Department of Energy

Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513
(859) 219-4000

July 11, 2023

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-02-10024146-23D

Mr. Victor Weeks
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Mr. Weeks:

TRANSMITTAL OF THE FIVE-YEAR REVIEW FOR REMEDIAL ACