perform the work. Should the laboratory not be able to meet the MDLs and PQLs identified in the Worksheets, the laboratory will submit documentation of its actual MDLs and PQLs, and this information will be appended to the QAPP.
[i] Only sampled at designated locations.
[j] Child resident NAL for TCDF, 2,3,7,8- used for project action limit.
[k] Child resident NAL for HxCDF, 2,3,7,8- used for project action limit.

QAPP Worksheet #17. Sampling Design and Rationale

The purpose of this project-specific QAPP is to document the collection protocols and sampling methodologies associated with the C-400 Complex RI/FS under CERCLA. The boundaries of the C-400 Complex area and the sectors within the C-400 Complex area are presented in figures in Chapter 9. Various media will be sampled during the course of this investigation, including, but not limited to, concrete, surface and subsurface soils, and groundwater. In addition, radiological field scans and field parameters will be collected when appropriate. An additional element of the scope is the selection of preferred analytical methods (radionuclides, VOCs, SVOCs, and metals) performing radiological scans and sampling and analysis of surface, subsurface soil and groundwater samples. Additional details on the sampling design and rationale are provided in Chapter 9.

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure Requirements Table for Screening Samples

Worksheet #18 provides information pertaining to sampling planned for this project.

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S1A-03	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	14 soil/7 groundwater	See Worksheet #21	See Worksheet #17
400-S1A-23	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1B-02	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	9 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S1B-04	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1B-05	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	9 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S1B-09	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	9 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S1B-21	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S1B-22	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1B-24	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	2 concrete/7 soil/ 3 groundwater	See Worksheet #21	See Worksheet #17
400-S1B-25	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1B-26	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1B-27	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete[f] /4 soil	See Worksheet #21	See Worksheet #17
400-S1B-28	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/12 soil/ 2 groundwater	See Worksheet #21	See Worksheet #17
400-S1B-41	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1B-42	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[g]	b	2 concrete[f] /9 soil/ 5 groundwater	See Worksheet #21	See Worksheet #17
400-S1B-43	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S1B-44	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1B-45	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1B-46	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1C-1	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1C-29	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-30	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	2 concrete/9 soil/ 2 groundwater	See Worksheet #21	See Worksheet #17
400-S1C-31	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-32	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/9 soil/ 5 groundwater	See Worksheet #21	See Worksheet #17
400-S1C-33	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-34	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	2 concrete/7 soil/ 2 groundwater	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S1C-35	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-36	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-37	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-38	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-39	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1C-40	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1D-06	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1D-07	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1D-08	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 soil	See Worksheet #21	See Worksheet #17
400-S1D-14	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1D-15	Solid (concrete), Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete[f] /9 soil/ 2 groundwater	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S1D-16	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1D-17	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1D-18	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1D-19	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S1D-20	Solid (concrete) & Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 concrete/4 soil	See Worksheet #21	See Worksheet #17
400-S02G01	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S02G02	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S02-01	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-02	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-03	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S02-04	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-05	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-06	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S02-07	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-08	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S02-09	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-10	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-11	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-12	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-13	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S02-14	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/2 groundwater	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S02GS1[i]	Soil	UCRS	Radionuclides	b	1 soil	See Worksheet #21	See Worksheet #17
400-S03G01	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S03G02	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S03-01	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S03-02	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S03-03	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S03-04	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S03-05	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/5 groundwater	See Worksheet #21	See Worksheet #17
400-S03-06	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S03-07	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical, Dioxins[g]	b	8 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S03-08	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S03GS1[i]	Soil	UCRS	Radionuclides	b	1 soil	See Worksheet #21	See Worksheet #17
400-S04G01[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G02[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G03[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G04[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G05[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G06[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G07[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04G08[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S04-01	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S04-02	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S04-03	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S04-04	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S04-05	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S04-06	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S04-07	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	13 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S04-08	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S04-10	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S04-11	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S04-12	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	15 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S04-13	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S04-14	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S04-15	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S04-16	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S04-17	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	10 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S04-18	Soil & Groundwater	UCRS/RGA /McNairy	VOCs	b	7 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S04GS1[i]	Soil	UCRS	Radionuclides	b	1 soil	See Worksheet #21	See Worksheet #17
400-S05G01[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G02[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G03[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G04[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G05[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S05G06[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G07[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G08[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G09[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G10[h]	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[h]	b	3[h] soil	See Worksheet #21	See Worksheet #17
400-S05G11	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S05G12	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S05G13	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S05G14	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S05G15	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S05G16	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S05G17	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S05-01	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil (surface soil)[f]	See Worksheet #21	See Worksheet #17
400-S05-02	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-03	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S05-04	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-05	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-06	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-07	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S05-08	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S05-09	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-10	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-11	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-12	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S05-13	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/6 groundwater	See Worksheet #21	See Worksheet #17
400-S05GS1[i]	Soil	UCRS	Radionuclides	b	1 soil	See Worksheet #21	See Worksheet #17
400-S06G01	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06G02	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06G03	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S06G04	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06G05	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06G06	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06G07	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06G08	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S06-01	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S06-02	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	8 soil/3 groundwater	See Worksheet #21	See Worksheet #17
400-S06-03	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S06-04	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S06-05	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S06-06	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S06-07	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S06-08	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S06GS1[i]	Soil	UCRS	Radionuclides	b	1 soil	See Worksheet #21	See Worksheet #17
400-S07G01	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07G02	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07G03	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07G04	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07G05	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S07G06	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07G07	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07G08	Soil	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	2 soil	See Worksheet #21	See Worksheet #17
400-S07-01	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S07-02	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides, Geotechnical & Geochemical	b	8 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S07-03	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides, Dioxins[g]	b	5 soil (surface soil)[f]	See Worksheet #21	See Worksheet #17
400-S07-04	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S07-05	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S07-06	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
400-S07-07	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S07-08	Soil	UCRS/RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	5 soil	See Worksheet #21	See Worksheet #17
400-S07-09	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S07-10	Soil & Groundwater	UCRS/RGA /McNairy	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	10 soil/2 groundwater	See Worksheet #21	See Worksheet #17
400-S07GS1[i]	Soil	UCRS	Radionuclides	B	1 soil	See Worksheet #21	See Worksheet #17
MW155	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW156	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW157	Groundwater	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW175	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW176	Groundwater	UCRS	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17

**QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples**

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
MW178	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW341	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW342	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW343	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW405-PRT5	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW406-PRT5	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW407-PRT4	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW408-PRT5	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW421-PRT1	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
MW421-PRT2	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW421-PRT3	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW422-PRT1	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW422-PRT2	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW422-PRT3	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW423-PRT1	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW423-PRT2	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW423-PRT3	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW424-PRT1	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17

**QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples**

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
MW424-PRT2	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW424-PRT3	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW425-PRT1	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW425-PRT2	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW425-PRT3	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW505	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW506	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW507	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	b	4 groundwater	See Worksheet #21	See Worksheet #17
MW557	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
MW558	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW559	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW560	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW561	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW562	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW563	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW564	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW565	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW566	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17

QAPP Worksheet #18. Sampling Locations and Methods/Standard Operating Procedure (Continued)
Requirements Table for Screening Samples

Sampling Location/ID Number	Matrix	Depth (units)	Analytical Group[a]	Concentration Level[b]	Number of Samples (Field Duplicate Sample 5% Total See Worksheet #20)[c]	Sampling SOP Reference[d]	Rationale for Sampling Location
MW567	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW568	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW569	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW570	Groundwater	Middle RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW571	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW572	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW573	Groundwater	Lower RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17
MW574	Groundwater	Upper RGA	VOCs, SVOCs, Metals, PCBs, Radionuclides	TBD	4 groundwater	See Worksheet #21	See Worksheet #17

[a] See Analytical SOP References Table (Worksheet #23).
[b] See Section 5 for historical data.
[c] Contingency locations not included. Anticipate up to 20% contingency for boring locations.
[d] See Field SOP References Table (Worksheet #21).
[e] See Tables 9.4 through 9.13 for sample depths for dioxins/furans.
[f] Sample will be analyzed for the additional radionuclides listed in Table 6.1.
[g] Dioxins and furans collected at surface and HU1 interval.
[h] Dioxins and furans and pentachlorophenol collected at 0-1 ft (if present), 1-4 ft and 4-7 ft. As discussed during scoping, soil is not anticipated to be present in the 0-1 ft interval at the railroad locations. Once soil is encountered, the soil sample will be collected, and this sample depth will be documented.
[i] As discussed in Section 9.1.1 and Appendix C of the Gamma Walkover Survey, one biased grab sample per sector will be collected, based on inflection point analysis for Sectors 2-7, and analyzed for radionuclides in Table 6.1.
NOTE: Monitoring wells will be sampled quarterly, for one year.
Metals analyses will include fluoride and mercury.
N/A = not applicable
SOP = standard operating procedure

QAPP Worksheet #19 and 30. Sample Containers, Preservation, and Hold Times
(UFP-QAPP Manual Section 3.1.2.2)
(EPA 2106-G-05 Section 2.3.2)

The purpose of this worksheet is to serve as a reference guide for field personnel. It is also an aid to completing the chain-of-custody form and shipping documents. Complete this table for each laboratory used. If laboratory accreditation/certification is required for this project, the project team must verify that the laboratory maintains current accreditation/certification status for each analyte/matrix/method combination, as applicable, throughout its involvement with the project. If the accreditation expiration dates are the same for entries then a global expiration date can be added at the top of the table, as appropriate.

Laboratory: TBD

List any required accreditations: DOE Consolidated Audit Program (DOECAP), if applicable

Back-up Laboratory: N/A

Sample Delivery Method: Overnight delivery

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
VOCs	Solid (Concrete)/Soil	EPA Method SW-846-8260	TBD	Soil cores—3 × 5-g Encore Samplers Concrete and other solids—1 2-oz wide mouth glass jar	0–6˚C	N/A	Soil cores—48 hours (EnCore™ Sampler) Concrete and other solids—14 day hold time	28 days
SVOCs	Solid (Concrete)/Soil	EPA Method SW-846-8270	TBD	1 × 250 ml wide mouth amber glass	0–6˚C	14 days	40 days	28 days

QAPP Worksheet #19 and 30. Sample Containers, Preservation, and Hold Times (Continued)
(UFP-QAPP Manual Section 3.1.2.2)
(EPA 2106-G-05 Section 2.3.2)

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
PCBs	Solid (Concrete)/Soil	SW-846-8082	TBD	1 × 250 ml wide mouth amber glass	0–6˚C	N/A	N/A*	28 days
Metals	Solid (Concrete)/Soil	EPA Method SW-846-6020	TBD	1 × 4 oz. wide mouth glass	N/A	N/A	180 days	28 days
Radionuclides	Solid (Concrete)/Soil	Alpha Spec, Gamma Spec, Liquid Scintillation, EPA-903.1-M, EPA-905.0-M	TBD	1 × 16 oz. wide mouth poly/plastic jar	N/A	N/A	180 days	28 days
Mercury	Solid (Concrete)/Soil	EPA Method SW-846-7471	TBD	1 × 4 oz. wide mouth glass	0–6˚C	N/A	28 days	28 days

QAPP Worksheet #19 and 30. Sample Containers, Preservation, and Hold Times (Continued)
(UFP-QAPP Manual Section 3.1.2.2)
(EPA 2106-G-05 Section 2.3.2)

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
Dioxins and Furans	Soil	EPA Method SW-846-8290	TBD	125 ml wide mouth amber glass	0–6˚C	30 days	45 days	28 days
VOCs	Groundwater	EPA Methods SW-846-8260	TBD	3 × 40 ml VOA vials jar	HCl to pH < 2; 0–6˚C	N/A	14 days	28 days
SVOCs	Groundwater	EPA Method SW-846-8270	TBD	2 × 1,000 ml amber glass	0–6˚C	7 days	40 days	28 days
PCBs	Groundwater	EPA Method SW-846-8082	TBD	2 × 1,000 ml amber glass	0–6˚C	N/A	N/A*	28 days
Metals	Groundwater	EPA Method SW-846-6010/6020	TBD	1 × 500 ml glass	HCl to pH < 2	N/A	180 days	28 days

QAPP Worksheet #19 and 30. Sample Containers, Preservation, and Hold Times (Continued)
(UFP-QAPP Manual Section 3.1.2.2)
(EPA 2106-G-05 Section 2.3.2)

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround Time
Radionuclides	Groundwater	Alpha Spec, Gamma Spec, Liquid Scintillation, EPA-903.1-M, EPA-905.0-M	TBD	2 × 1,000 ml amber glass	HCl to pH < 2	N/A	180 days	28 days
Mercury	Groundwater	EPA Method SW-846-7470	TBD	1 × 250 ml amber glass	HCl to pH < 2	N/A	28 days	28 days

NOTE: Sample volume and container requirements will be specified by the laboratory.
*There is no analytical holding time listed for PCB analysis by EPA Method 8082A.

HCL = hydrochloric acid

QAPP Worksheet #20. Field QC Summary
(UFP-QAPP Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.5)

Field Quality Control Sample Summary Table

This worksheet provides a summary of the types of samples to be collected and analyzed for the project. Its purpose is to show the relationship between the number of field samples and associated QC samples for each combination of analyte/analytical group and matrix. This worksheet also is useful for informing the laboratory of the number of samples to expect and for preparing analytical cost estimates. The number and types of QC samples should be based on project-specific DQOs, and this worksheet should be adapted as necessary to accommodate project-specific requirements. Not all types of QC samples shown in the example below will be necessary for all projects. Some projects may require additional QC samples (e.g., proficiency testing samples), which can be listed in the "other" column.

Samples that are collected at different depths at the same location, and analyzed separately, should be counted as separate field samples. Even if they are taken from the same container as the parent field sample, matrix spikes (MSs) and MS duplicates (MSDs) are counted separately, because they are analyzed separately. If composite samples or incremental samples are being collected, include only the sample that will be analyzed; subsamples and increments should not be listed separately; however, containers making up the sample (as received by the laboratory) must be labeled.

Matrix	Analyte/ Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Other	Total # of Analyses
Solid (Concrete)/Soil	VOCs	857	43	43	43	43	43	l per day or 1 per cooler	N/A	1072
Solid (Concrete)/Soil	Metals	857	43	43	43	43	43	N/A	N/A	1072
Solid (Concrete)/Soil	SVOCs	857	43	43	43	43	43	N/A	N/A	1072
Solid (Concrete)/Soil	PCBs	857	43	43	43	43	43	N/A	N/A	1072
Solid (Concrete)/Soil	Radionuclides	857	43	43	43	43	43	N/A	N/A	1072
Solid (Concrete)/Soil	Dioxins	63	4	4	4	4	4	N/A	N/A	83

QAPP Worksheet #20. Field QC Summary (Continued)
(UFP-QAPP Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.5)

Field Quality Control Sample Summary Table (Continued)

Matrix	Analyte/ Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Other	Total # of Analyses
Solid (Concrete)/Soil	Additional Radionuclides (thorium-228, thorium-232, actinium-227, cobalt-60, lead-210, protactinium-231, radium-226, strontium-90)	8	1	1	1	1	1	N/A	N/A	13
Groundwater (MWs)	VOCs	184	10	10	10	10	10	l per day or 1 per cooler	N/A	234 (plus) Trip Blanks)
Groundwater (MWs)	Metals	184	10	10	10	10	10	N/A	N/A	234
Groundwater (MWs)	SVOCs	184	10	10	10	10	10	N/A	N/A	234
Groundwater (MWs)	PCBs	184	10	10	10	10	10	N/A	N/A	234
Groundwater (MWs)	Radionuclides	184	10	10	10	10	10	N/A	N/A	234
Groundwater (Grab, Unfiltered)	VOCs	129	7	7	7	7	7	l per day or 1 per cooler	N/A	164
Groundwater (Grab, Unfiltered)	SVOCs (PAHs)	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, Unfiltered)	PCBs	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, Unfiltered)	Radionuclides (Tc-99)	129	7	7	7	7	7	N/A	N/A	164

QAPP Worksheet #20. Field QC Summary (Continued)
(UFP-QAPP Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.5)

Field Quality Control Sample Summary Table (Continued)

Matrix	Analyte/ Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Blanks	Equipment Blanks	Trip Blanks	Other	Total # of Analyses
Groundwater (Grab, filtered)	SVOCs (PAHs)	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, filtered)	PCBs	129	7	7	7	7	7	N/A	N/A	164
Groundwater (Grab, filtered)	Radionuclides (Tc-99)	129	7	7	7	7	7	N/A	N/A	164

QAPP Worksheet #21. Field SOPs
(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

Project Sampling SOP References Table

This worksheet is intended for use to document the specific field procedures being implemented, which is important for measurement traceability. The QAPP must contain detailed descriptions of procedures for field activities, including sample collection; sample preservation; equipment cleaning and decontamination; equipment testing, maintenance, and inspection; and sample handling and custody. If these procedures are included in existing SOPs, then the SOPs should be reviewed to make sure they either are (1) sufficiently prescriptive to be implemented as written or (2) modified as necessary for this project. If an SOP provides more than one procedure or option (for example, one SOP covers the use of several different types of field equipment for the same procedure) this worksheet must note the specific option or equipment being used. Basic information about the SOPs should be provided in this table, and the SOPs themselves should be included in an appendix to the QAPP. Field SOPs must be readily available to field personnel responsible for their implementation. The QAPP must explain any planned modifications to field SOPs. Modifications should be noted clearly on the SOPs. The specific type(s) of SOP modifications/deviations must be summarized in the comments column or a reference provided.

QAPP Worksheet #21. Field SOPs (Continued)
(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

Project Sampling SOP References Table

Reference Number	Title and Number[a] Revision Date	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
1	CP4-ES-0043, *Temperature Control for Sample Storage* (1/3/2019)	Contractor	Sampling	N	N/A
2	CP2-WM-0001, *Four Rivers Nuclear Partnership, LLC Paducah Deactivation and Remediation Project Waste Management Plan* (10/2018)	Contractor	N/A	N	N/A
3	CP2-ES-0026, *Wet Chemistry and Miscellaneous Analyses Data Verification and Validation Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/13/2017)	Contractor	N/A	N	N/A
4	CP2-ES-0811, *Pesticide and PCB Analyses Data Verification and Validation Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/13/2017)	Contractor	N/A	N	N/A
5	CP4-ES-1001, *Transmitting Data to the Paducah Oak Ridge Environmental Information System* (12/21/2017)	Contractor	N/A	N	N/A
6	CP2-ES-0063, *Environmental Monitoring Data Management Implementation Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (7/2018)	Contractor	N/A	N	N/A
7	CP4-ES-2100, *Groundwater Level Measurement* (1/3/2019)	Contractor	Sampling	N	N/A
8	CP4-ES-2101, *Groundwater Sampling* (1/10/2018)	Contractor	Sampling	N	N/A

QAPP Worksheet #21. Field SOPs (Continued)
(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

Project Sampling SOP References Table (Continued)

Reference Number	Title and Number[a] Revision Date	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
9	CP4-ES-0074, *Monitoring Well Inspection and Maintenance* (1/3/2018)	Contractor	Sampling	N	N/A
10	CP4-ES-2700, *Logbooks and Data Forms* (12/4/2017)	Contractor	N/A	N	N/A
11	CP4-ES-2702, *Decontamination of Sampling Equipment and Devices* (1/4/2018)	Contractor	Sampling	N	N/A
12	CP4-ES-2704, *Trip, Equipment, and Field Blank Preparation* (1/2/2018)	Contractor	N/A	N	N/A
13	CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals* (12/12/2017)	Contractor	N/A	N	N/A
14	CP3-ES-5003, *Quality Assured Data* (1/9/2018)	Contractor	N/A	N	N/A
15	CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling* (6/25/2018)	Contractor	N/A	N	N/A
16	CP3-OP-0500, *Performance Observations* (5/1/2019)	Contractor	N/A	N	N/A
17	CP3-QA-1003, *Management and Self Assessment* (3/27/2019)	Contractor	N/A	N	N/A
18	CP3-RD-0010, *Records Management Process* (10/22/2018)	Contractor	N/A	N	N/A
19	CP4-ES-2303, *Borehole Logging* (11/30/2017)	Contractor	N/A	N	N/A
20	CP4-RP-1110, *Radiation Surveys* (12/18/2017)	Contractor	N/A	N	N/A

QAPP Worksheet #21. Field SOPs (Continued)
(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

Project Sampling SOP References Table (Continued)

Reference Number	Title and Number[a] Revision Date	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
21	CP4-ES-5007, *Data Management Coordination* (4/25/2019)	Contractor	N/A	N	N/A
22	CP2-ES-5102, *Radiochemical Analysis Data Verification and Validation Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/13/2017)	Contractor	N/A	N	N/A
23	CP2-ES-5103, *Polychlorinated Dibenzodioxins/Polychlorinated Dibenzofurans Analyses Data Verification and Validation Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/13/2017)	Contractor	N/A	N	N/A
24	CP2-ES-5105, *Volatile and Semivolatile Analyses Data Verification and Validation Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (9/2018)	Contractor	N/A	N	N/A
25	CP2-ES-5107, *Inorganic Analyses Data Verification and Validation Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (12/13/2017)	Contractor	N/A	N	N/A
26	CP3-ES-1003, *Developing, Implementing, and Maintaining Data Management Plans* (12/27/2017)	Contractor	N/A	N	N/A
27	CP4-ES-1002, *Submitting, Reviewing, and Dispositioning Changes to the Environmental Databases* (12/21/2017)	Contractor	N/A	N	N/A

QAPP Worksheet #21. Field SOPs (Continued)
(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

Project Sampling SOP References Table (Continued)

Reference Number	Title and Number[a] Revision Date	Originating Organization[b]	Equipment Type	Modified for Project Work? (Y/N)	Comments
28	*CP4-ES-2300, Collection of Soil Samples* (1/17/2018)	Contractor	N/A	N	N/A
29	CP4-ER-1020, *Collection of Soil Samples with Direct Push Technology Sampling* (12/4/2017)	Contractor	N/A	N	N/A
30	*CP4-ES-2002, Sampling of Structural Elements and Miscellaneous Surfaces* (1/4/2018)	Contractor	N/A	N	N/A
31	CP2-RP-1002, *Radiological Contamination Control and Monitoring Technical Basis Document for the Paducah Gaseous Diffusion Plant, Paducah Kentucky* (10/2018)	Contractor	N/A	N	N/A
32	CP2-RP-1009, *Radiological Protection Instrumentation Operation Technical Basis Document* (12/2017)	Contractor	N/A	N	N/A
33	CP3-RP-1109, *Radioactive Contamination Control and Monitoring* (8/6/2018)	Contractor	N/A	N	N/A
34	CP4-RP-1309, *Setup for Operability Tests of Portable Field Instruments* (1/8/2018)	Contractor	N/A	N	N/A
35	CP4-RP-1336, *Radiological Instrumentation Field Operability Tests* (10/20/2017)	Contractor	N/A	N	N/A
36	*Standard Operating Procedure for Sampling Porous Surfaces for Polychlorinated Biphenyls (PCBs)* (EPA 2011)	EPA	N/A	N	N/A

[a] SOPs are posted to the FRNP external website. It is understood that SOPs are contractor specific. The RI/FS Report will specify any deviation between the procedures presented in this worksheet, at the FRNP external website (https://pubdocs.pad.pppo.gov/?dir=C-400%20RIFS%20Work%20Plan%20Procedures), and those actually used during the RI/FS field work.
[b] The work will be conducted by FRNP staff or a subcontractor. In either case, SOPs listed will be followed.
N/A = not applicable

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection
(UFP-QAPP Manual Section 3.1.2.4)
(EPA 2106-G-05 Section 2.3.6)

Field Equipment Calibration, Maintenance, Testing, and Inspection Table

This project will result in the collection of slab concrete, surface and subsurface soil, and groundwater samples for fixed-based laboratory analysis for potential contaminants. Field qualitative instrumentation will be utilized during the RI/FS, including, but not limited to, photoionization detectors (PIDs), and alpha/beta/gamma meters. Field instrumentation will be utilized in the selection or collection of the soil samples daily. These pieces of equipment that may require calibration will have such calibration performed based on manufacturer's recommendation, internal SOP, or regulation. These calibration efforts and information will be summarized and recorded in the field notes/logs.

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection (Continued)
(UFP-QAPP Manual Section 3.1.2.4)
(EPA 2106-G-05 Section 2.3.6)

Field Equipment Calibration, Maintenance, Testing, and Inspection Table

The following is the field equipment to be used on the project.

Field Equipment*	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
PID	Calibrate at the beginning of the day; check at the end of the day	As needed in the field; semiannually by the supplier	Measure known concentration of isobutylene 100 ppm (calibration gas)	Upon receipt, successful operation	Calibrate a.m., check p.m.	± 10% of the calibrated value	Manually zero meter or service as necessary and recalibrate	Field Team Leader	Manufacturer's specifications
Water Quality Meter	Calibrate at the beginning of the day	Performed monthly and as needed	Measure solutions with known values (National Institute for Standards and Technology traceable buffers and conductivity calibration solutions)	Upon receipt, successful operation	Daily before each use	pH: ± 0.1 s.u. Specific Conductivity: ± 3% ORP: ± 10 mV DO: ± 0.3 mg/L Temp.: ± 0.3ºC	Recalibrate or service as necessary	Field Team Leader	Manufacturer's specifications
Turbidity Meter (Nephthelometer)	Calibrate daily before each use	As needed	Measure solutions with known turbidity standards	Upon receipt, successful operation	Daily before each use	N/A (instrument zeroed)	Manually zero meter or service as necessary and recalibrate	Field Team Leader	Manufacturer's specifications
Electronic Water Level Meter	N/A	None	Check daily before each use	Upon receipt, successful operation	Check daily before each use	Pass/Fail	Return to rental company for replacement	Field Team Leader	Manufacturer's specifications

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection (Continued)
(UFP-QAPP Manual Section 3.1.2.4)
(EPA 2106-G-05 Section 2.3.6)

Field Equipment Calibration, Maintenance, Testing, and Inspection Table (Continued)

Field Equipment*	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Alpha Scintillator	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Return to rental company for replacement	RCT Supervisor	Manufacturer's specifications
Geiger Mueller	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Return to rental company for replacement	RCT Supervisor	Manufacturer's specifications
Gamma Scintillator or FIDLER	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Service by manufacturer	RCT Supervisor	Manufacturer's specifications
Field Equipment GPS	Daily check of known point beginning and end of each field day	Per manufacturers specifications	Measure known control points and compare values	Upon receipt, successful operation	Beginning and end of each field day	Pass/Fail	Service by manufacturer	Field Team Leader	Manufacturer's specifications
GPS Gamma Ray Survey Instrumentation	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Annually or as needed	Pass/Fail	Return to rental company for replacement	RCT Supervisor	Manufacturer's specifications
MIP Transfer Line and Detectors	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Service by manufacturer	RCT Supervisor	Manufacturer's specifications
MIP Soil Conductivity Tip	Annually or as specified by manufacturer	Annually or as needed	Daily prior to use	Upon receipt, successful operation	Daily prior to use	Pass/Fail	Service by manufacturer	RCT Supervisor	Manufacturer's specifications
DyeLIF	As specified by manufacturer	As specified by manufacturer	As specified by manufacturer	As specified by manufacturer	As specified by manufacturer	As specified by manufacturer	As specified by manufacturer	TBD	As specified by manufacturer

QAPP Worksheet #22. Field Equipment Calibration, Maintenance, Testing, and Inspection (Continued)
(UFP-QAPP Manual Section 3.1.2.4)
(EPA 2106-G-05 Section 2.3.6)

Field Equipment Calibration, Maintenance, Testing, and Inspection Table (Continued)

*Additional equipment may be needed; additional equipment will follow manufacturer's specifications for calibration, maintenance, inspection, and testing. Calibration data will be documented in logbooks consistent with CP4-ES-2700, *Logbooks and Data Forms*.

FIDLER = field instrument for detection of low energy radiation
GPS = Global Positioning System
N/A = not applicable
PCB = polychlorinated biphenyl
RCT = radiological control technician

QAPP Worksheet #23. Analytical SOPs
(UFP-QAPP Manual Section 3.2.1)
(EPA 2106-G-05 Section 2.3.4)

Analytical SOP References Table

This worksheet documents information about the specific sample preparation and analytical procedures to be used, which is important for measurement traceability. Screening data are used for interim investigations and/or will not be used for final risk assessment or site assessment decisions unless they have been confirmed with definitive procedures.

QAPP Worksheet #23. Analytical SOPs (Continued)
(UFP-QAPP Manual Section 3.2.1)
(EPA 2106-G-05 Section 2.3.4)

Analytical SOP References Table

Reference Number*	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group/ Matrix	Instrument	Organization Performing Analysis	Modified for Project Work?(Y/N)
SW-846-8260	VOCs by GC/MS	Definitive	VOCs/Concrete, Soil, & Groundwater	GC/MS	TBD	No
SW-846-8082	PCBs by GC/ECD	Definitive	PCBs/Concrete Soil, & Groundwater	GC	TBD	No
SW-846-6010	Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	Definitive	Metals/ Concrete Soil, & Groundwater	ICP	TBD	No
SW-846-6020	ICP-MS	Definitive	Metals/ Concrete Soil, & Groundwater	ICP-MS	TBD	No
SW-846-8270	SVOCs by GC/MS	Definitive	SVOCs/Concrete Soil, & Groundwater	GC/MS	TBD	No
SW-846-7470/7471	Cold Vapor Atomic Absorption (AA)	Definitive	Mercury/ Concrete, Soil, & Groundwater	AA	TBD	No
Alpha Spec	Alpha Spectrometry	Definitive	Rads/Concrete Soil, & Groundwater	Alpha Spectrometry	TBD	No
Gamma Spec	Gamma Spectrometry	Definitive	Rads/Concrete Soil, & Groundwater	Gamma Spectrometry	TBD	No
EPA-903.1-M	Alpha-Emitting Radium Isotopes	Definitive	Rads/Concrete Soil, & Groundwater	Lucas Cell	TBD	No

QAPP Worksheet #23. Analytical SOPs (Continued)
(UFP-QAPP Manual Section 3.2.1)
(EPA 2106-G-05 Section 2.3.4)

Analytical SOP References Table (Continued)

Reference Number*	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group/ Matrix	Instrument	Organization Performing Analysis	Modified for Project Work?(Y/N)
EPA-905.0-M	Radioactive Strontium	Definitive	Rads/Concrete Soil, & Groundwater	Radioactive Strontium	TBD	No
Liquid Scintillation	Tc-99 by Liquid Scintillation	Definitive	Rads/Concrete Soil, & Groundwater	Liquid Scintillation	TBD	No
SW-846-8290	Dioxins and Furans by High Resolution Gas Chromatography (HRGC) and High Resolution Mass Spectrometry (HRMS)	Definitive	Dioxins/Concrete Soil	HRGC/HRMS	TBD	No
EPA Method SW-846/9056	Fluoride by TBD	Definitive	Fluoride	Ion Chromatography	TBD	No

*Information will be based on laboratory used. Analysis will be by the most recent revision of that series.

QAPP Worksheet #24. Analytical Instrument Calibration
(UFP-QAPP Manual Section 3.2.2)
(EPA 2106-G-05 Section 2.3.6)

Analytical Instrument Calibration

Laboratories used by the DOE Prime Contractor are participants in DOECAP. In the fall of 2017, DOECAP began implementing accreditation of environmental laboratories through third party organizations. If not in DOECAP, laboratories are audited by contractors for compliance with DOECAP program requirements. As such, laboratory equipment and instruments used for quantitative measurements are calibrated in accordance with the laboratory's formal calibration program as summarized in the SOPs. The laboratory is responsible for maintaining instrument calibration information per its QA Plan, including control charts established for instrumentation.

Whenever possible, the laboratory uses recognized procedures for calibration such as those published by EPA or ASTM. If established procedures are not available, the laboratory develops a calibration procedure based on the type of equipment, stability, characteristics of the equipment, required accuracy, and the effect of operation error on the quantities measured. Whenever possible, physical reference standards associated with periodic calibrations such as weights or certified thermometers with known relationships to nationally recognized standards are used. Where national reference standards are not available, the basis for the reference standard is documented. Equipment or instruments that fail calibration or become inoperable during use are tagged to indicate they are out of calibration. Such instruments or equipment are repaired and successfully recalibrated prior to reuse. High resolution mass spectrometer instruments undergo extensive tuning and calibration prior to running each sample set. The calibrations and ongoing instrument performance parameters are recorded and reported as part of the analytical data package.

Instrument*	Calibration Procedure	Calibration Range	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
*							

*The laboratory is responsible for maintaining instrument calibration information per their QA Plan, including control charts established for instrumentation. This information is audited. This information is audited annually. Additional certifications may be needed based on project-specific requirements (e.g., National Environmental Laboratory Accreditation Program). Field survey/sampling instrumentation will be calibrated according to manufacturer's instructions.

QAPP Worksheet #25. Analytical Instrument and Equipment Maintenance, Testing, and Inspection (UFP-QAPP Manual Section 3.2.3) (EPA 2106-G-05 Section 2.3.6)

Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

The contracted laboratory(s) is a participant in DOECAP. As such, laboratory instrument and equipment maintenance, testing, and inspection are conducted under a certified quality system as documented in the laboratory's quality manual (however named).

QAPP Worksheet #25. Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (Continued)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference*
All	Per laboratory quality manual	QC standards	Per laboratory quality manual	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Section Manager	See Worksheet #23
GC-MS	Replace/clean ion source; clean injector, replace injector liner, replace/clip capillary column, flush/replace tubing on purge and trap; replace trap	QC standards	Ion source, injector liner, column, column flow, purge lines, purge flow, trap	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Section Manager	See Worksheet #23
GC	Electron capture detector (ECD)/flame ionization detector (FID) maintenance; replace/clip capillary column	QC standards	ECD, FID, injector, injector liner, column, column flow	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Section Manager	See Worksheet #23
ICP-AES	Clean plasma torch; clean filters; clean spray and nebulizer chambers; replace pump tubing	Metals	Torch, filters, nebulizer chamber, pump, pump tubing	As needed	Initial and/or continuing calibration criteria must be met	Repeat maintenance activity or remove from service	Laboratory Area Supervisor	See Worksheet #23
ICP-MS	Clean plasma torch; clean filters; clean spray and nebulizer chambers; replace pump tubing	Metals	Torch, filters, nebulizer chamber, pump, pump tubing	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Area Supervisor	See Worksheet #23

QAPP Worksheet #25. Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (Continued)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference*
pH Meter	Clean probe	QC standards	Probe	As needed	The value for each of the certified buffer solutions must be within ± 0.05 pH units of the expected value	Repeat maintenance activity or remove from service	Laboratory Manager	See Worksheet #23
Spectro-photometer	Flush/replace tubing	QC standards	Tubing	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Manager	
TOC Analyzer (NDIRD)	Replace sample tubing, clean sample boat, replace syringe	QC standards	Tubing, sample boat, syringe	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Manager	See Worksheet #23
CVAA	Replace tubing, check instrument lines and connections, check windows in cell, ensure lamp operational	Metals	Instrument lines and connections, windows and lamp	As needed	Must meet initial and/or continuing calibration criteria	Repeat maintenance activity or remove from service	Laboratory Area Supervisor	See Worksheet #23

CVAA = cold vapor atomic absorption
FID = flame ionization detector
GC-MS = gas chromatography-mass spectrometry
GC = gas chromatography
ICP-AES = inductively coupled plasma atomic emission spectroscopy
ICP-MS = inductively coupled plasma mass spectroscopy
NDIRD = nondispersive infrared detector
QC = quality control
TOC = total organic carbon

*The laboratory is responsible for maintaining instrument and equipment maintenance, testing, and inspection information per their QA Plan. Laboratories used by the DOE Prime Contractor are participants in DOECAP. Field survey/sampling instrumentation will be maintained, tested, and inspected according to manufacturer's instructions.

QAPP Worksheet #26 and 27. Sample Handling, Custody, and Disposal
(UFP-QAPP Manual Section 3.3)
(EPA 2106-G-05 Section 2.3.3)

This worksheet is used to document responsibilities for maintaining custody of samples from sample collection through disposal. Examples of forms, sample labels, and chain-of-custody documentation should be included as an attachment to the QAPP. The information in this worksheet table can be referenced to the appropriate SOPs if they are attached to the QAPP.

The Optimized–UFP QAPP guidance provides the following text and table for sample handling, custody, and disposal.

Sampling Organization: TBD

Laboratory: TBD

Method of sample delivery (shipper/carrier): Overnight

Number of day from reporting until sample disposal: Six months (182 days)

Activity	Organization and Title or Position of Person Responsible for the Activity	SOP Reference
Sample labeling	Sampling Teams/DOE Prime Contractor and Subcontractors	CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*; and CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*
Chain-of-custody form completion	Sampling Teams/DOE Prime Contractor and Subcontractors	CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*; and CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*
Packaging	Sampling Teams/DOE Prime Contractor and Subcontractors	CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*; and CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*
Shipping coordination	Sample Management Office/DOE Prime Contractor	CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*; and CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*
Sample receipt, inspection, & log-in	Sample Management/Contracted Laboratory	TBD
Sample custody and storage	Sample Management/Contracted Laboratory	TBD
Sample disposal	Sample Management/Contracted Laboratory	TBD

QAPP Worksheet #28. Analytical Quality Control and Corrective Action
(UFP-QAPP Manual Section 3.4 and Tables 4, 5, and 6)
(EPA 2106-G-05 Section 2.3.5)

The purpose of this worksheet is to ensure that the selected analytical methods are capable of meeting project-specific MPC, which are based on PQOs/DQOs. Complete a separate worksheet for each sampling technique, analytical method/SOP, matrix, and analytical group. If method/SOP QC acceptance criteria do not meet the project-specific MPC, the data obtained may be unusable for making reliable project decisions. In this case, the project team should consider selecting an alternate method or modifying the method. The list of QC samples in this example is incomplete. See Section 2.2 of Part 2B of the UFP-QAPP QA/QC Compendium, the QA Matrix in Section 3.4, and Tables 4, 5, and 6 for further information and guidance on QC samples.

QAPP Worksheet #28. Analytical Quality Control and Corrective Action (Continued)
(UFP-QAPP Manual Section 3.4 and Tables 4, 5, and 6)
(EPA 2106-G-05 Section 2.3.5)

QC Samples Table [Solid (Concrete), soil]

Matrix: Solid (Concrete), soil
Analytical Group/Concentration Level: VOC, Metals, PCBs, Radionuclides, SVOCs, Dioxin, Furan, and Fluoride
Sampling SOP: See Worksheet #21
Analytical Method/SOP Reference: See Worksheet #23
Sampler's Name/Field Sampling Organization: TBD
Analytical Organization: TBD
No. of Sample Locations: 100+

QC Sample	Frequency/Number*	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field blank	Minimum 5%	≤ CRQL**	Verify results; reanalyze	Laboratory should alert project	Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Trip blank	1 per cooler containing VOC samples	≤ CRQL**	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Equipment blank	Minimum 5%	≤ CRQL**	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Spiked field samples (MS/and/or MSD)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy/Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Laboratory spike blanks (LCS)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Contamination—Accuracy/Bias	See procedure CP3-ES-5003, *Quality Assured Data*

QAPP Worksheet #28. QC Samples Table (Continued)

QC Sample	Frequency/Number*	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, 5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples	Laboratory should alert project	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Surrogate Standards	All samples, blanks, and QA samples	See data validation plans CP2-ES-0811, -5105	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Internal standards	All samples, blanks, and QA samples	See data validation plans CP2-ES-5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Field duplicate	Minimum 5%	None	Data reviewer will place qualifiers on samples affected	Project	Homogeneity/ Precision	RPD ≤ 50% soils, RPD < 25% aqueous, Specific RPD defined for each group in Worksheet #12
Laboratory duplicate	Per laboratory procedure	See data validation plans CP2-ES-0026, -0811, 5102, -5103,-5105, -5107	Verify results re-prepare and reanalyze	Laboratory analyst	Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Tracers/Carriers	Each sample tested by a radiochemical separations method	See data validation plan CP2-ES-5102	Check calculations and instrument; reanalyze affected samples	Laboratory analyst	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*

*The number of QC samples is listed on Worksheet #20.
**Unless dictated by project-specific parameters, ≤ CRQL (contract-required quantitation limit).

QAPP Worksheet #28. QC Samples Table (Continued)

QC Samples Table (Groundwater)

Matrix: Groundwater						
Analytical Group/Concentration Level: VOC, Metals, PCBs, Radionuclides, SVOCs, Dioxin, Furan, and Fluoride						
Sampling SOP: See Worksheet #21						
Analytical Method/SOP Reference: See Worksheet #23						
Sampler's Name/Field Sampling Organization: TBD						
Analytical Organization: TBD						
No. of Sample Locations: 100+						
QC Sample	**Frequency/Number***	**Method/SOP QC Acceptance Limits**	**Corrective Action**	**Person(s) Responsible for Corrective Action**	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
Field blank	Minimum 5%	≤ CRQL**	Verify results; reanalyze	Laboratory should alert project	Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Trip blank	1 per cooler containing VOC samples	≤ CRQL**	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Equipment blank	Minimum 5%	≤ CRQL**	Verify results; reanalyze		Contamination—Accuracy/bias	See procedure CP3-ES-5003, *Quality Assured Data*
Spiked field samples (MS/and/or MSD)	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy/Precision	See procedure CP3-ES-5003, *Quality Assured Data*
LCS	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, -5102, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Contamination—Accuracy/Bias	See procedure CP3-ES-5003, *Quality Assured Data*

QAPP Worksheet #28. QC Samples Table (Continued)

QC Sample	Frequency/Number*	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per analytical batch	See data validation plans CP2-ES-0026, -0811, 5102, -5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples	Laboratory should alert project	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Surrogate Standards	All samples, blanks, and QA samples	See data validation plans CP2-ES-0811, -5105	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Internal standards	All samples, blanks, and QA samples	See data validation plans CP2-ES-5103, -5105, -5107	Check calculations and instrument; reanalyze affected samples		Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*
Field duplicate	Minimum 5%	None	Data reviewer will place qualifiers on samples affected	Project	Homogeneity/ Precision	RPD ≤ 50% soils, RPD < 25% aqueous, Specific RPD defined for each group in Worksheet #12
Laboratory duplicate	Per laboratory procedure	See data validation plans CP2-ES-0026, -0811, 5102, -5103,-5105, -5107	Verify results re-prepare and reanalyze	Laboratory analyst	Precision	See procedure CP3-ES-5003, *Quality Assured Data*
Tracers/Carriers	Each sample tested by a radiochemical separations method	See data validation plan CP2-ES-5102	Check calculations and instrument; reanalyze affected samples	Laboratory analyst	Accuracy	See procedure CP3-ES-5003, *Quality Assured Data*

*The number of QC samples is listed on Worksheet #20.
**Unless dictated by project-specific parameters, ≤ CRQL.

QAPP Worksheet #29. Project Documents and Records
(UFP-QAPP Manual Section 3.5.1)
(EPA 2106-G-05 Section 2.2.8)

This worksheet should be used to record information for documents and records that will be generated for the project. It describes how information will be collected, verified, and stored. Its purpose is to support data completeness, data integrity, and ease of retrieval.

The Optimized–UFP QAPP guidance provides the following example tables for project documents and records.

Sample Collection and Field Records			
Record	**Generation**	**Verification**	**Storage location/archival**
Field logbook or sample data forms	Field Team	Field Team Leader	Project File
Chain-of-Custody Forms	Field Team	Field Team Leader	Project File
Air Bills	Contract Laboratory	Contract Laboratory	Project File
Equipment Calibration Forms	Field Team	Field Team Leader	Project File
Deviations	Project Manager	Project Director	Project File
Corrective Action Reports	Project Manager	Project Director	Project File
Correspondence	Project Manager	Project Director	Project File

Project Assessments			
Record	**Generation**	**Verification**	**Storage location/archival**
Data verification checklists	SMO/ Data Validator	SMO	Project File
Data validation report	Data Validator	SMO	Project File
Data usability assessment report	Data Validator	SMO	Project File

Laboratory Records			
Record	**Generation**	**Verification**	**Storage location/archival**
Level IV Laboratory Reports	Laboratory Staff	Laboratory Project Manager	Project File
Electronic Data Deliverables (EDDs)	Laboratory Staff	Laboratory Project Manager	Project File

QAPP Worksheets #31, 32, and 33. Assessments and Corrective Action
(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)
(EPA 2106-G-05 Section 2.4 and 2.5.5)

Planned Project Assessments Table

This worksheet is used to document responsibilities for conducting project assessments, responding to assessment findings and implementing corrective action. Appropriately scheduled assessments allow management to implement corrective action in a timely manner, thereby correcting nonconformances and minimizing their impact on DQOs/PQOs. Assessment checklists should be included in the QAPP or referenced.

Assessments:

Assessment Type	Responsible Party & Organization	Number/Frequency	Estimated Date	Assessment Deliverable	Deliverable Due Date
Off-site Laboratory Technical Systems Audit	Laboratory Manager/Technical Director	Annually	Annually/Ongoing	Internal Audit Repot	Per Individual Laboratory QA Manual

QAPP Worksheets #31, 32, and 33. Assessments and Corrective Action (Continued)
(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)
(EPA 2106-G-05 Section 2.4 and 2.5.5)

Planned Project Assessments Table

Assessment Response and Corrective Action:

Assessment Type	Responsibility for Responding to Assessment Findings	Assessment Response Documentation	Time Frame for Response	Responsibility for Implementing Corrective Action	Responsible for Monitoring Corrective Action Implementation
Off-site Laboratory Technical Systems Audit	Laboratory Manager/Technical Director	Internal Audit Report Deficiency Memorandum	7 days following receipt of proficiency testing deficiency report and before analysis field samples	Laboratory Technical Director	QA Manager/FRNP

QAPP Worksheet #34. Data Verification and Validation Inputs
(UFP-QAPP Manual Section 5.2.1 and Table 9)
(EPA 2106-G-05 Section 2.5.1)

This worksheet is used to list the inputs that will be used during data verification and validation. Inputs include planning documents, field records, and laboratory records. Data verification is a check that specified activities involved in collecting and analyzing samples have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Data validation is the evaluation of conformance to stated requirements, including those in the contract, methods, SOPs, and the QAPP. Examples of records subject to verification and validation are listed below. The actual inputs required should be based on the graded approach, as defined during project planning.

The Optimized—FP QAPP guidance provides the following example table for data verification and validation inputs.

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Planning Documents/Records			
1	Approved QAPP	X	X
2	Contract	X	X
3	Field SOPs	X	X
4	Laboratory SOPs	X	X
Field Records			
5	Field logbooks and/or sample data forms	X	X
6	Equipment calibration records	X	X
7	Chain-of-custody forms	X	X
8	Sampling diagrams/surveys	X	X
9	Relevant correspondence	X	X
10	Change orders/deviations	X	X

QAPP Worksheet #34. Data Verification and Validation Inputs (Continued)
(UFP-QAPP Manual Section 5.2.1 and Table 9)
(EPA 2106-G-05 Section 2.5.1)

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Analytical Data Package			
11	Cover sheet (laboratory identifying information)	X	X
12	Case narrative	X	X
13	Internal laboratory chain-of-custody	X	X
14	Sample receipt records	X	X
15	Sample chronology (i.e., dates and times of receipt, preparation, and analysis)	X	X
16	Communication records	X	X
17	Project-specific proficiency testing sample results	X	X
18	Limit of detection/limit of quantification establishment and verification	X	X
19	Standards traceability	X	X
20	Instrument calibration records	X	X
21	Definition of laboratory qualifiers	X	X
22	Results reporting forms	X	X
23	QC sample results	X	X
24	Corrective action reports	X	X
25	Raw data	X	X
26	EDD	X	X

QAPP Worksheet #35. Data Verification Procedures
(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)

This worksheet documents procedures that will be used to verify project data. It applies to both field and laboratory records. Data verification is a completeness check to confirm that required activities were conducted, specified records are present, and the contents of the records are complete. As illustrated in the following example, verification often is performed at more than one step by more than one person.

Records Reviewed	Requirement Documents	Process Description	Responsible Person/Organization
Field logbook and/or sample data forms	QAPP, field SOPs	Verify that records are present and complete for each day of field activities. Verify that all planned samples including field QC samples were collected and that sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and were reported in accordance with requirements. Verify that any required field monitoring was performed and results are documented.	Field Team Leader/FRNP— SMO/FRNP
Data deliverables, analytes, and holding times	QAPP, contract, and procedures	The documentation from the contractual screening will be included in the data assessment packages, per DOE Prime Contractor procedure CP3-ES-5003, *Quality Assured Data*.	Laboratory PM/Contract Laboratory SMO/FRNP

QAPP Worksheet #35. Data Verification Procedures (Continued)
(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)

Records Reviewed	Requirement Documents	Process Description	Responsible Person/Organization
Chain-of-custody, sample handling, sampling methods and procedures, and field transcription	QAPP, contract, and procedures	These items will be validated during the data assessment process as required by DOE Prime Contractor procedure CP3-ES-5003, *Quality Assured Data*, and CP3-ES-1003, *Developing, Implementing, and Maintaining Data Management Plans*. The documentation of this validation will be included in the data assessment packages.	SMO/FRNP
Analytical methods and procedures, laboratory data qualifiers, and standards	QAPP, contract, and procedures	These items will be reviewed during the data validation process as required by DOE Prime Contractor data validation procedures. Data validation will be performed in parallel with data assessment. The data validation report and data validation qualifiers will be considered when the data assessment process is being finalized.	Data Validation Subcontractor and SMO/FRNP
Audit reports, corrective action reports	QAPP and procedures	Verify that all planned audits were conducted. Examine audit reports. For any deficiencies noted, verify that corrective action was implemented according to plan.	QA Manager/FRNP
Deviations and qualifiers	QAPP and procedures	Any deviations and qualifiers resulting from process will be documented in the data assessment packages.	SMO/FRNP

**QAPP Worksheet #36. Data Validation Procedures
(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)**

This worksheet documents procedures that will be used to validate project data. Data validation is an analyte and sample-specific process for evaluating compliance with contract requirements, methods/SOPs, and MPC. The scope of data validation needs to be defined during project planning because it affects the type and level of documentation required for both field and laboratory activities. If data validation procedures are contained in an SOP or other document, the procedures should be referenced in this table and included as an attachment to the QAPP.

Data Validator: Wastren Advantage, Inc.; Veolia Nuclear Solutions Federal Services

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator [a] (Title and Organizational Affiliation)
Step IIa/IIb	Solid (Concrete), Soil, and Groundwater	All	All	National Functional Guidelines; Worksheets #12, #15, and #28; and CP2-ES-0026, CP2-ES-0811, CP2-ES-5102, CP2-ES-5105, CP2-ES-5103, and CP2-ES-5107	Wastren Advantage, Inc.; Veolia Nuclear Solutions Federal Services

[a] Validation is to be conducted by a qualified individual, independent from sampling, laboratory, project management, or other decision making personnel for the task. This could be an outside party or someone within FRNP who is not involved in the project.

QAPP Worksheet #37. Data Usability Assessment
(UFP-QAPP Manual Section 5.2.3 including Table 12)
(EPA 2106-G-05 Section 2.5.2, 2.5.3, and 2.5.4)

Usability Assessment

The purpose of the project is to obtain concrete cores, surface soil, subsurface soil, and groundwater samples from select areas within the C-400 Complex. The samples collected then will be analyzed for potential contamination. One hundred nine boring locations were selected by the FFA parties from which analytical samples will be collected. The data will be utilized to the extent needed to support characterization of affected concrete, soil, and groundwater in the C-400 Complex Area.

FRNP will determine the adequacy of data based on the results of validation and verification. The usability step involves assessing whether the process execution and resulting data meet project quality objectives documented in this work plan.

Summarize the usability assessment process and procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: Field and analytical data are verified and assessed per procedure CP3-ES-5003, *Quality Assured Data*. Data assessment packages will be created per this procedure. Data assessment packages will include field and analytical data, chains-of-custody, data verification and assessment queries, and other project-specific information needed for personnel to review the package adequately. Data assessment packages will be reviewed to document any issues pertaining to the data and to indicate if DQOs of the project were met. For data selected for validation, the following plans are used: CP2-ES-0026, CP2-ES-0811, CP2-ES-5102, CP2-ES-5103, CP2-ES-5105, and CP2-ES-5107.

Describe the evaluative procedures used to assess overall measurement error associated with the project: Precision, accuracy, representativeness, comparability, completeness, and sensitivity parameters will be evaluated per procedure, CP3-ES-5003, *Quality Assured Data*. This information will be included in the data assessment packages for review by project personnel. Data assessment also will include documentation of QC exceedances, trends, and/or bias in the data set. Data assessment will document any statistics used.

Identify the personnel responsible for performing the usability assessment:

Project Director: James Miller
Project QA Manager: Jennie Freels
C-400 Complex RI/FS PM: Todd Powers
Risk Assessor: LeAnne Garner

Data Validator: Wastren Advantage, Inc.; Veolia Nuclear Solutions Federal Services
Sample Management Office: Lisa Crabtree
Field Team Leader: TBD

QAPP Worksheet #37. Data Usability Assessment (Continued)
(UFP-QAPP Manual Section 5.2.3 including Table 12)
(EPA 2106-G-05 Section 2.5.2, 2.5.3, and 2.5.4)

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies: Data assessment packages will be created, which will include data assessment comments/questions and laboratory comments. Data verification and assessment queries indicating any historical outliers and background exceedances also will be included in the data assessment packages.

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12. DATA MANAGEMENT IMPLEMENTATION PLAN

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 C-400 Complex RI/FS project at the Paducah Site. Data management provides a system for efficiently generating and maintaining technically and legally defensible data that provide the basis for making sound decisions regarding the environmental and waste characterization at the Paducah Site.

Data management for this project is implemented throughout the life cycle for environmental measurements data. This life cycle occurs from the planning of data for environmental and waste characterization, through the collection, review, and actual use of the data for decision-making purposes, to the long-term storage of data.

Data types to be managed for the project include analytical data. Historical data are downloaded from Paducah OREIS, if available. Analytical data are planned and managed through Paducah PEMS and transferred to Paducah OREIS for long-term storage and reporting. Environmental data is transferred from Paducah OREIS to PEGASIS. Gamma walkover and other radiological survey results are stored and reported separately from Paducah PEMS and Paducah OREIS.

To meet current regulatory requirements for DOE environmental management projects, complete documentation of the information flow is established. Each phase of the data management process (planning, collecting, analyzing, managing, verifying, assessing, reporting, consolidating, and archiving) must be appropriately planned and documented. The C-400 Complex RI/FS project team is responsible for data collection and data management for this project.

The scope of this DMIP is limited to environmental information generated under the C-400 Complex RI/FS project. This information includes electronic and/or hard copy records obtained by the project that describe environmental conditions. Both information generated by the project (e.g., laboratory analytical results from samples collected) and information obtained from sources outside the project (historical data) fall 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 PROJECT MISSION

Requirements and responsibilities described in this plan apply to activities conducted by the project team in support of the C-400 Complex RI/FS project. Specific activities involving data include, but are not limited to, sampling of soil, solids (concrete), and groundwater; storing, analyzing, and shipping samples; and evaluation, verification, validation, assessment, and reporting of analytical results.

12.2 DATA MANAGEMENT ACTIVITIES

The following are data management activities for the C-400 Complex RI/FS project.

- Acquire existing data
- Plan data collection
- Prepare for sampling activities
- Collect field data

- Collect field samples
- Submit samples for analysis
- Process field measurement and laboratory analytical data
- Laboratory Contractual Screening
- Verify data
- Validate data
- Assess data
- Consolidate, analyze, and use data and records
- Submit data to the Paducah OREIS

Section 12.7 contains a detailed discussion of the activities listed above.

12.3 DATA MANAGEMENT INTERACTIONS

The SMO oversees the use of Paducah PEMS and ensures that data deliverables meet DOE's standards. The SMO enters information into Paducah PEMS related to the fixed-base laboratory data once the samples have been delivered and the results of analyses have been received. The fixed-base laboratory EDDs are loaded into Paducah PEMS by the SMO. The SMO will perform electronic data verification and coordinate data validation. The C-400 Complex RI/FS project team is responsible for data assessment. The SMO is responsible for preparing the data for transfer from Paducah PEMS to Paducah OREIS.

The SMO develops the SOW to be performed by an analytical laboratory in the form of a project-specific laboratory SOW. Analytical methods, reporting limits, and deliverable requirements are specified in this SOW.

The SMO receives EDDs, performs contractual screenings, distributes data packages, and ensures that electronic-deliverable formats are properly specified and interfaces with the contract laboratory to ensure that the requirements are understood and met.

12.3.1 Data Needs and Sources

Multiple data types will be generated and/or assessed during this project. These data types include analytical data and GIS data.

12.3.2 Historical Data

Historical data that are available electronically have been downloaded from Paducah OREIS, as described in Chapter 5.

12.3.3 Analytical Data

Analytical data for the project consist of laboratory analyses for environmental and waste characterization.

12.3.4 GIS Coverage

The Paducah GIS network is used for preparing maps used in data analysis and reporting of both historical and newly generated data. Coordinates will be recorded as state plane coordinates. The following details the coverage for use during the project.

- Stations (station coordinates are downloaded from Paducah OREIS)
- Facilities
- Plant roads
- Plant fences
- Plant utilities
- Streams
- Topographic contours

12.4 DATA FORMS AND LOGBOOKS

Field logbooks, chain-of-custody forms, data packages with associated QA/QC information, and sample data forms are maintained according to the requirements defined in procedure CP3-RD-0010, *Records Management Process*.

Duplicates of field records are maintained until the completion of the project. Logbooks and field documentation are copied periodically. The originals are forwarded to Records Management, and copies are maintained in the field office.

12.4.1 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 on sample data forms, chain-of-custody forms, or sample labels. This information is entered directly into Paducah PEMS by the SMO.

Sample chain-of-custody forms contain sample-specific information recorded during collection of the sample. Any deviations from the sampling plan are noted on the sample chain-of-custody form or sample data form. The Sampling Team reviews each sample chain-of-custody form for accuracy and completeness as soon as practical following sample collection.

Sample chain-of-custody forms are generated from Paducah PEMS with the following information.

Information that is preprinted:		**Information that is entered manually:**	
13	Laboratory chain-of-custody number	14	Sample date and time
15	Project name or number	16	Sample comments (optional)
17	Sample ID/identification number		
18	Sampling location		
19	Sample type (e.g., REG = regular sample)		
20	Sample matrix (e.g., SO = soil)		
21	Sample preservation type		
22	Analysis (e.g., TCE)		
23	Sample container (volume, type)		

Sample data forms are utilized as an aid for recording sampling information in the field. Logbooks and sample data forms are kept in accordance with CP4-ES-2700, *Logbooks and Data Forms*.

12.4.2 Sample Numbering System

The sample numbering method will be utilized and identified in PEMS. Sample identification numbers are assigned by the C-400 Complex RI/FS project. The sample numbering scheme used for this work plan is 400RISSNNMA### where:

- 400RI Designates the C-400 Complex RI/FS project.
- SS Identifies the sector being investigated.
- NN Identifies the boring number.
- M Identifies the media type ("W" identifies the sample as water, "S" identifies the sample as soil, "C" identifies the sample as concrete).
- A Identifies the sequential sample ("A" for a primary sample and "B" for a secondary sample). If additional rounds of sampling are required, the sequential letter designations will continue.
- ### Identifies the planned depth of the samples in ft bgs.

12.4.3 Lithologic Description Forms

Lithologic description forms will be used as necessary for this project. Lithologic descriptions are entered into the field logbook and later may be added to a lithologic description form or electronic file. An example lithologic description form can be found in CP4-ES-2303, *Borehole Logging*.

12.4.4 Well Construction Detail Forms

Well construction detail forms will be used as necessary for this project. Well construction and installation are entered into the field logbook and later added to a well construction detail form. Copies of the well construction detail forms will be provided to the SMO and GIS organizations in order for the information to be added to Paducah OREIS and PEGASIS. An example of a completed well construction detail form can be found in CP4-ES-0069, *Monitoring Well and Associated Infrastructure Installation*.

12.5 DATA AND DATA RECORDS TRANSMITTALS

12.5.1 Paducah OREIS Data Transmittals

Data to be stored in Paducah OREIS are loaded to Paducah OREIS prior to reporting. Official data reporting will be generated from data stored in Paducah OREIS.

12.5.2 Data Records Transmittals

The C-400 Complex RI/FS Records Custodian will transfer project records to Records Management. The SMO will transfer laboratory data packages and data assessment packages, which include data validation reports, to Records Management.

12.6 DATA MANAGEMENT SYSTEMS

12.6.1 Paducah PEMS

Paducah PEMS is the data management system that supports the project's sampling and measurement collection activities and generates Paducah OREIS RTL files. The SMO accesses Paducah PEMS throughout the life cycle of the project. The SMO uses Paducah PEMS to support the following functions.

- Initiate the project
- Plan for sampling
- Record sample collection and field measurements
- Record the dates of sample shipments to the laboratory
- Receive and process analytical results
- Verify data
- Access and analyze data
- Assess data and enter data validation qualifiers
- Transfer project data (in RTL format) to Paducah OREIS

Paducah PEMS is used to generate sample chain-of-custody forms and sample data forms, import laboratory-generated data, update laboratory data based on data verification, data validation if applicable, data assessment, and transfer of data to Paducah OREIS. Requirements for addressing the day-to-day operations of Paducah PEMS include backups and security.

The Information Technology group performs system backups daily. The security precautions and procedures implemented by the SMO are designed to minimize the vulnerability of the data to unauthorized access or corruption. Only members of the SMO have access to the project's Paducah PEMS and the data files.

12.6.2 Paducah OREIS

Paducah OREIS is the centralized, standardized, quality assured, and configuration-controlled data management system that is the long-term repository of environmental data (measurements and geographic) for Paducah environmental projects. Paducah OREIS is comprised of hardware, commercial software, customized integration software, an environmental measurements database, a geographic database, and associated documentation. The C-400 Complex RI/FS project will use Paducah OREIS for the following functions.

- Access to existing data
- Spatial analysis
- Report generation
- Long-term storage of project data (as applicable)

12.6.3 Paducah Analytical Project Tracking System

The Paducah Analytical Project Tracking System is the business management information system that manages analytical sample analyses for Paducah environmental projects. The Paducah Analytical Project Tracking System provides 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 is automatically transferred to Paducah PEMS).

12.6.4 PEGASIS

The PEGASIS application provides a systematic approach to retrieve, display, and download analytical, geotechnical, and hydrological data, maps, and geophysical information for PPPO sites, regulators, and the public using a web browser. The information includes analytical sample results from various environmental studies, restoration reports and supporting documents, maps, facility drawings, and photography.

PEGASIS is a website that will allow data users to have access to sampling data for hundreds of investigative wells and sampling events, SWMUs, and site-specific GIS features from all of the environmental studies at the site. Analytical data available on PEGASIS are copied from Paducah OREIS periodically.

12.7 DATA MANAGEMENT TASKS

The following data management tasks are numbered and grouped according to the activities summarized in Section 12.2. An explanation of the data review process is provided in the following sections.

12.7.1 Acquire Existing Data

The primary background data for this project consists of historical analytical data from previous sampling events in the C-400 Complex. Paducah OREIS was queried for the existing information that is discussed in Chapter 5.

12.7.2 Plan Data Collection

Other documents for this project provide additional information for the tasks of project environmental data collection, including sampling and analysis planning, QA, waste management, and health and safety. Also, a laboratory SOW will be developed for this project in accordance with CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*.

12.7.3 Prepare for Sampling Activities

The data management tasks involved in sample preparation, as specified in CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*, include identifying all sampling locations, preparing descriptions of these stations, identifying sample containers and preservation, developing sample data forms, preparing sample kits and chains-of-custody forms, and coordinating sample delivery to the laboratory. The SMO conducts activities associated with the analytical laboratories. Coordinates for sample locations will be obtained using a GPS and/or civil survey.

12.7.4 Collect Field Data and Samples

Paducah PEMS is used to identify, track, and monitor each sample and associated data from the point of collection through final data reporting. Project documentation includes sample data forms, chain-of-custody forms, and hard-copy analytical results.

Data management requirements for sample data forms and field forms specify that (1) sampling documentation must be controlled from initial preparation to completion, (2) sampling documentation generated must be maintained in a project file, and (3) modifications to planned activities and deviations from procedures shall be recorded.

Before the start of sampling, the SMO specifies the contents of sample kits, which includes sample containers provided by the laboratories, labels, preservatives, and chain-of-custody forms. Sample labels and chain-of-custody forms are completed according to CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*.

The sampling team will record pertinent sampling information on the chain-of-custody forms and sample data forms. The SMO enters the information from the chain-of-custody forms into Paducah PEMS.

12.7.5 Submit Samples for Analysis

Before the start of field sampling, the sampling team coordinates the delivery of samples with the SMO who, in turn, coordinates with the analytical laboratories, according to CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*. The SMO presents a general sampling schedule to the analytical laboratories. The SMO also coordinates the receipt of samples and containers with the laboratories. The SMO ensures that laboratory data packages and EDDs from the laboratories contain the appropriate information and are in the correct format.

12.7.6 Process Field Measurement and Laboratory Analytical Data

Data packages and EDDs received from the laboratory are tracked, reviewed, and maintained in a secure environment. Paducah PEMS is used for tracking project-generated data. The following information is tracked, as applicable: sample delivery group number, date received, number of samples, sample analyses, receipt of EDD, and comments. The laboratory EDDs are checked as specified in CP4-ES-5007, *Data Management Coordination*.

Gamma walkover survey data is recorded on electronic data loggers incorporated with GPS information. This survey data will include date and time stamps. This data is stored separately from Paducah PEMS.

12.7.7 Laboratory Contractual Screening

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 analytes requested, total number of analyses, method used, EDDs, units, holding times, and reporting limits achieved. Contractual screening is performed for 100% of the data. The SMO is responsible for the contractual screening upon receipt of data from the analytical laboratory according to CP3-ES-5003, *Quality Assured Data.*

12.7.8 Data Verification

Data verification is the process for comparing a data set against a set standard or contractual requirement. Verification is performed by the SMO electronically, manually, or by a combination of both according to CP3-ES-5003, *Quality Assured Data*. Verification is performed for 100% of data. Data verification includes contractual screening and criteria specific to the C-400 Complex RI/FS project. Verification qualifiers may be applied to the data based on holding time exceedance, criteria exceedance, historical exceedance, or background exceedance. Verification qualifiers are stored in Paducah PEMS and transferred with the data to Paducah OREIS.

12.8 DATA VALIDATION AND USABILITY

To ensure the quality of the analytical data, all laboratory data packages will be produced by the laboratory performing the analysis as Level IV (i.e., EPA Stage 4) laboratory data deliverables, to the extent possible. Level IV data deliverables contain all raw data and QC such that data verification and data validation of all sample collection, sample handling, sample preparation, analytical performance, data reduction, and data manipulation (i.e., calculation, weights, and cold leaching) can be performed. Results will receive 100% contract compliance verification.

Initial review of analytical data is performed by the SMO and includes verification that all required deliverables were provided by the laboratory within the required turnaround time.

Data validation will be performed in accordance with DOE Prime Contractor data validation plans.

12.8.1 Data Validation

Data validation is the process performed by a qualified third-party individual. Third-party validation is defined as validation performed by persons independent of sampling, laboratory, and decision making for the program/project (i.e., not the program/PM). Data validation evaluates the laboratory adherence to analytical-method requirements. Data validation is managed and coordinated with the SMO. The Data Validator performs data validation according DOE Prime Contractor data validation plans. Data validation is documented in a formal deliverable from the data validator. Validation qualifiers are input and stored in Paducah PEMS and transferred to Paducah OREIS.

A minimum of 10% percent of the total number of RI/FS samples will be validated for this project. Data validation will apply only to the definitive data.

12.8.2 Data Assessment

Data assessment is the process for assuring 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. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100% to ensure data is useable.

The data assessment is conducted by the C-400 Complex RI/FS project according to CP3-ES-5003, *Quality Assured Data.* Assessment qualifiers are stored in Paducah PEMS and transferred with the data to Paducah OREIS. Any problems found during the review process are resolved and documented in the data assessment package.

12.8.3 Data Consolidation and Usage

The data consolidation process consists of the activities necessary to prepare the evaluated data for the users. The SMO prepares files of the assessed data from Paducah PEMS and transmits them to Paducah OREIS for future use in accordance with CP4-ES-1001, *Transmitting Data to the Paducah Oak Ridge Environmental Information System*. The SMO is responsible for transferring the data to Paducah OREIS. Data used in reports distributed to external agencies are obtained from data in Paducah OREIS and have been through the data review process. All data reported have the approval of the SMO.

12.9 DOCUMENTATION AND RECORDS

12.9.1 Quality Assurance Guidance

The QA program is designed in accordance with CP3-ES-5003, *Quality Assured Data*, and EPA Guidance on Systematic Planning using the DQO Process (EPA/240/B-06/001) (EPA 2006). The following QA records are generated by this characterization sampling event.

- SAP/QAPP
- Field logbooks
- Chain-of-custody forms

- Sample data forms
- Sample data
- Field change from this SAP
- Data validation
- Data assessment packages

12.9.1.1 Field logbook and sample data forms

The sampling team shall maintain sample data forms in accordance with CP4-ES-2700, *Logbooks and Data Forms*. This procedure provides guidelines for the minimum entries to be made on sample data forms to ensure that day-to-day events are documented properly during the preparation, performance, and closure of field sampling activities. Sample data form entries shall be made in a manner that provides a defensible record of the work that has been performed with sufficient data and observations to enable participants to reconstruct events that occurred during work execution. All sample data form entries shall be factual, detailed, and objective.

12.9.1.2 Chain-of-custody

The sampling team shall maintain custody, document transfer, and ship or transfer samples in accordance with CP4-ES-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*. This procedure describes the protocol for documenting possession (i.e., custody, transfer, and shipment) of samples from the point of collection to the point of acceptance by the designated laboratory to ensure integrity of the samples. This procedure includes requirements for generation, use, and completion of chain-of-custody forms.

12.9.1.3 Change control

Deviations from the work plan will be communicated upward through the chain of command to the regulatory agencies using communication tools commensurate with the issue.

12.10 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.

12.10.1 DOE Prime Contractor C-400 Complex RI/FS PM

The PM is responsible for the day-to-day operation of the C-400 Complex RI/FS project. The PM ensures the requirements of policies and procedures are met. The PM or designee assesses data in accordance with CP3-ES-5003, *Quality Assured Data*. The PM is responsible to flow down data management requirements to subcontractors, as required.

12.10.2 DOE Prime Contractor Project Team

The project team consists of the technical staff and support staff (including the SMO) that conducts the various tasks required to successfully complete the project.

12.10.3 Data User

Data users are members of the project team who require access to project information to perform reviews, analyses, or ad hoc queries of the data. The data user determines project data usability by comparing the data against predefined acceptance criteria and assessing that the data are sufficient for the intended use.

12.10.4 DOE Prime Contractor SMO

The SMO enters the data into Paducah PEMS, including chain-of-custody information, data assessment and data validation qualifiers, and any pertinent sampling information. After receiving a notification that a fixed-base laboratory EDD is available to download, the SMO loads the EDD to Paducah PEMS, performs electronic verification of the data, and then compiles the data assessment package. The SMO also prepares data for transfer from Paducah PEMS to Paducah OREIS.

The SMO is responsible for contracting any fixed-base laboratory utilized during the sampling activities. The SMO also provides coordination for sample shipment to the laboratory, ensures contractual screening of data packages, coordinates data validation support, and ensures transmittal of data packages to Records Management.

12.10.5 DOE Prime Contractor Project Records Custodian

The Project Records Custodian is responsible for the long-term storage of project records. The C-400 Complex RI/FS project team will interface with the Project Records Custodian and will transfer documents and records in accordance with DOE requirements.

12.10.6 DOE Prime Contractor 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.

12.10.7 DOE Prime Contractor Environmental Monitoring and SMO Manager

The Environmental Monitoring and SMO Manager is responsible for long-term storage of project data and for transmitting data to external agencies according to the *Data and Documents Management and Quality Assurance Plan for Paducah Environmental Management and Enrichment Facilities*, DOE/OR/07-1595&D2, and the Paducah Data Management Policy. The Environmental Monitoring and SMO Manager ensures compliance with procedures relating to data management with respect to the project and that the requirements of CP3-ES-5003, *Quality Assured Data*, are followed.

13. WASTE MANAGEMENT PLAN

13.1 OVERVIEW

This WMP documents the management and disposition of IDW, decontamination water, and wastewater that will be generated during the C-400 Complex RI/FS. The RI/FS entails the collection of debris (e.g., concrete); soil; and groundwater samples from the C-400 Complex and analysis of those samples. Previous investigations and process knowledge indicate that elevated levels of radiological contamination, PCBs, RCRA hazardous metals, and VOCs may be present at the C-400 Complex location.

This WMP addresses the specific management of wastes generated during the performance of the RI/FS and any treatability studies from generation through final disposition. No treatability studies are planned at this time. All waste generated will also be managed according to the most recent revision of the *Four Rivers Nuclear Partnership, LLC Paducah Deactivation and Remediation Project Waste Management Plan*, CP2-WM-0001.

A copy of the WMP (electronic or hardcopy) will be available on-site during execution of the RI. The Waste Management Coordinator will be responsible for daily oversight of waste management activities and for ensuring compliance with this WMP.

This WMP emphasizes the following objectives:

- Manage the waste(s) in a manner that is protective of human health and the environment.

- Minimize waste generation, as feasible, thereby reducing unnecessary costs (analytical, storage, disposal, etc.).

- Select appropriate of storage and/or disposal methods for generated waste(s).

All waste management activities must comply with this WMP, applicable contractor procedures, and *Waste Acceptance Criteria for the Treatment, Storage and Disposal Facilities at the Paducah U.S. Department of Energy Site*, CP2-WM-0011 (WAC), for on-site treatment, storage, and disposal facilities that may be designated to receive C-400 Complex RI/FS waste. Off-site disposal of CERCLA-generated waste must comply with the CERCLA Off-Site Rule.

During the course of the RI/FS, additional contractor and DOE waste management requirements may be identified. If necessary, revisions will be made to the WMP to ensure project compliance.

13.2 TYPES AND MANAGEMENT OF IDW, SAMPLE RESIDUALS, AND MISCELLANEOUS WASTE

A variety of IDW is expected to be generated during the RI/FS. All waste generated has the potential to contain contaminants related to known or suspected past operational or disposal practices. IDW generated during sampling activities may include materials such as soil, concrete, PPE, plastic, sampling residuals and returns, sampling equipment, field laboratory waste, wastewater, sediment and mud from wastewater treatment, filter media, filter bags/cloths, purge and development wastewater. Waste will be stored at the designated CERCLA waste storage areas during the waste characterization period prior to disposal.

The waste generated from field-related activities of this RI/FS has the potential to contain contaminants related to past operations. Waste that is likely to have either hazardous or radiological contamination typically will be stored on-site in containers within the area of contamination and/or other CERCLA waste storage areas in accordance with CP3-WM-1037, *Generation and Temporary Storage of Waste Materials*, during the characterization period and prior to treatment/disposal.

Brief descriptions of each expected waste stream are outlined in the following sections.

13.2.1 Soil

Soil samples will be obtained from the C-400 Complex area. Each sample's waste material must be segregated exclusive from other waste to facilitate waste characterization at the conclusion of field activities. Soil will be containerized in appropriate containers.

PPE will be worn by appropriate project personnel as specified in the HASP and will be characterized concurrently with contacting waste materials. Plastic sheeting, other plastic used during sampling activities, associated debris, and PPE also can be included in this waste stream. To facilitate waste characterization, this debris and PPE waste must be segregated and labeled.

13.2.2 Sampling Equipment, Sample Residuals

Sampling residuals will be generated from sampling activities. Sample returns, sample containers, and disposable sampling equipment will be containerized or be added to the original waste that was sampled and characterized by associated analytical results and/or process knowledge. Each waste steam will be segregated, labeled, and stored in an approved container.

13.2.3 Decontamination Water, Solvents, and Contaminated Environmental Media

Decontamination water, solvents, contaminated environmental media, or other similar materials may be generated during drilling/sampling equipment decontamination. The decontamination water will be containerized and stored at on-site storage facilities. The water will be characterized by associated analytical results and/or process knowledge and treated, if necessary, to meet discharge limits before it is discharged through an existing KPDES Outfall or a CERCLA outfall or managed at an off-site wastewater treatment facility, if needed. Each waste steam will be segregated and will be labeled and stored in an approved container.

13.2.4 Wastewater

Wastewater may be generated by excess sample residues, well development activities, purge water, drilling activities, or decontamination of equipment. The wastewater will be containerized and stored at on-site storage facilities. The water will be sampled and, if necessary, treated (e.g., C-612 Treatment Facility) before it is discharged through an existing KPDES Outfall or a CERCLA outfall or managed at an off-site wastewater treatment facility, if needed.

13.2.5 Waste Generation Estimate

Table 13.1 contains a rough order of magnitude (ROM) estimate of the quantity of waste expected to be generated during the performance of the RI/FS. The wastes are subdivided into expected waste types.

Table 13.1. Estimate of Waste Generation for C-400 Complex RI/FS Project

Spoils (Soil)

Quantity	Boring Type	Depth, ft	In place Volume, ft^3	Volume with Swell Factor (1.3 x ft^3)
77	HU4 SB	65	1,882	2,446
18	McNairy SB	120	812	1,056
17	McNairy SB	145	927	1,205
2	Geotechnical	65	49	64
6	Geotechnical	120	271	352
2	Geotechnical	145	109	142
2	MIP/DyeLIF Analytical	120	90	117
50	MIP/DyeLIF	100	1,880	2,444
1	TBD McNairy Location	145	55	71
7	RGA MWs	95	419	545
5	RGA MWs	85	268	348
6	RGA MWs	75	284	369
Estimated Total Spoils, ft^3			7,044	9158
Estimated Total Spoils, yd^3			261	339

Monitoring Well Development/Purge Water

Quantity 4-inch MWs	IDW Source	Boring Type	Depth, ft	Estimated Volume of Development Water per well (gal)	Estimated Cumulative Volume of Development/Purge Water (gal)
18	Purge Water	U/M/L RGA	75-100	2,775	49,950

Monitoring Well Drilling Produced Water

Quantity 4-inch MWs	IDW source	Boring Type	Depth, ft	Estimated Volume of Development Water per well (gal)	Estimated Cumulative Volume of Development/Purge Water (gal)
18	Drilling Water	U/M/L RGA	75-100	750	13,500

Soil Boring Produced Water

Quantity Soil Borings	IDW Source	Boring Type	Depth, ft	Produced H2O Average Volume Per NE Plume PZ Wells, Gal/Well	Estimated Cumulative Volume of Purge Water (gal)
77	Drilling Water	HU4	65	358	27,528
18	Drilling Water	McNairy	120	660	11,880
18	Drilling Water	HU4	145	798	14,355

Table 13.1. Estimate of Waste Generation for C-400 Complex OU RI/FS Project (Continued)

Soil Boring Purge Water

Quantity Soil Boring Grab GW Samples	IDW Source	Boring Type	Depth, ft	Estimated Purge Water, gal/sample	Estimated Cumulative Volume of purge water (gal)
128 Samples	Purge Water	McNairy	95/145	500	64,000

Drilling Equipment Decon Water

Quantity Boring Locations	IDW Source	Estimated Decon Water, gal/location	Estimated Cumulative Volume decon water (gal)
113*	DeconWater	100	11,300

* Includes 1 McNairy TBD location

Other solid waste, including sediment from dewatering (Geobags), decontamination facility sump material, PPE, excess top soil from well pad install, and other miscellaneous sources, is estimated at approximately 200 yd^3 of solids, as shown in Table 13.2.

Table 13.2. RI/FS Project Estimated Solid Waste

Total estimated spoils (see Table 13.1):	339 yd^3
Other solids (e.g., dewatering):	200 yd^3

Total project waste estimates are shown in Table 13.3.

Table 13.3. RI/FS Project Waste Estimated Totals

Solids:	539 yd^3
Liquids:	192,513 gal (water)

13.3 MANAGEMENT OF WASTE

RI/FS activities may result in generation of the following waste:

- RCRA solid waste or hazardous waste (e.g., hazardous debris containing lead paint, metals considered RCRA Toxicity Characteristic waste, and/or RCRA Listed Wastes F001/F002/U228),
- Low-level radioactive waste,
- Mixed waste,
- Asbestos-containing waste materials, and
- TSCA waste, as amended (PCB bulk-product waste and/or PCB remediation waste).

Although some characterization of materials located in the C-400 Complex area has been performed in the past, additional waste streams may be identified during implementation of this RI/FS. PCB remediation waste, as defined in 40 *CFR* § 761.3, contains PCBs as a result of a spill, release, or other unauthorized disposal of PCBs. It includes rags and other debris generated as a result of any PCB-spill cleanup in buildings and other man-made structures that are contaminated from leaking PCBs or PCB-contaminated transformers. PCB remediation waste also includes PCB-contaminated nonporous surfaces such as smooth glass, unpainted marble, granite, or porous surfaces such as fiberglass, painted stone, and corroded metal.

All primary wastes (e.g., soil, sediment, sludge, removed waste materials) and secondary wastes (e.g., contaminated PPE, decontamination wastes) generated during the RI/FS will serve as the point of generation and be characterized appropriately as RCRA (solid or hazardous waste), asbestos, TSCA, low-level waste (LLW), and/or mixed wastes and managed accordingly. In many cases, debris generated from RI/FS activities can result in heterogeneous waste streams. Characterization activities will focus on determining the overall average properties of the waste streams using both representative sampling and process/generator knowledge in accordance with state and federal regulations and approaches described in EPA preamble discussions contained in 57 *FR* 990 (Preamble to the Proposed Rule—Treatment Standards for Contaminated Debris, January 9, 1992). Any RCRA hazardous debris must be treated to meet Land Disposal Restrictions (LDR) treatment standards for hazardous debris at 40 *CFR* § 268.45 prior to disposal in an approved landfill unless the debris has been determined no longer to be contaminated with hazardous waste.

13.3.1 Contained-In/Contaminated-With Determinations

Based on process knowledge of past operations at the C-400 Cleaning Building and review of existing historic sampling data, waste streams (e.g., environmental media and debris contaminated by environmental media) generated during RI/FS activities may be contaminated with listed hazardous waste [i.e., TCE, 1,1,1-trichloroethane (1,1,1-TCA)]. If either TCE and/or 1,1,1-TCA is determined to be present based on detectable concentrations of TCE and/or 1,1,1-TCA, the waste stream in question shall be managed as a RCRA hazardous waste per the contained-in policy until such time the waste stream is determined no longer to contain the listed hazardous waste. Contaminated debris and environmental media is no longer considered to contain hazardous waste when (1) they no longer exhibit a characteristic of hazardous waste, and (2) concentrations of the listed hazardous constituents are below health-based levels. Sampling, process knowledge, or a combination of both may be used to make such determinations, Kentucky Division of Waste Management (KDWM) and EPA Region 4 previously have approved site-specific, health-based levels for making no longer contained-in/contaminated-with determinations for environmental media and debris at the Paducah Site, with respect to TCE and 1,1,1-TCA. The health-based levels originally were approved by KDWM in the 2003 Agreed Order. The health-based levels originally were approved by EPA in correspondence dated March 5, 2009, and May 19, 2009, and the *Remedial Action Work Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0004&D2/R2/A1 (DOE 2010). The approved health-based levels for TCE and 1,1,1-TCA are shown in Table 13.4.

Table 13.4. Approved Health-Based Contaminant Levels for Solids and Aqueous Liquids

Listed Constituent	Solids	Aqueous Liquids
TCE	39.2 ppm	0.081 ppm
1,1,1-TCA	2,080 ppm	Not Applicable*

*Aqueous solutions that meet the health-based level for TCE also shall be deemed no longer to contain 1,1,1-TCA.

DOE shall be responsible for comparing characterization data and/or using process knowledge for the environmental media/debris streams suspected as being contaminated with TCE and/or 1,1,1-TCA to the approved health-based levels. If, based on DOE's comparison, the total detectable concentrations of TCE and/or 1,1,1-TCA are below the approved health-based levels, the waste stream will be deemed as not to contain or be contaminated-with a listed hazardous waste.

13.4 WASTE MANAGEMENT TRACKING RESPONSIBILITIES

Waste generated during the RI/FS sampling activities will require implementation of a comprehensive waste tracking system to maintain waste inventory. The tracking system will document waste container numbers and locations; waste description; generation date; sampling, treatment and disposal date; and disposal location. The Technical Services Organization includes the Waste Generator Services Group, Waste Transportation Group, and Waste Operations Group. The Waste Generator Services Group will maintain the tracking system and will maintain a waste inventory system such that all waste generated during the RI/FS is tracked properly and identified. To prevent inappropriate disposal of waste, generation data and information necessary to determine the amount of contamination present will be documented so that proper disposal methods can be implemented. Determination of the ultimate disposal method is the responsibility of the Waste Transportation Group and the C-400 Complex OU RI/FS PM. The following are additional responsibilities of the Waste Generator Services Group.

- Ensure that waste storage areas are properly established, maintained, and closed in accordance with state and federal regulations.

- Track and update waste inventory database and reports.

- Support project waste personnel in the selection of containers and in the segregation of wastes.

- Provide Authorization Basis approval for movement and storage of waste containers to appropriate on-site storage facilities as needed.

- Maintain waste container inventories.

- Coordinate with off-site disposal facilities on waste acceptance and disposal pricing and disposition.

The following information is included in the waste inventory database.

- Generation date
- Request for disposal (RFD) number
- Origin location
- Waste type
- Description
- Quantity
- Storage location

Examples of additional support personnel who fall under the Technical Services Director (key personnel identified in Section 2.1) and who may support the project are included below.

13.4.1 DOE Prime Contractor Project Waste Management Coordinator

The Project's Frontline Supervisor, Field Team Leader, or designee will assume responsibility of Project Waste Management Coordinator (PWMC) to ensure that all waste management activities comply with contractor procedures, contractor requirements, and the WMP, as appropriate. Responsibilities of the PWMC include coordination of activities with field personnel, oversight of waste management operations, and maintenance of the waste management logbook that contains a complete history of generated waste and the current status of individual waste containers.

Additional responsibilities of the PWMC include the following:

- Generation and containerization of all project waste;
- Ensuring adequate containers are available at worksite by coordinating with Waste Operation group;
- Maintaining an adequate supply of labels;
- Interfacing with Waste Transportation and Waste Operations Groups for necessary support;
- Preparing RFDs;
- Preparing Waste Item Container Log (WICL) for each waste container;
- Ensuring waste containers are properly labeled;
- Requesting Authorization Basis approval for movement of waste containers to on-site storage facilities;
- Coordinating waste transfers from field; and
- Providing field support for sampling of waste containers to characterize wastes.

13.4.2 DOE Prime Contractor Transportation Group and Waste Operations Group

The Waste Transportation Group and Waste Operations 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 CP3-QA-2500, *Procurement, Inspection, and Management of Items Critical for Paducah Off-Site Waste Shipments*. Additionally, the PWMC will ensure that wastes expected to be disposed of at the C-746-U Landfill are packaged and managed according to the WAC.

Additional responsibilities of the Waste Transportation Group and Waste Operations Group include the following by individual group.

13.4.3 Waste Transportation Group

- Interface with necessary personnel.
- Provide subject matter experts to support project field activities when needed.
- Characterize and document project waste.
- Provide technical support associated with waste handling and segregation to project personnel.
- Prepare Sample Analysis Event Plans for the sampling of waste containers.

- Manifest off-site shipments of waste.
- Verify container packaging and labeling are DOT compliant.
- Verify shipment is compliant with DOT and DOE Orders and or regulations.

13.4.4 Waste Operations Group

- Provide containers as requested to project location.
- Pick up and move waste containers to approved storage facility.
- Pick up and transport waste containers as needed for on-site movement.
- Assist project in waste handling as required.

13.5 IDW WASTE REQUEST FOR DISPOSAL, STORAGE, AND LABELING

13.5.1 Request for Disposal

All waste will be documented using Forms CP2-WM-0011 F02, *Request for Disposal*, and CP2-WM-0011 F03, *Request for Disposal RCRA Regulatory Codes-Attachment B* (if applicable), in accordance with the WAC.

The PWMC is responsible for initiating an RFD, identifying, and documenting the type and quantity of waste that will be generated.

Waste Transportation Group Waste Engineer(s) is responsible for reviewing and approving the waste stream prior to generating waste. In addition, the Waste Engineer(s) will determine the anticipated path to disposal of the waste, the on-site storage facility, and provide guidance in selecting a container.

After Waste Engineer approval, PWMC is responsible for processing RFD documentation to the Waste Generator Services Group for processing.

The Waste Generator Services Group will enter the RFD into the Waste Tracking System.

13.5.2 Waste Identification Container Log

The PWMC will document each container of waste on Form CP3-WM-3015 F01, *Waste Item Container Log*. The PWMC completes the form, filling in all information including, but not limited to, RFD number, description, volume, container type, container number.

After container is filled, the PWMC is responsible for processing WICL documentation to the Waste Generator Services Group for processing.

The Waste Generator Services Group will enter the container into the Waste Tracking System.

13.5.3 Labeling

The PWMC is responsible for labeling each container in accordance with the WAC and CP3-WM-3015, *Waste Packaging*.

13.5.4 Storage

Containers will be stored in an appropriate storage area set up by Waste Generator Services Group in accordance with CP3-WM-1037.

Waste also may be stored within the area of contamination.

13.6 TRANSPORTATION AND STORAGE OF IDW

13.6.1 Transportation of IDW

Any remediation waste transferred off-site or transported in commerce along public rights-of-way must be conducted in compliance with all applicable laws and regulations. These transportation requirements include provisions for proper packaging, labeling, marking, manifesting, recordkeeping, and placarding that must be complied with fully for shipment. In addition, CERCLA Section 121(d)(3) provides that the off-site transfer of any hazardous substance, pollutant, or contaminant generated during CERCLA response actions be sent to a treatment, storage, or disposal facility that complies with applicable federal and state laws and has been approved by EPA for acceptance of CERCLA waste (see the CERCLA "Off-Site Rule" at 40 *CFR* § 300.440 *et seq*.).

13.6.2 Storage of IDW

The WMES Waste Generator Services Group will establish and maintain an appropriate waste storage area for the RI/FS in accordance with contractor procedure CP3-WM-1037.

13.6.3 Required Equipment

Equipment that will be used to move or handle IDW must be inspected following procedure CP3-SM-0020, *Administrative Controls for Powered Industrial Trucks*. Equipment that does not pass this inspection will be tagged out-of-service until corrective actions have been completed and the equipment reinspected. Transportation of waste will require the use of forklift trucks, flatbed trailers, and flatbed trucks. A drum grabber will be mounted on the forklift to place drums onto pallets for transport.

13.6.4 Containerization and Transportation of Solid IDW

Solid waste must be containerized in DOE-approved containers for waste. Absorbent material will be added to the wastes; the quantity depends on potential free liquids and will be established by the Waste Transportation Group Waste Engineer and added under the supervision of the PWMC prior to transporting waste material to a treatment, storage, or disposal facility in accordance with CP3-WM-3015, *Waste Packaging*, and applicable state and federal regulations for waste going off-site.

13.6.5 Containerization and Transportation of Liquid IDW

Liquid waste must be containerized in DOE-approved containers in accordance with CP3-WM-3015, *Waste Packaging*, and applicable state and federal regulations for waste going off-site.

13.7 SCREENING OF ANALYTICAL SAMPLES

In situ screenings of analytical samples are performed by RADCON personnel for radiation and radioactive contamination. Additional screenings are performed prior to samples being shipped off-site.

Prior to shipping samples, analytical samples are surveyed in accordance with CP3-WM-3028, *Off-site Shipping*. Survey procedures CP3-RP-1109, *Radiation Contamination Control and Monitoring*; CP3-RP-1108, *Posting and Labeling*; and CP4-RP-1110, *Radiation Surveys*, are used to perform the various radiation and contamination surveys required.

13.8 IDW CHARACTERIZATION, SAMPLING, AND ANALYSIS

13.8.1 IDW Characterization

Sampling and analysis of all RI/FS waste shall comply with this Work Plan and the WAC. Because all waste will be segregated according to boring number, the waste will be characterized according to analytical results of the environmental samples. The potential COCs for this RI/FS include radionuclides, PCBs, PAHs, VOCs, and metals. PPE will be characterized based on analytical results of the samples from the boring in which it was used. Since most PPE such as Tyvek coveralls, tape, inner gloves, booties, etc. will be used throughout the entire borehole, the most stringent waste classification based on analytical results will be applied to all PPE from a given borehole.

For solid waste, the "20 times" rule may be used to determine if the waste is characteristically hazardous. If the total concentration of RCRA constituents is greater than 20 times the toxicity characteristic leachate procedure (TCLP) limits in 40 *CFR* § 261.24, then the waste will be considered characteristically hazardous and placed into RCRA storage until further TCLP analysis can be performed for complete analysis.

Characterization requirements and guidance are provided in the site WAC, CP3-WM-0437, *Waste Characterization and Profiling*, and CP3-WM-1037, *Generation and Temporary Storage of Waste Materials.* Tables 13.5 through 13.8 list the analytical testing methods that will be used for analysis. The Waste Transportation Group will coordinate with the C-400 Complex OU RI/FS PM and SMO for required analyses and guidance on collection and transfer of characterization samples to a fixed-base laboratory that participates in DOECAP.

13.8.2 Waste Sampling and Analysis Plan

Wastes generated from sites designated as potentially contaminated will be characterized to classify the waste for proper handling, recordkeeping, transfer, storage, and disposal. Waste analyses will be performed using EPA-approved procedures, as applicable. Analyses required for hazardous waste classification will reference EPA SW-846 or other EPA-approved methods. QA/QC requirements and data management requirements, as specified in Chapter 11 of this document, will be followed for waste characterization sampling activities.

Table 13.5. TCLP Parameters for Analysis of Solid Waste

Constituent	Method	TCLP Regulatory Limit (mg/L)	20 Times TCLP Regulatory Limit (mg/kg)
1,1-Dichloroethene	8260	0.7	14
1,2-Dichloroethane	8260	0.5	10
Arsenic	6010/6020	5.0	100
Barium	6010/6020	100.0	2,000
Benzene	8260	0.5	10
Cadmium	6010/6020	1.0	20
Carbon tetrachloride	8260	0.5	10
Chlordane	8081	0.03	0.6
Chlorobenzene	8260	100.0	2,000
Chloroform	8260	6.0	120
Chromium	6010/6020	5.0	100
Lead	6010/6020	5.0	100
Mercury	7470	0.2	4
Methyl ethyl ketone	8260	200.0	4,000
Selenium	6010/6020	1.0	20
Silver	6010/6020	5.0	100
Tetrachloroethene	8260	0.7	14
Trichloroethene	8260	0.5	10
Vinyl chloride	8260	0.2	4

Table 13.6. Analytical Parameters for Radiological and PCB Characterization

Constituent	Method
Total Uranium	Mass Spec
Uranium-234	Mass Spec
Uranium-235	Mass Spec
Uranium-238	Mass Spec
Americium-241	Alpha Spec
Neptunium-237	Alpha Spec
Plutonium-239/240	Alpha Spec
Plutonium-238	Alpha Spec
Thorium-228/232	Alpha Spec
Thorium-230	Alpha Spec
Technetium-99	Liquid Scintillation
Cesium-137	Gamma Spec
PCB	8082

Table 13.7. Waste Characterization Requirements for Solid Waste

Constituent	Method
TCLP VOCs	SW-846 1311, 8260
TCLP metals	SW-846 1311, 6010/6020/7470
Acetone	8260
Toluene	8260

Table 13.8. Waste Characterization Requirements for Decontamination, Development, and Purge Water

Parameter	Method	Detection Limit
TCE	EPA 624.1	0.001 mg/L
1,1,1-TCA	EPA 624.1	0.001 mg/L
PCBs	EPA 608.3	varies by Aroclor
Total recoverable metals*	EPA 200.8/245.2	varies by metal
Total suspended solids	EPA 160.2	30 mg/L

*Total recoverable metals: antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, nickel, calcium, silver, tantalum, uranium, zinc, and mercury.

13.8.2.1 Waste Classification

Waste characterization sampling will be performed in accordance with procedure CP3-WM-0437, *Waste Characterization and Profiling*. 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)
- LLW
- Mixed waste or
- Nonhazardous solid waste

13.8.2.1.1 RCRA-listed hazardous waste

Based on process knowledge and existing historical sample data, generation of RCRA-listed hazardous waste is expected on this project due to the presence of TCE and/or 1,1,1-TCA. Environmental releases of listed waste sources from C-400 have resulted in contamination of environmental media and debris, including subsurface soils and groundwater. Waste generated from soil borings and well installations (i.e., drilling cuttings, purge water, sample residuals) with detectable TCE and/or 1,1,1-TCA will be classified as RCRA-listed hazardous wastes with waste codes F001, F002, and U228, if the boring locations are inside the industrial facility or from the RGA and if analytical results for the associated soil samples and water samples are above the health-based levels discussed in Table 13.4. If the concentrations are below the levels contained in Table 13.4, then the waste will be deemed not to contain or not to be contaminated-with a RCRA listed waste (based on TCE/TCA content). If the WAC is met, the waste will be disposed of properly in the C-746-U Landfill.

Aqueous liquids that have undergone wastewater treatment and meet the health-based levels listed in Table 13.4 shall be considered no longer to contain listed hazardous waste (i.e., TCE). This aqueous liquid that meets the surface discharge limits may be discharged directly to permitted KPDES Outfall 001 or on-site ditches that flow to permitted KPDES Outfall 001 or CERCLA outfall.

13.8.2.1.2 RCRA-characteristic hazardous waste

Based on process knowledge and existing historical sample data, generation of RCRA characteristic-hazardous waste is possible during this action.

13.8.2.1.3 PCB waste

Based on process knowledge and existing historical sample data, generation of PCB-contaminated waste is possible on this project.

13.8.2.1.4 TRU waste

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. If TRU waste is generated in performing this work, the waste will be managed in accordance with DOE Prime Contractor procedures.

13.8.2.1.5 Low-level waste

LLWs are described as any nonhazardous, non-PCB, or non-TRU waste that contains radioactivity or other radionuclides in a concentration greater than authorized limits or the latest off-site release criteria and are not classified as high-level waste.

13.8.2.1.6 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.

13.8.2.1.7 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. Nonhazardous solid waste will be generated as part of this project. The types of materials expected to be nonhazardous solid wastes are construction debris, waste concrete, grout, shipping materials, and containers (e.g., boxes, bags).

Wastes generated from sites designated as potentially contaminated will be characterized to classify the waste for proper handling, recordkeeping, 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 or other EPA-approved methods. QA/QC requirements and data management requirements will be followed for waste characterization sampling activities. Characterization requirements and guidance are provided in the site WAC and CP3-WM-0437, *Waste Characterization and Profiling*. The Waste Transportation Group will coordinate with the C-400 Complex RI/FS PM and SMO for required analyses and guidance on collection and transfer of characterization samples to a fixed-base laboratory that participates in DOECAP.

13.8.2.2 Sampling IDW

13.8.2.2.1 RI/FS Sampling Team

The RI/FS sampling team must coordinate closely with the PWMC concerning daily sampling locations. The PWMC will contact the Waste Operations Manager or designee and have waste containers delivered to the sampling location.

13.8.2.2.2 Waste Sampling Operations

When necessary, the PWMC will be responsible for interfacing with the RI/FS sampling team to schedule characterization sampling of waste for on-site disposal. The sampling team will complete all chain-of-custody forms, and the sampling team is responsible for packaging and submitting samples to the contracted laboratory.

13.8.2.2.3 IDW Segregation

To facilitate waste characterization at the conclusion of field activities, each PPE and sample waste will be segregated by borehole number until analytical results are obtained or process knowledge is available. Using the analytical results and/or process knowledge, the appropriate waste classification will be applied to all PPE and waste soil from a given borehole. As feasible, soil waste and PPE will be segregated and bagged to facilitate storage of the materials while awaiting final disposition. Each bag of waste will be labeled with the key information such as boring number, date, potentially applicable sample numbers, etc. PPE and plastic also will be placed in an appropriate container.

13.8.2.2.4 Container Labeling and Identification

Each waste stream (soil, PPE and plastic, sample residuals, etc.) will be tracked and labeled with the RFD (form CP2-WM-0011 F02, “Request for Disposal”) system. All containers of a single waste stream will be tracked under the same RFD number and each container’s contents represented on a WICL (form CP3-WM-3015 F01). Containers will be labeled per the WAC.

13.9 EFFECTS OF LDRS

A combination of other regulatory methods will be used to provide for efficient and cost-effective management of generated waste, such as application of the area of contamination policy, corrective action management units, and temporary units. RCRA wastes may be managed in accordance with EPA’s area of contamination policy dated March 13, 1996, where appropriate, when consolidating wastes and/or contaminated soils within a delineated AOC. RI/FS waste that is RCRA hazardous wastes and removed from the AOC must comply with applicable LDR treatment standards prior to land disposal in an approved landfill unless the remediation waste has been determined no-longer to contain or be contaminated-with a hazardous waste.

14. COMMUNITY RELATIONS PLAN

Community relations and communication requirements for the C-400 Complex RI/FS are described in the *Community Relations Plan under the Federal Facility Agreement at the U.S. Department of Energy, Paducah Gaseous Diffusion Plant* (CRP) and any subsequent updates of the Community Relations Plan (DOE 2018d). Community relations and public participation will evolve throughout performance of the project; however, this section summarizes the currently planned activities.

The C-400 Complex RI/FS project will address all sources of contamination the C-400 Cleaning Building and adjacent area included within the C-400 Complex boundary. The following are the CERCLA public involvement activities planned (Table 14.1).

Table 14.1. Public Involvement for the C-400 Complex OU Investigation and Remediation

CERCLA Process Steps	Public Involvement Activity
Upon commencement of RI/FS phase	• Publish a notice of availability of the Administrative Record file in a major local newspaper of general circulation (e.g., *The Paducah Sun*)
Final Proposed Plan	• Publish a notice of availability of the final Proposed Plan, including a brief summary, in a major local newspaper of general circulation (e.g., *The Paducah Sun)* • Notice announces a comment period (e.g., 45 days) • Host a public meeting, if requested
Signed ROD (including comment responsiveness summary) prior to the commencement of the Remedial Action	• Announce the availability of the signed ROD in a major local newspaper of general circulation (e.g., *The Paducah Sun*) • Place the final ROD in the EIC for public inspection • Include a written summary of significant comments and any significant new data submitted during the comment period and DOE's response to such comments and data.

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APPENDIX A

ARARs

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
EPA	U.S. Environmental Protection Agency
Fed. Reg.	Federal Register
FS	feasibility study
RI	remedial investigation
TBC	To Be Considered

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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 requirements (ARARs) to the hazardous substances or circumstances at a site (unless the ARAR is waived).

This appendix supplies the approach for evaluation and identification of available federal and state chemical-, location-, and action-specific-ARARs that may be associated with potential remedial actions at the C-400 Complex at the Paducah Gaseous Diffusion Plant. 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 will be identified are subject to change as site-specific contamination at the C-400 Complex is characterized further and alternatives are developed and evaluated further. Site-specific ARARs will be identified further during the remedial action development in the RI/FS. The final ARARS will be included with any record of decision developed for the C-400 Complex.

The U.S. Environmental Protection Agency (EPA) differentiates ARARs as either "applicable" or "relevant and appropriate" to a site. The following are the terms and conditions of these categories.

- *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).

EPA also categorizes ARARs based on whether they are specific to the chemical(s) presenting risk at the site (chemical-specific), the remedial action being evaluated (action-specific), or the location of the site (location-specific). 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 fit definitively into any one category. The following terms and conditions relevant to this categorization are included in the list.

- *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 provide health- or risk-based concentration limits or discharge limitations in environmental media (i.e., surface water, groundwater, soil, or air) for specific hazardous substances, pollutants, or contaminants. Action-specific ARARs include, for example, performance and design standards. Location-specific ARARs include, for example, regulations covering preservation of historic sites and protection of wetlands and floodplains. However, wetlands and floodplains are not located in the vicinity of the C-400 Cleaning Building.

Pursuant to CERCLA § 121(e) [42 U.S.C.A. § 9621(e)(1)], response actions, or portions of response actions entirely on-site, 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 but unpromulgated information that does not 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 required in developing CERCLA remedies. Because ARARs do not exist for every chemical or circumstance that may be found at a CERCLA site, 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 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.

EPA requires compliance with Occupational Safety and Health Association standards through § 300.150 of the National Oil and Hazardous Substances Pollution Contingency Plan, 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.

As mentioned above, ARARs identification is an iterative process that changes continually as the RI/FS progresses. Based on the remedial action ultimately selected, ARARs specific to that action will be identified later in the remedial action process and ultimately documented in the record of decision.

A.2 REFERENCES

DOE (U.S. Department of Energy) 1994. *Secretarial Policy Statement on the National Environmental Policy Act*, U.S. Department of Energy, Washington, DC, June 13.

DOE 2001. *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1857&D2, U.S. Department of Energy, Paducah, KY, August.

EPA (U.S. 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.

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APPENDIX B

HISTORICAL DATA

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Appendix B Historical Data (CD)

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APPENDIX C

GAMMA WALKOVER SURVEY PLAN FOR C-400 COMPLEX SECTORS

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CONTENTS

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TABLE

FIGURES

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ACRONYMS

cpm	counts per minute
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GWS	gamma walkover survey
KDEP	Kentucky Department for Environmental Protection
KRCEE	Kentucky Research Consortium for Energy and Environment
OU	operable unit
QC	quality control
PM	project manager
RI	remedial investigation

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C.1. INTRODUCTION AND PURPOSE

The *Remedial Investigation/Feasibility Study Work Plan for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* was developed to define investigation field sampling to support the C-400 Complex final remedial action. The Field Sampling Plan for this investigation, which includes radiological gamma walkover surveys (GWSs), can be found in Section 9 of this Work Plan. This survey plan describes how GWSs will be performed. This survey plan is consistent with the Soils Operable Unit (OU) remedial investigation (RI) survey plan (DOE 2014).

The purpose of this survey plan is to define the highest count rate area/location within a sector and sample the area/location with the highest count rate. These biased samples will be collected using the same methods described in Section 9, Field Sampling Plan and Section 11, Quality Assurance Project Plan of this Work Plan for other samples of the same matrix type. Walkover surveys of accessible areas will be performed for Sectors 2–7 using a Field Instrument for the Detection of Low Energy Radiation (FIDLER) or similar instrument coupled with a Global Positioning System (GPS) device. Examples of areas that are not accessible include structures that remain following deactivation activities (e.g., C-403 Neutralization Pit) and areas close to the C-400 Building structure that impact GPS surveying, etc. In order to facilitate evaluation of the C-400 Complex, the area has been divided into seven sectors. Table C.1 presents the sectors included for GWS under this Work Plan. The seven sectors that comprise the C-400 Complex are illustrated in Figure C.1. Figures C.2 through C.7 show the locations of the sectors that will be evaluated by this survey plan. Sector 1, the C-400 Cleaning Building, will not be evaluated because the entire sector area is covered by concrete.

Table C.1. C-400 Complex Sectors Identified for Characterization

Sector	Location	Description
2	Northeast corner of the C-400 Complex	Concrete and asphalt pavement with limited area of exposed soil
3	East of the C-400 Cleaning Building	Asphalt pavement and gravel with limited area of exposed soil
4	Southeast of the C-400 Cleaning Building	Concrete, asphalt pavement, and gravel with limited area of exposed soil
5	Southwest of the C-400 Cleaning Building	Concrete with area of soil and gravel mixture
6	West of the C-400 Cleaning Building	Concrete and gravel with grassy soils
7	Northwest of the C-400 Cleaning Building	Concrete and gravel with limited area of exposed soil

C.2. SITE DESCRIPTION AND HISTORY

The site description and history can be found in Section 4 of this Work Plan.

C.3. HISTORICAL DATA REVIEW

Historical data for the C-400 Complex have been reviewed and evaluated and considered in the design of this survey plan. Historical data evaluations can be found in Section 5 of this Work Plan.

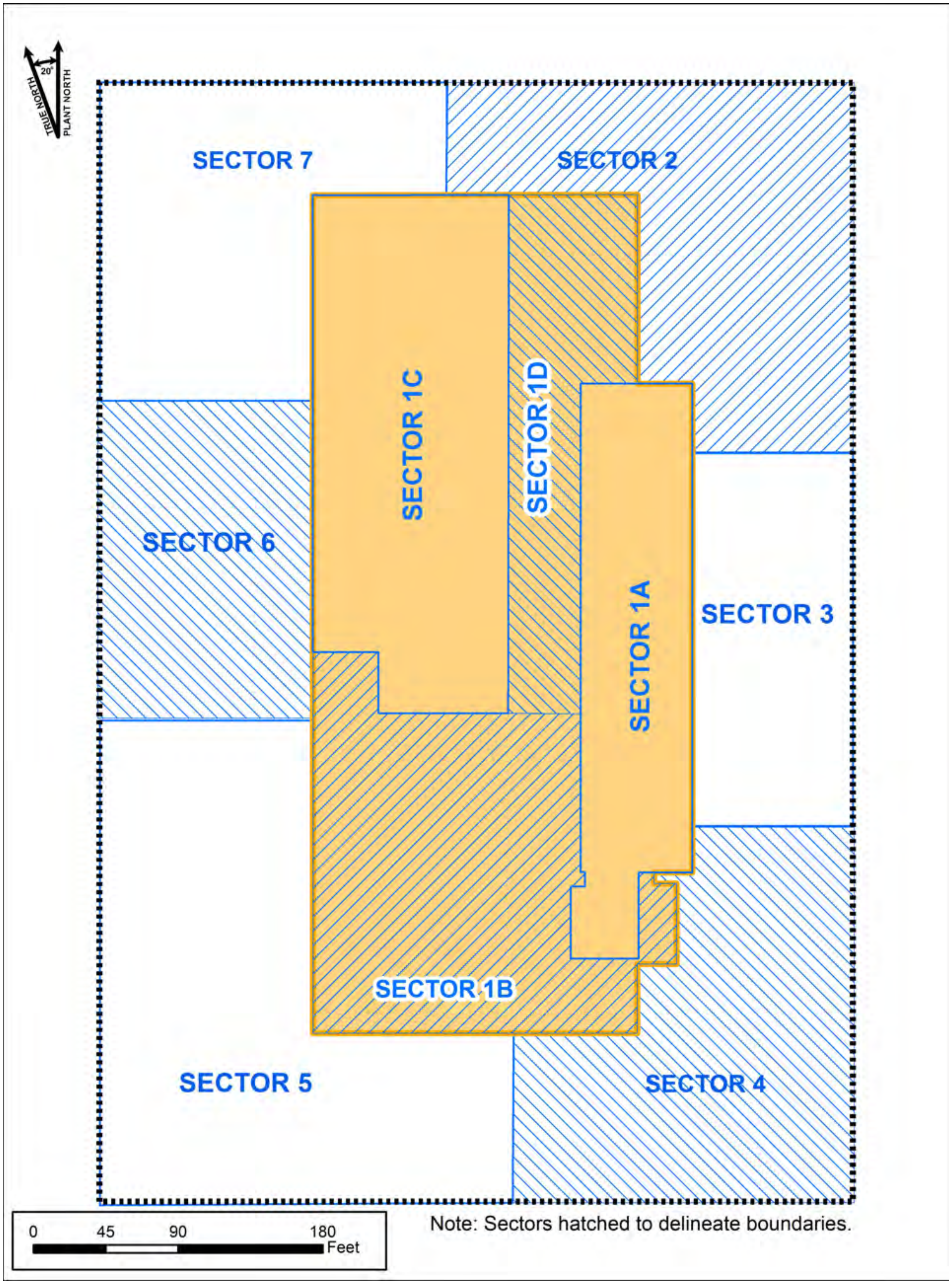


Figure C.1. C-400 Complex Sectors for the RI/FS

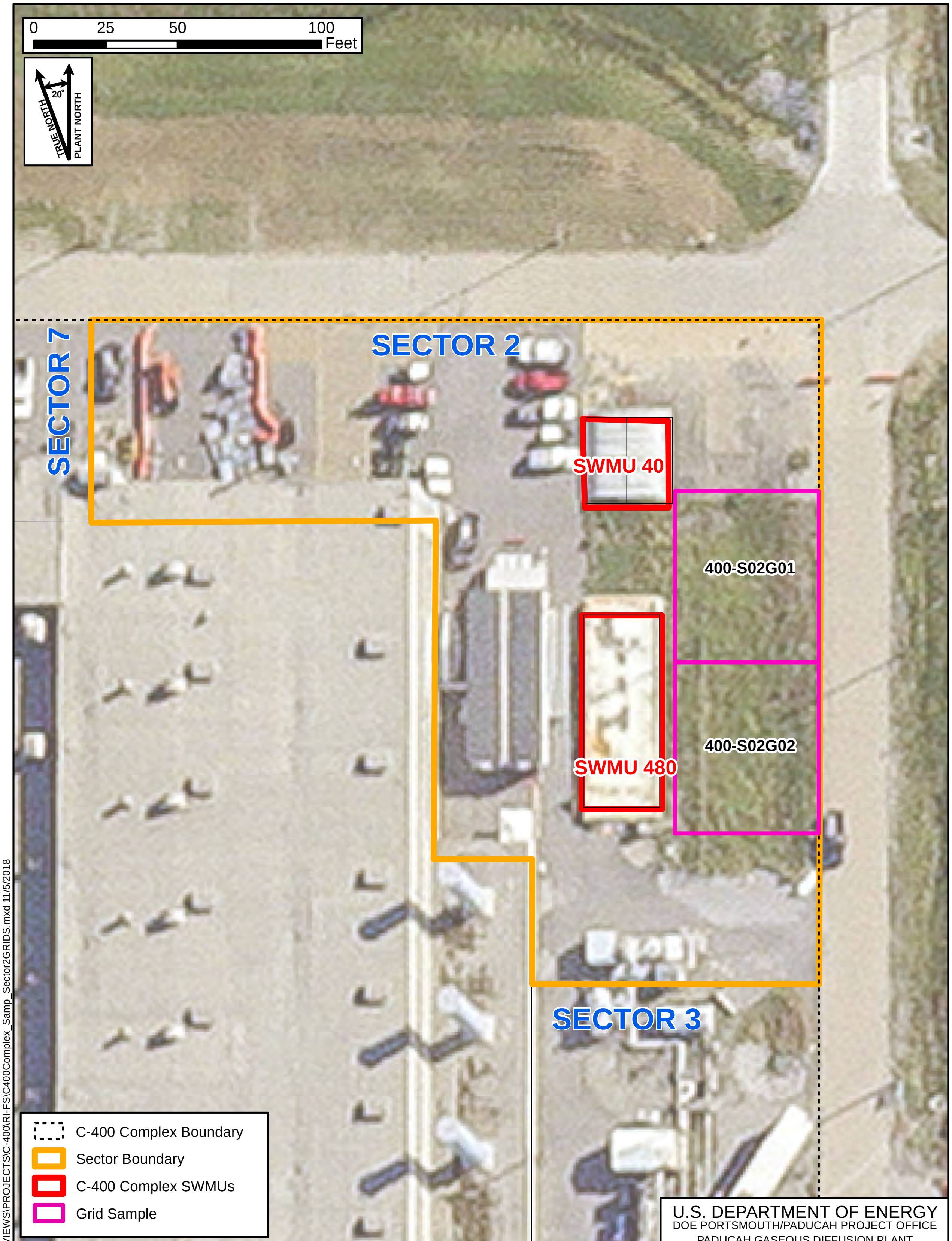


Figure C.2. C-400 Complex Sector 2

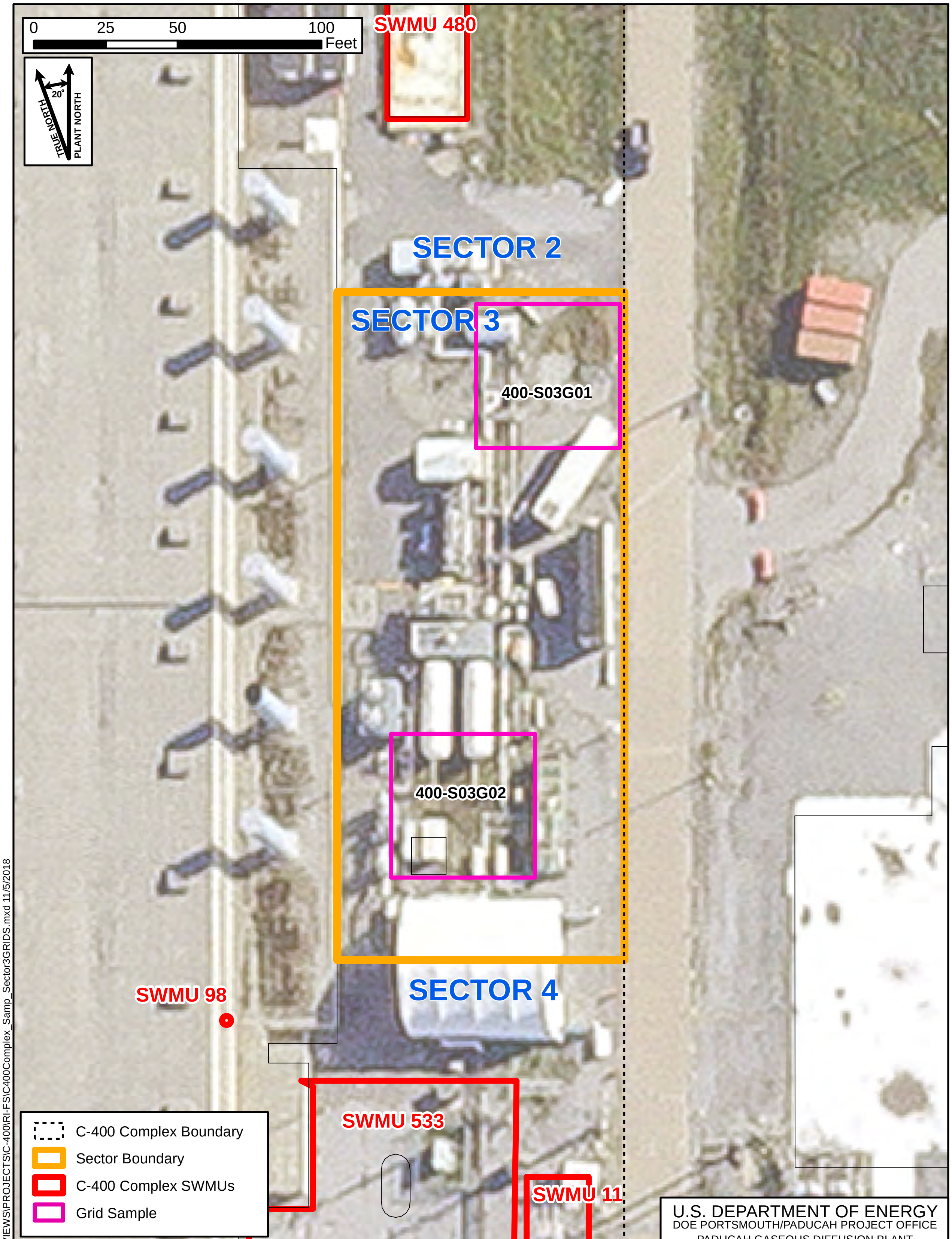
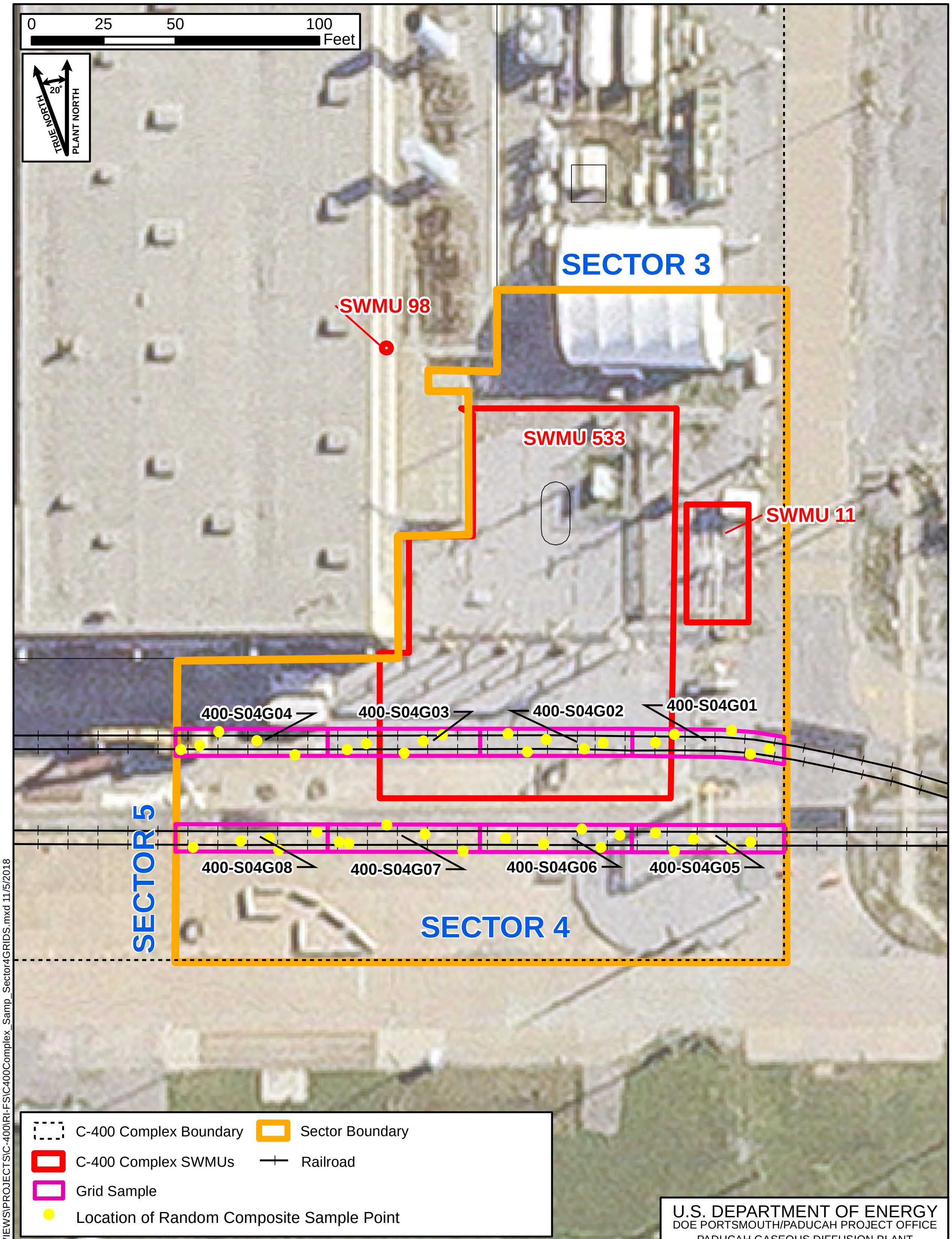


Figure C.3. C-400 Complex Sector 3



G:\GIS\ARCVIEWS\PROJECTS\C-400\RI-FS\C400Complex_Samp_Sector4GRIDS.mxd 11/5/2018

Figure C.4. C-400 Complex Sector 4

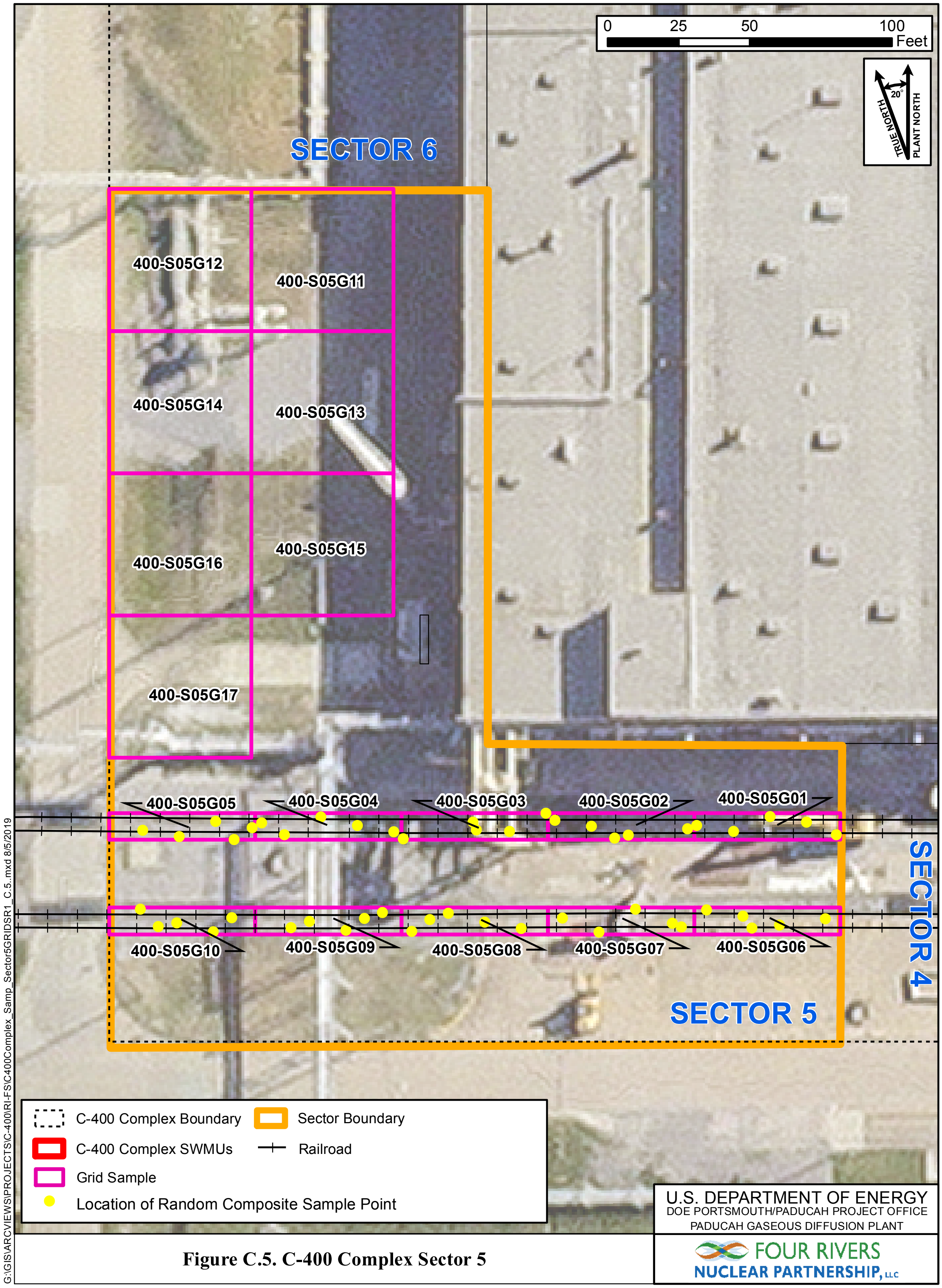


Figure C.5. C-400 Complex Sector 5

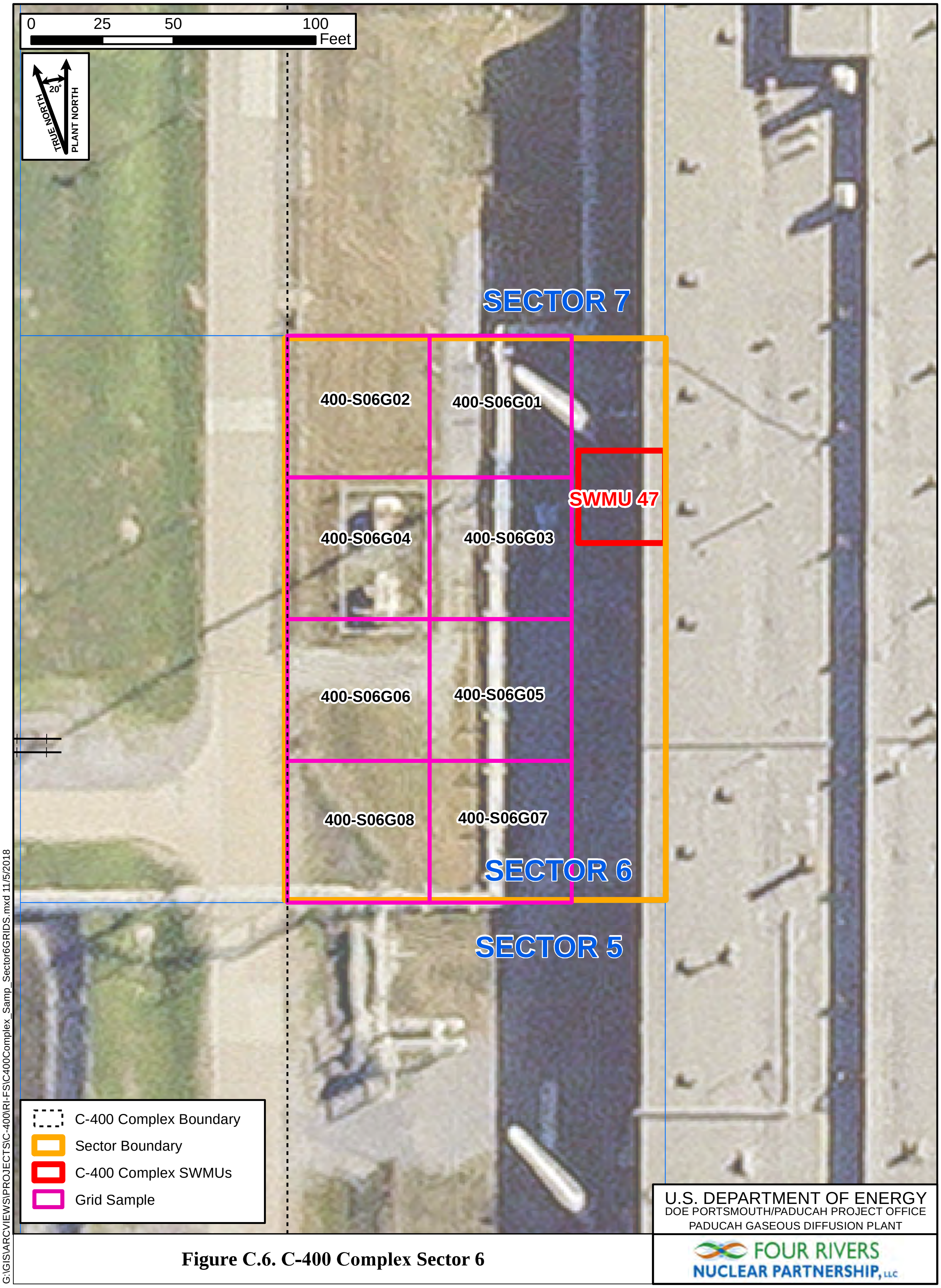


Figure C.6. C-400 Complex Sector 6

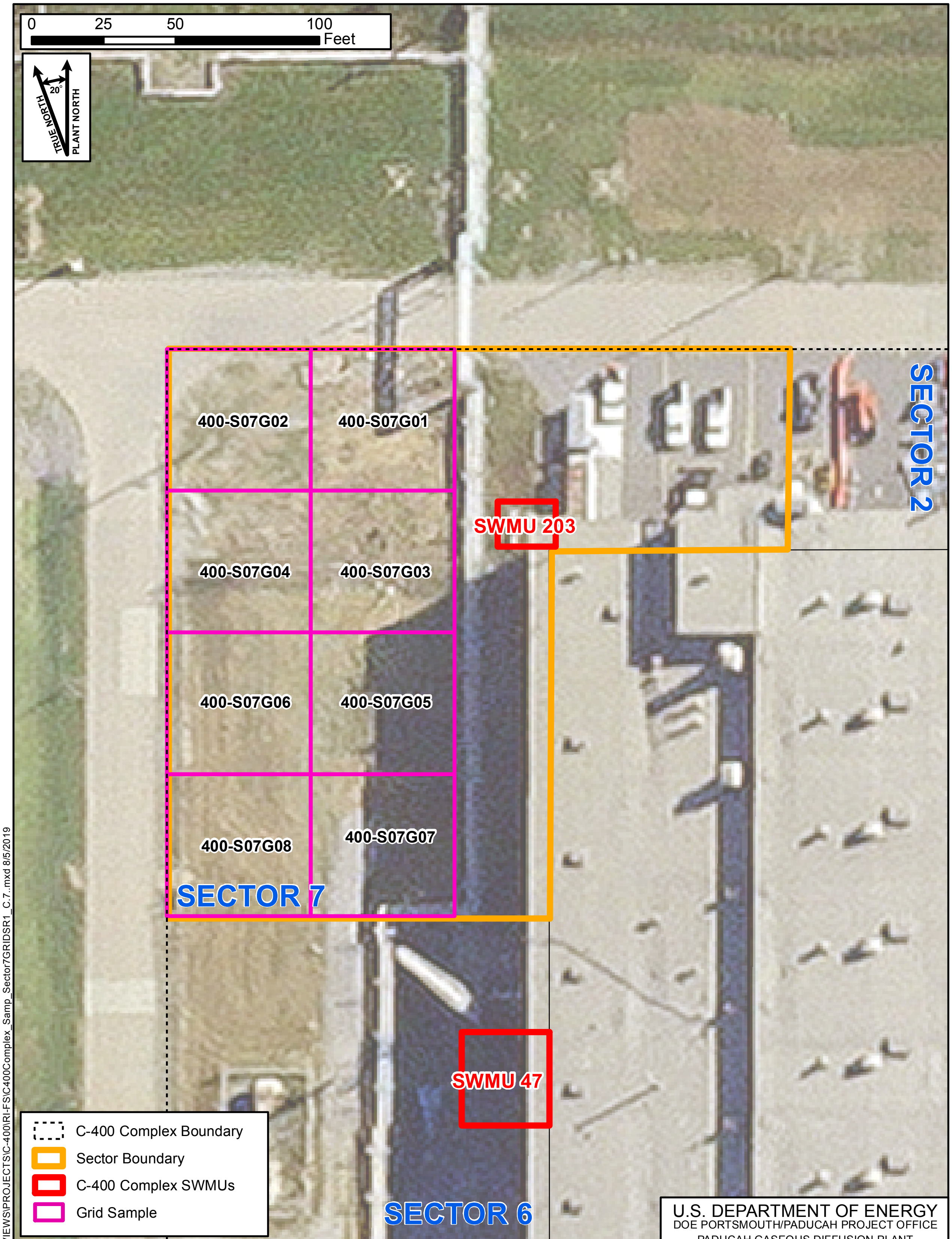


Figure C.7. C-400 Complex Sector 7

C.4. GAMMA WALKOVER SURVEY AND DATA ASSESSMENT

C.4.1 SURVEY INPUT PARAMETERS

For the purpose of the survey, the area/location with the highest count rate is used as the indicator for establishing the sampling location for radiological contaminants.

- GWSs will be conducted by walking lines parallel to one other where possible, separated by approximately one meter.
- Stakes or other indicators will be used, as necessary, to ensure properly spaced lines.
- GWSs will be conducted at a progression rate of approximately one-half meter per second to ensure a data density of at least one measurement per square meter.
- The detector will be held approximately five inches above the ground (± 1 inch) and moved slowly in a serpentine fashion.
- Surface geometries and media other than soil (such as saturated soils, concrete and asphalt surfaces, etc.) that can impact GWS results will be noted.
- GWS data will be logged along with accompanying Global Positioning System (GPS) information in State Plane and/or Plant Coordinates (in feet).
- The units of measurement for GWSs will be gross counts per minute (cpm).

Potential detectors include the following.

- Rexon G5 FIDLER: Per the manufacturer's specification sheet, the Rexon G5 FIDLER is a 5-inch diameter by 1/16-inch thick sodium iodide (thallium) crystal coupled to a photo multiplier tube encased in a 0.020-inch thick aluminum housing. The crystal is optimized for low-energy X-ray and gamma radiation detection. Its recommended energy range is 15–1,000 keV. The ruggedized version of the G5 FIDLER has an aluminum, open-mesh, screen covering a 0.10-inch thick beryllium window.
- Ludlum Model 44-10: The Ludlum Model 44-10 consists of a 2 inch diameter by 2-inch tall sodium iodide (thallium) crystal coupled to a photo multiplier tube encased in a 0.062-inch thick aluminum housing. Its recommended energy range is 60–2000 keV. The probe weighs about 2.3 lb.

Both the Ludlum 44-10 and Rexon G-5 FIDLER will be connected to a Ludlum Model 2221 digital ratemeter/scaler. The Ludlum Model 2221 has adjustable settings that allow for specific energy pulses to be counted. In essence, the Ludlum Model 2221 can be used as a kind of single-channel analyzer. This is useful when one has *a priori* knowledge about the makeup of the radiological constituents in the area being scanned. For example, if one is looking for cesium-137, then the energy range can be set to 662 + 30 keV so that only cesium-137 pulses are counted. In this case, the Ludlum Model 2221 will be set to count all energy pulses rather than for a specific radionuclide. This will facilitate use of the inflection point technique.

C.4.2 SURVEY QUALITY CONTROL

Before radiation surveys of the sectors, fieldwork is to begin with calibration and assessment of all radiation detectors to be utilized for GWS of soils. A radiation survey instrument will be calibrated as described in American National Standards Institute standard, N323A-1997. This step is necessary for establishing quality control (QC) for this survey plan. If QC for a radiation detector falls outside its established 2σ control limit based on the mean, it will be rechecked to determine whether service or recalibration is needed for the radiation detector.

Prior to the start of surveys, 10 measurements will be taken with a known source in a repeatable geometry. The 10 measurements will be used to establish a QC chart that provides mean and two standard deviations above and below the mean for the radiation detector dataset. At the beginning and end of each survey, the radiation detector will be checked with the original source in the original geometry used to establish the QC chart. Detectors will be checked prior to start of work each day, at or around lunch time, and again at the end of the day. Those detectors that fall outside 2σ will have data from those detectors stricken, and the area will be resurveyed. Detectors with multiple exceedances will be removed from service. Detector response outside of two standard deviations based on the QC chart will be evaluated to ensure the radiation detector is within the established control limits.

Background levels for the sectors will be determined at the area illustrated in Figure C.8. This area was chosen because a quality dataset from the Kentucky Research Consortium for Energy and Environment (KRCEE) 2008 Real Time Demonstration Project is available for the area (KRCEE 2008). Figure C.9 shows the GWS for the area using gross count data from KRCEE's 2008 Real Time Demonstration. This is an area that has not been impacted by PGDP activities. Ten one-minute static count readings will be taken at the background site. The background level used for comparison will be the mean of the background readings and the 95% confidence level will be determined by the standard deviation of the readings (after testing the normality of the distribution). If a radiation detector falls outside its established two sigma control limit based on the mean, the detector will be rechecked to determine whether service or recalibration is needed for the radiation detector.

C.4.3 DATA ASSESSMENT AND SELECTION OF SAMPLE LOCATION

The following describes how the survey data will be evaluated and used to select a sample location.

- GWS data will be downloaded each day, and the data will be evaluated the next business day, following completion of the survey and any confirmation survey.

- The GWS data will be overlaid on a map of the sector.

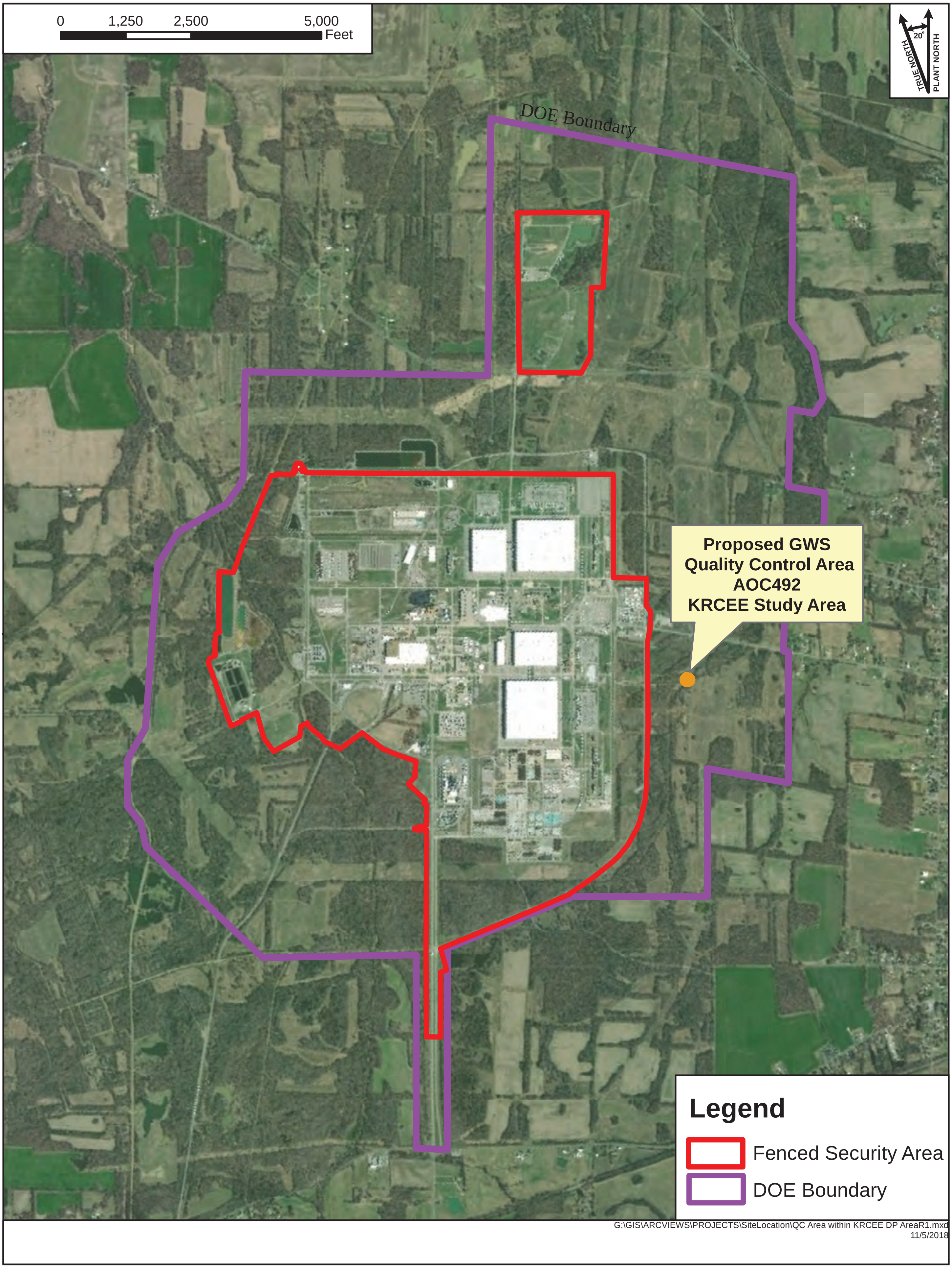


Figure C.8. Quality Control Area within KRCEE Demonstration Project Area

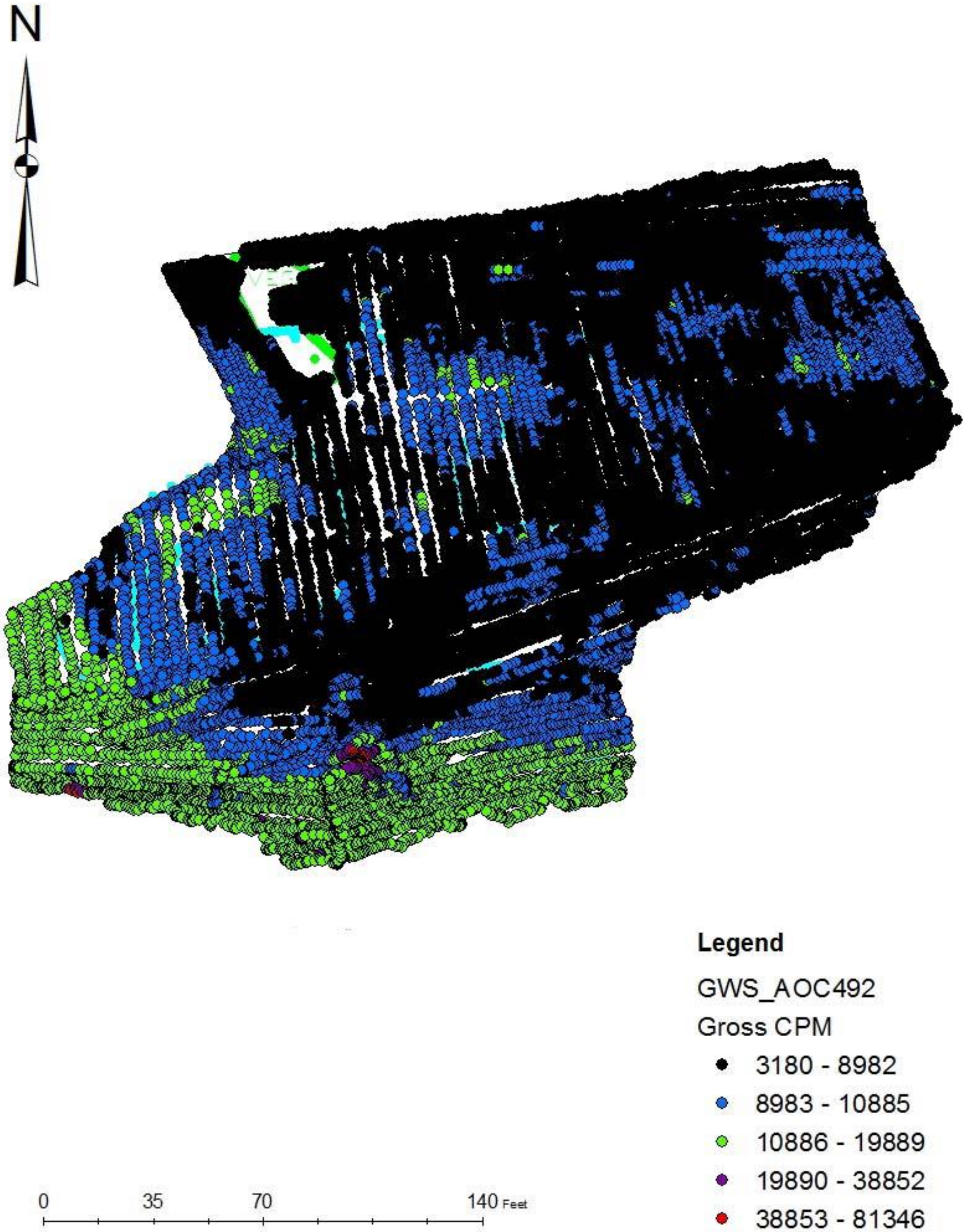


Figure C.9. GWS for Area of Concern 492 and Adjacent Areas Using KRCEE Gross Count Data

- Areas of a sector where GWS data are incomplete or questionable because of GPS signal or incomplete coverage will undergo additional GWS.

- The GWS data for the sector will be analyzed using inflection point analysis.

- Probability plots will be used to determine whether a break/inflection point occurs in the data (DOE 2014).

- Data above the break/inflection point will be mapped to determine the location of the data above the inflection point within the sector. The analysis may indicate the following:

  Case 1: A sector with one area with a group of data points with elevated count rate;

  Case 2: A sector with multiple areas with a group data points with elevated count rate;

  Case 3: A sector with a single area with a single data point with an elevated count rate (no adjacent points with elevated count rate data);

  Case 4: A sector with a combination of the above; or

  Case 5: If no inflection point is observed for the probability plot, data points above the 95th percentile will be mapped and used, along with professional judgment, to determine the location for a judgmental sample.

- After survey data are mapped, the following will be used to determine sample locations.

  Case 1: A sector may have a single area with a group of elevated count rate data points. In this case, the sample area will be resurveyed (e.g., confirmation) to determine the boundary of the area (e.g., count rates above the break/inflection point) and the location with the highest count rate within the area. The location within the area with the highest count rate will be chosen for sampling.

  Case 2: A sector may have multiple areas with a group of elevated count rate data points. The sample areas will be resurveyed (e.g., confirmation) to determine the boundary of the each area (e.g., count rate above the break/inflection point) and the location with the highest count rate within each area. From the areas, the area with the highest count rate will be chosen for sampling at the location with the highest count rate.

  Case 3: A sector may have a single area with elevated count rate with no adjacent elevated points. The single location with the elevated count rate with no adjacent locations with elevated count rate will be resurveyed using a 5 m × 5 m area centered on the single point. The location with the highest count rate within the 5 m × 5 m area will be chosen for sampling.

  Case 4: A sector may have single areas with a group of elevated count rate data points, multiple areas with a group of elevated count rate data points, and/or a single area with elevated count rate with no adjacent elevated points. Professional judgment will be used to determine sample location, with a focus on the location with the highest count rate.

  Case 5: If no inflection point is observed for the probability plot, data points above the 95th percentile will be mapped and used, along with professional judgment, to determine the location for a judgmental sample.

- If the observed highest location is associated with debris within a sector, additional measurements will be conducted to determine if the elevated count rate is from debris or adjacent soil. These additional measurements will not be combined with the initial survey data for mapping or inflection point analysis. The sample location will be determined as discussed above.

- If the highest count rate is associated with debris, the debris will be moved, if possible, manually. The area under the debris will be surveyed. If moving the debris manually is not possible, the survey will be considered complete. Sample location will be determined as discussed above.

- After a sampling location within a sector has been determined, a discussion will be held with the Kentucky Department for Environmental Protection (KDEP) and the U.S. Environmental Protection Agency (EPA) to gain agreement of the sampling location. KDEP and EPA will send agreement of the sampling location or a proposed alternate location within three business days.[1] If there is continued disagreement of the sampling location, discussions will be held to determine an agreed upon location.

- Surveys will be conducted prior to sampling to ensure accurate sample placement.

C.5. SURVEY PLAN SUMMARY

This survey plan provides a systematic methodology for defining the criteria that the GWS and sample design should satisfy including types of analyses and measurements, when and where to perform measurements, and the decision errors. The survey plan summary is as follows.

- All GWS radiation detectors will be operated and maintained by qualified personnel, in accordance with U.S. Department of Energy (DOE) Prime Contractor procedures;

- Real-time logged GWS data will be downloaded immediately after completion of the GWS (within three business days) to ensure data are of sufficient quality and quantity to meet the intended use of the data;

- Radiation detectors will operate under daily QC to ensure the detectors are operating within control limits; and

- GWS speed, detector height, and integration time shall be maintained throughout the survey to ensure the collection of at a minimum one measurement per square meter.

C.5.1 FIELD APPROACH

A survey team consisting of two surveyors will obtain the specified radiological measurements. The DOE Prime Contractor GWS supervisor will ensure that data from each sector are archived separately, and the data files include all specified data. GWS will progress until completion. GWS operations will cease for inclement weather. GWS of accessible areas will be performed for Sectors 2-7 using a Field Instrument for the Detection of Low Energy Radiation (FIDLER) or similar instrument coupled with a Global

[1] Three business days is an expectation for scheduling purposes.

Positioning System (GPS) device. Examples of areas that are not accessible include structures that remain following deactivation activities (e.g., C-403 Neutralization Pit) and areas close to the C-400 Building structure that impact GPS surveying, etc..

C.5.2 SAFETY HAZARDS

Safety hazards likely to be encountered during the performance of this survey effort include insects (seasonal), wildlife (seasonal), vegetation, slips, trips, falls, heat/cold stress, falling debris, and driving hazards. All survey efforts conducted in support of this plan will be performed in accordance with the Health and Safety Plan found in Section 10 of this Work Plan. Surveyors will use the buddy system at all times and maintain radio communications with the DOE Prime Contractor GWS supervisor and the Paducah Site plant shift superintendent. Surveyors shall report his/her position to the DOE Prime Contractor GWS supervisor at regular intervals.

C.5.3 SURVEY LOCATIONS

The sectors included for radiation survey under this Work Plan are presented in Table C.1 and their locations are shown in Figure C.1.

C.5.4 GWS

GWS are performed by moving the detector in a serpentine pattern approximately 1-m wide, while advancing at a rate of approximately 0.5 m/sec. The sensitive area of the detector is maintained as close to the surface as practical, considering the surface conditions; approximately 5 inches (± 1 inch) is a reasonable distance. Parallel scanning passes will be made across the sector where possible. The GWS coverage is based on guidance in Multi-Agency Radiation Survey and Site Investigation Manual/MARSSIM for providing a high confidence level of collecting data for areas with elevated count rate.

C.5.5 SEQUENCING OF WORK

Data evaluation will be conducted in parallel with the collection effort to ensure a timely review of data and to ensure that data gaps are identified while the project is underway. Upon completion of the GWS and data collection for a sector, the C-400 Complex project team will evaluate the data and determine whether further surveys of the sector are necessary.

C.6. DATA MANAGEMENT

Data collected in support of this effort shall be managed as follows.

- A new data file shall be created for each sector.

- If multiple instruments are used on an individual anomaly, unique data files for each instrument will be created.

- Data files shall include time stamps with both date and time collected.
- Data files shall include X and Y coordinates in State Plane and/or Plant Coordinate System (in feet).
- Data files shall be archived on the network in a dedicated folder. Access will be restricted to the C-400 Complex project team members.
- A written GWS record shall be prepared for each sector that includes data file name, instrument, surveyor, and area-specific information. The GWS also should include a narrative of any unusual condition or material noted for the sector. If sketches or photographs of the sector are produced, these shall be attached to the written survey record.
- A copy of the written survey shall be provided to the DOE Prime Contractor C-400 Complex RI/Feasibility Study (FS) Project Manager (PM).

C.7. ANALYSES AND DATA REPORTING SCHEDULE

Data will be reported in the C-400 Complex RI/FS Report to be issued in accordance with the project schedule found in Section 2 of this Work Plan.

C.8. DATA REPORTING

The DOE Prime Contractor GWS supervisor will routinely report the progress and results to the DOE Prime Contractor C-400 Complex RI/FS PM. Data reporting shall include the number of completed GWS for sectors, the number of surveys in progress, and the location of the highest count rate in each sector.

C.8.1 IN-PROCESS DATA REVIEW

The DOE Prime Contractor GWS supervisor routinely will review data to determine if the requirements of this survey plan are being met. Additionally, the review will ensure that data gaps are identified and corrected during the GWS of each sector.

C.8.2 DATA PRESENTATION METHODOLOGY

Data collected in support of this survey plan, including, but not limited to, GWS data, inflection point analysis, mapping of data, area of highest count rate, and QC will be presented in the C-400 Complex RI/FS Report.

C.8.3 DATA ARCHIVAL

Data files, written surveys, and instrument calibration records shall be archived electronically with the C-400 Complex OU project files.

C.9. REFERENCES

DOE (U.S. Department of Energy) 2014. *Addendum to the Work Plan for the Soils Operable Unit Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Remedial Investigation 2, Sampling and Analysis Plan*, DOE/LX/07-0120&D2/R2/A1/R1, U.S. Department of Energy, Paducah, KY, August.

KRCEE (Kentucky Research Consortium for Energy and Environment) 2008. *Real Time Technology Application Demonstration Project Final Report at the Paducah Gaseous Diffusion Plant, Paducah*, Kentucky, UK/KRCEE DOC#. P18.32 2008, December.

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APPENDIX D

PADUCAH GASEOUS DIFFUSION PLANT C-400 BASEMENT SLAB AND SUBSURFACE STRUCTURES DATA SUMMARY REPORT

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DOE/LX/07-2442&D1

Paducah Gaseous Diffusion Plant
C-400 Basement Slab and Subsurface Structures
Data Summary Report

CLEARED FOR PUBLIC RELEASE

DOE/LX/07-2442&D1

Paducah Gaseous Diffusion Plant
C-400 Basement Slab and Subsurface Structures
Data Summary Report

Date Issued—September 2019

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

CLEARED FOR PUBLIC RELEASE

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CONTENTS

FIGURES

TABLES

ACRONYMS

AL	action level
DOE	U.S. Department of Energy
DQO	data quality objective
DSR	data summary report
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FOD	frequency of detection
FOE	frequency of exceedance
FS	feasibility study
GC/MS	gas chromatography/mass spectrometry
GEL	General Engineering Laboratories, LLC
HSPD	Homeland Security Presidential Directive
LSC	liquid scintillation counter
MDL	Method Detection Limit
MOA	memorandum of agreement
MS/MSD	matrix spike/matrix spike duplicate
MSA	method of standard additions
N/A	not applicable
NAL	no action level
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PC	personal computer
PCB	polychlorinated biphenyl
PCSR	preliminary characterization summary report
PEMS	Paducah Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PQL	practical quantitation limit
QAPP	quality assurance project plan
QC	quality control
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
SAP	sampling and analysis plan
SMO	sample management office
SVOA	semivolatile organic analyte
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TEF	toxicity equivalence factor
TIC	tentatively identified compound
VOA	volatile organic analyte
VOC	volatile organic compound

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EXECUTIVE SUMMARY

This Data Summary Report (DSR) describes the field investigation, data evaluation, risk evaluation, and summary and conclusions for the sampling collected under the sampling and analysis plan (SAP), which is documented in the *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan,* DOE/LX/07-2430&D1 (July 2018 SAP) (DOE 2018a). Sampling data for this report was collected July–September 2018. Historical data referenced in this report may be used qualitatively for the RI/FS. In accordance with the July 2018 SAP, samples were collected from various sample media from sub-grade and at-grade areas within and, in one case, adjacent to the C-400 Cleaning Building. Sampling included concrete floors and walls (including visually stained locations), surface coatings on walls and floors, sludges in floor drains, and caulk.

Sampling of the C-400 Cleaning Building basement slab and subsurface structures was conducted pursuant to the Four Rivers Nuclear Partnership, LLC, Deactivation Contract requirement to demonstrate physically that all hazardous materials required to support the demolition phase have been removed to levels that support the planned disposal paths and air dispersion calculations. The primary intent of this sampling was to support internal contractual requirements for deactivation under the U.S. Department of Energy's Atomic Energy Act authority. The samples that were collected in accordance with the July 2018 SAP were developed to be consistent with the procedures and protocols required by the Comprehensive Environmental Response, Compensation, and Liability Act and the Toxic Substances Control Act, and the samples provide data that inform the nature and extent of contamination within the C-400 Complex, help characterization in the RI, and support decisions in the FS.

A memorandum of agreement (MOA) was signed on August 1, 2019, by the Paducah Federal Facility Agreement (FFA) parties that to avoid delays in finalizing the C-400 Complex D2 Remedial Investigation/Feasibility Study (RI/FS) Work Plan, reporting of the C-400 Deactivation data will be merged with the D2 RI/FS Work Plan to accelerate the documentation process consistent with FFA Section XX.C (DOE 2019a). This DSR is being submitted concurrently with submittal of the C-400 Complex D2 RI/FS Work Plan, as an appendix, to document the sampling results (available at the time of submittal) from implementation of the Four Rivers Nuclear Partnership, LLC, July 2018 C-400 Cleaning Building Deactivation Basement Slab and Subsurface Structures, Sampling and Analysis Plan/Quality Assurance Project Plan [i.e., *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan,* DOE/LX/07-2430&D1 (DOE 2018a)].

The MOA stated the appendix will follow the Preliminary Characterization Summary Report (PCSR) outline in Appendix D of the Paducah FFA (DOE 2019a). This DSR was prepared to be equivalent to the guidance for a PCSR in Appendix D of the FFA for Paducah Gaseous Diffusion Plant and contains additional information regarding sampling and data quality information; therefore, this DSR meets the intent of the MOA (EPA 1998). The outline used for the DSR is consistent with conversations among DOE, U.S. Environmental Protection Agency, and the Kentucky Department for Environmental Protection held on August 5, 2019.

The FFA parties will use the information in this report for determining if additional RI/FS sampling associated with the basement areas, subsurface structures, and sub-grade environmental media is needed to finalize the C-400 Complex RI/FS Work Plan.

Results from concrete sampling were sufficient to characterize the nature and extent of contamination within the C-400 Basement Slab and Subsurface Structures and to assess the potential risk from direct exposure. No analyses in concrete exceeded industrial worker action levels. Analyses that exceeded both industrial worker no action levels and background values (if available) were the metals, chromium, cobalt, and uranium; total polychlorinated biphenyls (Total PCBs); and the radionuclides, neptunium-237 (Np-237), technetium-99 (Tc-99), uranium-233/234 (U-233/234), uranium-235/236 (U-235/236), and uranium-238 (U-238).

Results from paint, coating material, and caulk sampling were sufficient to characterize the nature and extent of contamination within the C-400 Basement Slab and Subsurface Structures and to assess the potential risk from direct exposure. Industrial worker action levels were exceeded in paint/coating for the metals, iron, lead, uranium; Total PCBs; and the radionuclides, Np-237, U-235/236, and U-238. Analyses that exceeded both industrial worker no action levels and background values (if available) were the metals, arsenic, chromium, cobalt, iron, lead, and uranium; Total PCBs; and the radionuclides, cesium-137, Np-237, plutonium-239/240, Tc-99, thorium-230, U-233/234, U-235/236, and U-238.

Consistent with the July 2018 SAP, information was collected from open floor drains. A video borescope system was deployed into each accessible drain until refusal was encountered. Liquid and sludge samples from the drains were collected, when possible, and analyzed. The results of the analyses indicate that volatile organic compounds, Total PCBs, Total carcinogenic polycyclic aromatic hydrocarbons (Total PAHs), anion (fluoride), metals, and radionuclides (see Sections 4.2, 4.9, and 4.10 for full analyte list) are present at concentrations exceeding risk-based screening values in these media.

The sample results from all media are sufficient to support the future remedial decision. Subsurface drains that were not accessible at the time of July 2018 SAP implementation should be considered to be similar to, with respect to nature of contamination, the drains accessible for video borescoping and sampling.

1. INTRODUCTION

1.1 PURPOSE OF REPORT

A sampling and analysis plan (SAP), which is documented in the *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan,* DOE/LX/07-2430&D1 (July 2018 SAP), was implemented in advance of the C-400 Complex Operable Unit (OU), in part, to provide information to support decisions for the areas sampled and the areas to which contaminants might have migrated prior to initiating any removal actions (DOE 2018a). Sampling data for this report were collected July–September 2018. Historical data referenced in this report may be used qualitatively for the RI/FS. The samples were collected in accordance with the July 2018 SAP, which was developed to be consistent with the procedures and protocols required by Comprehensive Environmental Response, Compensation, and Liability Act and Toxic Substances Control Act, and to provide data to be used to help inform the remedial investigation/feasibility study (RI/FS). This Data Summary Report (DSR) describes the field investigation, data evaluation, risk evaluation, and summary and conclusions for the sampling. A technical memorandum of field activities is presented in Appendix A.

The July 2018 SAP collected various sample media from the sub-grade areas within the C-400 Cleaning Building. Sampling included concrete floors and walls (including visually stained locations); surface coatings on walls and floors; sludges in floor drains; and caulk. Appendix B of this document provides data from these samples. Additionally, video borescopes were collected of pipes that penetrate and underlie the concrete foundation. This information is included in Appendix C.

1.2 SITE BACKGROUND

The Paducah Site, including Paducah Gaseous Diffusion Plant (PGDP), is located within the Jackson Purchase region of western Kentucky. PGDP is a former uranium enrichment facility that is owned by the U.S. Department of Energy (DOE). PGDP initially was owned and managed 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 PGDP enrichment facilities under a lease agreement with DOE to supply nuclear fuel to electric utilities worldwide. United States Enrichment Corporation ceased uranium enrichment activities in 2013 and returned leased Paducah facilities to DOE control in 2014.

Solid waste management units (SWMUs) and areas of concern at the Paducah Site have been combined into OUs for evaluation of remedial alternatives. These OUs include the C-400 Complex OU (C-400 Complex); the C-400 Cleaning Building is a component of that OU.

1.3 SITE DESCRIPTION

The C-400 Cleaning Building is located inside the plant Limited Area near the center of the industrial section of the Paducah Site (Figure 1). Generally, the C-400 Cleaning Building has a concrete slab on grade. In certain areas, however, the building includes basements, sumps, or pits, constructed with concrete walls and a below grade concrete floor. The basements, sumps, and pits greater than 1 ft below

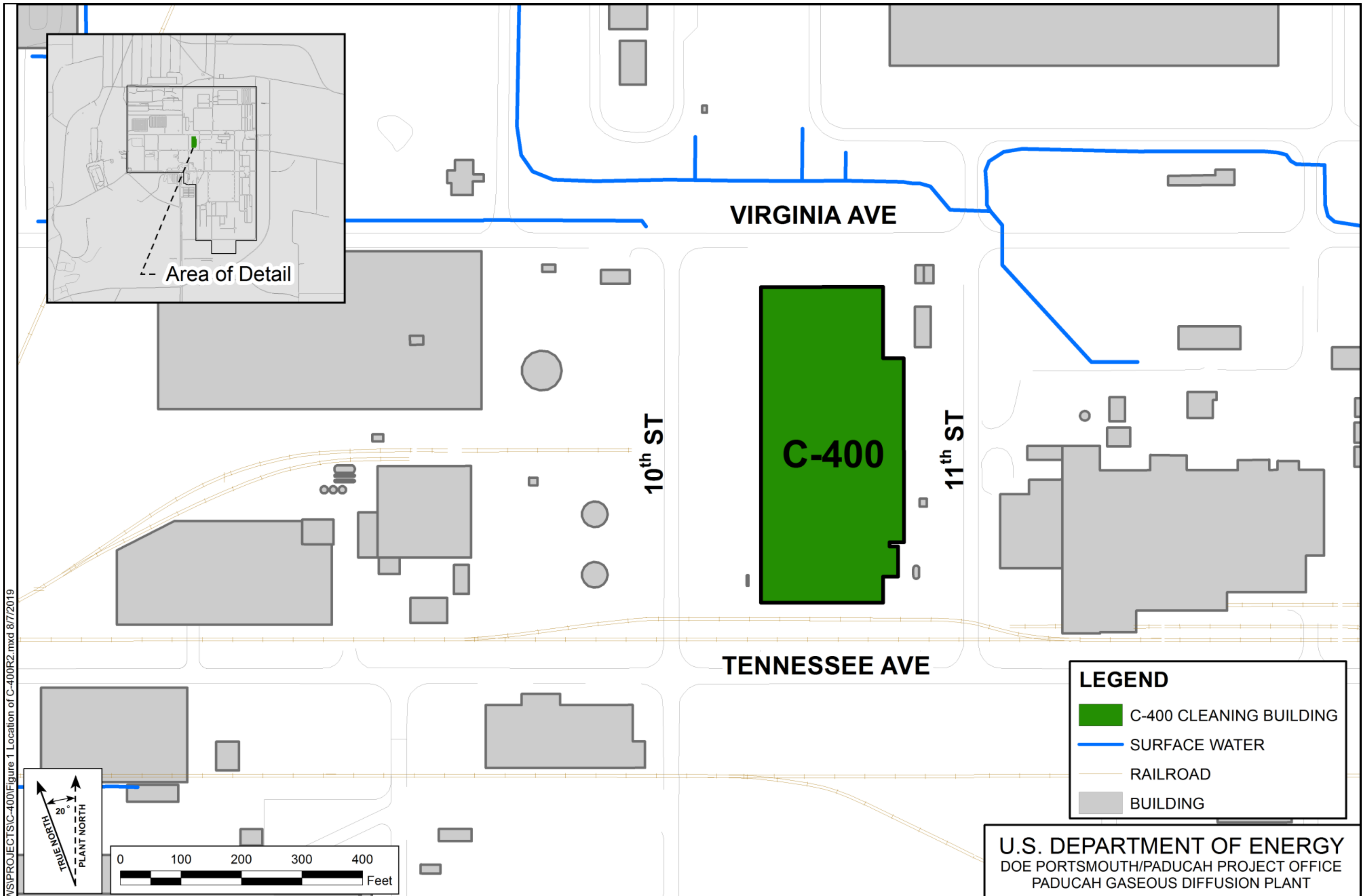

Figure 1. Location of the C-400 Cleaning Building at PGDP

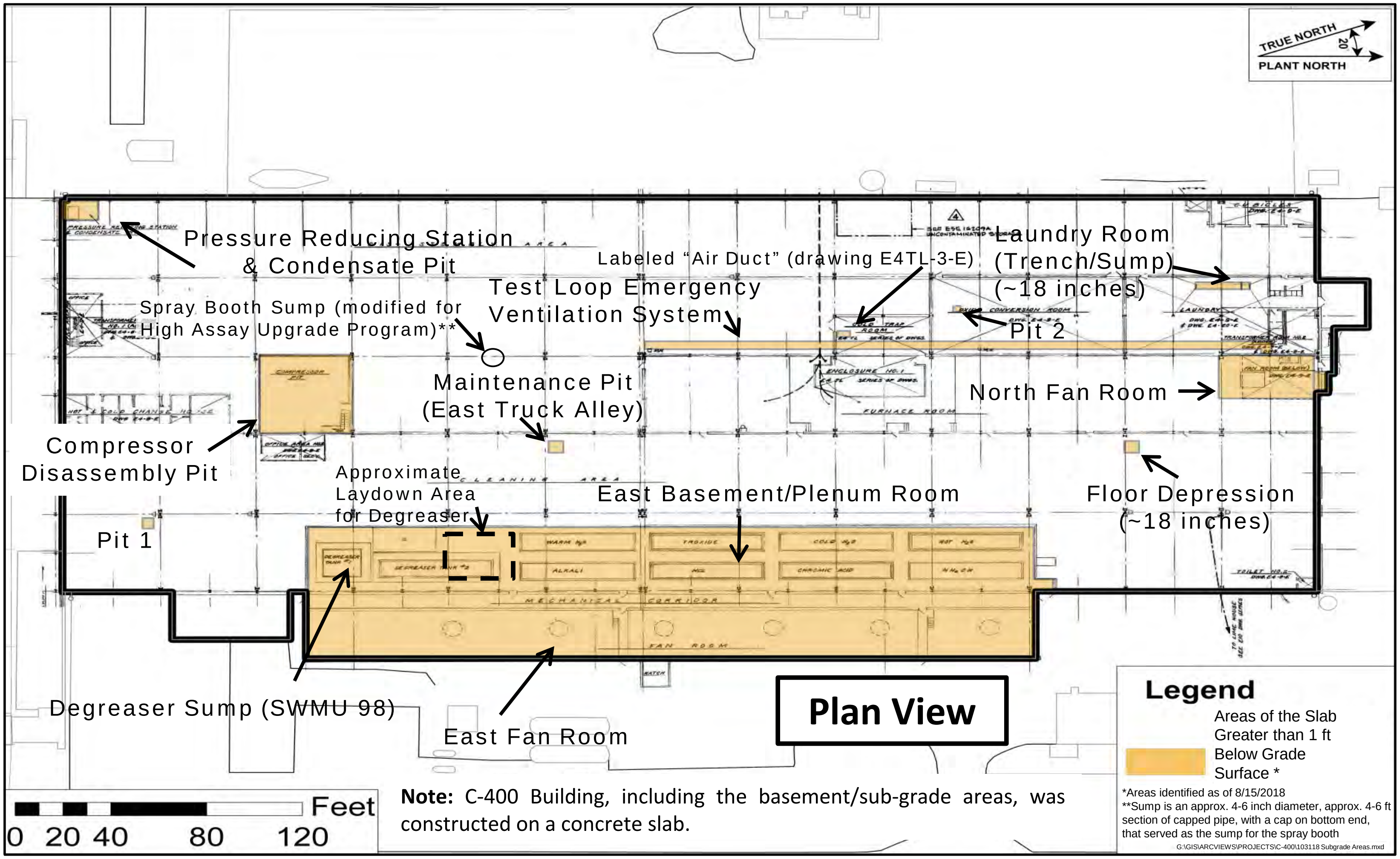

Figure 2. Basements/Sub-grade Areas with Depths Greater than 1 ft (Used to Plan Sampling Locations)

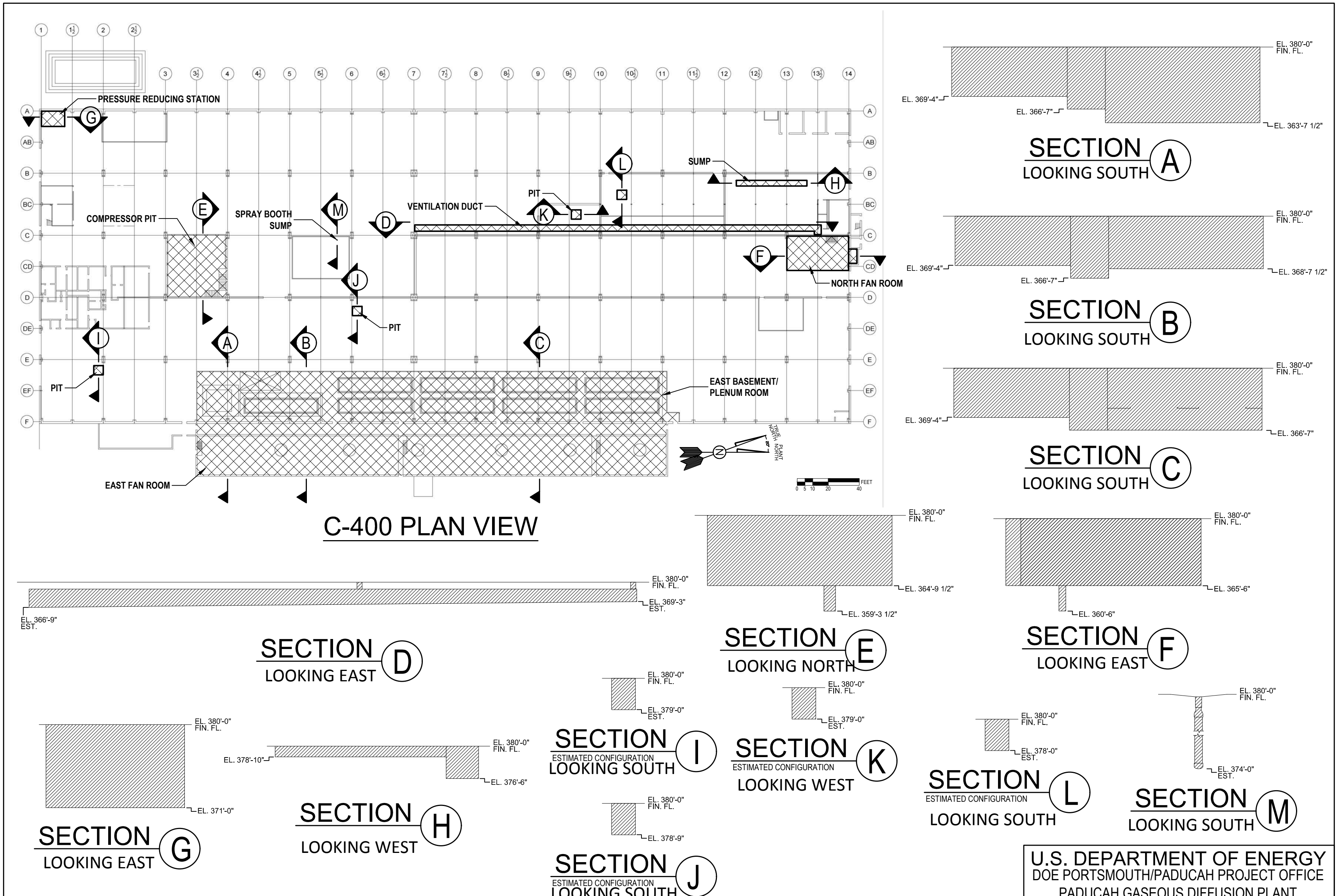

Figure 3. Configuration of the C-400 Cleaning Building Slab Floors

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There are 13 distinct sub-grade areas within the C-400 Building, as listed below and depicted in Figure 2.

- East Basement/Plenum Room;
- Degreaser Sump (SWMU 98);
- East Fan Room;
- Compressor Disassembly Pit;
- Pressure Reducing Station and Condensate Pit;
- Maintenance Pit (East Truck Alley);
- North Fan Room;
- Laundry Room Floor Trench/Sump;
- Labeled "Air Duct" (drawing E4TL-3-E);
- Pit 1 (Small pit located in the southeast area of the building);
- Pit 2 (Small pit located in the northwest area of the building);
- Test Loop Emergency Ventilation System; and
- Floor Depression (Small depression located in the northeast corner of the building).

Of these 13 sub-grade areas, 7 sub-grade areas were identified for sampling in the July 2018 SAP. Preselected concrete sample locations were discussed by the Federal Facility Agreement (FFA) parties during the RI/FS Work Plan scoping and primarily are based on future subsurface borings during the RI/FS field work. Additionally, the SAP specified sampling the floor of Laydown Area for Degreaser, which is at grade level in the C-400 Building. These eight sampling areas (seven sub-grade areas and one area at grade level) that were identified in the July 2018 SAP were selected based on process knowledge (i.e., areas where contamination was expected to be present based on past activities in the C-400 Building). Each of the eight sampling areas and their history are listed below.

East Basement/Plenum Room. The Plenum Room is a partial basement area that lies directly beneath and houses the sub-grade portion of the dip tanks, degreaser tank, and associated piping. The dip tanks were operated as open-top vats used to clean and pickle metal parts. Each tank was designed with a skirt around the top of the tank that drew a vacuum to remove fumes from the surface of the tank down to the underlying Plenum Room and into the east exhaust fan room (East Fan Room) where the fumes then were vented through several stacks to the outside. Direct discharges from the dip tanks would travel through the underlying piping and discharge either to the acid drain system and ultimately to the C-403 Neutralization Pit in the northeast corner of the C-400 Complex or directly to the storm sewer system. Any overflow or leaks from the dip tanks would discharge to the underlying Plenum Room and flow into the Plenum Room floor drains that also discharged to the acid discharge system or storm sewer system. The East Basement area historically housed the trichloroethene (TCE) product storage and the sub-grade portion of TCE degreasing tank/equipment. A basement sump is located next to the base of the TCE Detrex degreaser (#1 degreaser) that discharged to the storm sewer system located on the southeast corner of the C-400 Cleaning Building.

East Fan Room. Housed ventilation fans and motors and is adjacent to the Plenum Room. Ventilated exhaust vapors from the Plenum Room to the building's large stacks.

Compressor Disassembly Pit. Location where compressors and equipment were disassembled, cleaned, and rebuilt.

Pressure Reducing Station and Condensate Pit. Pit that captured building steam condensate and sent the condensate to the C-600 Steam Plant for recycle.

Maintenance Pit (East Truck Alley). Used to allow maintenance workers access to elevated equipment from below.

North Fan Room/Ventilation System. Housed emergency fan and equipment to evacuate air from the diffusion test loop.

Laydown Area for Degreaser (Main Ground-Level Slab). Degreased equipment was laid in these areas to drain. Any spills and/or releases from the equipment drained to floor drains piped to the acid discharge system.

Degreaser Sump (SWMU 98). Basement sump that received discharges from TCE Detrex degreaser (#1 degreaser) unit. Discharges from this sump drained to the storm sewer.

Field observations led to two additional sampling areas that were not specified in the July 2018 SAP; these additional locations are described below.

Spray Booth Sump. The Spray Booth Sump consists of a 4-inch cap at floor elevation that transitions to a 6-inch diameter by 4-ft pipe, with a cap on the bottom end that served as the sump for the spray booth. The sump was modified for a high assay upgrade program in 2000 and was discovered during deactivation activities. During investigation of drawings to determine what this sump was, the drawings revealed that there was a larger sump that had been filled with concrete as part of the high assay upgrade program. Large equipment, such as compressors, converters, coolers, condensers, large valves, and associated equipment removed from the enrichment facilities, was decontaminated in the C-400 spray booth.

Additional Pipeline Sample. A liquid sample was collected from an underground acid drain line located immediately east of the northeast corner of the C-400 Cleaning Building after the borescope video revealed the presence of liquid.

Additional information about the C-400 Cleaning Building is in the process document for the C-400 Cleaning Building (DOE 1995).

1.4 SITE HISTORY

In June 1986, a routine construction excavation along the 11th Street storm sewer encountered TCE soil contamination. The cause of the contamination was determined to be a leak in a drain line from the C-400 Cleaning Building's degreaser sump (SWMU 98) to the storm sewer. The amount of TCE released is unknown. The area of contamination became known as the C-400 Trichloroethylene Leak Site, and was designated as SWMU 11 (Figure 4). SWMU 11 and the C-400 Cleaning Building area have been the subjects of several investigations since the initial discovery. In addition to solvent cleaning, a number of

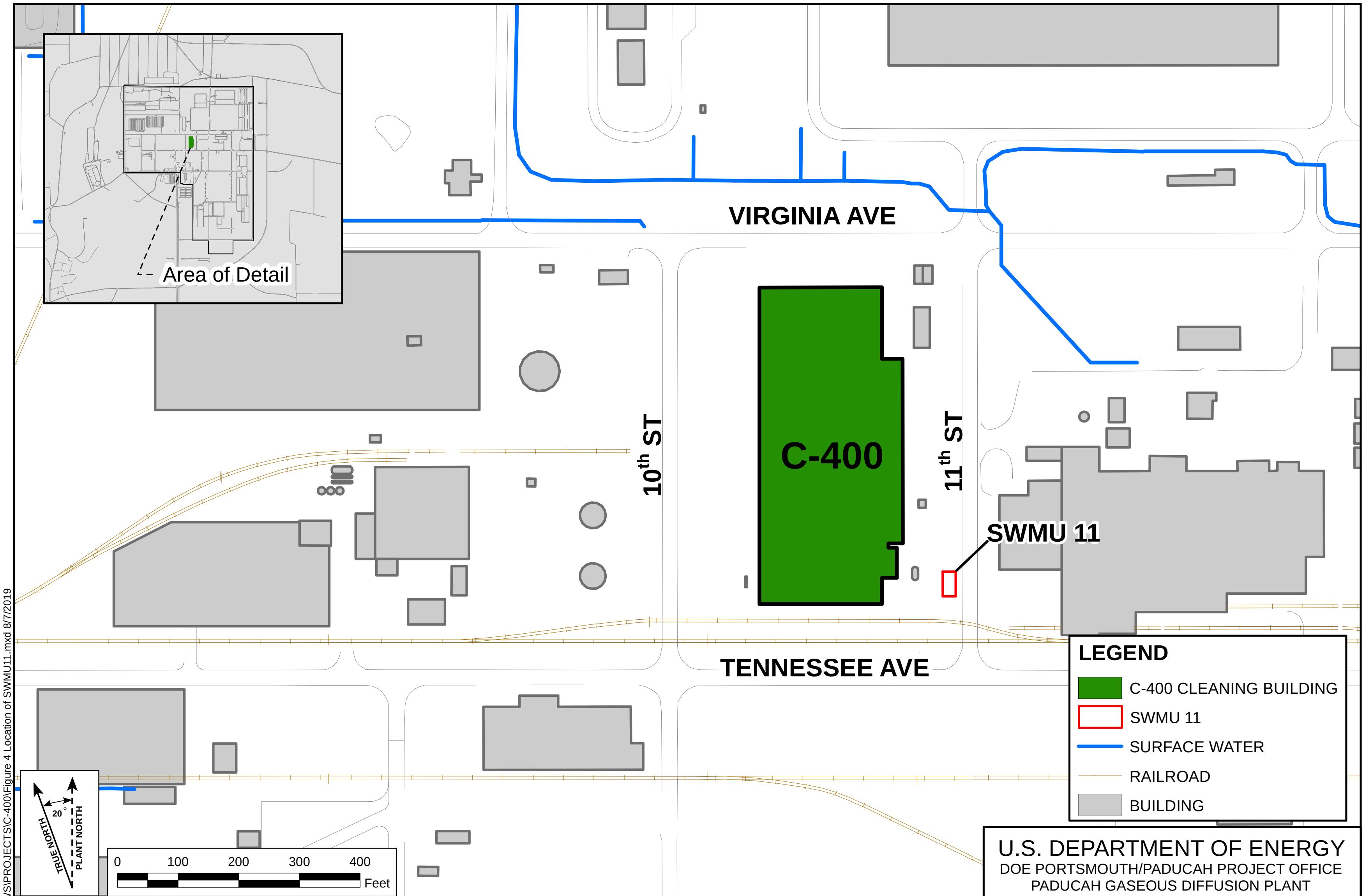

Figure 4. Location of SWMU 11

G:\GIS\ARCVIEWS\PROJECTS\C-400\Figure 4 Location of SWMU11.mxd 8/7/2019 other processes were conducted in the building that utilized other compounds that may be chemicals or radionuclides of potential concern.

In August 2017, the *Memorandum of Agreement on the C-400 Complex under the Federal Facility Agreement for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (MOA) was signed by the FFA parties (DOE 2017). That MOA included resequencing the approved fiscal year 2015 Site Management Plan milestones and accelerating the investigation and cleanup of the C-400 Complex OU for all sources of contamination associated with and underlying the C-400 Cleaning Building. Consistent with the requirements of the MOA, the C-400 Cleaning Building facility is undergoing deactivation.

In August 2019, Memorandum of Agreement for Resolution of Formal Disputes on EPA Conditional Concurrence on the *Removal Notification for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2420&D2 and the *Engineering Evaluation/Cost Analysis for Demolition of the C-400 Cleaning Building in the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2425&D2, was signed (DOE 2019a). This MOA provided for this DSR to be submitted concurrently with submittal of the D2 RI/FS Work Plan, as an appendix, to document the sampling results (available at the time of submittal) from implementation of the Four Rivers Nuclear Partnership, LLC, July 2018 C-400 Cleaning Building Deactivation Basement Slab and Subsurface Structures SAP [i.e., *Paducah Gaseous Diffusion Plant C-400 Cleaning Building Basement Slab and Subsurface Structures Sampling and Analysis Plan*, DOE/LX/07-2430&D1 (July 2018 SAP) (DOE 2018a)].

1.5 PREVIOUS INVESTIGATIONS

Several investigations have taken place in the C-400 area. The majority of these investigations have focused on environmental media surrounding the facility. The following are the investigations included.

- Waste Area Grouping 6 RI (DOE 1999)
- Six-Phase Heating Treatability Study (DOE 2004)
- Historical sampling included in the July 2018 Sampling and Analysis Plan (DOE 2018a)
- Interim Remedial Action Studies (DOE 2018b)
- Vapor Intrusion Study (an appendix to the 2013 Five-Year Review) (DOE 2018c)

During the C-400 Vapor Intrusion Study, air samples were collected from sub-slab locations, floor cracks, and in the breathing zone; they were analyzed for TCE and its degradation products (DOE 2018c). Additionally, several sampling events have supported operations and deactivation of the facility for the time frame 1988 to 2018. Examples of these sampling events are sampling from the C-400 Plenum Exhaust Fan Gasket Material (collected during 2017); C-400 Plenum Room Residue (collected during 2016); and C-400 Plenum Exhaust Fans Holdup Material (collected during 2017). Results from relevant, previous sampling events are summarized in the July 2018 SAP (DOE 2018a).

1.6 REPORT ORGANIZATION

This DSR was prepared to be equivalent to the guidance found in Appendix D of the FFA for PGDP for a PCSR and contains additional information regarding sampling and data quality information (EPA 1998); therefore, this DSR meets the intent of the 2019 MOA. The following is a crosswalk of the preliminary characterization summary report outline found in the FFA and this DSR. The outline used for the DSR is consistent with conversations among DOE, U.S. Environmental Protection Agency (EPA), and the Kentucky Department for Environmental Protection held on August 5, 2019.

Crosswalk of Preliminary Characterization Summary Report to Data Summary Report

PCSR Outline*	DSR Outline
EXECUTIVE SUMMARY	EXECUTIVE SUMMARY
1. Introduction	**1. Introduction**
1.1 Background	1.2 Site Background
	1.3 Site Description
	1.4 Site History
	1.5 Previous Investigations
1.2 RFI Process	1.1 Purpose of Report
1.3 PCSR Organization	1.6 Report Organization
(additional information, not included in PCSR outline)	**2. Field Investigation Summary**
	2.1 Sampling Procedures
	2.1.1 Floor Drain and Lines Survey
	2.1.2 Concrete Sampling
	2.2 Analytical Methods
	2.3 East Basement/Plenum Room
	2.3.1 Concrete Sampling
	2.3.2 Paint/Coating Sampling
	2.3.3 Liquid and Sludge Sampling
	2.4 East Fan Room
	2.4.1 Concrete Sampling
	2.4.2 Paint Sampling
	2.4.3 Caulk Sampling
	2.5 Compressor Disassembly Pit
	2.6 Pressure Reducing Station and Condensate Pit
	2.6.1 Concrete Sampling
	2.6.2 Paint Sampling
	2.7 Maintenance Pit (East Truck Alley)
	2.8 North Fan Room/Ventilation System
	2.9 Laydown Area for Degreaser (Main Ground-Level Slab)
	2.10 Additional Pipeline Sample
	2. Field Investigation Summary (Continued)
	2.11 Spray Booth Sump
	2.12 Quality Assurance/Quality Control
	2.12.1 Field QC
	2.12.2 Laboratory QC
	2.12.3 Data Management QC

Crosswalk of Preliminary Characterization Summary Report to Data Summary Report (Continued)

PCSR Outline*	DSR Outline
2. Screening and Evaluation Methods	**3. Data and Risk Evaluation**
2.1 Introduction	3.1 Risk Screening Process
2.2 Evaluation Methods	3.1 Risk Screening Process
2.3 Background Reference Values	*Source of values are referenced to the programmatic document (Risk Methods Document)*
2.4 Risk-Based Screening Values (PRGs)	
2.4.1 Site-Specific Exposure Scenarios	3.1 Risk Screening Process
2.4.2 Target Risk Levels	3.1 Risk Screening Process
2.4.3 Toxicity Values	*(Risk Methods Document)*
2.5 Certainty Analysis	*(Included with screening)*
3. PRG/Background Screening Results	
3.1 WAG 1	3.2 East Basement/Plenum Room
3.l.l SWMU 1	3.2.1 Concrete Sampling
3.1.2 SWMU 2	3.2.2 Paint/Coating Sampling
3.1.3 SWMU 3	3.2.3 Liquid and Sludge Sampling
3.2 WAG 2	3.3 East Fan Room
3.2.1 SWMU 4	3.3.1 Concrete Sampling
3.2.2 SWMU 5	3.3.2 Paint Sampling
	3.3.3 Caulk Sampling
	3.4 Compressor Disassembly Pit
	3.5 Pressure Reducing Station And Condensate Pit
	3.5.1 Concrete Sampling
	3.5.2 Paint Sampling
	3.6 Maintenance Pit (East Truck Alley)
	3.7 North Fan Room/Ventilation System
	3.8 Laydown Area for Degreaser (Main Ground-Level Slab)
	3.9 Additional Pipeline Sample
	3.10 Spray Booth Sump
	3.11 Data and Risk Screening Conclusions
4. SWMU Summary and Recommendations	**4. Summary and Conclusions**
	4.1 Floor Drain and Lines Survey
	4.2 East Basement/Plenum Room
	4.3 East Fan Room
	4.4 Compressor Disassembly Pit
	4.5 Pressure Reducing Station And Condensate Pit
	4.6 Maintenance Pit (East Truck Alley)
	4.7 North Fan Room/Ventilation System
	4.8 Laydown Area For Degreaser (Main Ground-Level Slab)
	4.9 Additional Pipeline Sample
	4.10 Spray Booth Sump
	4.11 Uncertainty Analysis Discussion

Crosswalk of Preliminary Characterization Summary Report to Data Summary Report (Continued)

PCSR Outline*	DSR Outline
5. References	**5. References**
Appendix A: Figures	*Not required, included with text*
Appendix B: Tables	*Not required, included with text*
Appendix C: Preliminary Remediation Goal Calculations	*Not required, included in programmatic document (Risk Methods Document)*
Appendix D: Statistical Evaluation Method for Chemical Sample Results From the Paducah Site	*Not required, included in programmatic document (Risk Methods Document)*
Appendix E: Laboratory Data Qualifier Definitions	**Appendix B:** Analytical Data and QA/QC Results *(Laboratory Data Qualifier Definitions included in Section 2.11)*
(additional information, not included in PCSR outline)	**Appendix A:** Technical Memoranda for Field Activities 1) Concrete cores smear results compared to analytical results 2) Deviations from the July 2018 SAP 3) Expected end state Deactivation
	Appendix C: Results of Video Borescopes

*"NOTE: Elements included in this outline shall be considered and incorporated, as appropriate, when developing the above-referenced document (EPA 1998)."

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2. FIELD INVESTIGATION SUMMARY

Data were collected in accordance with the July 2018 SAP specifically for characterization of the concrete floors and walls (including visually stained locations), surface coatings on walls and floors, sludges in floor drains, and caulk located in the sub-grade areas (DOE 2018a). Sampling locations are shown in Figure 5. Sampling locations were biased to areas where contamination was expected to be present (judgmental), and locations were selected in one of the following ways.

- Process information and existing data (e.g., adjacent to floor drains)
- Visual observations (e.g., staining)

The following are the matrix types sampled.

- Construction materials (e.g., concrete, walls/floors, piers)
- Coatings on floors and walls (caulking compounds, paints, waterproof coating)
- Sludge from floor drains and sumps
- Liquid from floor drains and sumps

2.1 SAMPLING PROCEDURES

2.1.1 Floor Drain and Lines Survey

Information was collected from open floor drains located in each of the basements. Many of the floor drains were plugged intentionally over the years to control the flow of materials from the drains. There are two types of drain systems located in the sub-grade areas: discard waste system and acid drain system. The process document for the C 400 Cleaning Building (DOE 1995) states, "The Discard Waste System [sic] reportedly consists of connective piping (high silica –"duriron" beneath the building and vitrified clay elsewhere)…." A portion of the discard waste system was video borescoped. The acid drain system includes an 8-inch diameter pipe (manifold) that was present along the eastern edge of the East Basement. A portion of this acid drain pipe was video borescoped utilizing the clean out ports located at various locations along the drain. For drains that remain open or with alternate means available for entry into the drainpipe, a video borescope was run into each drain in the sub-grade areas (to existing equipment limitations) until refusal by blockage or contortion of drain pipe or the extent of the borescope range was met.

Along with a visual observation of drainpipe condition, the video information was reviewed to determine if there was liquid/sludge materials present in the drainpipes that could be sampled and analyzed. The video and samples collected are intended to be used to support the development of the C-400 Complex RI/FS Report. If the drains were plugged, no effort was made to clear the drain in an attempt to evaluate the drainpipes with a video borescope. During the course of the survey, two different borescopes were utilized. The first borescope was able to pass through bends more readily. The second borescope incorporated a self-leveling camera and accurate on-screen footage.

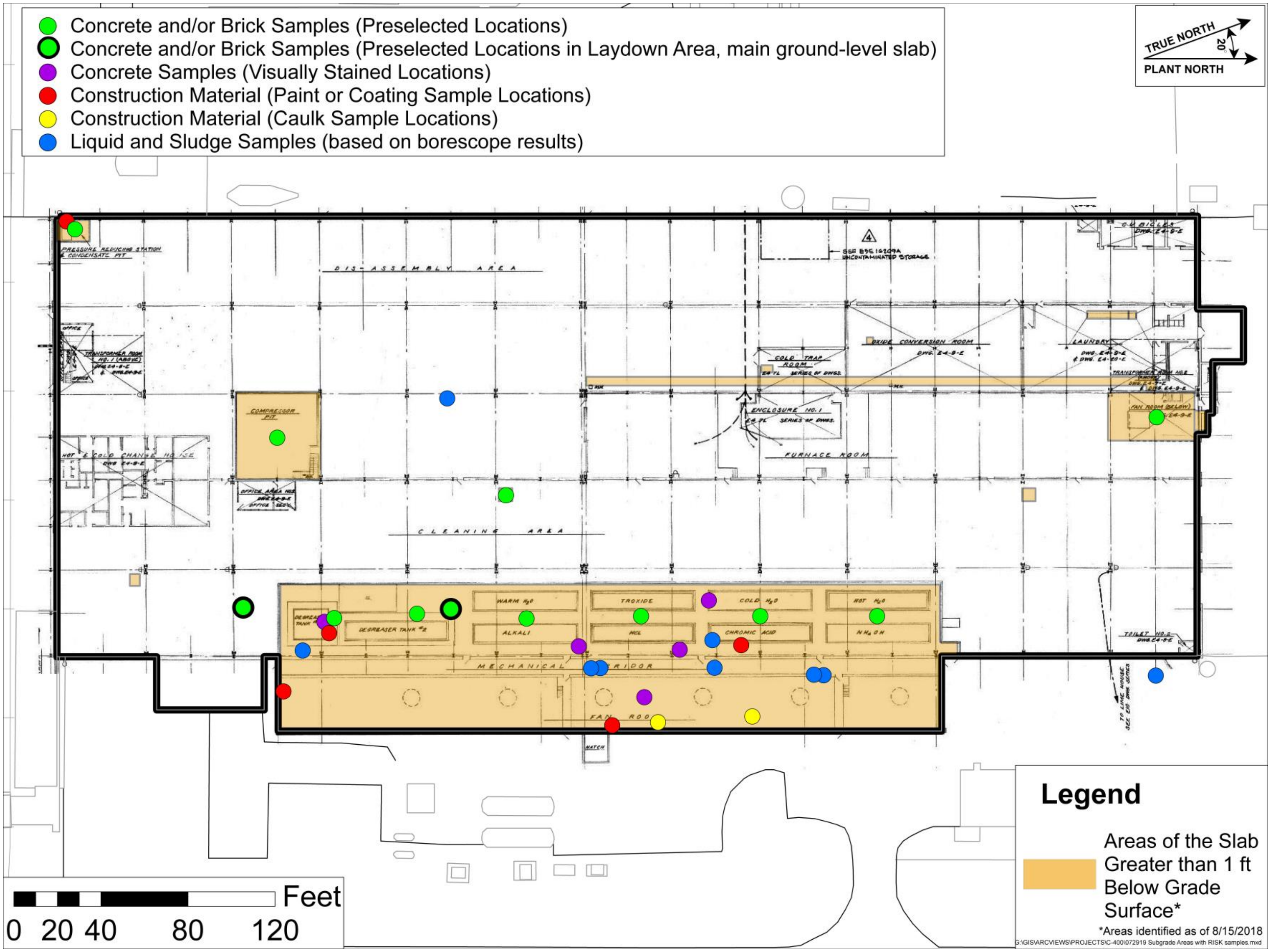

Figure 5. Sampling Locations

Video footage of the floor drain surveys and a map depicting the borescope locations are included in Appendix C. Each video narrative is provided below and was derived from the narratives included in Appendix C. The footage referenced in the narratives indicate ft of video borescope cable. In cases where a sample was collected from the drain, a note has been appended to the narrative that links the narrative to a sample number. Figure 6 provides a reference for the locations described.

1. <u>C-400 Southeast Acid Waste Cleanout Vent.</u> A borescope was guided through the 180° 4-inch vent pipe and down toward the acid waste drain. The cleanout pipe ties into the vent pipe at the 04:50 minute mark of the inspection. The vent pipe continues to traverse downward toward the acid drain. The borescope was inserted approximately 10 ft into the pipe during the inspection before encountering resistance. The pinkish haze seen in the video is a defect in the borescope camera.

2. <u>C-400 SWMU 98.</u> A borescope was used to inspect the 18-inch diameter sump walls and determine the level of water and sediment. The borescope was rotated continually around the sump to examine the wall surfaces above and below the liquid level. The liquid level was 22 inches below the floor level, which calculated to 50 inches of material in the sump based on drawing E4-24-M. Inspection of the tile seams at the 03:30 minute mark shows air bubbles trapped between the sections. The drain into the sump appears at 05:45 minutes; 9 inches of sediment was encountered at 07:30 minutes. Sediment level was estimated based on drawing E4-24-M. Note: A sludge sample (400-BASE7SSLDG-08) from this location was collected and analyzed. See Numbers 28–31 for further inspections.

3. <u>C-400 West Center Thru-Wall Drain.</u> The borescope entered the 4-inch pipe located next to the west side center pedestrian door that exits the building at floor level then turned down 10 ft toward the discard solution drain. No water was present; dry debris was present in the pipe. No sample was collected because the debris was not retrievable. See Number 19 for further inspection with the second borescope.

4. <u>C-403 Neutralization Pit.</u> The pit was inspected to determine the height of the liquid above the C-400 acid drain inlet line. The water level was estimated at 9 ft above the acid drain entry to the pit, based on counting courses of brick. The drain enters at approximately 361.5 ft above mean sea level. This location is outside the C-400 Cleaning Building.

5. <u>C-400 Drain under Spray Booth.</u> When the spray booth walls were removed, a drain was discovered and examined. The liquid rose as the borescope was inserted. At 6 ft, rocky sediment was encountered at 01:03 minutes. Further inspection indicated that the drain entered a larger pipe; however, the sediment prevented continued exploration. Upon further evaluation, including review of building drawings (specifically, drawing M5E-ZA0054-A03), this "drain" was determined to be a sump for the spray booth. This sump is constructed of 4-inch pipe that flanges out to a 6-inch vertical pipe with a cap on the bottom. During operations, liquids that accumulated in this pipe were removed via pumping. Total length of the pipe is approximately 6 ft. The drawings further indicate that the 6-inch pipe is located within a larger sump that was taken out of service and filled with concrete approximately in the 2000 time frame. Note: A liquid sample (400-Z9LIQ-01) from this location was collected and analyzed.

6. <u>C-400 Northeast Acid Drain Cleanout.</u> The cap was removed from a 4-inch cleanout located 24 ft from the northeast corner of the building. The liquid level, seen at 03:50 minutes, was 150 inches below the cleanout. At 05:39 minutes, the acid drain is visible, but continued examination stirred up debris impairing visibility. Note: A liquid sample (400-BASE8LLIQD-11) from this location was collected and analyzed. See Number 32 for post draining inspection.

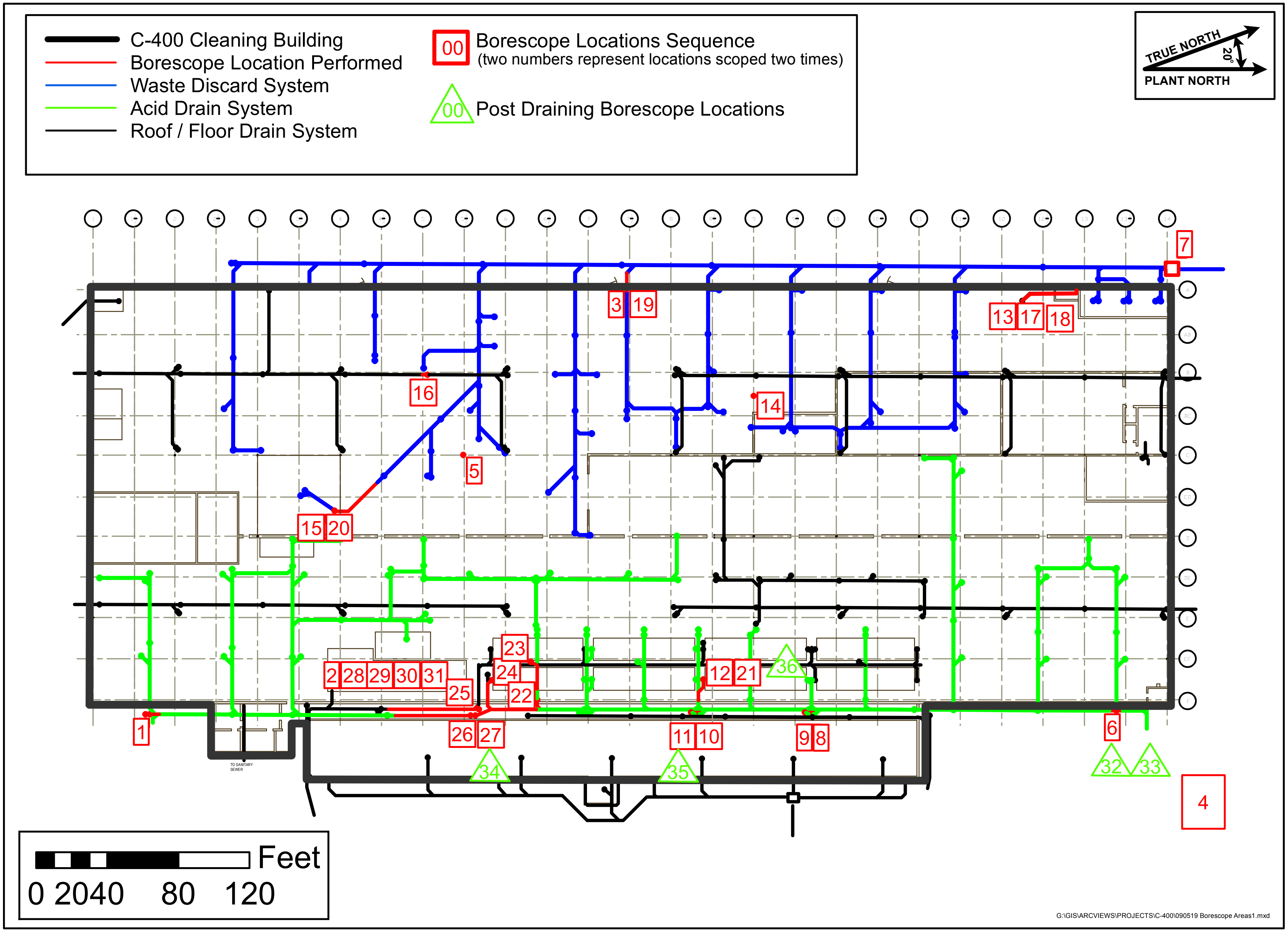

Figure 6. Video Borescope Locations

7. C-400 Northwest Discard Solution Sump. The video provides an overall visual inspection of the sump. Liquid level just above the drain inlet is indicated at the 03:07 minute mark. This location is outside the C-400 Cleaning Building.

8. C-400 Plenum Room North Backwater Valve Pit. Water level was below the floor drain. Duriron backwater valve[1] was not visible during inspection due to murkiness and depth of water. Note: Two sludge samples (400-BASE1SSLDG-01 and 400-BASE1SSLDG-02) from this location were collected and analyzed. Because the samples contained a significant amount of suspended solids, no liquid sample was collected.

9. C-400 Plenum Room North Floor Drain. Water level was below the drain. The drain line is 3 inches in diameter. Water level rose as borescope was inserted. Duriron backwater valve was closed to prevent water return from C-403. Note: Two sludge samples (400-BASE1SSLDG-01 and 400-BASE1SSLDG-02) from this location were collected and analyzed. Because the samples contained a significant amount of suspended solids, no liquid sample was collected.

10. C-400 Plenum Room Center Backwater Valve Pit. Water level was below floor drain level. Duriron backwater valve[2] was present. Note: A liquid sample (400-BASE1LLIQD-04) and a sludge sample (400-BASE1SSLDG-03) from this location were collected and analyzed.

11. C-400 Plenum Room Center Floor Drain. Water level was above the drain. The drain line is 3 inches in diameter. Duriron backwater valve was closed to prevent water return from C-403. See Number 35 for post draining inspection. Note: A liquid sample (400-BASE1LLIQD-04) and a sludge sample (400-BASE1SSLDG-03) from this location were collected and analyzed.

12. C-400 Plenum Room Chromic Acid Tank South Drain. The borescope entered floor drain through a previously sectioned opening in pipe. Water level was slightly above or at floor level. See Number 21 for further inspection with the second borescope. See Number 21 for further inspection with the second borescope and Number 36 for post draining inspection. Note: A liquid sample (400-BASE1LLIQD-07) from this location was collected and analyzed.

13. C-400 above Floor Capped Drain. A 4-ft long, 3-inch diameter pipe extends above floor level at an approximate 30° angle. Approximately 12 ft of pipe was borescoped before encountering resistance. See Numbers 17 and 18 for further inspection of this sanitary drain with the second borescope.

14. C-400 Floor Valve Column B-9. Because the pipe was filled with mortar, no borescope was attempted.

15. C-400 Compressor Pit Sump Drain. Approximately 8 ft of 4-inch diameter line was borescoped before encountering resistance. See Number 20 for further inspection with the second borescope.

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[1] The Duriron backwater valve was a valve pit located in the floor of the Plenum Room. This valve pit contained a backflow preventer in the Plenum Room floor drain lines because certain floor drains from the Plenum Room drained to the acid drain system. In the event water backed up in the acid drain system, the backflow preventer ensured water did not enter the Plenum Room through the floor drains. Based upon difficulties with video borescoping because of the presence of the backflow preventer in the valve pits at locations 8, 9, 10, and 11, it was determined that video borescoping of the backwater valve pits and associated drains was not possible beyond the backflow preventer. Because of this, video borescoping in the south backwater valve pit was not attempted; however, two sludge samples (400-BASE1SSLDG-05 and 400 BASE1SSLDG-06) were collected at the C-400 Plenum Room south backwater valve pit.

[2] See Footnote 1.

16. C-400 Covered Drain Cleanout Column B-5. The borescope encountered water above the removable 4-inch cleanout just below floor level. The cleanout was punctured for access. It was determined that the cleanout was tied to the roof drain and was sealed temporarily.

17. C-400 above Floor Capped Drain (Second Borescope). The sanitary drain was reinspected with the second borescope. At 02:45 minutes, 22 ft into the sanitary drain, a very small amount of water was present; and at 04:22 minutes, 40 ft, a sludge covered the camera lens. See Number 13 for initial inspection and Number 18 for further inspection.

18. C-400 above Floor Capped Drain 2nd Sludge. A further look at the sludge encountered showed no obstruction was in pipe. A layer of material was present on the bottom of pipe. See Numbers 13 and 17 for previous inspections.

19. C-400 West Center Thru-Wall Drain (Second Borescope). The second borescope would not pass through first bend in the 4-inch pipe. See Number 3 for initial inspection.

20. C-400 Compressor Pit Sump Drain (Second Borescope). The 4-inch drain was reinspected with the second borescope. At 02:25 minutes, 35 ft into the drain, significant debris was encountered in the line. The debris covered the lens when the camera came in contact with material. A sample was not collected because the material was not retrievable. See Number 15 for initial inspection.

21. C-400 Plenum Room Chromic Acid Tank South Drain (Second Borescope). The 6-inch drain was reinspected with the second borescope. The liquid was slightly above or at floor level and 2.5 ft above the bottom of the drain. This is initially a 6-inch drain, and it expands to 8 inches. At 02:09 minutes, 9 ft into the pipe, the camera lens is covered with material. The borescope was inserted 19 ft until resistance was encountered with the video signal cutting in and out, as further inspection of the drain was performed. See Number 12 for initial inspection and Number 36 for post draining inspection. Note: A liquid sample (400-BASE1LLIQD-07) from this location was collected and analyzed.

22. C-400 Plenum Room Top Floor Drain #7. The 4-inch drain, located near the alkali tank, was inspected with the second borescope. The drain drops and turns 90° west below the floor surface, then 90° south to a common header for the acid drain system. Approximately 7 ft into the line, resistance was encountered, but no obstruction was observed. Liquid was observed, but a sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

23. C-400 Plenum Room Top Floor Drain #6. The 4-inch drain, located near the warm water tank, was inspected with the second borescope. The liquid was below floor grade and 6 inches above the bottom of the drain. Inspection of the acid drain lines stirred up material located throughout the piping, as shown at 00:39 minutes, 11 ft into the common pipe toward drain #7 (see Number 22). A liquid sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

24. C-400 Plenum Room Alkali Tank South Drain. The 6-inch drain was inspected with the second borescope. The liquid was at floor level and 1.5 ft above the bottom of the drain. At 01:13 minutes, 9 ft into the pipe, it was possible to insert the borescope more rapidly, providing a brief view of the pipe condition before the material disturbance obscured the view. The borescope was inserted 19 ft until resistance was encountered, with the video signal cutting in and out as further inspection of the drain was performed. A liquid sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

25. C-400 Plenum Room Drain To Storm Sewer. The 8-inch drain was inspected with the second borescope. Dry scaly material covered the borescope as it was pushed through the pipe. At 02:26 minutes, 38 ft into the pipe, liquid was present in the pipe. At 03:11 minutes, 48 ft, the borescope was submerged below the material preventing proper draining. The borescope was inserted 60 ft until resistance was encountered. Total blockage of pipe was not observed on the camera; however, the scope could not be advanced due to mechanical limitations. A sample was not collected because the material was not retrievable.

26. C-400 Plenum Room Southward Acid Waste Drain. The drain was inspected with the second borescope. Wet flakey material covered the borescope lens as it was pushed through the pipe. At 02:01 minutes, 19.5 ft into the pipe, the material covered the borescope lens. The dry material was encountered at several locations in the pipe. The borescope was inserted 78 ft until resistance was encountered. A sample was not collected because the material was not retrievable.

27. C-400 Plenum Room Northward Acid Waste Drain. The drain was inspected with the second borescope. The liquid was at floor level and precipitate covered the bottom of the pipe. The borescope stirred up the material, completely blocking the camera. At 02:11 minutes, 14 ft into the pipe, it was possible to insert the borescope more rapidly, providing a brief view of the drain condition before the material disturbance obscured the view. The borescope was inserted 32 ft until resistance was encountered. See Number 34 for post draining inspection. A liquid sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

28. C-400 SWMU 98 Post Pumped Part 1. Total inspection of the sump required multiple attempts due to the formation of condensation on the lens when inserted into the sump; the condensation repeatedly reduced the video quality; the borescope lens was cleaned, and inspection continued (see Numbers 29 and 30). From approximately 00:40 minutes to approximately 01:25 minutes, the seam between the two portions of the sump is visible. The remaining material was 78 inches from the floor level. See Number 2 for initial inspection and Numbers 29–31 for further inspections. Note: A liquid sample (400-BASE7LLIQD-09) from this location was collected and analyzed.

29. C-400 SWMU 98 Post Pumped Part 2. From approximately 00:30 minutes to approximately 02:20 minutes, the seam between the two portions of the sump is visible. The inlet to the sump is visible beginning at approximately 02:20 minutes. The sump floor was not visible. See Number 2 for initial inspection and Numbers 28, 30, and 31 for further inspections.

30. C-400 SWMU 98 Post Pumped Part 3. The sump floor was not visible. See Number 2 for initial inspection and Numbers 28, 29, and 31 for further inspections.

31. C-400 SWMU 98 Post Pumped Inlet. The inlet was inspected with the second borescope. The 4-inch drain into the sump is reduced to approximately 1 inch due to material buildup, and it could not be accessed with the borescope. See Number 2 for initial inspection and Numbers 28, 29, and 30 for further inspections.

32. C-400 Northeast Cleanout Post C-403 Pumping. The cleanout located 24 ft from the northeast corner of the building was reexamined after pumping out the C-403 pit to a point that was below the acid drain tie in inlet line. The liquid level, seen at 00:48 minutes, was 12.5 ft into the pipe from the cleanout and at approximately the same height as observed previously, indicating the acid drain is isolated from the pit and not draining into the pit. At 05:32 minutes, 20 ft into the cleanout, the connecting pipe to the pit was visible. As the borescope was maneuvered into the connecting pipe, the camera lens was covered with debris. The inspection continued another 6.5 ft until resistance was

encountered. See Number 6 for initial inspection. Note: A liquid sample (400-BASE8LLIQD-11) from this location was collected and analyzed.

33. C-400 Northeast Cleanout Post Drain Line Pumping. The cleanout located 24 ft from the northeast corner of the building was reexamined after pumping out as much of the liquid from the drain line as physically possible. The liquid level encountered at 01:36 minutes is 15 ft into the pipe, from the cleanout. At 02:35 minutes, the borescope self-rotated lying horizontally in the pipe, and the camera lens becomes covered with debris at 16.5 ft into the pipe. Due to debris covering the camera lens, no further inspection into the drain was performed. Note: A liquid sample (400-BASE8LLIQD-11) from this location was collected and analyzed.

34. C-400 Plenum Room Northward Acid Waste Drain Post Pumping. The drain was reexamined after pumping out the northeast cleanout. At 00:50 minutes, 2 ft into the drain, scaling was present on the pipe wall. At 01:07 minutes, 3.5 ft into the drain, debris was present in the bottom of the drain. Several attempts were made to traverse northward through the drain as previously performed; however, the debris lying in the bottom of the pipe covered the camera lens, preventing further inspection of the drain. There was no liquid visible during the inspection. See Number 27 for initial inspection. A liquid sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

35. C-400 Plenum Room Center Floor Drain Post Drain Line Pumping. The floor drain was reexamined after pumping out the northeast cleanout. All standing water, as previously noted, had drained through the backflow preventer valve into the acid drain. See Number 11 for initial inspection. A liquid sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

36. C-400 Plenum Room Chromic Acid Tank South Drain Post Drain Line Pumping. The drain was reexamined after pumping out the northeast cleanout. At 00:30 minutes, 3 ft into the line, debris was present in the bottom of the drain. Several attempts were made to traverse the drain as previously performed; however, the debris lying in the bottom of the pipe covered the camera lens preventing further inspection of the drain. There was no liquid visible during the inspection. A liquid sample was not collected at this location because the samples collected as noted in Numbers 6, 12, 21, 32, and 33 were considered to be representative due to being connected by a common header.

2.1.2 Concrete Sampling

Sampling locations were biased to areas where contamination was expected to be present (judgmental), and locations were selected in one of the following ways.

- Preselected concrete sample locations were discussed by the FFA parties during the RI/FS Work Plan scoping and primarily are based on future subsurface borings during the RI/FS field work. Process information and existing data (e.g., adjacent to floor drains) were used to preselect sample locations;

- During field implementation, visually stained concrete locations were selected for sampling.

The locations of preselected samples and visually stained samples are discussed within this section. At locations that had multiple depths sampled, the sample depths were the upper portion (of sufficient thickness to collect the amount of material necessary for analysis) and the lower portion (of sufficient thickness to collect the amount of material necessary for analysis) of the concrete core sampling location.

The depth of the lower portion of the concrete to be sampled was based on the anticipated thickness of the concrete at the sampling location.

Concrete core locations were identified and marked, and the sampling/boring work area was set up. Smears and direct radiological readings were obtained at the preselected sampling/boring location prior to collecting the core.

A water recovery system and/or vacuum was set up at the sampling/boring location as necessary to capture the water used by the equipment during drilling. Concrete core drilling occurred according to the manufacturer's instructions. When each concrete core was cut to depth and removed from the floor, both smears and direct radiological readings were obtained from the preselected concrete core sample. Upon confirmation that the alpha/beta activity levels from the direct readings were below limits set forth by the radiation work permit, a band saw, hammer, and chisel were used to cut or break a section (puck) off of the concrete bore sample. The resulting puck was size-reduced and placed into a sample container and handled according to CP4-ES-5004, *Sample Tracking, Lab Coordination, and Sample Handling*. Samples were obtained according to CP4-ES-2002, *Sampling of Structural Elements and Miscellaneous Surfaces*.

Archived concrete core material was labeled on the top and bottom surface of the core with a permanent marker; the labels were marked with sampling location, top/bottom (orientation) of core, and date collected. Core boring waste was removed from the work area and disposed of according to CP3-WM-3015, *Waste Packaging*. Holes greater than 4 inches deep that had been created by removal of concrete cores were filled with sand and bentonite (i.e., sand was poured into the hole and then capped with bentonite); holes less than 4 inches where filled in the same manner if they presented a tripping hazard (e.g., if they were located in areas of high foot traffic).

For all but polychlorinated biphenyl (PCB) samples, the drill bit and any other portion of the drilling apparatus, as appropriate, then were cleaned and decontaminated according to CP4-ES-2702, *Decontamination of Sampling Equipment and Devices*. The drill bit then was rinsed using deionized water after each drilling activity before moving to the next work activity location.

In order to sample the concrete for PCBs, a collocated area was used. These concrete samples were collected, and drilling and sampling equipment was decontaminated, consistent with *Standard Operating Procedure for Sampling Porous Surfaces for Polychlorinated Biphenyls (PCBs)* (EPA 2011).

In some preselected sampling locations, original construction of the basement included a primary concrete floor with a finish slab of concrete above. One location was constructed of a brick floor with a concrete slab below. Where multiple media types were present (i.e., brick and concrete) in the sub-grade areas, samples were collected from each media type. If media types were the same (i.e., finish slab above primary concrete), the samples were collected at the surface and final lower depth of the sampling location.

For visually stained locations and two locations at grade (i.e., on the main floor), samples were collected only from the surface of the floor, rather than at the surface and below the surface as described above for sub-grade, preselected locations.

2.2 ANALYTICAL METHODS

Analytical methods were performed, as described in the July 2018 SAP (DOE 2018a).

2.3 EAST BASEMENT/PLENUM ROOM

Samples from concrete, paint, liquid, and sludge were collected in this region of the C-400 Building. Their locations are shown in Figure 7.

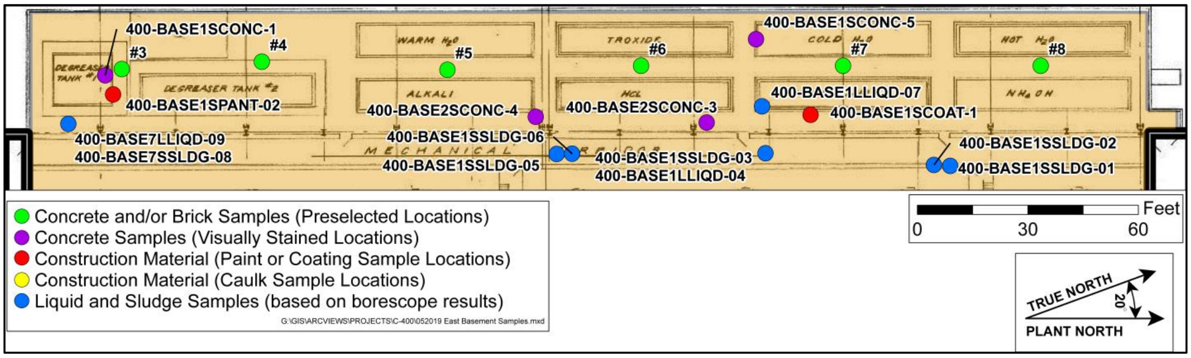

Figure 7. East Basement/Plenum Room Sampling Locations

2.3.1 Concrete Sampling

A total of 16 samples and 1 duplicate were collected in this region of the C-400 Building. During concrete core sampling activities, at locations #5 through #8, it was discovered that at an approximate 4-inch depth the concrete had an existing seam that appeared to be created from a separate pour. In addition, during concrete core sampling activities at locations #3 and #4, it was discovered that at an approximate 1½-inch depth, the concrete had an existing seam.

2.3.1.1 Preselected locations

A total of 12 samples and 1 duplicate were collected from six preselected locations within this region: eight samples were collected from the Plenum Room and four samples were collected from the East Basement. At each location, one sample was collected from the top (or upper portion) and one sample from the bottom (or lower portion) of a concrete core. Sample numbers were designated as follows:

- Location #3: 400-BASE1SCONC-01 and 400-BASE1SCONC-01D (upper) and 400-BASE1SCONC-02 (lower)
- Location #4: 400-BASE1SCONC-03 (upper) and 400-BASE1SCONC-04 (lower)
- Location #5: 400-BASE1SCONC-05 (upper) and 400-BASE1SCONC-06 (lower)
- Location #6: 400-BASE1SCONC-07 (upper) and 400-BASE1SCONC-08 (lower)
- Location #7: 400-BASE1SCONC-09 (upper) and 400-BASE1SCONC-10 (lower)
- Location #8: 400-BASE1SCONC-11 (upper) and 400-BASE1SCONC-12 (lower)

The concrete samples were analyzed for an anion (fluoride); organics [volatile organic compounds (VOCs), also called volatile organic analytes (VOAs); semivolatile organic compounds (SVOCs), also called semivolatile organic analytes (SVOAs)]; PCBs (collected from a collocated area)]; metals; asbestos (top sample only); and radionuclides.

Additionally, total alpha/beta activity (i.e., direct radiological readings) and removable alpha/beta activity (i.e., smear radiological readings) were measured on the concrete samples. These readings are presented in Appendix A.

2.3.1.2 Visually stained locations

A total of four samples were collected from visually stained locations within this region. Three samples were collected from the Plenum Room (400-BASE1SCONC-5, 400-BASE2SCONC-3, and 400-BASE2SCONC-4) and one sample was collected from the East Basement (400-BASE1SCONC-1). The visually stained samples were analyzed for PCBs and radionuclides. Additionally, total alpha/beta activity and removable alpha/beta activity were measured on the concrete sample 400-BASE2SCONC-3 for health and safety purposes.

2.3.2 Paint/Coating Sampling

A total of two paint/coating samples were collected from locations within this region. One sample of coating was collected from the Plenum Room (400-BASE1SCOAT-1). One sample of paint was collected from the East Basement (400-BASE1SPANT-02) from the degreaser tank, which will be removed during deactivation. These samples were analyzed for an anion (fluoride), metals, PCBs, and radionuclides.

2.3.3 Liquid and Sludge Sampling

A total of nine liquid and/or sludge samples were collected from locations within this region. The three liquid samples [400-BASE1LLIQD-04, 400-BASE1LLIQD-07, and 400-BASE7LLIQD-09 (from SWMU 98)] and six sludge samples [400-BASE1SSLDG-01, 400-BASE1SSLDG-02, 400-BASE1SSLDG-03, 400-BASE1SSLDG-05, 400-BASE1SSLDG-06, 400-BASE7SSLDG-08 (from SWMU 98)] were collected from open drain lines, valve pits, and sump. These samples were analyzed as follows:

- 400-BASE1LLIQD-04, 400-BASE1LLIQD-07: VOCs and radionuclides;
- 400-BASE7LLIQD-09: Radionuclides;
- 400-BASE7LLIQD-09R: Anion (fluoride), metals, VOCs, SVOCs, and PCBs;
- 400-BASE1SSLDG-01, 400-BASE1SSLDG-02, 400-BASE1SSLDG-03, and 400-BASE1SSLDG-05, 400-BASE1SSLDG-06: Anion (fluoride), metals, SVOCs, PCBs, and radionuclides;
- 400-BASE1SSLDG-01R, 400-BASE1SSLDG-02R, 400-BASE1SSLDG-03R, and 400-BASE1SSLDG-05R, 400-BASE1SSLDG-06R: VOCs; and
- 400-BASE7SSLDG-08: Anion (fluoride), metals, VOCs, SVOCs, PCBs, and radionuclides.

In the initial sampling event, five of the sludge samples (400-BASE1SSLDG-01, 400-BASE1SSLDG-02, 400-BASE1SSLDG-03, 400-BASE1SSLDG-05, 400-BASE1SSLDG-06) contained air in the VOC aliquot. Resampling was conducted for those five samples for VOCs; an "R" was appended to the original sample number to signify the results of the resampling for VOCs. One of the liquid samples location was sampled twice; first, for radionuclides (400-BASE7LLIQD-09), then for an anion (fluoride), metals, VOCs, SVOCs, and PCBs (400-BASE7LLIQD-09R).

2.4 EAST FAN ROOM

Samples from concrete, paint, and caulk were collected in this region of the C-400 Building. Their locations are shown in Figure 8.

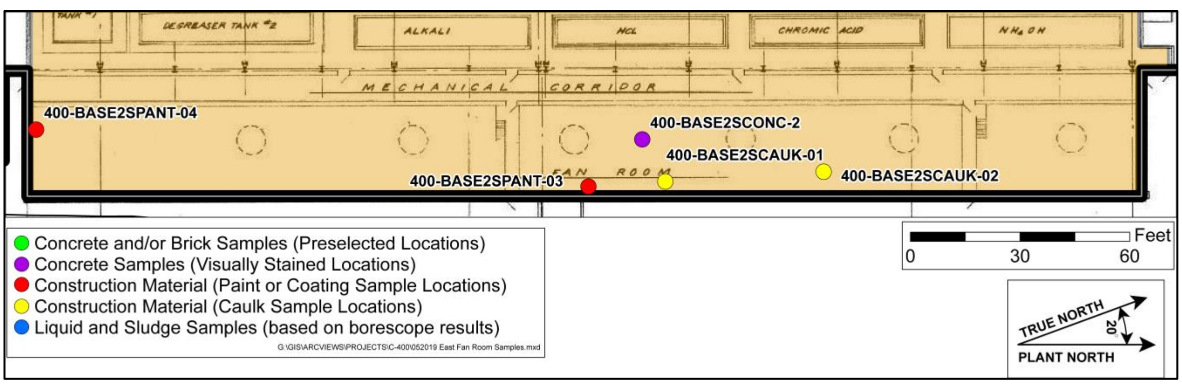

Figure 8. East Fan Room Sampling Locations

2.4.1 Concrete Sampling

No preselected concrete sampling locations were identified in this area. One sample (400-BASE2SCONC-2) was collected from a visually stained motor mount base located in this area of C-400. The sample was analyzed for PCBs and radionuclides.

2.4.2 Paint Sampling

A total of two paint samples (400-BASE2SPANT-03 and 400-BASE2SPANT-04) were collected from locations within this region. These samples were analyzed for an anion (fluoride), metals, PCBs, and radionuclides.

2.4.3 Caulk Sampling

A total of two caulk samples (400-BASE2SCAUK-01 and 400-BASE2SCAUK-02) were collected from locations within this region. The caulk was located between concrete wall expansion joints. These samples were analyzed for PCBs.

2.5 COMPRESSOR DISASSEMBLY PIT

Two concrete samples and two brick samples were collected from a preselected location in this region of the C-400 Building. The location is shown in Figure 9.

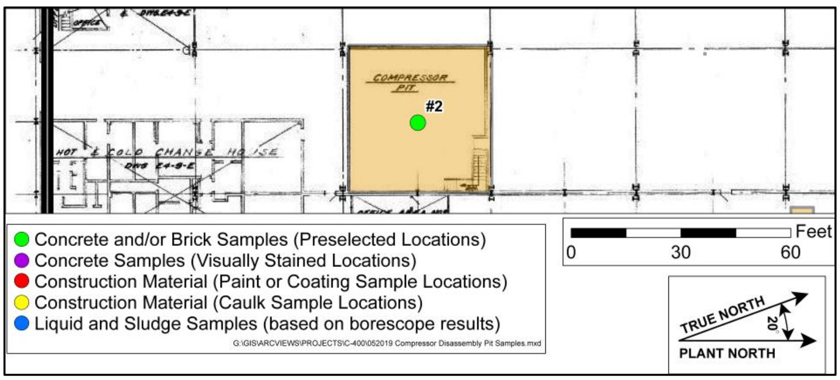

Figure 9. Compressor Disassembly Pit Sampling Locations

Because the Compressor Pit's floor was lined with brick with concrete underlying the brick, core samples were taken of the top and bottom of each material. One sample was collected from the top of the brick (400-BASE3SBRCK-01) and one sample from the bottom of the brick (400-BASE3SBRCK-02). One sample was collected from the top of the concrete underlying the brick (400-BASE3SCONC-01) and one sample from the bottom of the concrete underlying the brick (400-BASE3SCONC-02). These samples were analyzed for asbestos (top concrete sample only); an anion (fluoride); metals; organics [VOCs, SVOCs, and PCBs (collected from a collocated area)]; and radionuclides.

Additionally, total alpha/beta activity and removable alpha/beta activity were measured on the concrete samples. These readings are presented in Appendix A.

2.6 PRESSURE REDUCING STATION AND CONDENSATE PIT

Samples from concrete and paint were collected in this region of the C-400 Building. Their locations are shown in Figure 10.

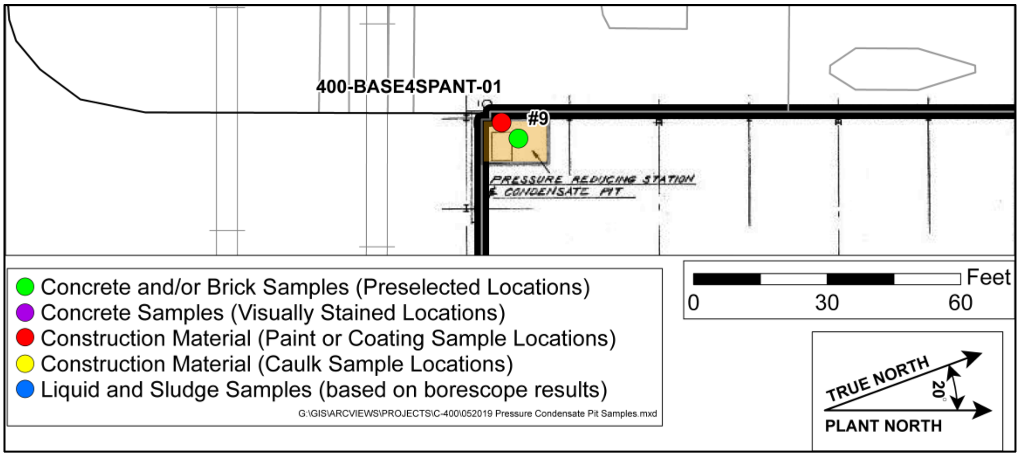

Figure 10. Pressure Reducing Station and Condensate Pit Sampling Locations

2.6.1 Concrete Sampling

Samples were collected from two preselected locations in this region of the C-400 Building. One sample was collected from the top (400-BASE4SCONC-01) and one sample from the bottom (400-BASE4SCONC-02R) of core(s). PCB samples were collected from a collocated area (400-BASE4SCONC-01P and 400-BASE4SCONC-02P). Samples were analyzed for asbestos (top sample only); an anion (fluoride); metals; organics [VOCs, SVOCs, and PCBs (collected from a collocated area)]; and radionuclides. In the initial sampling event, equipment was decontaminated improperly, so the lower concrete core sample was resampled, and the data from the initial sample were rejected. Decontamination at subsequent locations was performed correctly.

Additionally, total alpha/beta activity (i.e., direct radiological readings) and removable alpha/beta activity (i.e., smear radiological readings) were measured on the concrete samples. These readings are presented in Appendix A.

2.6.2 Paint Sampling

One paint sample (400-BASE4SPANT-01) was collected from this region. This sample was analyzed for an anion (fluoride), metals, PCBs, and radionuclides.

2.7 MAINTENANCE PIT (EAST TRUCK ALLEY)

Two concrete samples and one duplicate were collected from one preselected location in this region of the C-400 Building. One sample was collected from the top (400-BASE5SCONC-01) and one sample and a duplicate from the bottom (400-BASE5SCONC-02 and 400-BASE5SCONC-02D) of a core. In this area, the slab thickness was thinner than anticipated (approximately 5 inches). The concrete coring machine penetrated the entire slab; the resulting hole was filled. The location is shown in Figure 11.

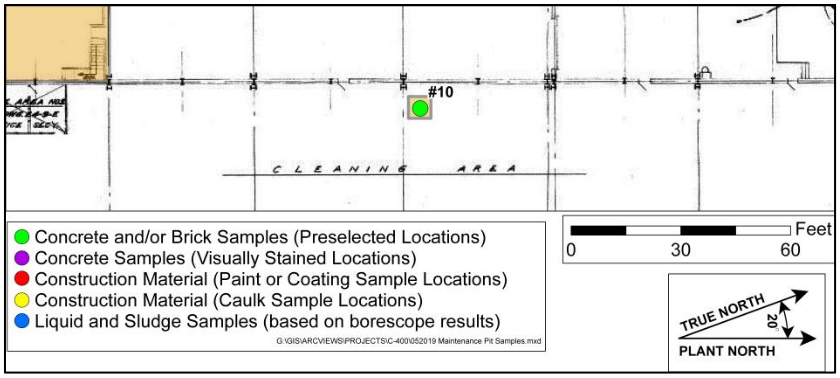

Figure 11. Maintenance Pit Sampling Locations

The samples were analyzed for asbestos (top sample only), an anion (fluoride); metals; organics [VOCs, SVOCs, and PCBs (collected from a collocated area)]; and radionuclides.

Additionally, total alpha/beta activity (i.e., direct radiological readings) and removable alpha/beta activity (i.e., smear radiological readings) were measured on the concrete samples. These readings are presented in Appendix A.

2.8 NORTH FAN ROOM/VENTILATION SYSTEM

Two samples from concrete were collected from a preselected location in this region of the C-400 Building. One sample was collected from the top (400-BASE6SCONC-01) and one sample from the bottom (400-BASE6SCONC-02) of a core. Its location is shown in Figure 12.

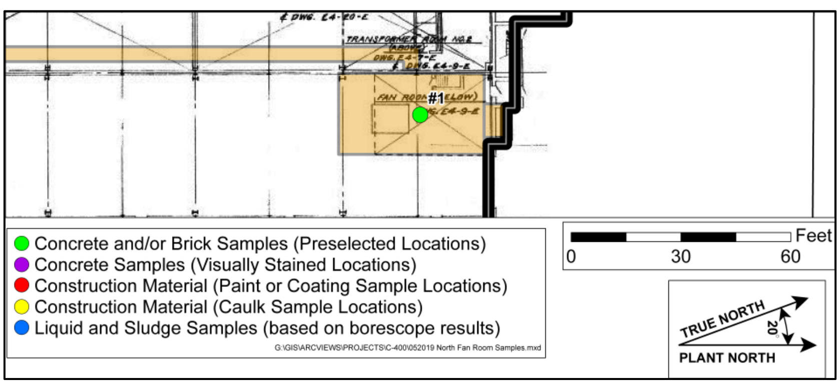

Figure 12. North Fan Room Sampling Locations

During concrete core sampling activities, at location #1, it was discovered that at an approximate 1-in depth the concrete had an existing seam. Wire mesh existed in this 1-inch layer of concrete. These concrete samples were analyzed for asbestos (top sample only); an anion (fluoride); metals; PCBs (collected from a collocated area); and radionuclides.

Additionally, total alpha/beta activity (i.e., direct radiological readings) and removable alpha/beta activity (i.e., smear radiological readings) were measured on the concrete samples. These readings are presented in Appendix A.

2.9 LAYDOWN AREA FOR DEGREASER (MAIN GROUND-LEVEL SLAB)

Two samples were collected from preselected locations in this region of the C-400 Building. Their locations are shown in Figure 13.

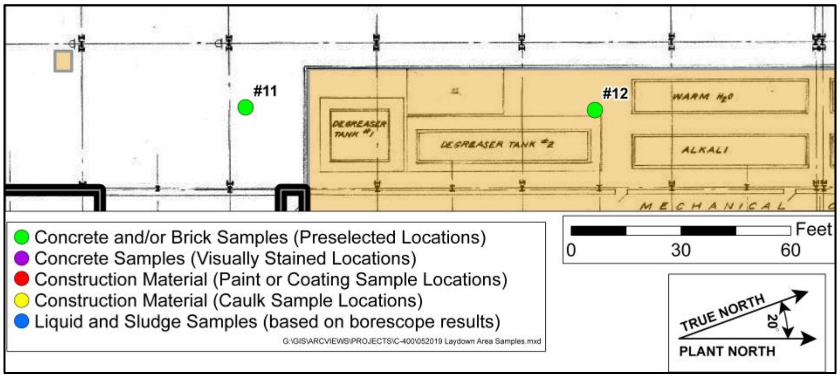

Figure 13. Laydown Area Sampling Locations

Location #11 (sample 400-BASE8SCONC-01) consisted of concrete, while Location #12 (sample 400-BASE8SCONC-02) was brick. These samples were analyzed for asbestos; an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides.

Additionally, total alpha/beta activity (i.e., direct radiological readings) and removable alpha/beta activity (i.e., smear radiological readings) were measured on the concrete samples. These readings are presented in Appendix A.

2.10 ADDITIONAL PIPELINE SAMPLE

One additional liquid sample (400-BASE8LLIQD-11) was collected from an acid drain line located outside the northeast corner of the building. The liquid sample was analyzed for an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. The sampling location is shown in Figure 14.

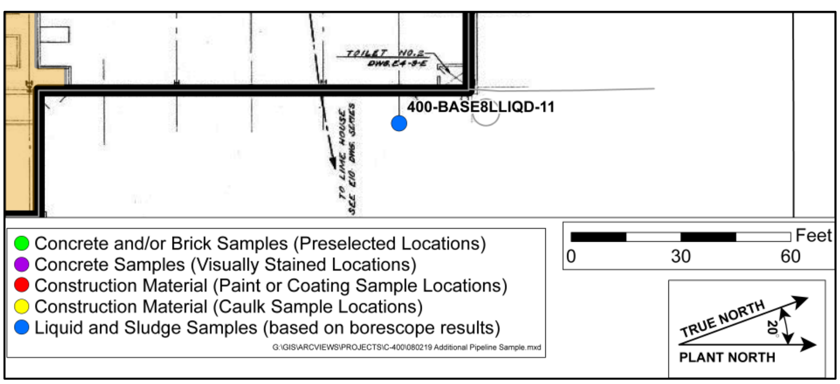

Figure 14. Additional Pipeline Sampling Location

2.11 SPRAY BOOTH SUMP

Although not originally identified in the July 2018 SAP, one liquid sample (400-Z9LIQ-01) was collected from this location when a sump was exposed after the Spray Booth floor pan was removed (see Appendix A). The liquid sample was analyzed for an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. The sampling location is shown in Figure 15.

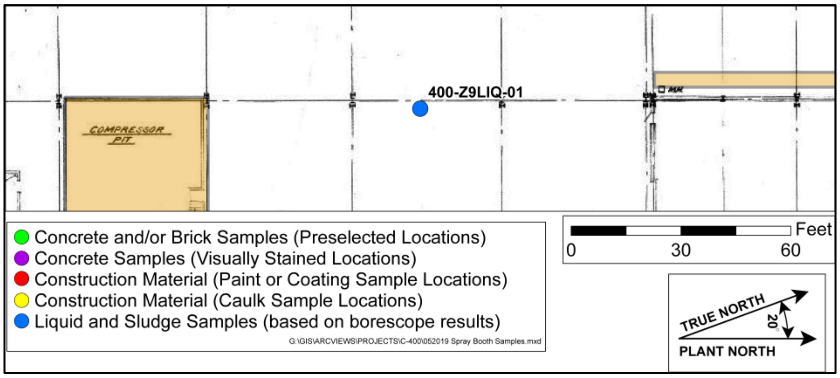

Figure 15. Spray Booth Sump Sampling Location

2.12 QUALITY ASSURANCE/QUALITY CONTROL

Project action levels listed in the Quality Assurance Project Plan (QAPP) reference the child resident no action levels (NALs) established by the Risk Methods Document to support project planning (DOE 2019b). Lower analytical reporting limits were not needed for constituents that did not meet the project action level child resident NAL because the area is expected to remain industrial.

QC was monitored throughout the investigation process. QC included field sampling, laboratory analysis, and data management. This section describes QC associated with the characterization of C-400 Basement slab and subsurface structures.

2.12.1 Field QC

Field QC samples were collected to assess data quality. Table 1 compares the number of actual field QC samples collected during field implementation with the number of field QC samples in the QAPP (DOE 2018a). Appendix B provides the data from the field QC samples in a searchable format on compact disk.

Table 1. Field QA Samples (Actual versus QAPP)

Analyte/ Analytical Group	Field Samples Actual/QAPP	Field Duplicates Actual/QAPP	Field Blanks Actual/QAPP	Equipment Blanks Actual/QAPP	Trip Blanks Actual/QAPP
VOCs	35/28	2/2	2/1	2/1	8/1
Metals	40/34	2/2	2/2	2/2	0/0
SVOCs	33/30	2/2	2/1	2/1	0/0
PCBs	47/53	2/3	2/1	2/1	0/0
Radionuclides	47/47	2/3	2/2	2/2	0/0
Asbestos	13/13	1/1	0/0	0/0	0/0

2.12.2 Laboratory QC

The field samples shown in Table 1 were sent to General Engineering Laboratories, LLC, (GEL); GEL analyzed for all target analytes, except asbestos. Asbestos samples were sent to Materials and Chemistry Laboratory, Inc., for asbestos analysis. The laboratories were contracted through the Sample Management Office (SMO) and participate in the Department of Energy Consolidated Audit Program and maintain a Radioactive Material License. Approved SW-846 methods were used for all samples, except those parameters for which other methods are necessary. Level 4 data packages were provided along with electronic data deliverables (EDDs).

The following data qualifiers were used for reporting fixed-base laboratory results.

Inorganic Qualifiers

* Duplicate analysis not within control limits
B Analyte found in the associated blank
E Result estimated due to matrix interferences
J Estimated value
N Sample spike (MS/MSD) recovery not within control limits
U Analyte analyzed for but not detected at or below the lowest concentration reported
X Other specific flags and footnotes may be required to properly define the results

Organic Qualifiers

J Estimated value
L LCS or LCSD recovery outside of control limits
L1 LCS/LCSD RPD outside acceptance criteria
P Difference between results from two GC columns outside control limits
S Sample surrogate recovery outside acceptance criteria
U Compound analyzed for but not detected at or below the lowest concentration reported
Y1 MS/MSD recovery outside acceptance criteria
Y2 MS/MSD RPD outside acceptance criteria

Rad Qualifiers

U Value reported is < the MDA and/or < 2 sigma TPE
X Other specific flags and footnotes may be required to properly define the results

Precision, accuracy, and completeness objectives were documented in Appendix A, QAPP, of the July 2018 SAP (DOE 2018a). An assessment of these objectives for laboratory analytical data was performed. Based on data verification, validation, and assessment, laboratory analytical data have been determined to be usable and to meet the DQOs.

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. The absolute difference between the two values calculated is referred to as the relative percent difference (RPD). Precision was determined for this investigation by reviewing laboratory-applied qualifiers that pertain to laboratory duplicates over all analyses. The percentage of results that were qualified by the laboratory was less than the objectives stated in the July 2018 SAP.

Accuracy refers to the nearness of a measurement to an accepted reference or true value. To determine the accuracy of an analytical method and/or the laboratory analysis, a periodic program of sample spiking is conducted. Accuracy for this investigation was determined by reviewing laboratory-applied qualifiers that pertain to laboratory spikes and blanks over all analyses. Based on this review, it was determined that the data were sufficient for project decisions.

Representativeness is the degree to which discrete samples accurately and precisely reflect a characteristic of a population, variations at a sampling location, or a changing 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. This objective was achieved for this investigation by evaluating field condition before and during the data acquisition process to ensure that the most representative sample set possible was collected.

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. Completeness is determined by comparing the number of valid analytical results reported to the number of analytical results requested. The completeness objective stated in the July 2018 SAP was exceeded during this investigation.

Comparability is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability was assessed in terms of field standard operating procedures, analytical methods, QC, and data reporting. In addition, data validation assesses the processes employed by the laboratory that affect data comparability. During data assessment, it was noted that the RPD between the sample and duplicate for some analyses was greater than the measurement performance criteria specified in the QAPP. The affected results were qualified appropriately.

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest. This is achieved for each analyte using the Method Detection Limit (MDL), Instrument Detection Limit, or by the laboratory Practical Quantitation Limit (PQL). MDLs and PQLs are laboratory-dependent and were obtained from the analytical laboratory selected to perform work. For this data set, sensitivity was evaluated by reviewing the reporting limits (RLs) received from the laboratory. RLs that exceeded the requested RLs listed on the laboratory statement of work were evaluated and noted during data verification and data assessment. The data collected met the sensitivity established for this project.

2.12.3 Data Management QC

The Paducah Project Environmental Measurements System (PEMS) was used to import laboratory-generated data; add data qualifiers based on data verification, validation, and assessment; and to transfer data to the Paducah Oak Ridge Environmental Information System (Paducah OREIS). PEMS includes data from point of collection through final data reporting. The system includes field measurements, chain of custody information, laboratory data package tracking, and EDDs. PEMS also includes information for field planning and data evaluation.

All data packages and EDDs received from the laboratory were tracked, reviewed, and maintained in a secure environment. The following information was tracked: project ID, sample delivery group numbers, date received, receipt of EDDs, and comments.

The data verification processes for laboratory data were implemented for both laboratory data packages and EDDs. The data packages and EDDs were reviewed to confirm that all samples had been analyzed for the requested parameters. As part of a series of internal integrity checks within PEMS, a check was run to identify which of the requested samples and analyses were not received in an EDD. Laboratory data packages were checked to confirm agreement with the associated EDD. Integrity checks in PEMS also were used to check the list of compounds generated by the laboratory to confirm that data were provided for all requested analytes.

Data verification is the process for comparing a data set against a set standard or contractual requirement. Data verification within PEMS included standardization of analytical methods, chemical names and units, and checks for holding time violations and RLs. Verification was performed for 100% of the data.

PEMS system requirements that address the day-to-day operations of PEMS include backups and security. The information technology group performs system backups daily. The security precautions and procedures implemented by the SMO are designed to minimize vulnerability of the data to unauthorized access or corruption. Only users approved by the SMO have access to the project's PEMS, hard copy, and electronic data files. Users have Homeland Security Presidential Directive (HSPD)-12 universal serial bus card readers installed on their personal computers (PCs) to control access to the PC and to the network.

To confirm that the data set could be used in the decision making process, the project team performed various checks and reviews during and after the fieldwork to maintain data consistency and identify problem areas. These checks and reviews included electronic verification and manual assessments by the project team, as well as independent validation of fixed-base laboratory data. Approximately 4,000 records were reviewed during the data assessment.

Data validation is a process performed for a data set by a qualified individual independent from sampling, laboratory, project management, and other decision making personnel for the project. Data validation is performed in accordance with EPA guidance. In the data validation process, the laboratory adherence to analytical method requirements is evaluated. Data collected for this investigation were validated at a minimum frequency of 10%.

As part of the data review process, findings were qualified as necessary to reflect data validation results. The following qualifiers were assigned by the data validators.

U Analyte compound or nuclide considered not detected above the reported detection limit.

J Analyte or compound identified; the associated numerical value is approximated.

UJ Analyte or compound not detected above the reported detection limit, and the reported detection limit is approximated due to quality deficiency.

= No qualifier is necessary.

3. DATA AND RISK EVALUATION

Appendix B of this document provides data from all of the samples. A narrative of detections is provided in this section. Total PCBs and Total PAHs were calculated consistent with *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE 2019b) (i.e., Risk Methods Document).

This section evaluates the risk potential from sampling locations within the C-400 Cleaning Building basement and sub-grade areas by comparing the highest area-specific concentrations of each detected contaminant to determine if data are sufficient to complete the following:

(1) Characterize the nature of contamination in the study area;

(2) Understand the extent of contamination in the study area; and

(3) Assess the potential risk to human health and the environment from the contamination present within the study areas and to areas where contamination may migrate.

To complete this evaluation, results are compared to human health screening criteria [i.e., Preliminary Remediation Goals (PRGs)] for the expected future use of the area and background concentrations of chemicals and radionuclides. The evaluation is consistent with the Risk Methods Document (DOE 2019b) for completing risk analyses during site evaluations. This risk evaluation is not a baseline risk assessment.

The available screening criteria do not consider either direct exposure to contaminated concrete and other infrastructure and migration of contaminants from concrete and other infrastructure; to allow for a risk comparison, it was agreed to use soil/sediment values for the resident and industrial worker.

No suitable screening criteria exist for an ecological risk evaluation.

3.1 RISK SCREENING PROCESS

Detected results for each location within the C-400 Cleaning Building basement and sub-grade areas are compared first with background[3] values for surface soil, if available, and then with PRGs. In the narratives, an analyte had to have a result greater than background before being identified as exceeding a PRG. The PRGs selected for this screening are NALs for the child resident exposed to soil/sediment, the NALs and action levels (ALs) for the industrial worker exposed to soil/sediment, and NALs and ALs for the child resident exposed to groundwater. While the NALs and ALs are for exposure scenarios not applicable to contaminated concrete and other infrastructure, completing the evaluation using these screening values allows for identification of the contaminants that exceed their risk-based values by the greatest amount. Risk screening summaries in each subsection provide minimum (min), maximum (max), average (avg) results of detected compounds and their frequencies of detection (FOD) in addition to frequencies of exceedance (FOE) for each of the screening values. Only detected results are summarized. Field duplicate results are included with the risk screening summaries.

Some radionuclide isotopes are reported together because the individual isotopes are not distinguished in the analysis. Because of this, screening levels will be used for the following: plutonium-239 for

[3] Background values are for surface soil and are not applicable to concrete and other infrastructure.

Pu-239/240, uranium-234 for U-233/234, and uranium-235 for U-235/236. Consistent with the Risk Methods Document, chromium is screened using chromium VI PRGs. (Chromium III is used for background screening because a background value is not available for chromium VI.) Further, consistent with the Risk Methods Document, individual PCB aroclors are not screened or summarized; only Total PCBs is screened and summarized. Total PCBs was derived by summing the detected concentrations of each PCB within a sample. For samples in which no PCBs were detected, the value for the minimum detection limit of the PCBs was used. Also consistent with the Risk Methods Document, Total carcinogenic PAHs is screened and summarized after calculation, using the toxicity equivalence factors (TEFs). Individual PAHs with TEFs are not screened or summarized.

3.2 EAST BASEMENT/PLENUM ROOM

3.2.1 Concrete Sampling

As stated in Section 2.3.1, 12 concrete core samples and 1 duplicate from preselected locations and 4 samples from visually stained concrete were collected. The concrete core samples from preselected locations were analyzed for asbestos (top sample only); an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. The samples from visually stained locations were analyzed for PCBs and radionuclides.

One sample (at sampling location #3) tested positive for asbestos. The reported result showed an asbestos concentration of 1%. The asbestos sample from location #3 was collected just under a piece of pipe that had undergone asbestos abatement. Asbestos is not included in risk screening.

Risk screening, as described in Section 3.1, for concrete sampling in the East Basement/Plenum Room is shown in Table 2. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

Only the metals, chromium and uranium, and the radionuclides, Np-237, U-235/236, and U-238, exceed both background[4] and industrial worker NALs. Total PCBs exceed the industrial worker NALs.[5] There were no detections exceeding industrial worker ALs.

In addition to those analytes exceeding industrial worker NALs, copper, Th-230, and U-233/234 also exceed both background and child resident NALs. Total PCBs exceed the child resident NALs.[6] One sample exceeded the child resident NAL for TCE, and one sample exceeded the child resident NAL for Total PAH.

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[4] Background values are for surface soil and are not applicable to concrete.

[5] One sample, 400-BASE1SCONC-1, did not detect PCBs; however, the laboratory detection limit for PCBs was greater than both the child resident and industrial worker NALs.

[6] One sample, 400-BASE1SCONC-1, did not detect PCBs; however, the laboratory detection limit for PCBs was greater than both the child resident and industrial worker NALs.

Table 2. Risk Screening Summary East Basement/Plenum Room—Concrete

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	3.59E-01	7.98E+00	1.73E+00	13/13	N/A	N/A	0/13	3.13E+02	0/13	9.33E+03	0/13	1.00E+05
METALS													
Aluminum	mg/kg	4.12E+03	1.05E+04	6.80E+03	13/13	0/13	1.30E+04	6/13	7.74E+03	0/13	1.00E+05	0/13	1.00E+05
Antimony	mg/kg	3.26E-01	6.16E-01	4.53E-01	6/13	6/13	2.10E-01	0/13	3.13E+00	0/13	9.34E+01	0/13	2.80E+03
Arsenic	mg/kg	2.31E+00	1.15E+01	5.16E+00	13/13	0/13	1.20E+01	13/13	3.56E-01	13/13	1.60E+00	0/13	1.60E+02
Barium	mg/kg	3.87E+01	9.26E+01	6.49E+01	13/13	0/13	2.00E+02	0/13	1.53E+03	0/13	4.04E+04	0/13	1.00E+05
Beryllium	mg/kg	1.73E-01	4.21E-01	2.82E-01	13/13	0/13	6.70E-01	0/13	1.56E+01	0/13	4.50E+02	0/13	1.35E+04
Boron	mg/kg	8.36E+00	6.66E+01	1.84E+01	13/13	N/A	N/A	0/13	1.56E+03	0/13	4.65E+04	0/13	1.00E+05
Cadmium	mg/kg	6.96E-02	1.44E+00	3.15E-01	13/13	5/13	2.10E-01	0/13	5.28E+00	0/13	6.05E+01	0/13	1.82E+03
Chromium	mg/kg	7.55E+00	7.24E+01	2.08E+01	13/13	7/13	1.60E+01	13/13	3.01E-01	7/13	1.23E+01	0/13	1.23E+03
Cobalt	mg/kg	2.51E+00	6.83E+00	4.19E+00	13/13	0/13	1.40E+01	13/13	2.34E+00	0/13	6.87E+01	0/13	2.06E+03
Copper	mg/kg	3.59E+00	3.82E+02	6.16E+01	13/13	7/13	1.90E+01	1/13	3.13E+02	0/13	9.34E+03	0/13	1.00E+05
Iron	mg/kg	4.96E+03	1.74E+04	1.05E+04	13/13	0/13	2.80E+04	12/13	5.48E+03	0/13	1.00E+05	0/13	1.00E+05
Lead	mg/kg	1.92E+00	1.91E+01	7.41E+00	13/13	0/13	3.60E+01	0/13	4.00E+02	0/13	8.00E+02	0/13	8.00E+02
Manganese	mg/kg	1.60E+02	5.95E+02	3.47E+02	13/13	0/13	1.50E+03	12/13	1.83E+02	0/13	4.72E+03	0/13	1.00E+05
Mercury	mg/kg	3.88E-03	9.23E-03	6.56E-03	2/13	0/13	2.00E-01	0/13	2.35E+00	0/13	7.01E+01	0/13	2.10E+03
Molybdenum	mg/kg	4.98E-01	4.19E+00	1.48E+00	13/13	N/A	N/A	0/13	3.91E+01	0/13	1.16E+03	0/13	3.48E+04
Nickel	mg/kg	7.74E+00	7.75E+01	2.92E+01	13/13	7/13	2.10E+01	0/13	1.55E+02	0/13	4.30E+03	0/13	1.00E+05
Selenium	mg/kg	3.44E-01	5.35E-01	4.36E-01	12/13	0/13	8.00E-01	0/13	3.91E+01	0/13	1.17E+03	0/13	3.51E+04
Uranium	mg/kg	1.24E+00	1.85E+02	3.19E+01	13/13	8/13	4.90E+00	12/13	1.56E+00	4/13	4.66E+01	0/13	1.40E+03
Vanadium	mg/kg	8.05E+00	2.56E+01	1.54E+01	13/13	0/13	3.80E+01	0/13	3.93E+01	0/13	1.15E+03	0/13	3.45E+04
Zinc	mg/kg	1.61E+01	7.17E+02	9.93E+01	13/13	3/13	6.50E+01	0/13	2.35E+03	0/13	7.01E+04	0/13	1.00E+05
PCBs													
PCB, Total	mg/kg	3.70E-02	1.90E+01	3.26E+00	16/17	N/A	N/A	12/17	7.88E-02	10/17	2.93E-01	0/17	2.93E+01
SVOCs													
Acenaphthene	mg/kg	1.23E-02	1.59E-02	1.41E-02	2/13	N/A	N/A	0/13	1.85E+02	0/13	1.38E+03	0/13	4.14E+04
Anthracene	mg/kg	1.12E-02	3.99E-02	2.56E-02	2/13	N/A	N/A	0/13	9.23E+02	0/13	6.89E+03	0/13	1.00E+05
Carbazole	mg/kg	1.02E-02	3.26E-02	1.83E-02	3/13	N/A	N/A	0/13	1.04E+01	0/13	4.06E+01	0/13	4.06E+03
Fluoranthene	mg/kg	2.82E-02	5.47E-01	1.54E-01	5/13	N/A	N/A	0/13	1.23E+02	0/13	9.19E+02	0/13	2.76E+04
Fluorene	mg/kg	1.42E-02	1.42E-02	1.42E-02	1/13	N/A	N/A	0/13	1.23E+02	0/13	9.19E+02	0/13	2.76E+04
Napthalene	mg/kg	1.33E-02	4.79E-02	3.14E-02	4/13	N/A	N/A	0/13	3.83E+00	0/13	1.67E+01	0/13	1.61E+03
Phenanthrene	mg/kg	1.09E-02	2.47E-01	8.96E-02	7/13	N/A	N/A	0/13	1.85E+02	0/13	1.38E+03	0/13	4.14E+04
Pyrene	mg/kg	1.56E-02	2.92E-01	8.23E-02	5/13	N/A	N/A	0/13	9.23E+01	0/13	6.89E+02	0/13	2.07E+04
Total PAH	mg/kg	1.07E-03	2.10E-01	4.90E-02	5/13	N/A	N/A	1/13	4.78E-02	0/13	6.43E-01	0/13	6.43E+01

Table 2. Risk Screening Summary East Basement/Plenum Room—Concrete (Continued)

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
VOCs													
1,2-Dichloroethene	mg/kg	6.30E-04	6.30E-04	6.30E-04	1/13	N/A	N/A	0/13	7.04E+01	0/13	2.10E+03	0/13	6.30E+04
1,2-Dimethylbenzene	mg/kg	5.10E-04	7.09E-03	2.81E-03	8/13	N/A	N/A	0/13	6.45E+01	0/13	2.81E+02	0/13	8.43E+03
cis-1,2-Dichloroethene	mg/kg	6.30E-04	6.30E-04	6.30E-04	1/13	N/A	N/A	0/13	1.56E+01	0/13	4.67E+02	0/13	1.40E+04
Ethylbenzene	mg/kg	3.50E-04	6.00E-04	5.10E-04	3/13	N/A	N/A	0/13	5.78E+00	0/13	2.66E+01	0/13	2.66E+03
m,p-Xylene	mg/kg	6.90E-04	7.86E-03	3.21E-03	9/13	N/A	N/A	0/13	5.76E+01	0/13	2.50E+02	0/13	7.50E+03
Tetrachloroethene	mg/kg	5.10E-04	5.50E-04	5.30E-04	2/13	N/A	N/A	0/13	8.10E+00	0/13	4.00E+01	0/13	1.20E+03
Toluene	mg/kg	3.13E-03	9.60E-01	1.38E-01	13/13	N/A	N/A	0/13	4.89E+02	0/13	6.25E+03	0/13	1.00E+05
Total Xylene	mg/kg	1.22E-03	1.47E-02	6.33E-03	8/13	N/A	N/A	0/13	5.76E+01	0/13	2.50E+02	0/13	7.50E+03
Trichloroethene	mg/kg	4.00E-04	5.73E-01	1.27E-01	8/13	N/A	N/A	1/13	4.12E-01	0/13	1.90E+00	0/13	5.70E+01
RADIONUCLIDES													
Neptunium-237	pCi/g	5.10E-01	1.44E+00	9.07E-01	6/17	6/17	1.00E-01	6/17	9.11E-02	6/17	2.49E-01	0/17	2.49E+01
Plutonium-239/240	pCi/g	1.02E+00	3.36E+00	2.19E+00	2/17	2/17	2.50E-02	0/17	3.77E+00	0/17	2.27E+01	0/17	2.27E+03
Technetium-99	pCi/g	7.72E+00	9.76E+01	3.67E+01	13/17	13/17	2.50E+00	0/17	1.10E+02	0/17	1.27E+03	0/17	1.00E+05
Thorium-230	pCi/g	5.76E-01	1.45E+01	2.49E+00	13/17	8/17	1.50E+00	1/17	4.93E+00	0/17	3.13E+01	0/17	3.13E+03
Uranium-233/234	pCi/g	6.20E-01	4.61E+01	7.47E+00	14/17	10/17	1.20E+00	5/17	5.77E+00	0/17	5.01E+01	0/17	5.01E+03
Uranium-235/236	pCi/g	3.53E-01	4.29E+00	1.23E+00	9/17	9/17	6.00E-02	9/17	1.48E-01	8/17	4.08E-01	0/17	4.08E+01
Uranium-238	pCi/g	6.50E-01	1.51E+02	1.48E+01	17/17	11/17	1.20E+00	17/17	5.56E-01	11/17	1.66E+00	0/17	1.66E+02

Legend:
One or more samples exceed background value. (orange)
One or more samples exceed NAL value. (green)

3.2.2 Paint/Coating Sampling

As stated in Section 2.3.2, one paint sample and one coating sample were collected. These samples were analyzed for an anion (fluoride); metals; PCBs; and radionuclides. The detections are presented in Table 3, along with their maximum detected results. It should be noted that the maximum Total PCB of the sampling event was 1,616 mg/kg, found in the coating sample.

The paint sample collected from the East Basement/Plenum Room was collected from the TCE degreaser tank, which is expected to be removed during deactivation. At this time of this report, the tank remained in place, and the paint sample is included in the risk screening.

Risk screening, as described in Section 3.1, for the paint and coating samples in the East Basement/Plenum Room is shown in Table 3. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

The metals chromium, cobalt, lead, and uranium, and the radionuclides Cs-137, Np-237, Pu-239/240, Tc-99, Th-230, U-233/234, U-235/236, and U-238, exceed both background[7] and industrial worker NALs. Of these metals and radionuclides, lead, uranium, Np-237, U-235/236, and U-238 also exceed industrial worker ALs. Total PCBs exceed the industrial worker NAL and industrial worker AL.

In addition to those analytes exceeding industrial worker NALs, antimony, barium, cadmium, copper, iron, manganese, nickel, zinc, and Am-241 also exceed both background (if available) and child resident NALs. Total PCBs exceed the child resident NAL.

[7] Background values are for surface soil and are not applicable to paint/coating.

Table 3. Risk Screening Summary East Basement/Plenum Room—Painting/Coating

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	3.52E+01	1.19E+02	7.71E+01	2/2	N/A	N/A	0/2	3.13E+02	0/2	9.33E+03	0/2	1.00E+05
METALS													
Aluminum	mg/kg	2.59E+03	8.16E+03	5.38E+03	2/2	0/2	1.30E+04	1/2	7.74E+03	0/2	1.00E+05	0/2	1.00E+05
Antimony	mg/kg	7.27E+00	7.27E+00	7.27E+00	1/2	1/2	2.10E-01	1/2	3.13E+00	0/2	9.34E+01	0/2	2.80E+03
Arsenic	mg/kg	4.04E+00	1.00E+01	7.02E+00	2/2	0/2	1.20E+01	2/2	3.56E-01	2/2	1.60E+00	0/2	1.60E+02
Barium	mg/kg	9.12E+01	2.11E+03	1.10E+03	2/2	1/2	2.00E+02	1/2	1.53E+03	0/2	4.04E+04	0/2	1.00E+05
Beryllium	mg/kg	8.28E-02	3.40E-01	2.11E-01	2/2	0/2	6.70E-01	0/2	1.56E+01	0/2	4.50E+02	0/2	1.35E+04
Boron	mg/kg	1.38E+01	1.40E+02	7.69E+01	2/2	N/A	N/A	0/2	1.56E+03	0/2	4.65E+04	0/2	1.00E+05
Cadmium	mg/kg	2.09E+00	1.87E+01	1.04E+01	2/2	2/2	2.10E-01	1/2	5.28E+00	0/2	6.05E+01	0/2	1.82E+03
Chromium	mg/kg	1.07E+02	9.36E+02	5.22E+02	2/2	2/2	1.60E+01	2/2	3.01E-01	2/2	1.23E+01	0/2	1.23E+03
Cobalt	mg/kg	1.98E+01	2.85E+02	1.52E+02	2/2	2/2	1.40E+01	2/2	2.34E+00	1/2	6.87E+01	0/2	2.06E+03
Copper	mg/kg	6.25E+02	9.06E+02	7.66E+02	2/2	2/2	1.90E+01	2/2	3.13E+02	0/2	9.34E+03	0/2	1.00E+05
Iron	mg/kg	9.41E+03	6.06E+04	3.50E+04	2/2	1/2	2.80E+04	2/2	5.48E+03	0/2	1.00E+05	0/2	1.00E+05
Lead	mg/kg	1.63E+02	4.43E+03	2.30E+03	2/2	2/2	3.60E+01	1/2	4.00E+02	1/2	8.00E+02	1/2	8.00E+02
Manganese	mg/kg	1.84E+02	1.71E+03	9.47E+02	2/2	1/2	1.50E+03	2/2	1.83E+02	0/2	4.72E+03	0/2	1.00E+05
Mercury	mg/kg	5.91E-02	1.61E-01	1.10E-01	2/2	0/2	2.00E-01	0/2	2.35E+00	0/2	7.01E+01	0/2	2.10E+03
Molybdenum	mg/kg	2.05E+00	5.91E+00	3.98E+00	2/2	N/A	N/A	0/2	3.91E+01	0/2	1.16E+03	0/2	3.48E+04
Nickel	mg/kg	9.02E+02	1.06E+03	9.81E+02	2/2	2/2	2.10E+01	2/2	1.55E+02	0/2	4.30E+03	0/2	1.00E+05
Selenium	mg/kg	6.36E-01	2.06E+00	1.35E+00	2/2	1/2	8.00E-01	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Silver	mg/kg	5.78E-01	1.14E+00	8.59E-01	2/2	0/2	2.30E+00	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Uranium	mg/kg	6.57E+02	1.77E+03	1.21E+03	2/2	2/2	4.90E+00	2/2	1.56E+00	2/2	4.66E+01	1/2	1.40E+03
Vanadium	mg/kg	1.09E+01	1.09E+01	1.09E+01	1/2	0/2	3.80E+01	0/2	3.93E+01	0/2	1.15E+03	0/2	3.45E+04
Zinc	mg/kg	4.41E+02	2.81E+04	1.43E+04	2/2	2/2	6.50E+01	1/2	2.35E+03	0/2	7.01E+04	0/2	1.00E+05
PCBS													
PCB, Total	mg/kg	7.27E+00	1.62E+03	8.12E+02	2/2	N/A	N/A	2/2	7.88E-02	2/2	2.93E-01	1/2	2.93E+01
RADIONUCLIDES													
Americium-241	pCi/g	4.35E+00	5.17E+00	4.76E+00	2/2	N/A	N/A	2/2	1.75E+00	0/2	6.01E+00	0/2	6.01E+02
Cesium-137	pCi/g	3.96E-01	7.07E-01	5.52E-01	2/2	1/2	4.90E-01	2/2	4.02E-02	2/2	1.08E-01	0/2	1.08E+01
Neptunium-237	pCi/g	3.31E+01	7.00E+01	5.16E+01	2/2	2/2	1.00E-01	2/2	9.11E-02	2/2	2.49E-01	2/2	2.49E+01
Plutonium-238	pCi/g	8.69E-01	8.69E-01	8.69E-01	1/2	1/2	7.30E-02	0/2	4.27E+00	0/2	2.65E+01	0/2	2.65E+03
Plutonium-239/240	pCi/g	1.33E+01	2.87E+01	2.10E+01	2/2	2/2	2.50E-02	2/2	3.77E+00	1/2	2.27E+01	0/2	2.27E+03
Technetium-99	pCi/g	6.27E+03	9.25E+03	7.76E+03	2/2	2/2	2.50E+00	2/2	1.10E+02	2/2	1.27E+03	0/2	1.00E+05
Thorium-230	pCi/g	7.47E+01	1.12E+02	9.34E+01	2/2	2/2	1.50E+00	2/2	4.93E+00	2/2	3.13E+01	0/2	3.13E+03
Uranium-233/234	pCi/g	4.36E+02	8.14E+02	6.25E+02	2/2	2/2	1.20E+00	2/2	5.77E+00	2/2	5.01E+01	0/2	5.01E+03
Uranium-235/236	pCi/g	3.22E+01	7.74E+01	5.48E+01	2/2	2/2	6.00E-02	2/2	1.48E-01	2/2	4.08E-01	1/2	4.08E+01
Uranium-238	pCi/g	7.01E+02	2.04E+03	1.37E+03	2/2	2/2	1.20E+00	2/2	5.56E-01	2/2	1.66E+00	2/2	1.66E+02

Legend:
- (orange) One or more samples exceed background value.
- (green) One or more samples exceed NAL value.
- (red) One or more samples exceed AL value.

3.2.3 Liquid and Sludge Sampling

Section 2.3.3 summarizes the nine locations that were sampled for liquid and/or sludge and the analyte list for each sample. An anion (fluoride); metals; organics (SVOCs, VOCs, and PCBs); and radionuclides that were detected are presented in Tables 4 and 5, along with their maximum detected result.

The liquid and sludge from SWMU 98 has been removed and managed as waste; however, for characterization purposes, these sample results are included in the risk screening.

Risk screening, as described in Section 3.1, for liquid and sludge sampling in open drain lines, valve pits, and sump are shown in Tables 4 and 5, respectively. Use of background in the screening for sludge is consistent with risk screening in surface soils and should be considered an uncertainty.

In liquid samples from open drain lines and valve pits, VOCs (TCE), and the radionuclides Am-241, Np-237, Pu-238, Pu-239/240, Tc-99, Th-230, U-233/234, U-235/236, and U-238 exceed child resident NALs. Of those, the radionuclides, Np-237, Pu-239/240, Tc-99, Th-230, U-233/234, and U-238, additionally exceed child resident ALs.

In the liquid sample from SWMU 98, an anion (fluoride); the metals aluminum, arsenic, barium, boron, cadmium, cobalt, copper, iron, manganese, nickel, uranium, and zinc; Total PCBs, the VOCs 1,1,2-trichloroethane, 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), benzene, *cis*-1,2-DCE, tetrachloroethene, TCE, and vinyl chloride; and the radionuclides Tc-99, Th-230, U-233/234, U-235/236, and U-238 exceed child resident NALs. Of those, fluoride; arsenic; cadmium; iron; manganese; uranium; 1,1,2-trichloroethane, 1,2-DCE, *cis*-1,2-DCE, TCE, vinyl chloride; and U-238 also exceed child resident ALs.

In sludge samples, from open drain lines and valve pits, the metals arsenic, chromium, iron, lead, and uranium; Total PCBs; Total PAHs; and the radionuclides Cs-137, Np-237, Tc-99, Th-230, U-235/236, and U-238 exceed both background[8] (if available) and industrial worker NALs. Additionally, chromium, iron, and lead, exceed industrial worker ALs.

In addition to analytes exceeding industrial worker NALs from sludge samples in open drain lines and valve pits, the following also exceed both background (if available) and child resident NALs: an anion (fluoride); the metals, antimony, cobalt, copper, and nickel; and the radionuclides, Am-241, Pu-239/240, U-233/234.

In sludge samples, from SWMU 98, Total PCBs, TCE, Np-237, U-233/234, U-235/236, and U-238 exceed both background (if available) and industrial worker NALs. Additionally, U-238 and TCE exceed industrial worker ALs. It should be noted that TCE in the SWMU 98 sludge sample was reported as 1.69E+08 μg/kg or 169 g/kg, which is above the solubility limit, indicating potential pure phase.

[8] Background values are for surface soil and are not applicable to sludge.

Table 4. Risk Screening Summary East Basement/Plenum Room—Liquid

Analysis	Unit	Detected Results			FOD	Child Resident		Child Resident	
		Min	Max	Avg		FOE	NAL	FOE	AL
Open Drain Lines and Valve Pits									
VOCS									
Trichloroethene	mg/L	4.10E-04	4.10E-04	4.10E-04	1/2	1/2	2.83E-04	0/2	8.49E-03
RADIONUCLIDES									
Americium-241	pCi/L	2.62E+01	2.62E+01	2.62E+01	1/2	1/2	5.04E-01	0/2	5.04E+01
Neptunium-237	pCi/L	6.93E+00	2.60E+02	1.33E+02	2/2	2/2	7.63E-01	1/2	7.63E+01
Plutonium-238	pCi/L	2.88E+00	2.88E+00	2.88E+00	1/2	1/2	3.98E-01	0/2	3.98E+01
Plutonium-239/240	pCi/L	6.10E+00	1.38E+02	7.21E+01	2/2	2/2	3.87E-01	1/2	3.87E+01
Technetium-99	pCi/L	8.65E+03	2.96E+04	1.91E+04	2/2	2/2	1.90E+01	2/2	1.90E+03
Thorium-230	pCi/L	1.66E+01	9.95E+02	5.06E+02	2/2	2/2	5.72E-01	1/2	5.72E+01
Uranium-233/234	pCi/L	3.13E+01	3.86E+02	2.09E+02	2/2	2/2	7.39E-01	1/2	7.39E+01
Uranium-235/236	pCi/L	3.94E+01	3.94E+01	3.94E+01	1/2	1/2	7.28E-01	0/2	7.28E+01
Uranium-238	pCi/L	5.74E+01	7.70E+02	4.14E+02	2/2	2/2	6.01E-01	1/2	6.01E+01
Sump (SWMU 98)									
ANIONS									
Fluoride	mg/L	7.18E+00	7.18E+00	7.18E+00	1/1	1/1	7.99E-02	1/1	2.40E+00
METALS									
Aluminum	mg/L	2.77E+00	2.77E+00	2.77E+00	1/1	1/1	2.00E+00	0/1	6.00E+01
Arsenic	mg/L	2.27E-02	2.27E-02	2.27E-02	1/1	1/1	5.17E-05	1/1	5.17E-03
Barium	mg/L	2.32E+00	2.32E+00	2.32E+00	1/1	1/1	3.77E-01	0/1	1.13E+01
Boron	mg/L	7.50E-01	7.50E-01	7.50E-01	1/1	1/1	3.99E-01	0/1	1.20E+01
Cadmium	mg/L	1.89E-01	1.89E-01	1.89E-01	1/1	1/1	9.22E-04	1/1	2.77E-02
Cobalt	mg/L	9.03E-03	9.03E-03	9.03E-03	1/1	1/1	6.01E-04	0/1	1.80E-02
Copper	mg/L	1.55E-01	1.55E-01	1.55E-01	1/1	1/1	7.99E-02	0/1	2.40E+00
Iron	mg/L	6.06E+02	6.06E+02	6.06E+02	1/1	1/1	1.40E+00	1/1	4.20E+01
Lead	mg/L	1.41E-02	1.41E-02	1.41E-02	1/1	0/1	1.50E-02	0/1	3.00E-02
Manganese	mg/L	1.38E+01	1.38E+01	1.38E+01	1/1	1/1	4.34E-02	1/1	1.30E+00
Molybdenum	mg/L	2.44E-03	2.44E-03	2.44E-03	1/1	0/1	9.98E-03	0/1	2.99E-01
Nickel	mg/L	3.97E-01	3.97E-01	3.97E-01	1/1	1/1	3.92E-02	0/1	1.18E+00
Uranium	mg/L	1.45E-01	1.45E-01	1.45E-01	1/1	1/1	3.99E-04	1/1	1.20E-02
Zinc	mg/L	1.64E+00	1.64E+00	1.64E+00	1/1	1/1	6.00E-01	0/1	1.80E+01
PCBS									
PCB, Total	mg/L	8.20E-05	8.20E-05	8.20E-05	1/1	1/1	4.36E-05	0/1	4.36E-03
SVOCS									
Acenaphthene	mg/L	3.27E-04	3.27E-04	3.27E-04	1/1	0/1	5.35E-02	0/1	1.61E+00
VOCS									
1,1,2-Trichloroethane	mg/L	1.97E-02	1.97E-02	1.97E-02	1/1	1/1	4.15E-05	1/1	1.25E-03
1,1-Dichloroethene	mg/L	8.61E-02	8.61E-02	8.61E-02	1/1	1/1	2.85E-02	0/1	8.55E-01
1,2-Dichloroethene	mg/L	2.53E+00	2.53E+00	2.53E+00	1/1	1/1	1.63E-02	1/1	4.89E-01
1,2-Dimethylbenzene	mg/L	8.10E-04	8.10E-04	8.10E-04	1/1	0/1	1.93E-02	0/1	5.79E-01
Benzene	mg/L	3.56E-03	3.56E-03	3.56E-03	1/1	1/1	4.55E-04	0/1	4.55E-02
cis-1,2-Dichloroethene	mg/L	1.31E+01	1.31E+01	1.31E+01	1/1	1/1	3.61E-03	1/1	1.08E-01
Ethylbenzene	mg/L	5.20E-04	5.20E-04	5.20E-04	1/1	0/1	1.50E-03	0/1	1.50E-01
m,p-Xylene	mg/L	1.52E-03	1.52E-03	1.52E-03	1/1	0/1	1.93E-02	0/1	5.79E-01
Tetrachloroethene	mg/L	5.31E-03	5.31E-03	5.31E-03	1/1	1/1	4.06E-03	0/1	1.22E-01
Toluene	mg/L	1.14E-03	1.14E-03	1.14E-03	1/1	0/1	1.10E-01	0/1	3.30E+00
Total Xylene	mg/L	2.33E-03	2.33E-03	2.33E-03	1/1	0/1	1.93E-02	0/1	5.79E-01
trans-1,2-Dichloroethene	mg/L	7.00E-03	7.00E-03	7.00E-03	1/1	0/1	9.29E-03	0/1	2.79E-01
Trichloroethene	mg/L	1.34E+02	1.34E+02	1.34E+02	1/1	1/1	2.83E-04	1/1	8.49E-03
Vinyl chloride	mg/L	2.46E+00	2.46E+00	2.46E+00	1/1	1/1	1.88E-05	1/1	1.88E-03
RADIONUCLIDES									
Technetium-99	pCi/L	5.21E+02	5.21E+02	5.21E+02	1/1	1/1	1.90E+01	0/1	1.90E+03
Thorium-230	pCi/L	2.66E+00	2.66E+00	2.66E+00	1/1	1/1	5.72E-01	0/1	5.72E+01
Uranium-233/234	pCi/L	4.33E+01	4.33E+01	4.33E+01	1/1	1/1	7.39E-01	0/1	7.39E+01
Uranium-235/236	pCi/L	7.97E+00	7.97E+00	7.97E+00	1/1	1/1	7.28E-01	0/1	7.28E+01
Uranium-238	pCi/L	8.17E+01	8.17E+01	8.17E+01	1/1	1/1	6.01E-01	1/1	6.01E+01

Legend:
- (green) One or more samples exceed NAL value
- (red) One or more samples exceed AL value.

Table 5. Risk Screening Summary East Basement/Plenum Room—Sludge

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
Open Drain Lines and Valve Pits													
ANIONS													
Fluoride	mg/kg	1.90E+02	4.02E+03	1.28E+03	5/5	N/A	N/A	4/5	3.13E+02	0/5	9.33E+03	0/5	1.00E+05
METALS													
Aluminum	mg/kg	3.42E+02	5.81E+03	3.02E+03	5/5	0/5	1.30E+04	0/5	7.74E+03	0/5	1.00E+05	0/5	1.00E+05
Antimony	mg/kg	4.57E+00	7.13E+00	5.85E+00	2/5	2/5	2.10E-01	2/5	3.13E+00	0/5	9.34E+01	0/5	2.80E+03
Arsenic	mg/kg	1.62E+00	2.24E+01	1.61E+01	5/5	4/5	1.20E+01	5/5	3.56E-01	5/5	1.60E+00	0/5	1.60E+02
Barium	mg/kg	6.16E+00	1.49E+02	7.66E+01	5/5	0/5	2.00E+02	0/5	1.53E+03	0/5	4.04E+04	0/5	1.00E+05
Beryllium	mg/kg	9.19E-02	1.50E-01	1.23E-01	3/5	0/5	6.70E-01	0/5	1.56E+01	0/5	4.50E+02	0/5	1.35E+04
Boron	mg/kg	8.15E+01	1.76E+02	1.10E+02	5/5	N/A	N/A	0/5	1.56E+03	0/5	4.65E+04	0/5	1.00E+05
Cadmium	mg/kg	1.70E-01	3.34E+00	1.56E+00	5/5	4/5	2.10E-01	0/5	5.28E+00	0/5	6.05E+01	0/5	1.82E+03
Chromium	mg/kg	2.74E+01	1.36E+03	5.85E+02	5/5	5/5	1.60E+01	5/5	3.01E-01	5/5	1.23E+01	1/5	1.23E+03
Cobalt	mg/kg	9.45E-01	2.23E+01	1.53E+01	5/5	4/5	1.40E+01	4/5	2.34E+00	0/5	6.87E+01	0/5	2.06E+03
Copper	mg/kg	4.72E+02	2.55E+03	1.23E+03	5/5	5/5	1.90E+01	5/5	3.13E+02	0/5	9.34E+03	0/5	1.00E+05
Iron	mg/kg	3.23E+03	2.50E+05	1.36E+05	5/5	4/5	2.80E+04	4/5	5.48E+03	4/5	1.00E+05	4/5	1.00E+05
Lead	mg/kg	2.88E+01	1.33E+03	5.83E+02	5/5	4/5	3.60E+01	3/5	4.00E+02	2/5	8.00E+02	2/5	8.00E+02
Manganese	mg/kg	3.39E+01	9.02E+02	6.12E+02	5/5	0/5	1.50E+03	4/5	1.83E+02	0/5	4.72E+03	0/5	1.00E+05
Mercury	mg/kg	2.57E-02	3.90E-01	1.56E-01	5/5	1/5	2.00E-01	0/5	2.35E+00	0/5	7.01E+01	0/5	2.10E+03
Molybdenum	mg/kg	2.09E+00	1.42E+01	1.08E+01	5/5	N/A	N/A	0/5	3.91E+01	0/5	1.16E+03	0/5	3.48E+04
Nickel	mg/kg	4.24E+01	1.26E+03	5.91E+02	5/5	5/5	2.10E+01	4/5	1.55E+02	0/5	4.30E+03	0/5	1.00E+05
Silver	mg/kg	2.47E+00	6.33E+00	3.82E+00	5/5	5/5	2.30E+00	0/5	3.91E+01	0/5	1.17E+03	0/5	3.51E+04
Uranium	mg/kg	1.13E+02	4.53E+02	2.52E+02	5/5	5/5	4.90E+00	5/5	1.56E+00	5/5	4.66E+01	0/5	1.40E+03
Vanadium	mg/kg	4.29E-01	3.54E+01	1.85E+01	5/5	0/5	3.80E+01	0/5	3.93E+01	0/5	1.15E+03	0/5	3.45E+04
Zinc	mg/kg	5.12E+01	1.75E+03	8.22E+02	5/5	4/5	6.50E+01	0/5	2.35E+03	0/5	7.01E+04	0/5	1.00E+05
PCBS													
PCB, Total	mg/kg	1.16E-01	1.28E+01	5.92E+00	4/5	N/A	N/A	4/5	7.88E-02	3/5	2.93E-01	0/5	2.93E+01
SVOCS													
Anthracene	mg/kg	4.03E-02	4.03E-02	4.03E-02	1/5	N/A	N/A	0/5	9.23E+02	0/5	6.89E+03	0/5	1.00E+05
Carbazole	mg/kg	7.66E-02	7.66E-02	7.66E-02	1/5	N/A	N/A	0/5	1.04E+01	0/5	4.06E+01	0/5	4.06E+03
Fluoranthene	mg/kg	3.35E-02	4.31E+00	1.06E+00	5/5	N/A	N/A	0/5	1.23E+02	0/5	9.19E+02	0/5	2.76E+04
Phenanthrene	mg/kg	1.12E-02	1.72E+00	6.69E-01	3/5	N/A	N/A	0/5	1.85E+02	0/5	1.38E+03	0/5	4.14E+04
Pyrene	mg/kg	2.86E-02	3.53E+00	1.36E+00	3/5	N/A	N/A	0/5	9.23E+01	0/5	6.89E+02	0/5	2.07E+04
Total PAH	mg/kg	2.46E-02	2.80E+00	8.16E-01	4/5	N/A	N/A	3/5	4.78E-02	1/5	6.43E-01	0/5	6.43E+01
VOCS													
Toluene	mg/kg	4.41E-02	5.29E-02	4.85E-02	2/5	N/A	N/A	0/5	4.89E+02	0/5	6.25E+03	0/5	1.00E+05

Table 5. Risk Screening Summary East Basement/Plenum Room—Sludge (Continued)

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
RADIONUCLIDES													
Americium-241	pCi/g	3.39E+00	4.43E+00	3.90E+00	3/5	N/A	N/A	3/5	1.75E+00	0/5	6.01E+00	0/5	6.01E+02
Cesium-137	pCi/g	6.99E-02	1.46E+00	6.43E-01	5/5	3/5	4.90E-01	5/5	4.02E-02	3/5	1.08E-01	0/5	1.08E+01
Neptunium-237	pCi/g	3.06E+00	2.39E+01	1.42E+01	5/5	5/5	1.00E-01	5/5	9.11E-02	5/5	2.49E-01	0/5	2.49E+01
Plutonium-238	pCi/g	3.76E-01	4.33E-01	4.05E-01	2/5	2/5	7.30E-02	0/5	4.27E+00	0/5	2.65E+01	0/5	2.65E+03
Plutonium-239/240	pCi/g	2.11E+00	1.61E+01	7.97E+00	5/5	5/5	2.50E-02	3/5	3.77E+00	0/5	2.27E+01	0/5	2.27E+03
Technetium-99	pCi/g	4.58E+02	4.97E+03	1.62E+03	5/5	5/5	2.50E+00	5/5	1.10E+02	1/5	1.27E+03	0/5	1.00E+05
Thorium-230	pCi/g	9.94E+00	5.39E+01	3.29E+01	5/5	5/5	1.50E+00	5/5	4.93E+00	3/5	3.13E+01	0/5	3.13E+03
Uranium-233/234	pCi/g	2.08E+01	4.81E+01	3.18E+01	5/5	5/5	1.20E+00	5/5	5.77E+00	0/5	5.01E+01	0/5	5.01E+03
Uranium-235/236	pCi/g	1.14E+00	3.69E+00	2.25E+00	5/5	5/5	6.00E-02	5/5	1.48E-01	5/5	4.08E-01	0/5	4.08E+01
Uranium-238	pCi/g	4.30E+01	8.14E+01	6.18E+01	5/5	5/5	1.20E+00	5/5	5.56E-01	5/5	1.66E+00	0/5	1.66E+02
Sump (SWMU 98)													
ANIONS													
Fluoride	mg/kg	1.97E+01	1.97E+01	1.97E+01	1/1	N/A	N/A	0/1	3.13E+02	0/1	9.33E+03	0/1	1.00E+05
METALS													
Aluminum	mg/kg	7.68E+00	7.68E+00	7.68E+00	1/1	0/1	1.30E+04	0/1	7.74E+03	0/1	1.00E+05	0/1	1.00E+05
Barium	mg/kg	1.99E+00	1.99E+00	1.99E+00	1/1	0/1	2.00E+02	0/1	1.53E+03	0/1	4.04E+04	0/1	1.00E+05
Cadmium	mg/kg	3.95E-01	3.95E-01	3.95E-01	1/1	1/1	2.10E-01	0/1	5.28E+00	0/1	6.05E+01	0/1	1.82E+03
Chromium	mg/kg	1.19E+00	1.19E+00	1.19E+00	1/1	0/1	1.60E+01	1/1	3.01E-01	0/1	1.23E+01	0/1	1.23E+03
Cobalt	mg/kg	5.68E-02	5.68E-02	5.68E-02	1/1	0/1	1.40E+01	0/1	2.34E+00	0/1	6.87E+01	0/1	2.06E+03
Copper	mg/kg	3.34E+01	3.34E+01	3.34E+01	1/1	1/1	1.90E+01	0/1	3.13E+02	0/1	9.34E+03	0/1	1.00E+05
Iron	mg/kg	4.43E+02	4.43E+02	4.43E+02	1/1	0/1	2.80E+04	0/1	5.48E+03	0/1	1.00E+05	0/1	1.00E+05
Lead	mg/kg	5.03E+00	5.03E+00	5.03E+00	1/1	0/1	3.60E+01	0/1	4.00E+02	0/1	8.00E+02	0/1	8.00E+02
Manganese	mg/kg	1.12E+00	1.12E+00	1.12E+00	1/1	1/1	1.50E+03	0/1	1.83E+02	0/1	4.72E+03	0/1	1.00E+05
Mercury	mg/kg	5.29E-02	5.29E-02	5.29E-02	1/1	0/1	2.00E-01	0/1	2.35E+00	0/1	7.01E+01	0/1	2.10E+03
Molybdenum	mg/kg	1.04E-01	1.04E-01	1.04E-01	1/1	N/A	N/A	0/1	3.91E+01	0/1	1.16E+03	0/1	3.48E+04
Nickel	mg/kg	1.06E+01	1.06E+01	1.06E+01	1/1	0/1	2.10E+01	0/1	1.55E+02	0/1	4.30E+03	0/1	1.00E+05
Uranium	mg/kg	1.86E+01	1.86E+01	1.86E+01	1/1	1/1	4.90E+00	1/1	1.56E+00	0/1	4.66E+01	0/1	1.40E+03
Zinc	mg/kg	3.45E+01	3.45E+01	3.45E+01	1/1	0/1	6.50E+01	0/1	2.35E+03	0/1	7.01E+04	0/1	1.00E+05
PCBS													
PCB, Total	mg/kg	4.94E+00	4.94E+00	4.94E+00	1/1	N/A	N/A	1/1	7.88E-02	1/1	2.93E-01	0/1	2.93E+01
SVOCS													
Fluoranthene	mg/kg	1.54E-01	1.54E-01	1.54E-01	1/1	N/A	N/A	0/1	1.23E+02	0/1	9.19E+02	0/1	2.76E+04
Pyrene	mg/kg	1.26E-01	1.26E-01	1.26E-01	1/1	N/A	N/A	0/1	9.23E+01	0/1	6.89E+02	0/1	2.07E+04
Total PAH	mg/kg	1.38E-02	1.38E-02	1.38E-02	1/1	N/A	N/A	0/1	4.78E-02	0/1	6.43E-01	0/1	6.43E+01
VOCS													
Trichloroethene	mg/kg	1.69E+05	1.69E+05	1.69E+05	1/1	N/A	N/A	1/1	4.12E-01	1/1	1.90E+00	1/1	5.70E+01

Table 5. Risk Screening Summary East Basement/Plenum Room—Sludge (Continued)

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
RADIONUCLIDES													
Americium-241	pCi/g	2.09E-01	2.09E-01	2.09E-01	1/1	N/A	N/A	0/1	1.75E+00	0/1	6.01E+00	0/1	6.01E+02
Cesium-137	pCi/g	1.12E-01	1.12E-01	1.12E-01	1/1	0/1	4.90E-01	1/1	4.02E-02	1/1	1.08E-01	0/1	1.08E+01
Neptunium-237	pCi/g	2.81E+00	2.81E+00	2.81E+00	1/1	1/1	1.00E-01	1/1	9.11E-02	1/1	2.49E-01	0/1	2.49E+01
Plutonium-239/240	pCi/g	9.89E-01	9.89E-01	9.89E-01	1/1	1/1	2.50E-02	0/1	3.77E+00	0/1	2.27E+01	0/1	2.27E+03
Technetium-99	pCi/g	1.08E+03	1.08E+03	1.08E+03	1/1	1/1	2.50E+00	1/1	1.10E+02	0/1	1.27E+03	0/1	1.00E+05
Thorium-230	pCi/g	2.54E+00	2.54E+00	2.54E+00	1/1	1/1	1.50E+00	0/1	4.93E+00	0/1	3.13E+01	0/1	3.13E+03
Uranium-233/234	pCi/g	1.58E+02	1.58E+02	1.58E+02	1/1	1/1	1.20E+00	1/1	5.77E+00	1/1	5.01E+01	0/1	5.01E+03
Uranium-235/236	pCi/g	9.10E+00	9.10E+00	9.10E+00	1/1	1/1	6.00E-02	1/1	1.48E-01	1/1	4.08E-01	0/1	4.08E+01
Uranium-238	pCi/g	2.58E+02	2.58E+02	2.58E+02	1/1	1/1	1.20E+00	1/1	5.56E-01	1/1	1.66E+00	1/1	1.66E+02

Legend:

One or more samples exceed background value.

One or more samples exceed NAL value.

One or more samples exceed AL value.

3.3 EAST FAN ROOM

3.3.1 Concrete Sampling

As stated in Section 2.4.1, one sample was collected. The sample from the visually stained location was analyzed for PCBs and radionuclides. Total PCBs and the detected radionuclides are presented in Table 6, along with their maximum result.

Risk screening, as described in Section 3.1, for concrete sampling in the East Fan Room is shown in Table 6. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

Only the radionuclides U-235/236 and U-238 exceed both background[9] and NALs for both the child resident and the industrial worker. There were no detections exceeding industrial worker ALs.

3.3.2 Paint Sampling

As stated in Section. 2.4.2, two paint samples were collected. These samples were analyzed for an anion (fluoride), metals, PCBs, and radionuclides. The detections are presented in Table 7, along with their maximum detected results.

Risk screening, as described in Section 3.1, for paint sampling in the East Fan Room is shown in Table 7. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

The metals arsenic, chromium, iron, lead, and uranium, and the radionuclides Np-237, U-235/236, and U-238 exceed both background[10] and industrial worker NALs. Of these, iron and lead also exceed industrial worker ALs. Total PCBs exceed the industrial worker NAL and industrial worker AL. In addition to those analytes exceeding industrial worker NALs, barium, cobalt, Tc-99, and U-233/234 also exceed both background and child resident NALs. Total PCBs exceed the child resident NAL.

3.3.3 Caulk Sampling

As stated in Section 2.4.3, two caulk samples were collected. These samples were analyzed for PCBs. The PCB detections are presented in Table 8, along with their maximum detected results.

Risk screening for caulk sampling in the East Fan Room is shown in Table 8. Total PCBs in these samples exceed the child resident and industrial worker NALs.

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[9] Background values are for surface soil and are not applicable to concrete.
[10] Background values are for surface soil and are not applicable to paint.

Table 6. Risk Screening Summary East Fan Room—Concrete

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
PCBS													
PCB, Total	mg/kg	5.04E-02	5.04E-02	5.04E-02	1/1	N/A	N/A	0/1	7.88E-02	0/1	2.93E-01	0/1	2.93E+01
RADIONUCLIDES													
Technetium-99	pCi/g	2.09E+01	2.09E+01	2.09E+01	1/1	1/1	2.50E+00	0/1	1.10E+02	0/1	1.27E+03	0/1	1.00E+05
Thorium-230	pCi/g	6.88E-01	6.88E-01	6.88E-01	1/1	0/1	1.50E+00	0/1	4.93E+00	0/1	3.13E+01	0/1	3.13E+03
Uranium-233/234	pCi/g	2.40E+00	2.40E+00	2.40E+00	1/1	1/1	1.20E+00	0/1	5.77E+00	0/1	5.01E+01	0/1	5.01E+03
Uranium-235/236	pCi/g	5.24E-01	5.24E-01	5.24E-01	1/1	1/1	6.00E-02	1/1	1.48E-01	1/1	4.08E-01	0/1	4.08E+01
Uranium-238	pCi/g	2.52E+00	2.52E+00	2.52E+00	1/1	1/1	1.20E+00	1/1	5.56E-01	1/1	1.66E+00	0/1	1.66E+02

Legend:
(orange) One or more samples exceed background value.
(green) One or more samples exceed NAL value.

Table 7. Risk Screening Summary East Fan Room—Paint

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	4.10E+01	4.47E+01	4.29E+01	2/2	N/A	N/A	0/2	3.13E+02	0/2	9.33E+03	0/2	1.00E+05
METALS													
Aluminum	mg/kg	9.18E+03	9.69E+03	9.44E+03	2/2	0/2	1.30E+04	2/2	7.74E+03	0/2	1.00E+05	0/2	1.00E+05
Antimony	mg/kg	1.32E+00	2.93E+00	2.13E+00	2/2	2/2	2.10E-01	0/2	3.13E+00	0/2	9.34E+01	0/2	2.80E+03
Arsenic	mg/kg	1.17E+01	1.23E+01	1.20E+01	2/2	1/2	1.20E+01	2/2	3.56E-01	2/2	1.60E+00	0/2	1.60E+02
Barium	mg/kg	1.47E+03	1.54E+03	1.51E+03	2/2	2/2	2.00E+02	1/2	1.53E+03	0/2	4.04E+04	0/2	1.00E+05
Beryllium	mg/kg	3.39E-01	3.47E-01	3.43E-01	2/2	0/2	6.70E-01	0/2	1.56E+01	0/2	4.50E+02	0/2	1.35E+04
Boron	mg/kg	6.40E+01	7.08E+01	6.74E+01	2/2	N/A	N/A	0/2	1.56E+03	0/2	4.65E+04	0/2	1.00E+05
Cadmium	mg/kg	1.30E+00	1.79E+00	1.55E+00	2/2	2/2	2.10E-01	0/2	5.28E+00	0/2	6.05E+01	0/2	1.82E+03
Chromium	mg/kg	2.92E+02	4.65E+02	3.79E+02	2/2	2/2	1.60E+01	2/2	3.01E-01	2/2	1.23E+01	0/2	1.23E+03
Cobalt	mg/kg	3.94E+01	4.36E+01	4.15E+01	2/2	2/2	1.40E+01	2/2	2.34E+00	0/2	6.87E+01	0/2	2.06E+03
Copper	mg/kg	1.03E+02	1.76E+02	1.40E+02	2/2	2/2	1.90E+01	0/2	3.13E+02	0/2	9.34E+03	0/2	1.00E+05
Iron	mg/kg	4.91E+04	1.13E+05	8.11E+04	2/2	2/2	2.80E+04	2/2	5.48E+03	1/2	1.00E+05	1/2	1.00E+05
Lead	mg/kg	9.11E+02	2.09E+03	1.50E+03	2/2	2/2	3.60E+01	2/2	4.00E+02	2/2	8.00E+02	2/2	8.00E+02
Manganese	mg/kg	9.67E+02	1.43E+03	1.20E+03	2/2	0/2	1.50E+03	2/2	1.83E+02	0/2	4.72E+03	0/2	1.00E+05
Mercury	mg/kg	3.09E-02	7.94E-02	5.52E-02	2/2	0/2	2.00E-01	0/2	2.35E+00	0/2	7.01E+01	0/2	2.10E+03
Molybdenum	mg/kg	1.14E+01	3.76E+01	2.45E+01	2/2	N/A	N/A	0/2	3.91E+01	0/2	1.16E+03	0/2	3.48E+04
Nickel	mg/kg	8.77E+01	1.11E+02	9.94E+01	2/2	2/2	2.10E+01	0/2	1.55E+02	0/2	4.30E+03	0/2	1.00E+05
Selenium	mg/kg	6.01E-01	1.30E+00	9.51E-01	2/2	1/2	8.00E-01	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Uranium	mg/kg	6.91E+01	1.97E+02	1.33E+02	2/2	2/2	4.90E+00	2/2	1.56E+00	2/2	4.66E+01	0/2	1.40E+03
Vanadium	mg/kg	2.18E+01	3.29E+01	2.74E+01	2/2	0/2	3.80E+01	0/2	3.93E+01	0/2	1.15E+03	0/2	3.45E+04
Zinc	mg/kg	9.65E+02	2.10E+03	1.53E+03	2/2	2/2	6.50E+01	0/2	2.35E+03	0/2	7.01E+04	0/2	1.00E+05
PCBS													
PCB, Total	mg/kg	4.43E+00	7.73E+01	4.09E+01	2/2	N/A	N/A	2/2	7.88E-02	2/2	2.93E-01	1/2	2.93E+01
RADIONUCLIDES													
Cesium-137	pCi/g	2.24E-01	2.24E-01	2.24E-01	1/2	0/2	4.90E-01	1/2	4.02E-02	1/2	1.08E-01	0/2	1.08E+01
Neptunium-237	pCi/g	9.99E-01	1.18E+00	1.09E+00	2/2	2/2	1.00E-01	2/2	9.11E-02	2/2	2.49E-01	0/2	2.49E+01
Plutonium-238	pCi/g	8.45E-01	8.45E-01	8.45E-01	1/2	1/2	7.30E-02	0/2	4.27E+00	0/2	2.65E+01	0/2	2.65E+03
Plutonium-239/240	pCi/g	8.76E-01	8.76E-01	8.76E-01	1/2	1/2	2.50E-02	0/2	3.77E+00	0/2	2.27E+01	0/2	2.27E+03
Technetium-99	pCi/g	1.96E+01	1.15E+02	6.73E+01	2/2	2/2	2.50E+00	1/2	1.10E+02	0/2	1.27E+03	0/2	1.00E+05
Thorium-230	pCi/g	1.23E+00	1.60E+00	1.42E+00	2/2	1/2	1.50E+00	0/2	4.93E+00	0/2	3.13E+01	0/2	3.13E+03
Uranium-233/234	pCi/g	9.00E+00	9.63E+00	9.32E+00	2/2	2/2	1.20E+00	2/2	5.77E+00	0/2	5.01E+01	0/2	5.01E+03
Uranium-235/236	pCi/g	4.00E-01	5.78E-01	4.89E-01	2/2	2/2	6.00E-02	2/2	1.48E-01	1/2	4.08E-01	0/2	4.08E+01
Uranium-238	pCi/g	1.42E+01	1.49E+01	1.46E+01	2/2	2/2	1.20E+00	2/2	5.56E-01	2/2	1.66E+00	0/2	1.66E+02

Legend:
- (orange) One or more samples exceed background value.
- (green) One or more samples exceed NAL value.
- (red) One or more samples exceed AL value.

Table 8. Risk Screening Summary East Fan Room—Caulk

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	**Max**	**Avg**		**FOE**	**Bkgd**	**FOE**	**NAL**	**FOE**	**NAL**	**FOE**	**AL**
PCBS													
PCB, Total	mg/kg	1.20E-01	1.20E+00	6.61E-01	2/2	N/A	N/A	2/2	7.88E-02	1/2	2.93E-01	0/2	2.93E+01

Legend:

(green) One or more samples exceed NAL value.

3.4 COMPRESSOR DISASSEMBLY PIT

As stated in Section 2.5, two concrete samples and two brick samples were collected. These samples were analyzed for asbestos (top concrete sample only); an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. No asbestos was detected. The detected analytes are presented in Table 9, along with their maximum detected results.

Risk screening, as described in Section 3.1, for concrete/brick sampling in the compressor disassembly pit is shown in Table 9. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

Only the metal uranium and the radionuclides Np-237, U-233/234, U-235/236, and U-238 exceed both background[11] and industrial worker NALs. Total PCBs exceed the industrial worker NAL. There were no detections that exceed industrial worker ALs.

In addition to those analytes exceeding industrial worker NALs, cobalt and Tc-99 also exceed both background and child resident NALs. Total PCBs exceed the child resident NAL.

[11] Background values are for surface soil and are not applicable to concrete/brick.

Table 9. Risk Screening Summary Compressor Disassembly Pit—Concrete/Brick

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	4.89E+00	2.53E+01	1.48E+01	3/4	N/A	N/A	0/4	3.13E+02	0/4	9.33E+03	0/4	1.00E+05
METALS													
Aluminum	mg/kg	2.96E+02	3.05E+03	1.72E+03	4/4	0/4	1.30E+04	0/4	7.74E+03	0/4	1.00E+05	0/4	1.00E+05
Arsenic	mg/kg	4.06E-01	1.82E+00	1.34E+00	3/4	0/4	1.20E+01	3/4	3.56E-01	2/4	1.60E+00	0/4	1.60E+02
Barium	mg/kg	9.10E+00	2.72E+01	1.82E+01	4/4	0/4	2.00E+02	0/4	1.53E+03	0/4	4.04E+04	0/4	1.00E+05
Beryllium	mg/kg	2.85E-02	1.36E-01	9.95E-02	3/4	0/4	6.70E-01	0/4	1.56E+01	0/4	4.50E+02	0/4	1.35E+04
Boron	mg/kg	3.07E+00	9.06E+00	5.88E+00	4/4	N/A	N/A	0/4	1.56E+03	0/4	4.65E+04	0/4	1.00E+05
Cadmium	mg/kg	5.33E-02	2.44E-01	1.34E-01	4/4	1/4	2.10E-01	0/4	5.28E+00	0/4	6.05E+01	0/4	1.82E+03
Chromium	mg/kg	3.32E+00	7.10E+00	5.38E+00	4/4	0/4	1.60E+01	4/4	3.01E-01	0/4	1.23E+01	0/4	1.23E+03
Cobalt	mg/kg	9.04E+00	2.04E+01	1.45E+01	4/4	2/4	1.40E+01	4/4	2.34E+00	0/4	6.87E+01	0/4	2.06E+03
Copper	mg/kg	2.89E+01	6.09E+01	4.38E+01	4/4	4/4	1.90E+01	0/4	3.13E+02	0/4	9.34E+03	0/4	1.00E+05
Iron	mg/kg	1.37E+03	4.82E+03	3.06E+03	4/4	0/4	2.80E+04	0/4	5.48E+03	0/4	1.00E+05	0/4	1.00E+05
Lead	mg/kg	2.79E+00	5.40E+00	4.21E+00	4/4	0/4	3.60E+01	0/4	4.00E+02	0/4	8.00E+02	0/4	8.00E+02
Manganese	mg/kg	2.51E+01	2.74E+02	1.33E+02	4/4	0/4	1.50E+03	2/4	1.83E+02	0/4	4.72E+03	0/4	1.00E+05
Mercury	mg/kg	4.10E-03	1.20E-02	7.23E-03	3/4	0/4	2.00E-01	0/4	2.35E+00	0/4	7.01E+01	0/4	2.10E+03
Molybdenum	mg/kg	1.61E-01	1.03E+00	5.36E-01	4/4	N/A	N/A	0/4	3.91E+01	0/4	1.16E+03	0/4	3.48E+04
Nickel	mg/kg	7.91E+00	1.69E+01	1.12E+01	4/4	0/4	2.10E+01	0/4	1.55E+02	0/4	4.30E+03	0/4	1.00E+05
Selenium	mg/kg	4.11E-01	4.11E-01	4.11E-01	1/4	0/4	8.00E-01	0/4	3.91E+01	0/4	1.17E+03	0/4	3.51E+04
Silver	mg/kg	1.12E-01	1.12E-01	1.12E-01	1/4	0/4	2.30E+00	0/4	3.91E+01	0/4	1.17E+03	0/4	3.51E+04
Uranium	mg/kg	3.98E+01	7.72E+02	3.34E+02	4/4	4/4	4.90E+00	4/4	1.56E+00	4/4	4.66E+01	0/4	1.40E+03
Vanadium	mg/kg	1.19E+00	5.59E+00	4.03E+00	3/4	0/4	3.80E+01	0/4	3.93E+01	0/4	1.15E+03	0/4	3.45E+04
Zinc	mg/kg	5.07E+00	2.85E+01	1.70E+01	4/4	0/4	6.50E+01	0/4	2.35E+03	0/4	7.01E+04	0/4	1.00E+05
PCBS													
PCB, Total	mg/kg	4.55E-02	2.95E+00	1.10E+00	4/4	N/A	N/A	2/4	7.88E-02	2/4	2.93E-01	0/4	2.93E+01
VOCS													
1,2-Dimethylbenzene	mg/kg	1.98E-03	1.98E-03	1.98E-03	1/4	N/A	N/A	0/4	6.45E+01	0/4	2.81E+02	0/4	8.43E+03
Benzene	mg/kg	2.06E-03	2.06E-03	2.06E-03	1/4	N/A	N/A	0/4	1.16E+00	0/4	5.31E+00	0/4	5.31E+02
Ethylbenzene	mg/kg	1.07E-03	1.07E-03	1.07E-03	1/4	N/A	N/A	0/4	5.78E+00	0/4	2.66E+01	0/4	2.66E+03
m,p-Xylene	mg/kg	4.47E-03	4.47E-03	4.47E-03	1/4	N/A	N/A	0/4	5.76E+01	0/4	2.50E+02	0/4	7.50E+03
Toluene	mg/kg	2.01E-01	5.15E-01	3.89E-01	4/4	N/A	N/A	0/4	4.89E+02	0/4	6.25E+03	0/4	1.00E+05
Total Xylene	mg/kg	6.45E-03	6.45E-03	6.45E-03	1/4	N/A	N/A	0/4	5.76E+01	0/4	2.50E+02	0/4	7.50E+03
Trichloroethene	mg/kg	3.27E-02	8.03E-02	5.65E-02	2/4	N/A	N/A	0/4	4.12E-01	0/4	1.90E+00	0/4	5.70E+01
RADIONUCLIDES													
Neptunium-237	pCi/g	6.29E+00	6.29E+00	6.29E+00	1/4	1/4	1.00E-01	1/4	9.11E-02	1/4	2.49E-01	0/4	2.49E+01
Plutonium-239/240	pCi/g	4.07E-01	4.07E-01	4.07E-01	1/4	1/4	2.50E-02	0/4	3.77E+00	0/4	2.27E+01	0/4	2.27E+03
Technetium-99	pCi/g	1.49E+01	2.60E+02	1.50E+02	4/4	4/4	2.50E+00	3/4	1.10E+02	0/4	1.27E+03	0/4	1.00E+05
Thorium-230	pCi/g	7.30E-01	1.59E+00	1.02E+00	4/4	1/4	1.50E+00	0/4	4.93E+00	0/4	3.13E+01	0/4	3.13E+03
Uranium-233/234	pCi/g	3.34E+00	7.90E+01	2.57E+01	4/4	4/4	1.20E+00	2/4	5.77E+00	1/4	5.01E+01	0/4	5.01E+03
Uranium-235/236	pCi/g	5.83E-01	5.67E+00	2.63E+00	3/4	3/4	6.00E-02	3/4	1.48E-01	3/4	4.08E-01	0/4	4.08E+01
Uranium-238	pCi/g	3.50E+00	1.10E+02	3.53E+01	4/4	4/4	1.20E+00	4/4	5.56E-01	4/4	1.66E+00	0/4	1.66E+02

Legend:
One or more samples exceed background value.
One or more samples exceed NAL value.

3.5 PRESSURE REDUCING STATION AND CONDENSATE PIT

3.5.1 Concrete Sampling

As stated in Section 2.6.1, samples were collected from two preselected locations in this region of the C-400 Building. PCB samples were collected from a collocated area. Samples were analyzed for asbestos (top sample only); an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. No asbestos was detected. The detected analytes are presented in Table 10, along with their maximum detected results.

Risk screening, as described in Section 3.1, for concrete sampling in the pressure reducing station and condensate pit is shown in Table 10. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

Only the metals chromium and uranium and the radionuclides U-235/236 and U-238 exceed both background[12] and industrial worker NALs. There were no detections that exceed industrial worker ALs.

In addition to those analytes exceeding industrial worker NALs, cobalt, iron, and U-233/234 also exceed both background and child resident NALs. Total PCBs exceed child resident NAL.

3.5.2 Paint Sampling

As stated in Section 2.6.2, one sample was collected. This sample was analyzed for an anion (fluoride); metals; PCBs; and radionuclides. The detected analytes are presented in Table 11 along with their maximum detected results.

Risk screening, as described in Section 3.1, for paint sampling in the pressure reducing station and condensate pit is shown in Table 11. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

The metals chromium, lead, and uranium, and the radionuclides Cs-137, Np-237, U-233/234, U-235/236 and U-238 exceed both background[13] and industrial worker NALs. Of these, lead and U-238 also exceed industrial worker ALs. Total PCBs exceed the industrial worker NAL.

In addition to those analytes exceeding industrial worker NALs, antimony, cobalt, iron, Tc-99, and Th-230 also exceed both background and child resident NALs. Total PCBs exceed the child resident NAL.

3.6 MAINTENANCE PIT (EAST TRUCK ALLEY)

As stated in Section 2.7, two concrete samples and a duplicate were collected. These samples were analyzed for asbestos (top sample only); an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. No asbestos was detected. The detected analytes are presented in Table 12, along with their maximum detected results.

Risk screening, as described in Section 3.1, for concrete sampling in the maintenance pit is shown in Table 12. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

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[12] Background values are for surface soil and are not applicable to concrete.
[13] Background values are for surface soil and are not applicable to paint.

Table 10. Risk Screening Summary Pressure Reducing Stations and Condensate Pit—Concrete

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	5.78E-01	5.78E-01	5.78E-01	1/2	N/A	N/A	0/2	3.13E+02	0/2	9.33E+03	0/2	1.00E+05
METALS													
Aluminum	mg/kg	3.99E+03	6.98E+03	5.49E+03	2/2	0/2	1.30E+04	0/2	7.74E+03	0/2	1.00E+05	0/2	1.00E+05
Arsenic	mg/kg	2.33E+00	7.36E+00	4.85E+00	2/2	0/2	1.20E+01	2/2	3.56E-01	2/2	1.60E+00	0/2	1.60E+02
Barium	mg/kg	3.94E+01	6.18E+01	5.06E+01	2/2	0/2	2.00E+02	0/2	1.53E+03	0/2	4.04E+04	0/2	1.00E+05
Beryllium	mg/kg	1.86E-01	3.13E-01	2.50E-01	2/2	0/2	6.70E-01	0/2	1.56E+01	0/2	4.50E+02	0/2	1.35E+04
Boron	mg/kg	8.64E+00	1.32E+01	1.09E+01	2/2	N/A	N/A	0/2	1.56E+03	0/2	4.65E+04	0/2	1.00E+05
Cadmium	mg/kg	2.34E-01	9.57E-01	5.96E-01	2/2	2/2	2.10E-01	0/2	5.28E+00	0/2	6.05E+01	0/2	1.82E+03
Chromium	mg/kg	8.03E+00	3.57E+01	2.19E+01	2/2	1/2	1.60E+01	2/2	3.01E-01	1/2	1.23E+01	0/2	1.23E+03
Cobalt	mg/kg	6.79E+00	3.53E+01	2.10E+01	2/2	1/2	1.40E+01	2/2	2.34E+00	0/2	6.87E+01	0/2	2.06E+03
Copper	mg/kg	1.50E+01	1.43E+02	7.90E+01	2/2	1/2	1.90E+01	0/2	3.13E+02	0/2	9.34E+03	0/2	1.00E+05
Iron	mg/kg	6.70E+03	3.43E+04	2.05E+04	2/2	1/2	2.80E+04	2/2	5.48E+03	0/2	1.00E+05	0/2	1.00E+05
Lead	mg/kg	2.21E+00	6.09E+01	3.16E+01	2/2	1/2	3.60E+01	0/2	4.00E+02	0/2	8.00E+02	0/2	8.00E+02
Manganese	mg/kg	3.26E+02	5.88E+02	4.57E+02	2/2	0/2	1.50E+03	2/2	1.83E+02	0/2	4.72E+03	0/2	1.00E+05
Molybdenum	mg/kg	7.29E-01	6.84E+00	3.78E+00	2/2	N/A	N/A	0/2	3.91E+01	0/2	1.16E+03	0/2	3.48E+04
Nickel	mg/kg	6.95E+00	2.50E+01	1.60E+01	2/2	1/2	2.10E+01	0/2	1.55E+02	0/2	4.30E+03	0/2	1.00E+05
Selenium	mg/kg	3.63E-01	4.40E-01	4.02E-01	2/2	0/2	8.00E-01	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Uranium	mg/kg	2.70E+00	6.68E+01	3.48E+01	2/2	1/2	4.90E+00	2/2	1.56E+00	1/2	4.66E+01	0/2	1.40E+03
Vanadium	mg/kg	8.23E+00	1.66E+01	1.24E+01	2/2	0/2	3.80E+01	0/2	3.93E+01	0/2	1.15E+03	0/2	3.45E+04
Zinc	mg/kg	2.62E+01	7.68E+01	5.15E+01	2/2	1/2	6.50E+01	0/2	2.35E+03	0/2	7.01E+04	0/2	1.00E+05
PCBS													
PCB, Total	mg/kg	7.16E-03	1.30E-01	6.84E-02	2/2	N/A	N/A	1/2	7.88E-02	0/2	2.93E-01	0/2	2.93E+01
SVOCS													
Fluoranthene	mg/kg	1.61E-02	1.61E-02	1.61E-02	1/2	N/A	N/A	0/2	1.23E+02	0/2	9.19E+02	0/2	2.76E+04
Napthalene	mg/kg	1.32E-02	1.32E-02	1.32E-02	1/2	N/A	N/A	0/2	3.83E+00	0/2	1.67E+01	0/2	1.61E+03
Phenanthrene	mg/kg	3.98E-02	3.98E-02	3.98E-02	1/2	N/A	N/A	0/2	1.85E+02	0/2	1.38E+03	0/2	4.14E+04
VOCS													
1,2-Dimethylbenzene	mg/kg	5.20E-04	5.20E-04	5.20E-04	1/2	N/A	N/A	0/2	6.45E+01	0/2	2.81E+02	0/2	8.43E+03
Benzene	mg/kg	3.80E-04	3.80E-04	3.80E-04	1/2	N/A	N/A	0/2	1.16E+00	0/2	5.31E+00	0/2	5.31E+02
Ethylbenzene	mg/kg	4.30E-04	4.30E-04	4.30E-04	1/2	N/A	N/A	0/2	5.78E+00	0/2	2.66E+01	0/2	2.66E+03
m,p-Xylene	mg/kg	1.05E-03	1.05E-03	1.05E-03	1/2	N/A	N/A	0/2	5.76E+01	0/2	2.50E+02	0/2	7.50E+03
Toluene	mg/kg	4.06E-01	4.06E-01	4.06E-01	1/2	N/A	N/A	0/2	4.89E+02	0/2	6.25E+03	0/2	1.00E+05
Total Xylene	mg/kg	1.57E-03	1.57E-03	1.57E-03	1/2	N/A	N/A	0/2	5.76E+01	0/2	2.50E+02	0/2	7.50E+03
Trichloroethene	mg/kg	1.92E-03	1.92E-03	1.92E-03	1/2	N/A	N/A	0/2	4.12E-01	0/2	1.90E+00	0/2	5.70E+01
RADIONUCLIDES													
Plutonium-239/240	pCi/g	3.05E-01	3.05E-01	3.05E-01	1/2	1/2	2.50E-02	0/2	3.77E+00	0/2	2.27E+01	0/2	2.27E+03
Technetium-99	pCi/g	2.16E+01	2.16E+01	2.16E+01	1/2	1/2	2.50E+00	0/2	1.10E+02	0/2	1.27E+03	0/2	1.00E+05
Thorium-230	pCi/g	1.59E+00	1.62E+00	1.61E+00	2/2	2/2	1.50E+00	0/2	4.93E+00	0/2	3.13E+01	0/2	3.13E+03
Uranium-233/234	pCi/g	6.72E+00	2.89E+01	1.78E+01	2/2	2/2	1.20E+00	2/2	5.77E+00	0/2	5.01E+01	0/2	5.01E+03
Uranium-235/236	pCi/g	1.29E+00	1.64E+00	1.47E+00	2/2	2/2	6.00E-02	2/2	1.48E-01	2/2	4.08E-01	0/2	4.08E+01
Uranium-238	pCi/g	8.05E+00	3.34E+01	2.07E+01	2/2	2/2	1.20E+00	2/2	5.56E-01	2/2	1.66E+00	0/2	1.66E+02

Legend:

One or more samples exceed background value. (orange)

One or more samples exceed NAL value. (green)

Table 11. Risk Screening Summary Pressure Reducing Stations and Condensate Pit—Paint

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	1.90E+01	1.90E+01	1.90E+01	1/1	N/A	N/A	0/1	3.13E+02	0/1	9.33E+03	0/1	1.00E+05
METALS													
Aluminum	mg/kg	1.08E+04	1.08E+04	1.08E+04	1/1	0/1	1.30E+04	1/1	7.74E+03	0/1	1.00E+05	0/1	1.00E+05
Antimony	mg/kg	7.94E+00	7.94E+00	7.94E+00	1/1	1/1	2.10E-01	1/1	3.13E+00	0/1	9.34E+01	0/1	2.80E+03
Arsenic	mg/kg	7.16E+00	7.16E+00	7.16E+00	1/1	0/1	1.20E+01	1/1	3.56E-01	1/1	1.60E+00	0/1	1.60E+02
Barium	mg/kg	1.24E+02	1.24E+02	1.24E+02	1/1	0/1	2.00E+02	0/1	1.53E+03	0/1	4.04E+04	0/1	1.00E+05
Beryllium	mg/kg	1.81E-01	1.81E-01	1.81E-01	1/1	0/1	6.70E-01	0/1	1.56E+01	0/1	4.50E+02	0/1	1.35E+04
Boron	mg/kg	2.43E+01	2.43E+01	2.43E+01	1/1	N/A	N/A	0/1	1.56E+03	0/1	4.65E+04	0/1	1.00E+05
Cadmium	mg/kg	3.17E+00	3.17E+00	3.17E+00	1/1	1/1	2.10E-01	0/1	5.28E+00	0/1	6.05E+01	0/1	1.82E+03
Chromium	mg/kg	3.69E+02	3.69E+02	3.69E+02	1/1	1/1	1.60E+01	1/1	3.01E-01	1/1	1.23E+01	0/1	1.23E+03
Cobalt	mg/kg	2.33E+01	2.33E+01	2.33E+01	1/1	1/1	1.40E+01	1/1	2.34E+00	0/1	6.87E+01	0/1	2.06E+03
Copper	mg/kg	1.65E+02	1.65E+02	1.65E+02	1/1	1/1	1.90E+01	0/1	3.13E+02	0/1	9.34E+03	0/1	1.00E+05
Iron	mg/kg	6.66E+04	6.66E+04	6.66E+04	1/1	1/1	2.80E+04	1/1	5.48E+03	0/1	1.00E+05	0/1	1.00E+05
Lead	mg/kg	2.08E+03	2.08E+03	2.08E+03	1/1	1/1	3.60E+01	1/1	4.00E+02	1/1	8.00E+02	1/1	8.00E+02
Manganese	mg/kg	5.55E+02	5.55E+02	5.55E+02	1/1	0/1	1.50E+03	1/1	1.83E+02	0/1	4.72E+03	0/1	1.00E+05
Mercury	mg/kg	8.32E-02	8.32E-02	8.32E-02	1/1	0/1	2.00E-01	0/1	2.35E+00	0/1	7.01E+01	0/1	2.10E+03
Molybdenum	mg/kg	1.93E+01	1.93E+01	1.93E+01	1/1	N/A	N/A	0/1	3.91E+01	0/1	1.16E+03	0/1	3.48E+04
Nickel	mg/kg	6.48E+01	6.48E+01	6.48E+01	1/1	1/1	2.10E+01	0/1	1.55E+02	0/1	4.30E+03	0/1	1.00E+05
Selenium	mg/kg	6.52E-01	6.52E-01	6.52E-01	1/1	0/1	8.00E-01	0/1	3.91E+01	0/1	1.17E+03	0/1	3.51E+04
Silver	mg/kg	6.16E-01	6.16E-01	6.16E-01	1/1	0/1	2.30E+00	0/1	3.91E+01	0/1	1.17E+03	0/1	3.51E+04
Uranium	mg/kg	5.16E+02	5.16E+02	5.16E+02	1/1	1/1	4.90E+00	1/1	1.56E+00	1/1	4.66E+01	0/1	1.40E+03
Vanadium	mg/kg	2.55E+01	2.55E+01	2.55E+01	1/1	0/1	3.80E+01	0/1	3.93E+01	0/1	1.15E+03	0/1	3.45E+04
Zinc	mg/kg	1.12E+03	1.12E+03	1.12E+03	1/1	1/1	6.50E+01	0/1	2.35E+03	0/1	7.01E+04	0/1	1.00E+05
PCBS													
PCB, Total	mg/kg	2.42E+00	2.42E+00	2.42E+00	1/1	N/A	N/A	1/1	7.88E-02	1/1	2.93E-01	0/1	2.93E+01
RADIONUCLIDES													
Americium-241	pCi/g	5.00E-01	5.00E-01	5.00E-01	1/1	N/A	N/A	0/1	1.75E+00	0/1	6.01E+00	0/1	6.01E+02
Cesium-137	pCi/g	2.96E+00	2.96E+00	2.96E+00	1/1	1/1	4.90E-01	1/1	4.02E-02	1/1	1.08E-01	0/1	1.08E+01
Neptunium-237	pCi/g	3.22E+00	3.22E+00	3.22E+00	1/1	1/1	1.00E-01	1/1	9.11E-02	1/1	2.49E-01	0/1	2.49E+01
Plutonium-239/240	pCi/g	3.01E+00	3.01E+00	3.01E+00	1/1	1/1	2.50E-02	0/1	3.77E+00	0/1	2.27E+01	0/1	2.27E+03
Technetium-99	pCi/g	6.26E+02	6.26E+02	6.26E+02	1/1	1/1	2.50E+00	1/1	1.10E+02	0/1	1.27E+03	0/1	1.00E+05
Thorium-230	pCi/g	2.84E+01	2.84E+01	2.84E+01	1/1	1/1	1.50E+00	1/1	4.93E+00	0/1	3.13E+01	0/1	3.13E+03
Uranium-233/234	pCi/g	2.51E+02	2.51E+02	2.51E+02	1/1	1/1	1.20E+00	1/1	5.77E+00	1/1	5.01E+01	0/1	5.01E+03
Uranium-235/236	pCi/g	1.46E+01	1.46E+01	1.46E+01	1/1	1/1	6.00E-02	1/1	1.48E-01	1/1	4.08E-01	0/1	4.08E+01
Uranium-238	pCi/g	2.81E+02	2.81E+02	2.81E+02	1/1	1/1	1.20E+00	1/1	5.56E-01	1/1	1.66E+00	1/1	1.66E+02

Legend:
- One or more samples exceed background value.
- One or more samples exceed NAL value.
- One or more samples exceed AL value.

Table 12. Risk Screening Summary Maintenance Pit (East Truck Alley)—Concrete

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	**Max**	**Avg**		**FOE**	**Bkgd**	**FOE**	**NAL**	**FOE**	**NAL**	**FOE**	**AL**
METALS													
Aluminum	mg/kg	5.39E+03	6.56E+03	6.03E+03	3/3	0/3	1.30E+04	0/3	7.74E+03	0/3	1.00E+05	0/3	1.00E+05
Arsenic	mg/kg	5.56E+00	6.38E+00	5.90E+00	3/3	0/3	1.20E+01	3/3	3.56E-01	3/3	1.60E+00	0/3	1.60E+02
Barium	mg/kg	5.40E+01	6.79E+01	6.09E+01	3/3	0/3	2.00E+02	0/3	1.53E+03	0/3	4.04E+04	0/3	1.00E+05
Beryllium	mg/kg	2.74E-01	3.16E-01	2.94E-01	3/3	0/3	6.70E-01	0/3	1.56E+01	0/3	4.50E+02	0/3	1.35E+04
Boron	mg/kg	9.49E+00	1.17E+01	1.10E+01	3/3	N/A	N/A	0/3	1.56E+03	0/3	4.65E+04	0/3	1.00E+05
Cadmium	mg/kg	8.59E-02	3.07E-01	1.68E-01	3/3	1/3	2.10E-01	0/3	5.28E+00	0/3	6.05E+01	0/3	1.82E+03
Chromium	mg/kg	9.73E+00	1.53E+01	1.25E+01	3/3	0/3	1.60E+01	3/3	3.01E-01	2/3	1.23E+01	0/3	1.23E+03
Cobalt	mg/kg	6.17E+00	1.37E+02	5.01E+01	3/3	1/3	1.40E+01	3/3	2.34E+00	1/3	6.87E+01	0/3	2.06E+03
Copper	mg/kg	6.66E+00	4.09E+02	1.42E+02	3/3	1/3	1.90E+01	1/3	3.13E+02	0/3	9.34E+03	0/3	1.00E+05
Iron	mg/kg	1.19E+04	1.54E+04	1.39E+04	3/3	0/3	2.80E+04	3/3	5.48E+03	0/3	1.00E+05	0/3	1.00E+05
Lead	mg/kg	4.07E+00	7.81E+00	5.40E+00	3/3	0/3	3.60E+01	0/3	4.00E+02	0/3	8.00E+02	0/3	8.00E+02
Manganese	mg/kg	3.40E+02	6.22E+02	4.59E+02	3/3	0/3	1.50E+03	3/3	1.83E+02	0/3	4.72E+03	0/3	1.00E+05
Molybdenum	mg/kg	8.74E-01	1.03E+00	9.31E-01	3/3	N/A	N/A	0/3	3.91E+01	0/3	1.16E+03	0/3	3.48E+04
Nickel	mg/kg	2.47E+01	3.32E+02	1.36E+02	3/3	3/3	2.10E+01	1/3	1.55E+02	0/3	4.30E+03	0/3	1.00E+05
Selenium	mg/kg	3.81E-01	4.37E-01	4.09E-01	2/3	0/3	8.00E-01	0/3	3.91E+01	0/3	1.17E+03	0/3	3.51E+04
Silver	mg/kg	1.17E-01	1.17E-01	1.17E-01	1/3	0/3	2.30E+00	0/3	3.91E+01	0/3	1.17E+03	0/3	3.51E+04
Uranium	mg/kg	5.18E+00	4.41E+01	1.93E+01	3/3	3/3	4.90E+00	3/3	1.56E+00	0/3	4.66E+01	0/3	1.40E+03
Vanadium	mg/kg	1.14E+01	1.47E+01	1.35E+01	3/3	0/3	3.80E+01	0/3	3.93E+01	0/3	1.15E+03	0/3	3.45E+04
Zinc	mg/kg	2.30E+01	7.49E+01	4.21E+01	3/3	1/3	6.50E+01	0/3	2.35E+03	0/3	7.01E+04	0/3	1.00E+05
PCBS													
PCB, Total	mg/kg	1.08E-02	2.72E-01	9.85E-02	3/3	N/A	N/A	1/3	7.88E-02	0/3	2.93E-01	0/3	2.93E+01
VOCS													
Toluene	mg/kg	4.04E-02	1.06E-01	6.72E-02	3/3	N/A	N/A	0/3	4.89E+02	0/3	6.25E+03	0/3	1.00E+05
RADIONUCLIDES													
Technetium-99	pCi/g	7.34E+02	1.53E+03	1.07E+03	3/3	3/3	2.50E+00	3/3	1.10E+02	1/3	1.27E+03	0/3	1.00E+05
Uranium-233/234	pCi/g	8.13E-01	1.39E+00	1.10E+00	2/3	1/3	1.20E+00	0/3	5.77E+00	0/3	5.01E+01	0/3	5.01E+03
Uranium-238	pCi/g	5.29E-01	1.97E+00	1.25E+00	3/3	2/3	1.20E+00	2/3	5.56E-01	1/3	1.66E+00	0/3	1.66E+02

Legend:

One or more samples exceed background value.

One or more samples exceed NAL value.

Only cobalt and the radionuclides Tc-99 and U-238 exceed both background[14] and industrial worker NALs. There were no detections that exceed industrial worker ALs.

In addition to those analytes exceeding industrial worker NALs, copper, nickel, and uranium also exceed both background and child resident NALs. Total PCBs exceed the child resident NAL.

3.7 NORTH FAN ROOM/VENTILATION SYSTEM

As stated in Section 2.8, two concrete samples were collected. These samples were analyzed for asbestos (top sample only), fluoride, metals, PCBs, and radionuclides. No asbestos was detected. The detected analytes are presented in Table 13, along with their maximum detected results.

Risk screening for concrete sampling in the North Fan Room/Ventilation System is shown in Table 13. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

Only the radionuclides U-235/236 and U-238 exceed both background[15] and industrial worker NALs. In addition to those analytes exceeding industrial worker NALs, uranium also exceeds both background and child resident NAL. There were no detections that exceed industrial worker ALs.

3.8 LAYDOWN AREA FOR DEGREASER (MAIN GROUND-LEVEL SLAB)

As stated in Section 2.9, two samples were collected, one concrete and one brick. These samples were analyzed for asbestos; an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. No asbestos was detected. The detected analytes are presented in Table 14, along with their maximum detected results.

Risk screening, as described in Section 3.1, for concrete sampling in the laydown area for degreaser is shown in Table 14. Use of background in the screening is consistent with risk screening in surface soils and should be considered an uncertainty.

Chromium, uranium, and the radionuclides U-233/234, U-235/236, and U-238 exceed both background[16] and industrial worker NALs. Total PCBs also exceed the industrial worker NALs. There were no detections that exceed industrial worker ALs.

In addition to those analytes exceeding industrial worker NALs, Tc-99 also exceeds both background and the child resident NAL. Total PCBs also exceed the child resident NAL.

[14] Background values are for surface soil and are not applicable to concrete.
[15] Background values are for surface soil and are not applicable to concrete.
[16] Background values are for surface soil and are not applicable to concrete/brick.

Table 13. Risk Screening Summary North Fan Room/Ventilation System—Concrete

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	8.29E-01	8.29E-01	8.29E-01	1/2	N/A	N/A	0/2	3.13E+02	0/2	9.33E+03	0/2	1.00E+05
METALS													
Aluminum	mg/kg	5.36E+03	8.32E+03	6.84E+03	2/2	0/2	1.30E+04	1/2	7.74E+03	0/2	1.00E+05	0/2	1.00E+05
Antimony	mg/kg	4.91E-01	4.91E-01	4.91E-01	1/2	1/2	2.10E-01	0/2	3.13E+00	0/2	9.34E+01	0/2	2.80E+03
Arsenic	mg/kg	2.97E+00	5.83E+00	4.40E+00	2/2	0/2	1.20E+01	2/2	3.56E-01	2/2	1.60E+00	0/2	1.60E+02
Barium	mg/kg	5.26E+01	1.21E+02	8.68E+01	2/2	0/2	2.00E+02	0/2	1.53E+03	0/2	4.04E+04	0/2	1.00E+05
Beryllium	mg/kg	2.15E-01	3.46E-01	2.81E-01	2/2	0/2	6.70E-01	0/2	1.56E+01	0/2	4.50E+02	0/2	1.35E+04
Boron	mg/kg	9.47E+00	1.44E+01	1.19E+01	2/2	N/A	N/A	0/2	1.56E+03	0/2	4.65E+04	0/2	1.00E+05
Cadmium	mg/kg	1.79E-01	1.88E-01	1.84E-01	2/2	0/2	2.10E-01	0/2	5.28E+00	0/2	6.05E+01	0/2	1.82E+03
Chromium	mg/kg	1.12E+01	1.45E+01	1.29E+01	2/2	0/2	1.60E+01	2/2	3.01E-01	1/2	1.23E+01	0/2	1.23E+03
Cobalt	mg/kg	3.47E+00	7.03E+00	5.25E+00	2/2	0/2	1.40E+01	2/2	2.34E+00	0/2	6.87E+01	0/2	2.06E+03
Copper	mg/kg	3.11E+00	6.17E+00	4.64E+00	2/2	0/2	1.90E+01	0/2	3.13E+02	0/2	9.34E+03	0/2	1.00E+05
Iron	mg/kg	6.69E+03	1.47E+04	1.07E+04	2/2	0/2	2.80E+04	2/2	5.48E+03	0/2	1.00E+05	0/2	1.00E+05
Lead	mg/kg	2.92E+00	5.64E+00	4.28E+00	2/2	0/2	3.60E+01	0/2	4.00E+02	0/2	8.00E+02	0/2	8.00E+02
Manganese	mg/kg	2.44E+02	1.34E+03	7.92E+02	2/2	0/2	1.50E+03	2/2	1.83E+02	0/2	4.72E+03	0/2	1.00E+05
Mercury	mg/kg	8.67E-03	8.67E-03	8.67E-03	1/2	0/2	2.00E-01	0/2	2.35E+00	0/2	7.01E+01	0/2	2.10E+03
Molybdenum	mg/kg	5.65E-01	1.92E+00	1.24E+00	2/2	N/A	N/A	0/2	3.91E+01	0/2	1.16E+03	0/2	3.48E+04
Nickel	mg/kg	1.25E+01	1.52E+01	1.39E+01	2/2	0/2	2.10E+01	0/2	1.55E+02	0/2	4.30E+03	0/2	1.00E+05
Selenium	mg/kg	3.82E-01	3.82E-01	3.82E-01	1/2	0/2	8.00E-01	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Silver	mg/kg	1.26E-01	1.26E-01	1.26E-01	1/2	0/2	2.30E+00	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Uranium	mg/kg	3.20E+00	6.67E+00	4.94E+00	2/2	1/2	4.90E+00	2/2	1.56E+00	0/2	4.66E+01	0/2	1.40E+03
Vanadium	mg/kg	1.41E+01	1.49E+01	1.45E+01	2/2	0/2	3.80E+01	0/2	3.93E+01	0/2	1.15E+03	0/2	3.45E+04
Zinc	mg/kg	3.27E+01	5.50E+01	4.39E+01	2/2	0/2	6.50E+01	0/2	2.35E+03	0/2	7.01E+04	0/2	1.00E+05
PCBS													
PCB, Total	mg/kg	1.20E-02	1.86E-02	1.53E-02	2/2	N/A	N/A	0/2	7.88E-02	0/2	2.93E-01	0/2	2.93E+01
RADIONUCLIDES													
Technetium-99	pCi/g	5.66E+00	1.52E+01	1.04E+01	2/2	2/2	2.50E+00	0/2	1.10E+02	0/2	1.27E+03	0/2	1.00E+05
Thorium-230	pCi/g	6.73E-01	7.08E-01	6.91E-01	2/2	0/2	1.50E+00	0/2	4.93E+00	0/2	3.13E+01	0/2	3.13E+03
Uranium-233/234	pCi/g	1.20E+00	2.81E+00	2.01E+00	2/2	1/2	1.20E+00	0/2	5.77E+00	0/2	5.01E+01	0/2	5.01E+03
Uranium-235/236	pCi/g	6.13E-01	6.13E-01	6.13E-01	1/2	1/2	6.00E-02	1/2	1.48E-01	1/2	4.08E-01	0/2	4.08E+01
Uranium-238	pCi/g	2.24E+00	4.40E+00	3.32E+00	2/2	2/2	1.20E+00	2/2	5.56E-01	2/2	1.66E+00	0/2	1.66E+02

Legend:

One or more samples exceed background value.

One or more samples exceed NAL value.

Table 14. Risk Screening Summary Laydown Area for Degreaser—Concrete/Brick

Analysis	Unit	Detected Results			FOD	Provisional Background		Child Resident		Industrial Worker		Industrial Worker	
		Min	Max	Avg		FOE	Bkgd	FOE	NAL	FOE	NAL	FOE	AL
ANIONS													
Fluoride	mg/kg	5.38E+00	9.19E+01	4.86E+01	2/2	N/A	N/A	0/2	3.13E+02	0/2	9.33E+03	0/2	1.00E+05
METALS													
Aluminum	mg/kg	8.85E+02	4.51E+03	2.70E+03	2/2	0/2	1.30E+04	0/2	7.74E+03	0/2	1.00E+05	0/2	1.00E+05
Antimony	mg/kg	3.22E-01	3.22E-01	3.22E-01	1/2	1/2	2.10E-01	0/2	3.13E+00	0/2	9.34E+01	0/2	2.80E+03
Arsenic	mg/kg	7.07E-01	2.63E+00	1.67E+00	2/2	0/2	1.20E+01	2/2	3.56E-01	1/2	1.60E+00	0/2	1.60E+02
Barium	mg/kg	2.04E+01	9.31E+01	5.68E+01	2/2	0/2	2.00E+02	0/2	1.53E+03	0/2	4.04E+04	0/2	1.00E+05
Beryllium	mg/kg	3.50E-02	2.11E-01	1.23E-01	2/2	0/2	6.70E-01	0/2	1.56E+01	0/2	4.50E+02	0/2	1.35E+04
Boron	mg/kg	1.12E+01	1.12E+01	1.12E+01	1/2	N/A	N/A	0/2	1.56E+03	0/2	4.65E+04	0/2	1.00E+05
Cadmium	mg/kg	8.22E-01	1.79E+00	1.31E+00	2/2	2/2	2.10E-01	0/2	5.28E+00	0/2	6.05E+01	0/2	1.82E+03
Chromium	mg/kg	1.67E+01	2.03E+01	1.85E+01	2/2	2/2	1.60E+01	2/2	3.01E-01	2/2	1.23E+01	0/2	1.23E+03
Cobalt	mg/kg	3.62E+00	6.92E+00	5.27E+00	2/2	0/2	1.40E+01	2/2	2.34E+00	0/2	6.87E+01	0/2	2.06E+03
Copper	mg/kg	2.03E+01	7.78E+01	4.91E+01	2/2	2/2	1.90E+01	0/2	3.13E+02	0/2	9.34E+03	0/2	1.00E+05
Iron	mg/kg	2.90E+03	5.56E+03	4.23E+03	2/2	0/2	2.80E+04	1/2	5.48E+03	0/2	1.00E+05	0/2	1.00E+05
Lead	mg/kg	1.76E+01	1.93E+01	1.85E+01	2/2	0/2	3.60E+01	0/2	4.00E+02	0/2	8.00E+02	0/2	8.00E+02
Manganese	mg/kg	3.49E+01	1.42E+02	8.85E+01	2/2	0/2	1.50E+03	0/2	1.83E+02	0/2	4.72E+03	0/2	1.00E+05
Mercury	mg/kg	2.24E-02	2.47E-02	2.36E-02	2/2	0/2	2.00E-01	0/2	2.35E+00	0/2	7.01E+01	0/2	2.10E+03
Molybdenum	mg/kg	9.08E-01	9.62E-01	9.35E-01	2/2	N/A	N/A	0/2	3.91E+01	0/2	1.16E+03	0/2	3.48E+04
Nickel	mg/kg	2.57E+01	7.31E+01	4.94E+01	2/2	2/2	2.10E+01	0/2	1.55E+02	0/2	4.30E+03	0/2	1.00E+05
Selenium	mg/kg	4.41E-01	5.44E+00	2.94E+00	2/2	1/2	8.00E-01	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Silver	mg/kg	3.13E-01	3.13E-01	3.13E-01	1/2	0/2	2.30E+00	0/2	3.91E+01	0/2	1.17E+03	0/2	3.51E+04
Uranium	mg/kg	1.06E+02	3.22E+02	2.14E+02	2/2	2/2	4.90E+00	2/2	1.56E+00	2/2	4.66E+01	0/2	1.40E+03
Vanadium	mg/kg	1.09E+01	1.09E+01	1.09E+01	1/2	0/2	3.80E+01	0/2	3.93E+01	0/2	1.15E+03	0/2	3.45E+04
Zinc	mg/kg	1.04E+02	2.35E+02	1.70E+02	2/2	2/2	6.50E+01	0/2	2.35E+03	0/2	7.01E+04	0/2	1.00E+05
PCBS													
PCB, Total	mg/kg	1.03E-01	7.47E-01	4.25E-01	2/2	N/A	N/A	2/2	7.88E-02	1/2	2.93E-01	0/2	2.93E+01
VOCS													
Toluene	mg/kg	8.17E-02	4.04E-01	2.43E-01	2/2	N/A	N/A	0/2	4.89E+02	0/2	6.25E+03	0/2	1.00E+05
RADIONUCLIDES													
Technetium-99	pCi/g	3.00E+02	3.25E+02	3.13E+02	2/2	2/2	2.50E+00	2/2	1.10E+02	0/2	1.27E+03	0/2	1.00E+05
Thorium-230	pCi/g	1.53E+00	2.91E+00	2.22E+00	2/2	2/2	1.50E+00	0/2	4.93E+00	0/2	3.13E+01	0/2	3.13E+03
Uranium-233/234	pCi/g	1.47E+01	8.84E+01	5.16E+01	2/2	2/2	1.20E+00	2/2	5.77E+00	1/2	5.01E+01	0/2	5.01E+03
Uranium-235/236	pCi/g	1.28E+00	4.42E+00	2.85E+00	2/2	2/2	6.00E-02	2/2	1.48E-01	2/2	4.08E-01	0/2	4.08E+01
Uranium-238	pCi/g	2.82E+01	1.18E+02	7.31E+01	2/2	2/2	1.20E+00	2/2	5.56E-01	2/2	1.66E+00	0/2	1.66E+02

Legend:
One or more samples exceed background value.
One or more samples exceed NAL value.

3.9 ADDITIONAL PIPELINE SAMPLE

As stated in Section 2.10, one additional liquid sample was collected from a location outside the northeast corner of the building. The liquid sample was analyzed for an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. Detected analytes are presented in Table 15, along with their maximum detected results.

Risk screening, as described in Section 3.1, for the additional liquid sample is shown in Table 15.

The following exceed child resident NALs: an anion (fluoride); the metals, aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, uranium, vanadium, and zinc; Total PCBs; Total PAH; chloroform; and the radionuclides Cs-137, Tc-99, Th-230, U-233/234, U-235/236, and U-238.

Of those, the following additionally exceed child resident ALs: an anion (fluoride); the metals, aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, thallium, uranium, vanadium, and zinc; Total PAH; and the radionuclides, Tc-99, U-233/234, and U-238.

Table 15. Risk Screening Summary Additional Pipeline—Liquid

Analysis	Unit	Detected Results			FOD	Child Resident		Child Resident	
		Min	Max	Avg		FOE	NAL	FOE	AL
				ANIONS					
Fluoride	mg/L	3.35E+00	3.35E+00	3.35E+00	1/1	1/1	7.99E-02	1/1	2.40E+00
				METALS					
Aluminum	mg/L	5.00E+02	5.00E+02	5.00E+02	1/1	1/1	2.00E+00	1/1	6.00E+01
Antimony	mg/L	9.84E-01	9.84E-01	9.84E-01	1/1	1/1	7.79E-04	1/1	2.34E-02
Arsenic	mg/L	2.89E+00	2.89E+00	2.89E+00	1/1	1/1	5.17E-05	1/1	5.17E-03
Barium	mg/L	8.09E+00	8.09E+00	8.09E+00	1/1	1/1	3.77E-01	0/1	1.13E+01
Beryllium	mg/L	1.12E-02	1.12E-02	1.12E-02	1/1	1/1	2.46E-03	0/1	7.38E-02
Boron	mg/L	2.06E+00	2.06E+00	2.06E+00	1/1	1/1	3.99E-01	0/1	1.20E+01
Cadmium	mg/L	8.62E-01	8.62E-01	8.62E-01	1/1	1/1	9.22E-04	1/1	2.77E-02
Chromium	mg/L	4.45E+01	4.45E+01	4.45E+01	1/1	1/1	3.50E-05	1/1	3.50E-03
Cobalt	mg/L	3.12E+00	3.12E+00	3.12E+00	1/1	1/1	6.01E-04	1/1	1.80E-02
Copper	mg/L	2.28E+03	2.28E+03	2.28E+03	1/1	1/1	7.99E-02	1/1	2.40E+00
Iron	mg/L	8.65E+03	8.65E+03	8.65E+03	1/1	1/1	1.40E+00	1/1	4.20E+01
Lead	mg/L	1.22E+02	1.22E+02	1.22E+02	1/1	1/1	1.50E-02	1/1	3.00E-02
Manganese	mg/L	8.60E+01	8.60E+01	8.60E+01	1/1	1/1	4.34E-02	1/1	1.30E+00
Mercury	mg/L	6.87E-02	6.87E-02	6.87E-02	1/1	1/1	5.66E-04	1/1	1.70E-02
Molybdenum	mg/L	1.76E+00	1.76E+00	1.76E+00	1/1	1/1	9.98E-03	1/1	2.99E-01
Nickel	mg/L	2.88E+02	2.88E+02	2.88E+02	1/1	1/1	3.92E-02	1/1	1.18E+00
Selenium	mg/L	1.12E-01	1.12E-01	1.12E-01	1/1	1/1	9.98E-03	0/1	2.99E-01
Silver	mg/L	9.47E-01	9.47E-01	9.47E-01	1/1	1/1	9.41E-03	1/1	2.82E-01
Thallium	mg/L	1.93E-02	1.93E-02	1.93E-02	1/1	1/1	2.00E-05	1/1	6.00E-04
Uranium	mg/L	1.32E+02	1.32E+02	1.32E+02	1/1	1/1	3.99E-04	1/1	1.20E-02
Vanadium	mg/L	9.52E-01	9.52E-01	9.52E-01	1/1	1/1	8.64E-03	1/1	2.59E-01
Zinc	mg/L	4.15E+02	4.15E+02	4.15E+02	1/1	1/1	6.00E-01	1/1	1.80E+01
				PCBS					
PCB, Total	mg/L	3.56E-04	3.56E-04	3.56E-04	1/1	1/1	4.36E-05	0/1	4.36E-03
				SVOCS					
Acenaphthene	mg/L	3.46E-04	3.46E-04	3.46E-04	1/1	0/1	5.35E-02	0/1	1.61E+00
Anthracene	mg/L	5.51E-04	5.51E-04	5.51E-04	1/1	0/1	1.77E-01	0/1	5.31E+00
Carbazole	mg/L	6.45E-04	6.45E-04	6.45E-04	1/1	0/1	2.03E-03	0/1	2.03E-01
Fluoranthene	mg/L	9.23E-03	9.23E-03	9.23E-03	1/1	0/1	8.02E-02	0/1	2.41E+00
Phenanthrene	mg/L	4.49E-03	4.49E-03	4.49E-03	1/1	0/1	5.35E-02	0/1	1.61E+00
Pyrene	mg/L	9.00E-03	9.00E-03	9.00E-03	1/1	0/1	1.21E-02	0/1	3.63E-01
Total PAH	mg/L	6.25E-03	6.25E-03	6.25E-03	1/1	1/1	2.51E-05	1/1	2.51E-03
				VOCS					
Chloroform	mg/L	1.63E-03	1.63E-03	1.63E-03	1/1	1/1	2.21E-04	0/1	2.21E-02
cis-1,2-Dichloroethene	mg/L	5.00E-04	5.00E-04	5.00E-04	1/1	0/1	3.61E-03	0/1	1.08E-01
				RADIONUCLIDES					
Cesium-137	pCi/L	2.30E+01	2.30E+01	2.30E+01	1/1	1/1	1.71E+00	0/1	1.71E+02
Technetium-99	pCi/L	2.62E+04	2.62E+04	2.62E+04	1/1	1/1	1.90E+01	1/1	1.90E+03
Thorium-230	pCi/L	1.56E+01	1.56E+01	1.56E+01	1/1	1/1	5.72E-01	0/1	5.72E+01
Uranium-233/234	pCi/L	4.00E+02	4.00E+02	4.00E+02	1/1	1/1	7.39E-01	1/1	7.39E+01
Uranium-235/236	pCi/L	2.66E+01	2.66E+01	2.66E+01	1/1	1/1	7.28E-01	0/1	7.28E+01
Uranium-238	pCi/L	1.11E+03	1.11E+03	1.11E+03	1/1	1/1	6.01E-01	1/1	6.01E+01

Legend:

(green) One or more samples exceed NAL value.

(red) One or more samples exceed AL value.

3.10 SPRAY BOOTH SUMP

As stated in Section 2.11, the liquid sample was analyzed for an anion (fluoride); metals; organics (VOCs, SVOCs, and PCBs); and radionuclides. Detected analytes are presented in Table 16, along with their maximum detected results.

Risk screening, as described in Section 3.1, for the spray booth sump sample is shown in Table 16.

The following exceed child resident NALs: an anion (fluoride); the metals, antimony, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, silver, uranium, and zinc; the VOCs, ethylbenzene, xylenes, TCE; and the radionuclides, Cs-137, Np-237, Tc-99, Th-230, U-233/234, U-235/236, and U-238.

Of those, the following additionally exceed child resident ALs: an anion (fluoride); the metals, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, nickel, uranium, and zinc; and the radionuclides, Cs-137, Np-237, Tc-99, U-233/234, U-235/236, and U-238.

Table 16. Risk Screening Summary Spray Booth Sump—Liquid

Analysis	Unit	Detected Results			FOD	Child Resident		Child Resident	
		Min	Max	Avg		FOE	NAL	FOE	AL
ANIONS									
Fluoride	mg/L	4.95E+02	4.95E+02	4.95E+02	1/1	1/1	7.99E-02	1/1	2.40E+00
METALS									
Antimony	mg/L	4.52E-02	4.52E-02	4.52E-02	1/1	1/1	7.79E-04	1/1	2.34E-02
Arsenic	mg/L	1.03E+00	1.03E+00	1.03E+00	1/1	1/1	5.17E-05	1/1	5.17E-03
Barium	mg/L	9.79E-03	9.79E-03	9.79E-03	1/1	0/1	3.77E-01	0/1	1.13E+01
Boron	mg/L	1.93E+00	1.93E+00	1.93E+00	1/1	1/1	3.99E-01	0/1	1.20E+01
Cadmium	mg/L	5.43E-01	5.43E-01	5.43E-01	1/1	1/1	9.22E-04	1/1	2.77E-02
Chromium	mg/L	3.83E+00	3.83E+00	3.83E+00	1/1	1/1	3.50E-05	1/1	3.50E-03
Cobalt	mg/L	1.22E+00	1.22E+00	1.22E+00	1/1	1/1	6.01E-04	1/1	1.80E-02
Copper	mg/L	5.67E+00	5.67E+00	5.67E+00	1/1	1/1	7.99E-02	1/1	2.40E+00
Iron	mg/L	2.69E+00	2.69E+00	2.69E+00	1/1	1/1	1.40E+00	0/1	4.20E+01
Lead	mg/L	4.91E-02	4.91E-02	4.91E-02	1/1	1/1	1.50E-02	1/1	3.00E-02
Manganese	mg/L	7.27E+00	7.27E+00	7.27E+00	1/1	1/1	4.34E-02	1/1	1.30E+00
Molybdenum	mg/L	1.39E-01	1.39E-01	1.39E-01	1/1	1/1	9.98E-03	0/1	2.99E-01
Nickel	mg/L	8.84E+01	8.84E+01	8.84E+01	1/1	1/1	3.92E-02	1/1	1.18E+00
Silver	mg/L	1.06E-02	1.06E-02	1.06E-02	1/1	1/1	9.41E-03	0/1	2.82E-01
Uranium	mg/L	9.96E+02	9.96E+02	9.96E+02	1/1	1/1	3.99E-04	1/1	1.20E-02
Zinc	mg/L	4.73E+01	4.73E+01	4.73E+01	1/1	1/1	6.00E-01	1/1	1.80E+01
VOCS									
1,2-Dimethylbenzene	mg/L	8.09E-03	8.09E-03	8.09E-03	1/1	0/1	1.93E-02	0/1	5.79E-01
Ethylbenzene	mg/L	3.48E-02	3.48E-02	3.48E-02	1/1	1/1	1.50E-03	0/1	1.50E-01
m,p-Xylene	mg/L	1.07E-01	1.07E-01	1.07E-01	1/1	1/1	1.93E-02	0/1	5.79E-01
Toluene	mg/L	1.25E-03	1.25E-03	1.25E-03	1/1	0/1	1.10E-01	0/1	3.30E+00
Total Xylene	mg/L	1.15E-01	1.15E-01	1.15E-01	1/1	1/1	1.93E-02	0/1	5.79E-01
Trichloroethene	mg/L	1.13E-03	1.13E-03	1.13E-03	1/1	1/1	2.83E-04	0/1	8.49E-03
RADIONUCLIDES									
Cesium-137	pCi/L	3.57E+02	3.57E+02	3.57E+02	1/1	1/1	1.71E+00	1/1	1.71E+02
Neptunium-237	pCi/L	2.93E+02	2.93E+02	2.93E+02	1/1	1/1	7.63E-01	1/1	7.63E+01
Technetium-99	pCi/L	2.35E+06	2.35E+06	2.35E+06	1/1	1/1	1.90E+01	1/1	1.90E+03
Thorium-230	pCi/L	4.15E+00	4.15E+00	4.15E+00	1/1	1/1	5.72E-01	0/1	5.72E+01
Uranium-233/234	pCi/L	2.68E+05	2.68E+05	2.68E+05	1/1	1/1	7.39E-01	1/1	7.39E+01
Uranium-235/236	pCi/L	1.78E+04	1.78E+04	1.78E+04	1/1	1/1	7.28E-01	1/1	7.28E+01
Uranium-238	pCi/L	3.42E+05	3.42E+05	3.42E+05	1/1	1/1	6.01E-01	1/1	6.01E+01

Legend:
One or more samples exceed NAL value.
One or more samples exceed AL value.

3.11 DATA AND RISK SCREENING CONCLUSIONS

Results from solid media sampling were compared to background values for surface soil, NALs for the child resident, and NALs and ALs for the industrial worker exposed to soil/sediment. While the NALs and ALs are for exposure scenarios not applicable to contaminated concrete and other infrastructure, completing the evaluation using these screening values allows for identification of the contaminants that exceed their risk-based values by the greatest amount.

The sampling for concrete was sufficient to characterize the nature and extent of contamination and to assess the potential risk from direct exposure. The following were exceeded for both the child resident NAL and background (if available): chromium, cobalt, copper, iron, nickel, uranium, Total PCBs, Total PAH, TCE, Np-237, Tc-99, Th-230, U-233/234, U-235/236, and U-238. Additionally, chromium, cobalt, uranium, Total PCBs, Np-237, Tc-99, U-233/234, U-235/236, and U-238 exceeded screening for both the industrial worker NAL and background (if available). No analyses in concrete exceeded industrial worker ALs. Uncertainties regarding migration risk are due to unavailability of risk-based values to complete the comparison. Uncertainties regarding the use of background in the screening are due to background values being specific to surface soil, not concrete.

The sampling of paint, coating materials, and caulk likely is sufficient to characterize the nature and extent of contamination and to assess the potential risk from direct exposure. The following were exceeded for both the child resident NAL and background (if available): antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc, Total PCBs, Am-241, Cs-137, Np-237, Pu-239/240, Tc-99, Th-230, U-233/234, U-235/236, and U-238. Additionally, arsenic, chromium, cobalt, iron, lead, and uranium, Total PCBs, Cs-137, Np-237, Pu-239/240, Tc-99, Th-230, U-233/234, U-235/236, and U-238 exceeded screening for both the industrial worker NAL and background (if available). Industrial worker ALs were exceeded in paint/coating for iron, lead, uranium, Total PCBs, Np-237, U-235/236, and U-238. Uncertainties regarding migration risk for paint, coating material, and caulk are due to the absence of suitable risk-based values necessary to complete the comparison.

The sampling of sludges/sediment and liquid that still remain in lines was not completed; however, what is known from samples that were collected indicates that it is likely that metals, radionuclides, PCBs, and some VOCs and PAHs are present at concentrations that exceed risk-based screening values in these media.

Figures 16 through 27 show sampling locations for concrete, paint/coating materials, caulk, sludges, and liquid that correspond to analytical results that exceed NALs and ALs for the following: Total PCBs, TCE, Cs-137, Np-237, Tc-99, U-233/234, U-235/236, U-238, arsenic, chromium, lead, and uranium. These analytes were selected for visualization based on C-400 Complex RI/FS scoping. NALs and ALs for industrial workers exposed to soil/sediment and residents exposed to groundwater were used to construct the figures. Background was not considered in development of these figures. Each of these analyses exceeded an AL. In addition to these, 1,2-DCE, vinyl chloride, and mercury also exceeded an AL, but are not depicted in these figures. 1,2-DCE had only two detections, and vinyl chloride had only one detection, so summary figures were not prepared for these two analyses. In only one sample, mercury exceeded either NALs or ALs (a liquid sample in a pipeline); a summary figure was not prepared for mercury.

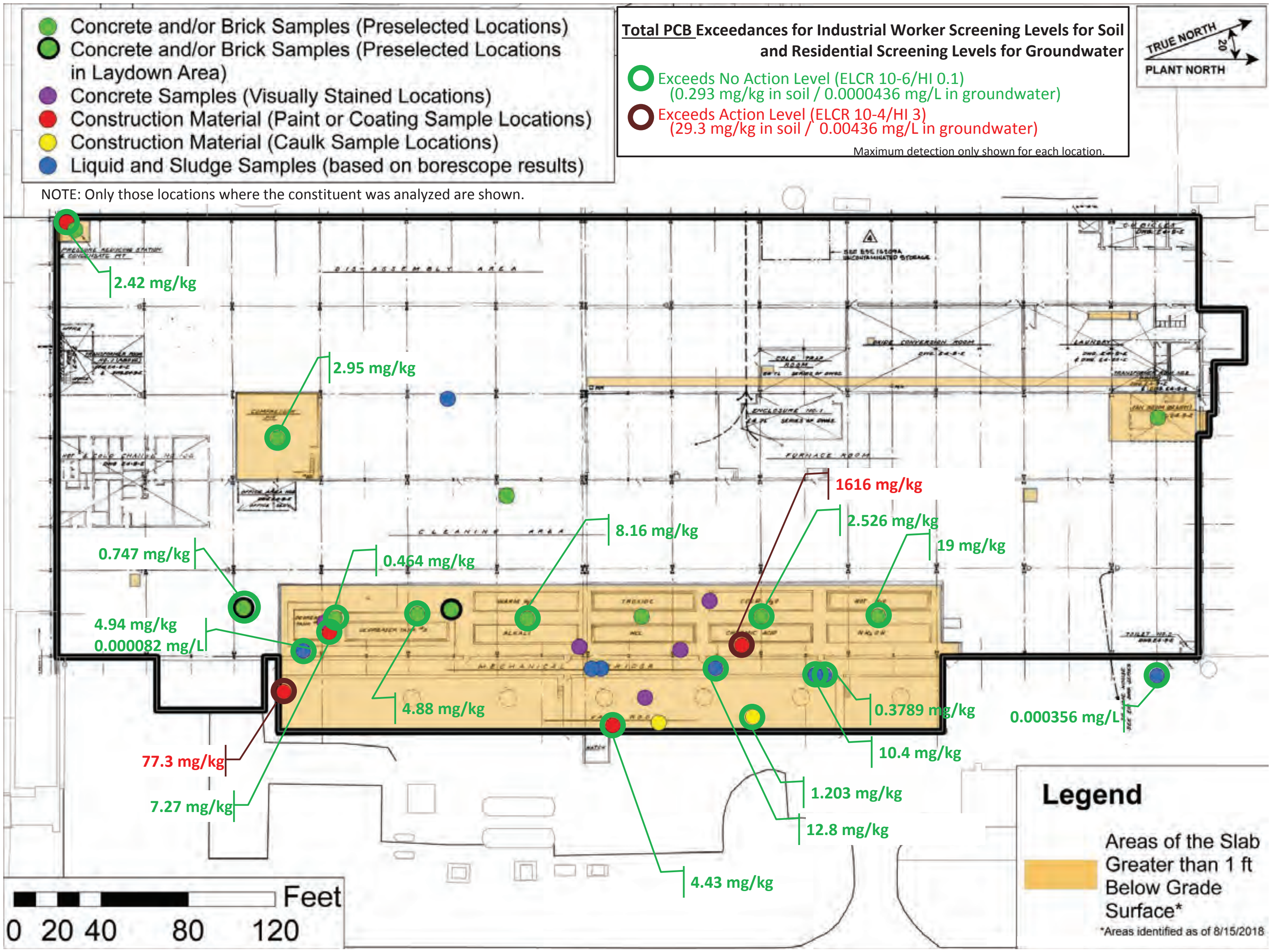

Figure 16. Risk Screening for Total PCBs

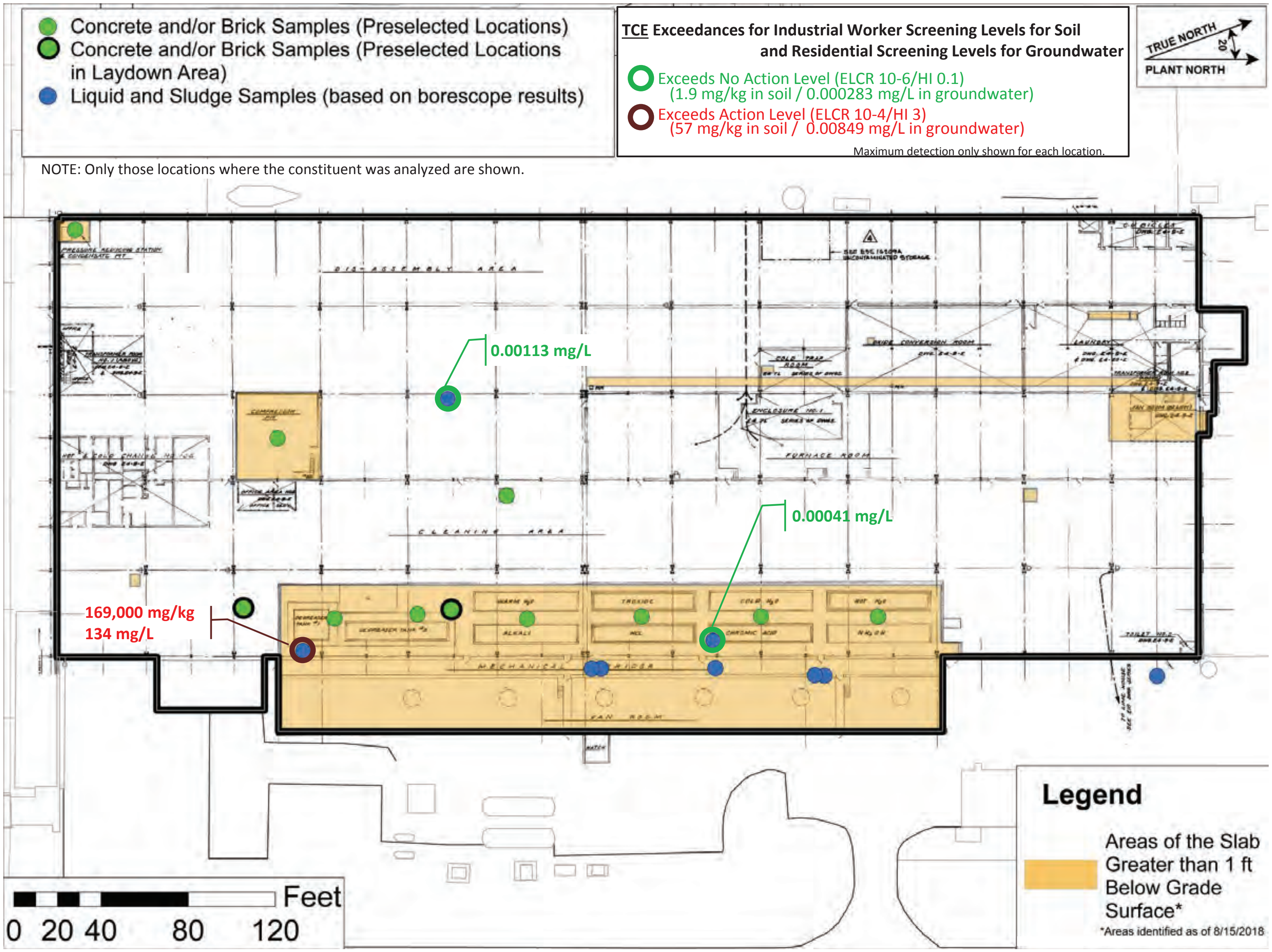

Figure 17. Risk Screening for Trichloroethene

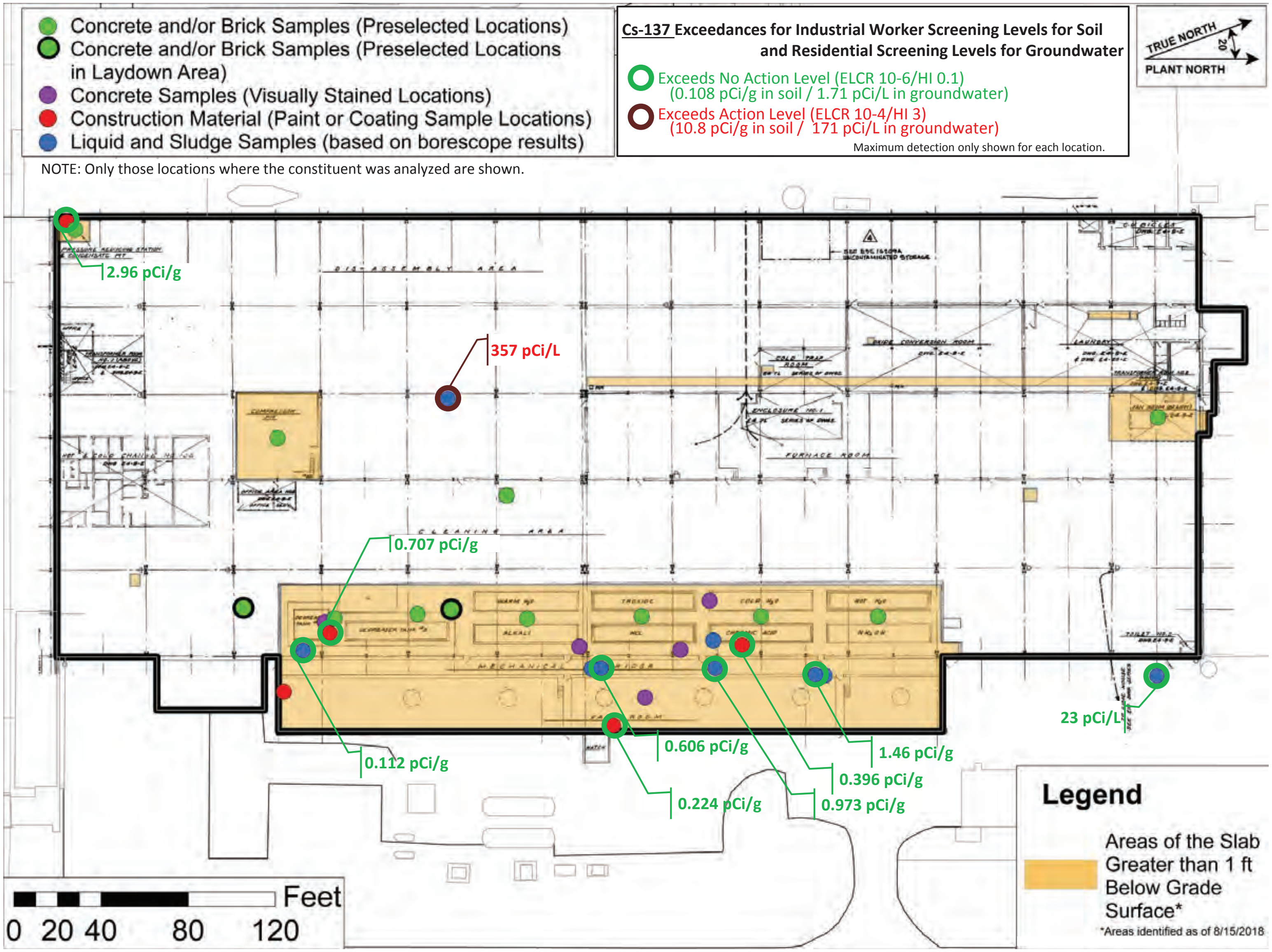

Figure 18. Risk Screening for Cesium-137

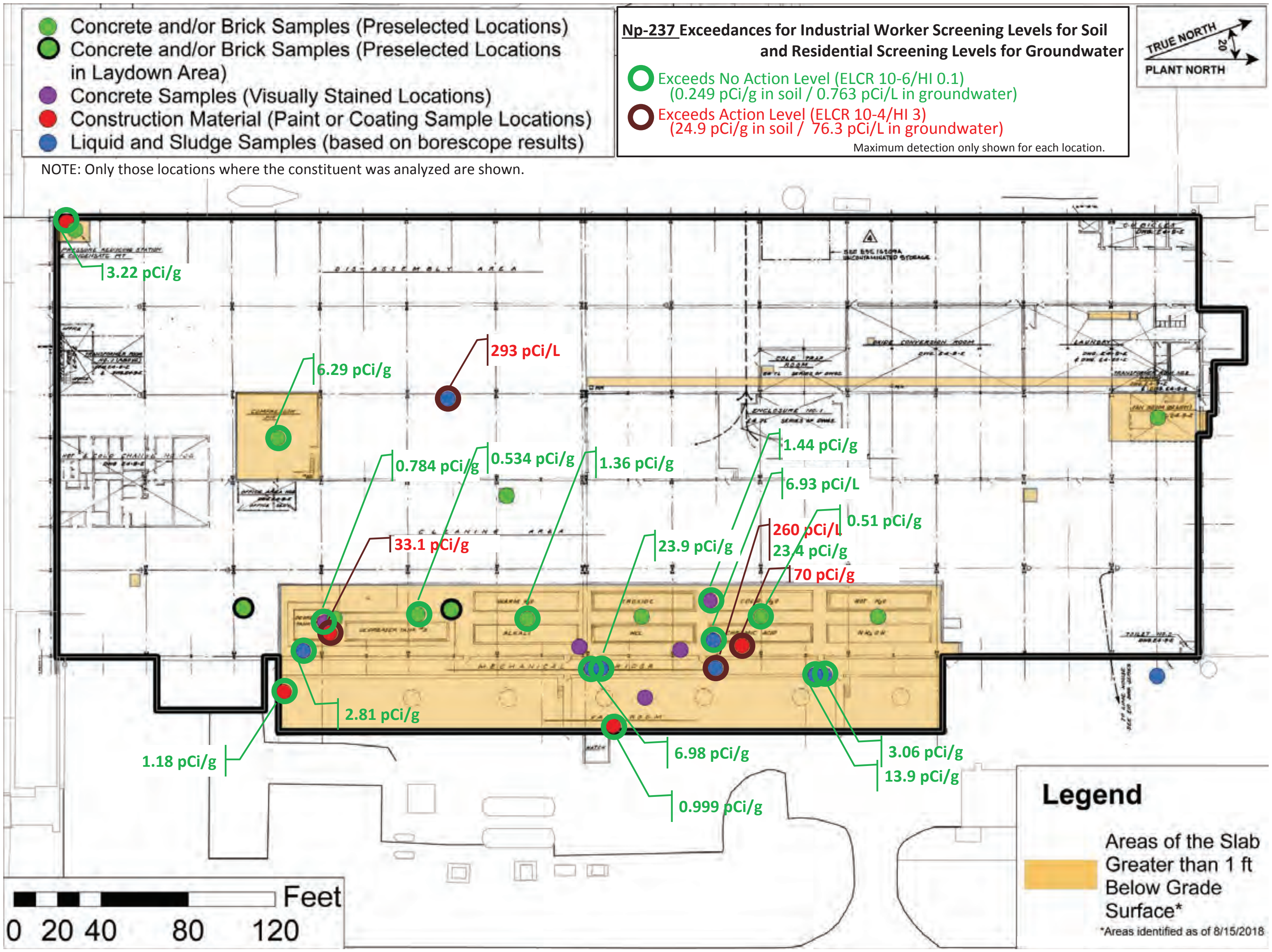

Figure 19. Risk Screening for Neptunium-237

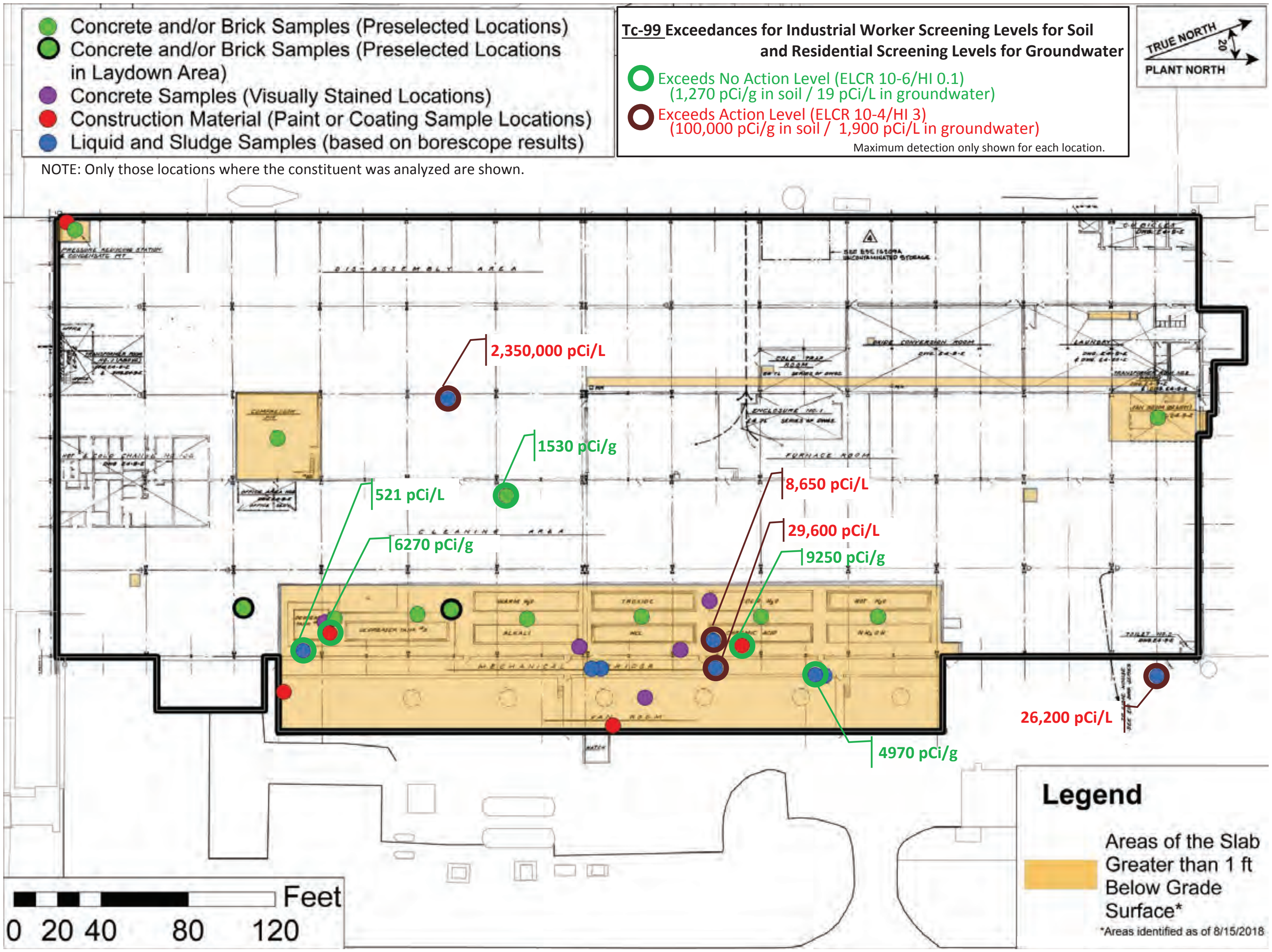

Figure 20. Risk Screening for Technetium-99

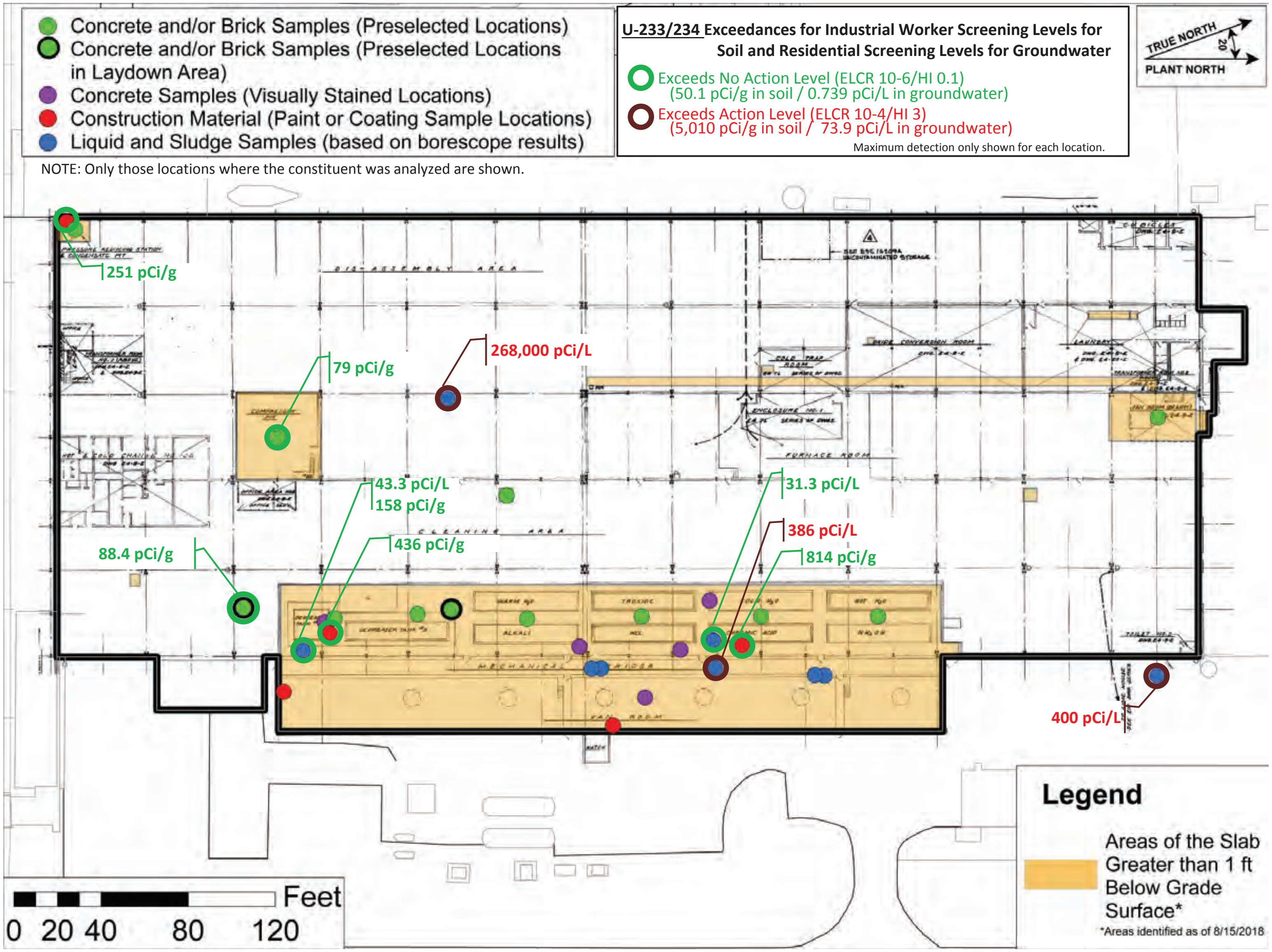

Figure 21. Risk Screening for Uranium-233/234

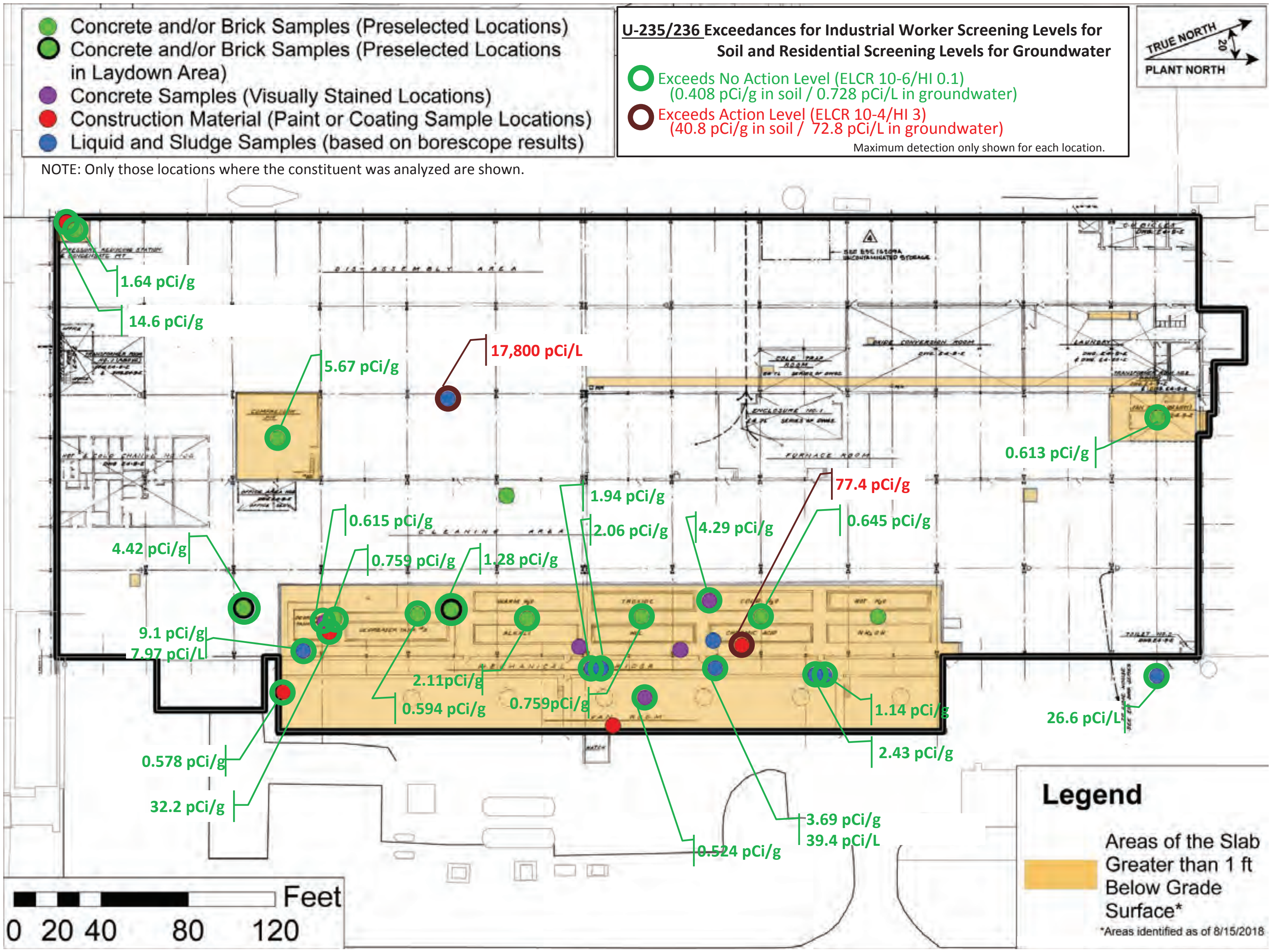

Figure 22. Risk Screening for Uranium-235/236

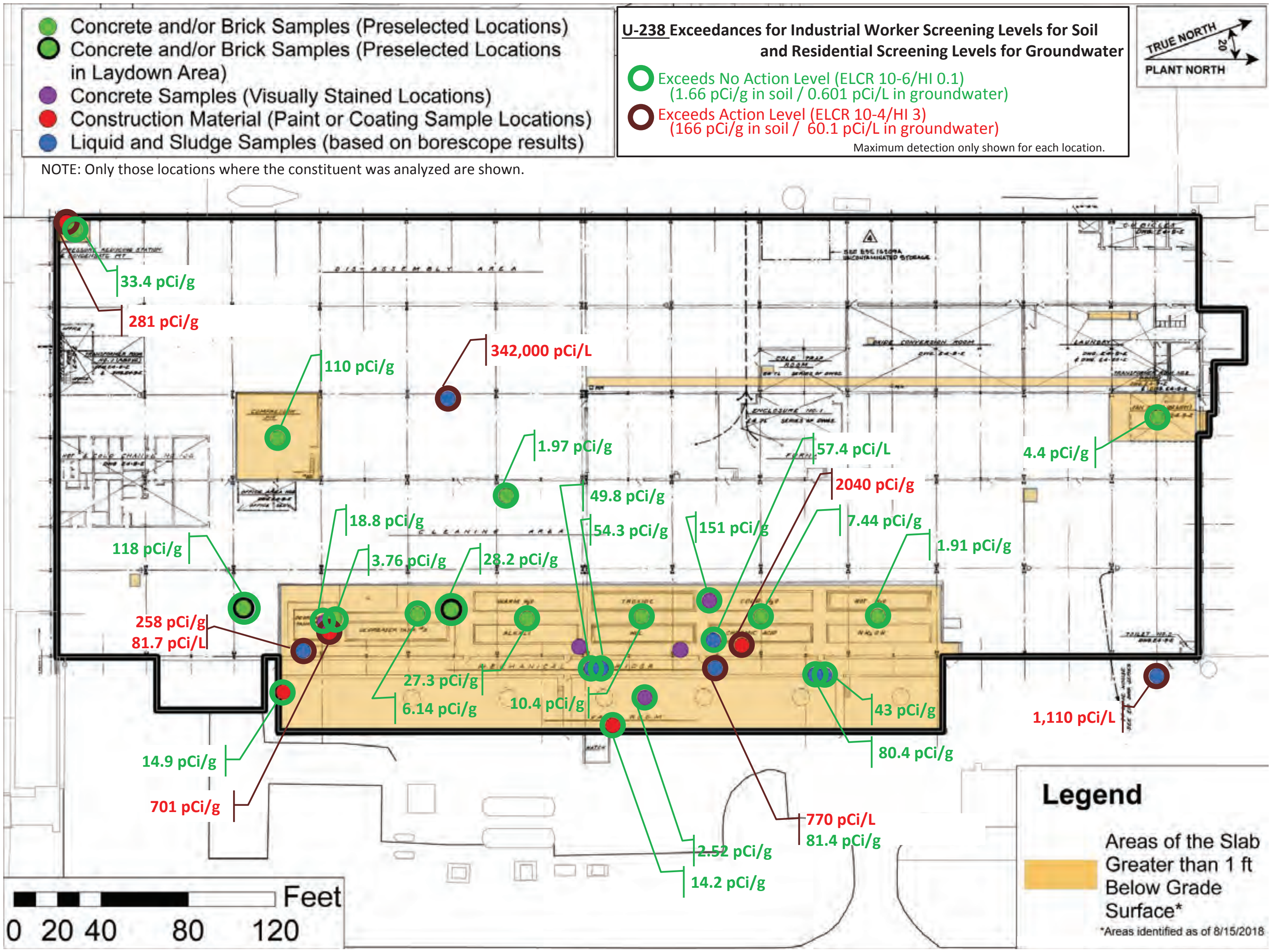

Figure 23. Risk Screening for Uranium-238

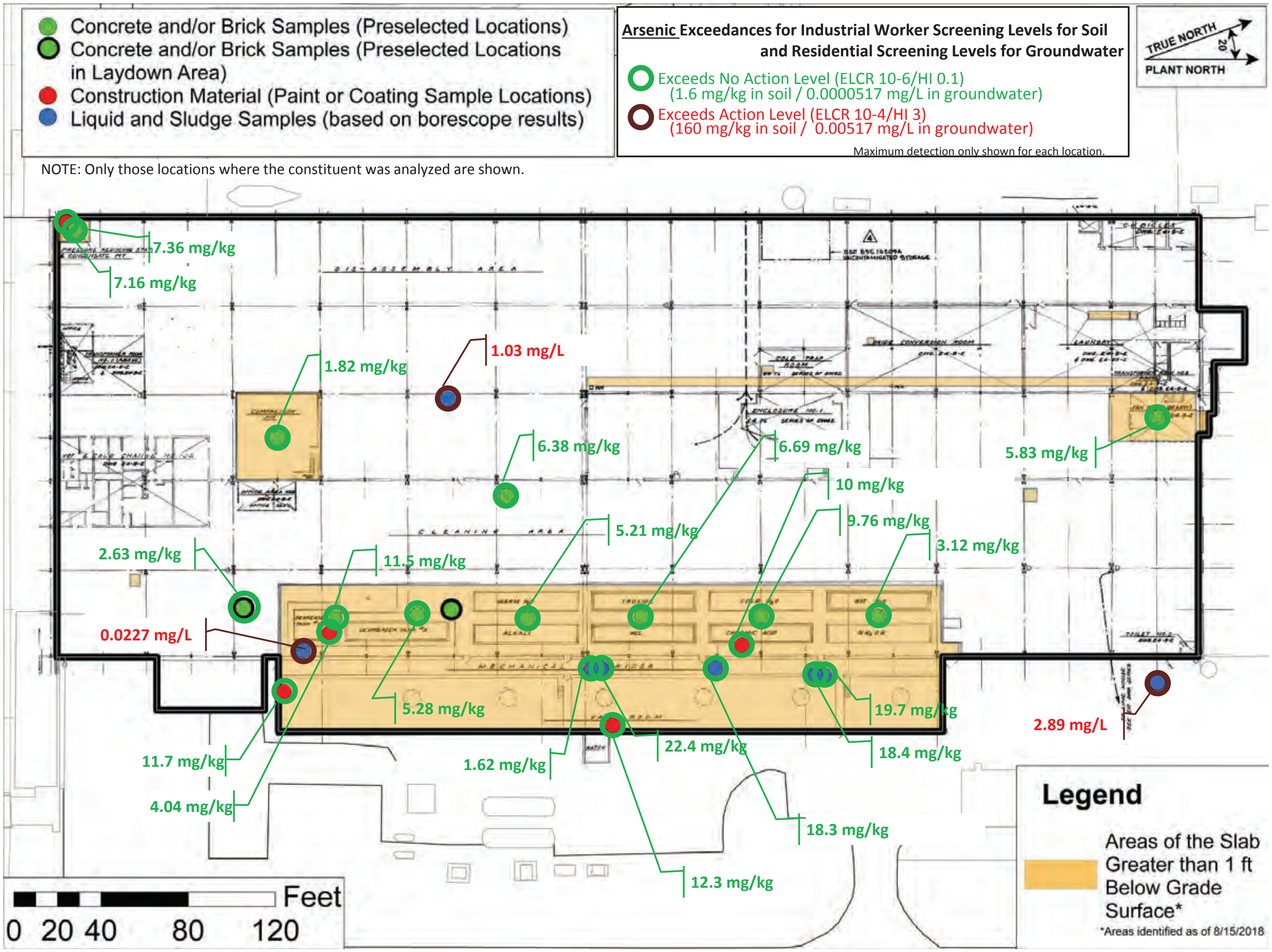

Figure 24. Risk Screening for Arsenic

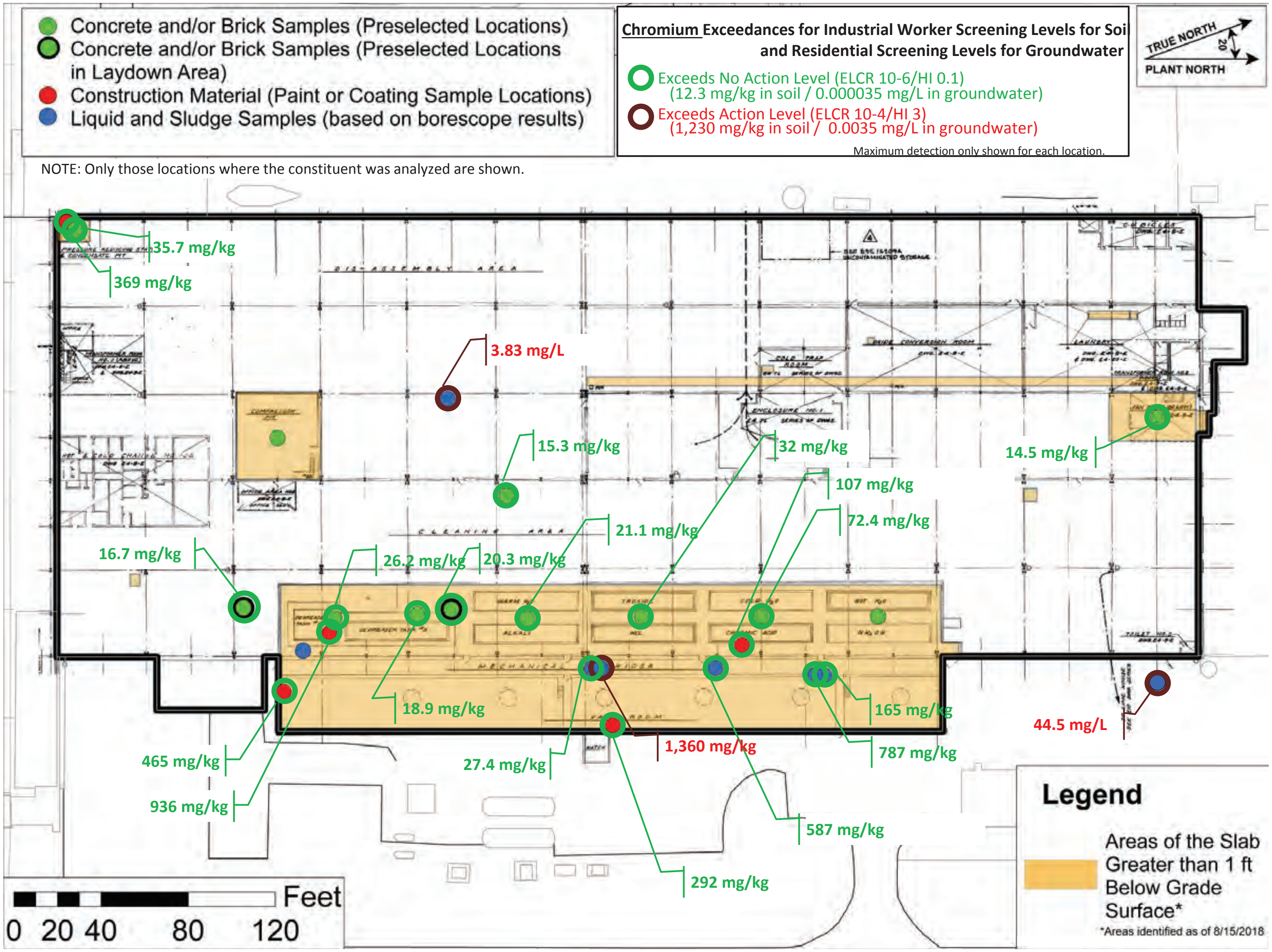

Figure 25. Risk Screening for Chromium

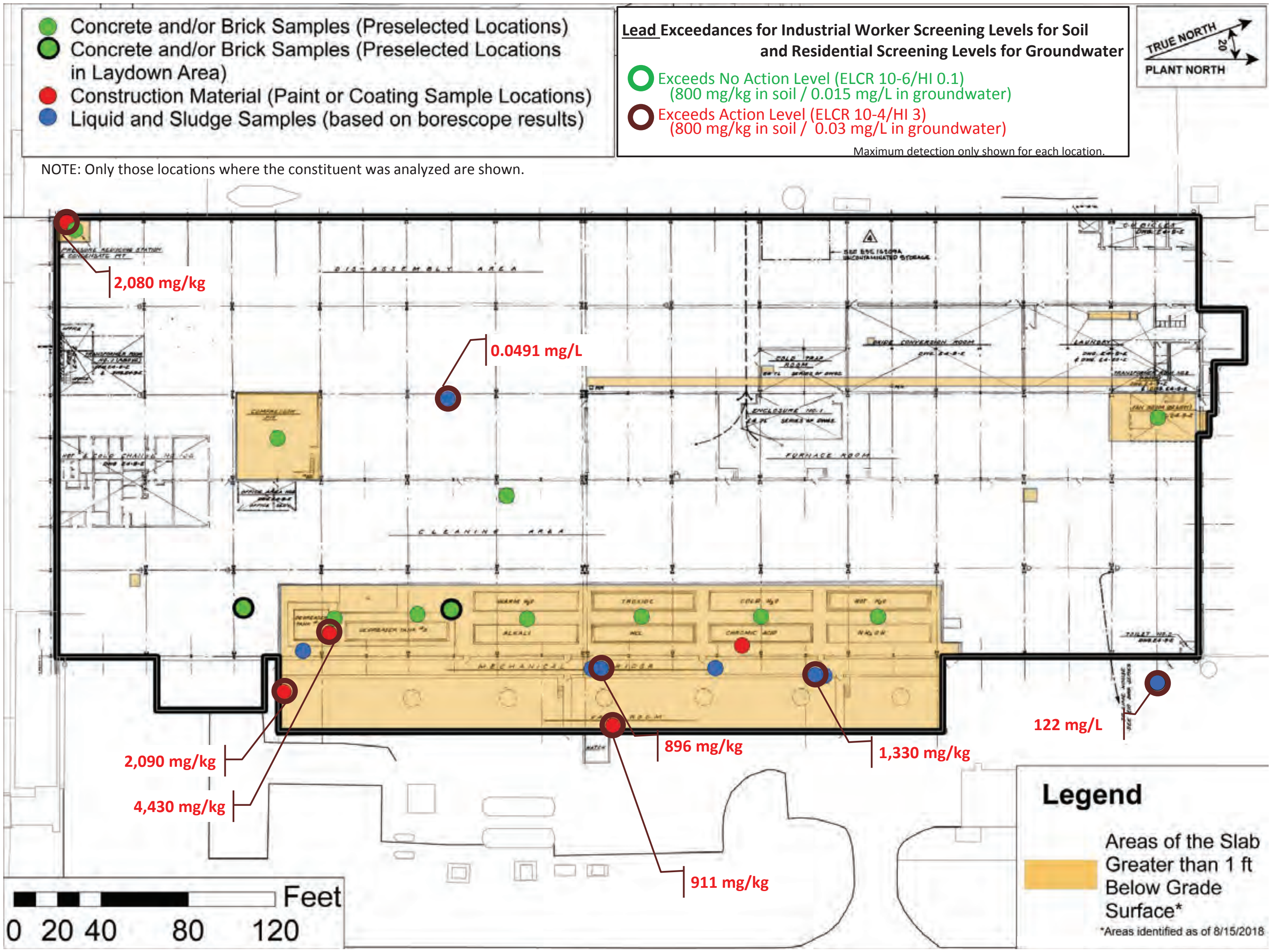

Figure 26. Risk Screening for Lead

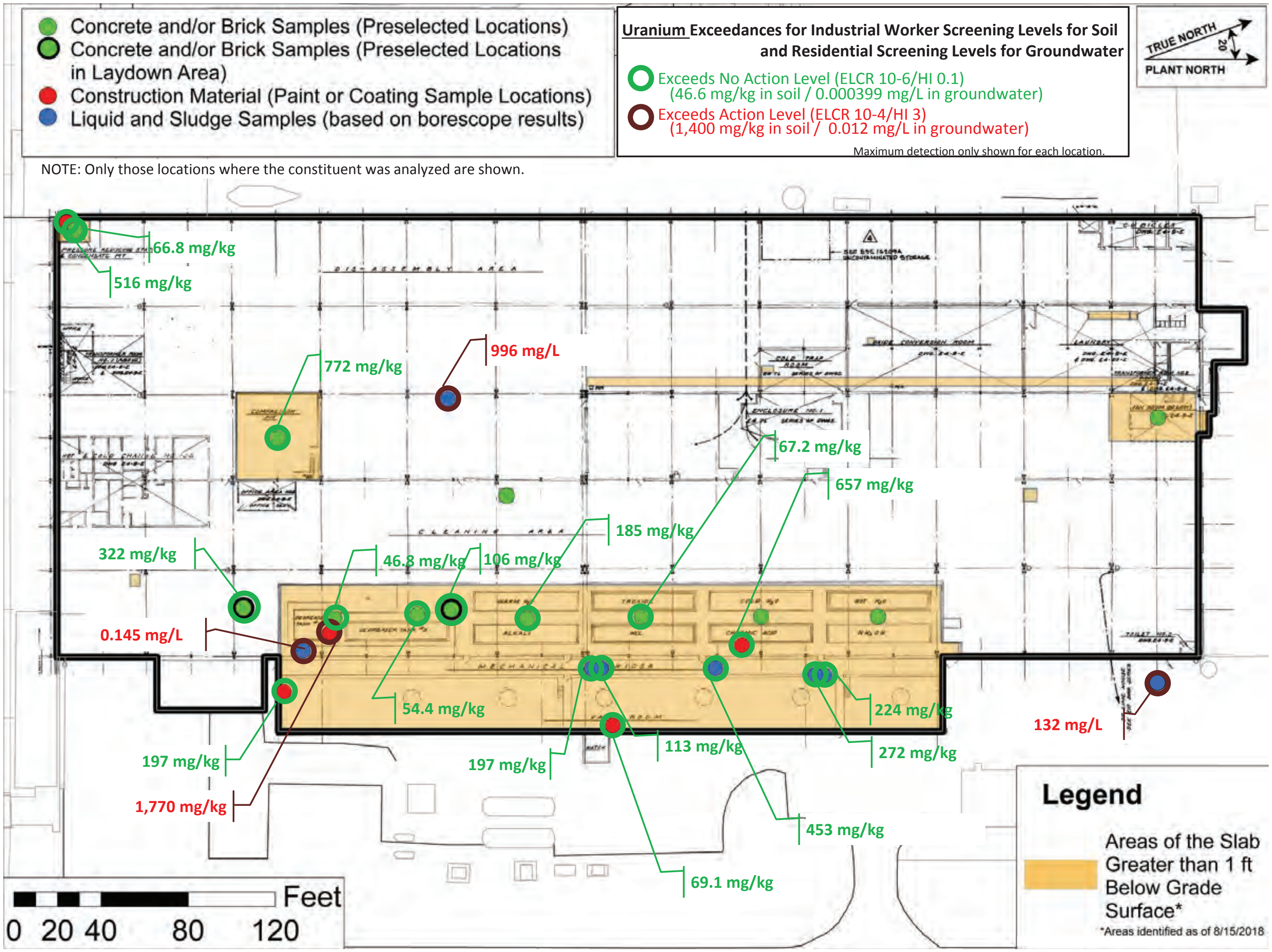

Figure 27. Risk Screening for Uranium

Thirteen samples were analyzed for asbestos content, as summarized in Table 17. Asbestos was not detected in 12 of the samples; 1 sample, 400-BASE1SCONC-01, collected from the East Basement/Plenum Room, contained 1% asbestos. Asbestos was not included in risk screening.

Table 17. Summary of Asbestos Data

Sample Identification Number	Analysis	Result
400-BASE1SCONC-01	Asbestos	1%
400-BASE1SCONC-01D	Asbestos	Not Detected
400-BASE1SCONC-03	Asbestos	Not Detected
400-BASE1SCONC-05	Asbestos	Not Detected
400-BASE1SCONC-07	Asbestos	Not Detected
400-BASE1SCONC-09	Asbestos	Not Detected
400-BASE1SCONC-11	Asbestos	Not Detected
400-BASE3SCONC-01	Asbestos	Not Detected
400-BASE4SCONC-01	Asbestos	Not Detected
400-BASE5SCONC-01	Asbestos	Not Detected
400-BASE6SCONC-01	Asbestos	Not Detected
400-BASE8SCONC-01	Asbestos	Not Detected
400-BASE8SCONC-02	Asbestos	Not Detected

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4. SUMMARY AND CONCLUSIONS

Summary and conclusions regarding the appropriateness of the data to support the future remedial decision for the C-400 basement and subsurface structure sampling are presented within this section. The sample results are sufficient to support the future remedial decision.

4.1 FLOOR DRAIN AND LINES SURVEY

Information was collected from open floor drains located in each of the basements. Drain systems located in the sub-grade areas were the storm-water flow drains, the acid drain system, and the waste discard lines. The video and samples collected are intended to be used to support development of the C-400 Complex RI/FS Report. Subsurface drains that were not accessible at the time of July 2018 SAP implementation should be considered to be similar to, with respect to nature of contamination, the drains accessible for video borescoping and sampling.

4.2 EAST BASEMENT/PLENUM ROOM

Concrete, paint/coating, and liquid and sludge samples were collected in the East Basement/Plenum Room.

One concrete sample tested positive for asbestos. Results from concrete samples were greater than industrial worker NALs for metals, chromium and uranium; Total PCBs; and the radionuclides Np-237, U-235/236, and U-238, but were not greater than industrial worker ALs.

One coating sample contained 1,616 mg/kg of Total PCBs. Results from paint and coating samples exceeded industrial worker ALs for lead, uranium, Np-237, U-235/236, U-238, and Total PCBs.

Sampling results from the East Basement/Plenum Room are sufficient to support the future remedial decision.

Liquid and sludge sampling in the East Basement/Plenum Room were collected from SWMU 98. A decision was made to remove the liquid and sludge and manage it as waste. The historical presence of this media and the associated sample results should be considered process knowledge. Liquid and sludge samples also were collected from open drain lines and valve pits in the East Basement/Plenum Room. Results from liquid and sludge sampling were greater than both industrial worker and resident NALs and ALs. Liquids exceeded resident ALs for an anion (fluoride), arsenic, cadmium, iron, manganese, uranium, 1,1,2-trichloroethane, 1,2-DCE, *cis*-1,2-DCE, TCE, vinyl chloride, Np-237, Pu-239/240, Tc-99, Th-230, U-233/234, and U-238. Sludge exceeded industrial worker ALs for chromium, iron, lead, U-238, and TCE. It should be noted that TCE in the SWMU 98 sludge sample was reported as 1.69E+08 μg/kg, or 169 g/kg, which is above the solubility limit, indicating potential pure phase.

4.3 EAST FAN ROOM

Concrete and paint samples were collected in the East Fan Room. Results from concrete samples were not greater than industrial worker ALs. Results from paint samples exceeded industrial worker ALs for iron, lead, and Total PCBs. Caulk sampling for Total PCBs did not show results greater than industrial worker ALs.

Sampling results in the East Fan Room are sufficient to support the future remedial decision.

4.4 COMPRESSOR DISASSEMBLY PIT

Concrete and brick samples were collected in the compressor disassembly pit. Results from concrete/brick samples were not greater than industrial worker ALs. Sampling results are sufficient to support the future remedial decision.

4.5 PRESSURE REDUCING STATION AND CONDENSATE PIT

Concrete and paint samples were collected in the pressure reducing station and condensate pit. Results from concrete samples were not greater than industrial worker ALs. Results from paint samples exceeded industrial worker ALs for lead and U-238, though no radionuclides were known to have been used at the pit. Sampling results are sufficient to support the future remedial decision.

4.6 MAINTENANCE PIT (EAST TRUCK ALLEY)

Concrete samples were collected in the maintenance pit (east truck alley). Results from concrete samples were not greater than industrial worker ALs. Sampling results are sufficient to support the future remedial decision.

4.7 NORTH FAN ROOM/VENTILATION SYSTEM

Concrete samples were collected in the North Fan Room/Ventilation System. Results from concrete samples were not greater than industrial worker ALs. Sampling results are sufficient to support the future remedial decision.

4.8 LAYDOWN AREA FOR DEGREASER (MAIN GROUND-LEVEL SLAB)

Concrete samples were collected in the laydown area for degreaser. Results from concrete samples were not greater than industrial worker ALs. Additional samples on the main ground-level slab are planned in the C-400 RI/FS Work Plan.

4.9 ADDITIONAL PIPELINE SAMPLE

One additional liquid sample was collected from an acid drain line located outside the northeast corner of the building. Results indicate fluoride, aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, thallium, uranium, vanadium, zinc, Total PAH, Tc-99, U-233/234, and U-238 exceed child resident action levels. The presence of this media, and the associated sample results, should be considered process knowledge and may be applicable to other acid drain lines that were not sampled.

4.10 SPRAY BOOTH SUMP

Although not originally identified in the July 2018 SAP, one liquid sample was collected from this location. Results indicate an anion (fluoride), antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, nickel, uranium, zinc, Cs-137, Np-237, Tc-99, U-233/234, U-235/236, and U-238 exceed child resident action levels. The historical presence of this media and the associated sample results should be considered process knowledge.

4.11 UNCERTAINTY ANALYSIS DISCUSSION

Uncertainties remain following the sampling performed as part of the July 2018 SAP. Uncertainties in risk screening and migration potential are discussed in Section 3; these uncertainties and those related to nature and extent of contamination, floor drains, residual solids and sediments, and floors and walls are summarized in Table 18.

Table 18. Summary of Uncertainties

Area/Process	Uncertainty	Mitigating Factor(s)
Nature and Extent of Contamination	Only judgmental samples were taken. Random sampling could have led to different results. Of the 13 sub-grade areas identified in July 2018 SAP, 7 sub-grade areas were sampled.	Judgmental sampling showed significant contamination in many areas. Based on process knowledge, locations assumed to be the most contaminated were selected for sampling.
Risk Screening and Migration Potential	Background values used in the DSR risk screening are for surface soil and are not applicable to concrete and other infrastructure. NALs and ALs used in the DSR risk screening are for exposure scenarios are not applicable to contaminated concrete and other infrastructure materials that were sampled and analyzed.	Completing the risk evaluation using these screening values allows for identification of the contaminants that exceed their risk-based values by the greatest amount.

Table 18. Summary of Uncertainties (Continued)

Area/Process	Uncertainty	Mitigating Factor(s)
Floor Drains	Information (borescope survey and sample analysis) was collected from open floor drains in a manner consistent with the July 2018 SAP; however, no information is available on approximately 90% of the total drainage system.	Existing data indicate contamination within the basement slab and subsurface structures greater than ALs. It is assumed that these areas of the drainage system are similar (in regard to nature of contamination) to what was sampled and borescoped. It is anticipated that at least one additional floor drain will become accessible from ongoing building deactivation activities and/or removal of equipment in the basement (e.g., TCE degreaser). This floor drain may be borescoped during building deactivation; sampled (if adequate material is present); and analyzed consistent with sampling described in the July 2018 SAP for liquid/sludge from floor drains for the same matrix type. Information will be collected near drain lines during the RI/FS field work.
Residual Solids/Sediments	To-date, samples of residual solids/sediments on the basement floor have not been sampled for analysis as described in the July 2018 SAP.	Other samples collected as part of the July 2018 SAP demonstrate the concrete slab on which the residual solids/sediments reside contains COPCs that exceed NALs. Residual solids/sediments, primarily under the dip tank area, are planned to be removed prior to the RI/FS field work and sampled for waste characterization. These waste characterization samples may be used as process knowledge during the RI/FS, if appropriate.
Floors and Walls	Because radiological surveys of basement floors and walls as planned in the July 2018 SAP were not conducted, the full extent of radiological impacts to these surfaces is unknown.	Existing analytical data and historical use of the area indicate radiological contamination within the basement slab and subsurface structures greater than ALs and is widespread.

5. REFERENCES

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APPENDIX A

TECHNICAL MEMORANDA FOR FIELD ACTIVITIES

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TECHNICAL MEMORANDA

The purpose of this appendix is to provide technical memoranda for the following:

- Comparison of concrete core smear results to analytical results;
- Field activities that deviated from the July 2018 Sampling and Analysis Plan (SAP) (DOE 2018a); and
- Expected end state deactivation for the C-400 Cleaning Building.

A.1 COMPARISON OF CONCRETE CORE SMEAR RESULTS TO ANALYTICAL RESULTS

As called for in Appendix B of the July 2018 SAP, smear results from concrete cores from preselected locations and one visually stained location were compared to the analytical results to attempt to define radionuclide distribution into the concrete. Table A.1 shows the comparison of radionuclide analytical results with total and removable alpha/beta activities.

Removable alpha/beta activities were measured from smears taken from the concrete cores. Where removable readings are lower than direct readings, information may imply that alpha/beta is locked into the concrete surface at that location. A correlation is not evident in the comparison.

Table A.1. Radiological Reading and Radiological Analytical Results

East Basement/Plenum Room															
		Radiological Readings (dpm/100 cm^2)				Analytical Results (pCi/g)									
Sample ID	Location #	Total alpha	Removable alpha	Total beta	Removable beta	Am-241	Cs-137	Np-237	Pu-238	Pu-239/240	Tc-99	Th-230	U-233/234	U-235/236	U-238
400-BASE1SCONC-01	#3 (upper)	308	45	19525	181	0.0999	-0.00322	-0.0508	0.0988	0.12	7.72	0.576	1.86	0.759	3.76
400-BASE1SCONC-01D						0.133	-0.0246	0.134	0.148	0.244	9.24	0.646	2.04	0.353	3.19
400-BASE1SCONC-02	#3 (lower)	< 9	38	1478	< 97	-0.0203	0.00551	-0.103	-0.394	-0.193	1.45	0.278	0.621	0.206	0.65
400-BASE1SCONC-03	#4 (upper)	189	< 9	6963	< 97	0.258	0.00444	0.534	-0.098	0.296	25	0.604	3.41	0.594	6.14
400-BASE1SCONC-04	#4 (lower)	< 9	< 9	2274	< 97	0.197	-0.012	-0.0574	0.0977	0.0672	1.78	0.657	0.838	0.374	0.972
400-BASE1SCONC-05	#5 (upper)	< 9	< 9	8327	< 97	0.0203	0.0287	1.36	0.0584	0.206	97.6	2.06	16.3	2.11	27.3
400-BASE1SCONC-06	#5 (lower)	238	38	17933	< 97	0.0223	-0.00642	0.812	0.0517	0.223	31.8	2	7.67	0.971	13.5
400-BASE1SCONC-07	#6 (upper)	60	< 9	15460	410	-0.127	0	0.206	0.162	0.047	45.8	2.5	6.05	0.759	10.4
400-BASE1SCONC-08	#6 (lower)	< 9	38	< 97	229	-0.0692	0.00864	0.0384	0.0968	0.0483	13.8	1.98	0.692	0.192	0.834
400-BASE1SCONC-09	#7 (upper)	100	31	6625	142	0.0938	-0.00179	-0.00913	0.219	0.408	52.1	1.55	3.19	0.645	7.44
400-BASE1SCONC-10	#7 (lower)	161	38	14602	210	0.0493	0.028	0.51	0.11	0.257	21.6	2.51	1.75	0.0505	3.06
400-BASE1SCONC-11	#8 (upper)	50	< 5	1000	105	-0.128	0.0562	-0.0809	0.156	0.35	11.7	0.596	0.346	0.186	0.957
400-BASE1SCONC-12	#8 (lower)	90	< 5	1352	< 108	-0.186	-0.0319	-0.0837	-0.0324	0.0648	15.3	1.09	0.62	0.162	1.91
400-BASE2SCONC-3*	N/A	< 7	85	32817	514	0.0452	0.0359	-0.0782	0.312	0.0221	2.9	0.383	1.1	0.0941	1.05
Compressor Disassembly Pit															
		Radiological Readings (dpm/100 cm^2)				Analytical Results (pCi/g)									
Sample ID	Location #	Total alpha	Removable alpha	Total beta	Removable beta	Am-241	Cs-137	Np-237	Pu-238	Pu-239/240	Tc-99	Th-230	U-233/234	U-235/236	U-238
400-BASE3SCONC-01	#2 (upper)	< 10	4	13530	< 60	0.103	-0.0171	0.212	0.228	-0.0418	14.9	0.789	4.6	0.281	6.33
Pressure Reducing Station and Condensate Pit															
		Radiological Readings (dpm/100 cm^2)				Analytical Results (pCi/g)									
Sample ID	Location #	Total alpha	Removable alpha	Total beta	Removable beta	Am-241	Cs-137	Np-237	Pu-238	Pu-239/240	Tc-99	Th-230	U-233/234	U-235/236	U-238
400-BASE4SCONC-01	#9 (upper)	< 7	93	< 134	< 134	0.056	0.0696	-0.0421	0.0245	0.0807	21.6	1.59	28.9	1.64	33.4
400-BASE4SCONC-02R	#9 (lower)	< 7	59	< 134	< 134	0.0592	0.0221	0.0385	0.0426	0.305	0.574	1.62	6.72	1.29	8.05
Maintenance Pit (East Truck Alley)															
		Radiological Readings (dpm/100 cm^2)				Analytical Results (pCi/g)									
Sample ID	Location #	Total alpha	Removable alpha	Total beta	Removable beta	Am-241	Cs-137	Np-237	Pu-238	Pu-239/240	Tc-99	Th-230	U-233/234	U-235/236	U-238
400-BASE5SCONC-01	#10 (upper)	< 9	< 9	2984	150	0.0185	0	-0.0639	0.367	0.0692	1530	0.264	1.39	0.0191	1.97
400-BASE5SCONC-02	#10 (lower)	< 9	< 9	711	212	-0.0473	0.0217	-0.0553	0.133	0.0733	936	0.298	0.813	-0.0346	1.26
North Fan Room/Ventilation System															
		Radiological Readings (dpm/100 cm^2)				Analytical Results (pCi/g)									
Sample ID	Location #	Total alpha	Removable alpha	Total beta	Removable beta	Am-241	Cs-137	Np-237	Pu-238	Pu-239/240	Tc-99	Th-230	U-233/234	U-235/236	U-238
400-BASE6SCONC-01	#1 (upper)	< 7	< 7	3181	< 134	-0.0885	0.0405	0.00255	-0.114	0.24	15.2	0.708	2.81	0.613	4.4
400-BASE6SCONC-02	#1 (lower)	< 7	< 7	< 134	< 134	0.0155	-0.0079	-0.0552	0.248	0.0769	5.66	0.673	1.2	0.14	2.24

Table A.1. Radiological Reading and Radiological Analytical Results (Continued)

Laydown Area for Degreaser (Main Ground-Level Slab)															
		Radiological Readings (dpm/100 cm^2)				Analytical Results (pCi/g)									
Sample ID	Location #	Total alpha	Removable alpha	Total beta	Removable beta	Am-241	Cs-137	Np-237	Pu-238	Pu-239/240	Tc-99	Th-230	U-233/234	U-235/236	U-238
400-BASE8SCONC-01	#11	< 7	51	< 134	< 134	0.202	0.0464	0.392	0.195	0.61	325	2.91	88.4	4.42	118
400-BASE8SCONC-02	#12	< 7	< 7	< 134	< 134	0.171	0.0733	0.395	0.388	0.319	300	1.53	14.7	1.28	28.2

Gray shading indicates result was qualified with a "U" by the laboratory (i.e., not detected).

* Sample 400-BASE2SCONC-3 is a concrete sample from a visually stained location from which a radiological reading was obtained for health and safety purposes. Other concrete samples from visually stained locations in the east basement/plenum room do not have radiological readings as part of this comparison.

A.2 FIELD ACTIVITIES THAT DEVIATED FROM THE JULY 2018 SAP

The purpose of this section is to describe field activities described in the July 2018 SAP, but not completed or that varied from the sampling or analysis as planned (DOE 2018a). Additionally, samples that were collected and not planned initially are described within this appendix.

A.2.1 Samples Not Collected

Concrete samples were not collected from Solid Waste Management Unit 98 because, after further inspection of the sump, it was determined concrete sampling was not practical and could undermine the integrity of the sump.

Because deactivation activities have not been completed to date, residual solids/sediments on the floor were not sampled, and the radiation survey of the floor and walls in the sub-grade areas, as described in Appendix B of the July 2018 SAP, was not conducted (DOE 2018a). Residual solids/sediments will be removed prior to the Remedial Investigation (RI)/Feasibility Study (FS) field work and sampled for waste characterization. These waste characterization samples may be used as process knowledge during the RI/FS, if appropriate.

A.2.2 Additional Sampling

During deactivation activities, the Spray Booth Sump was discovered. The sump is approximately a 6-ft section of capped pipe with a cap on the bottom end that served as the sump for the spray booth. The sump had been modified for a high assay upgrade program in 2000. A liquid sample was collected from the sump and analyzed consistent with sampling described in the July 2018 SAP for liquid/sludge from floor drains.

It is anticipated that at least one additional floor drain will become accessible from ongoing building deactivation activities and/or removal of equipment in the basement (e.g., TCE degreaser). This floor drain may be borescoped during building deactivation; sampled (if adequate material is present); and analyzed consistent with sampling described in the July 2018 SAP for liquid/sludge from floor drains for the same matrix type. Additional sampling (e.g., additional liquid that might be identified from additional borescoping) may be performed during deactivation activities. Any additional sampling will be collected using the methods described in the July 2018 SAP for the same matrix type. Results from any additional borescoping and/or sampling will be documented in the C-400 Complex RI/FS Report.

A.2.3 Slab Penetration during Coring

In the Maintenance Pit Area, the slab thickness was thinner than anticipated (approximately 5 inches), and the concrete coring machine penetrated the entire slab. The resulting hole was filled.

A.3 EXPECTED END STATE DEACTIVATION FOR THE C-400 CLEANING BUILDING EAST BASEMENT/PLENUM ROOM AND SPRAY BOOTH SUMP

The expected end state for the C-400 Cleaning Building basement slab and subsurface structures, at the time this report was written, is described within this appendix. Additional information regarding utilities and remaining infrastructure in the C-400 Complex is found in Section 8.9 of the C-400 Complex D2 RI/FS Work Plan.

A.3.1. East Basement/Plenum Room

The TCE degreaser tank and dip tanks and the residual solids beneath the tank and dip tanks are planned to be removed during deactivation. At the time of this report, the tanks and the residual solids beneath the tank and dip tanks remained in place.

Nature of contamination in inaccessible lines are is assumed to be consistent with other portions of line that were accessed (e.g., the nature of contamination in an inaccessible portion of the acid drain line is assumed to be consistent with nature of contamination from the portions of the accessed acid drain lines). To secure the lines and prevent release of contaminants, the current plan is to cut the utilities flush with grade and install plugs as part of C-400 deactivation activities. It should be noted that the acid drain lines that traverse underneath the dip tanks to the C-403 Neutralization Pit were grouted at the northeast corner (exterior) of the C-400 Building during the C-400 Building deactivation activities to allow borescoping of the acid drain lines and also to mitigate the potential for liquid from C-403 Neutralization Pit to back feed into the acid drain lines.

A.3.2. Spray Booth Sump

A decision was made to remove the liquid found in the spray booth sump and manage it as waste. At the time of this report, the liquid had not been removed.

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APPENDIX B

ANALYTICAL DATA AND QA/QC RESULTS

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Appendix B

Analytical Data (CD)

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APPENDIX C

RESULTS OF VIDEO BORESCOPES

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Appendix C

Video Borescopes (CD)
Disc 1 of 2

Appendix C

Video Borescopes (CD)
Disc 2 of 2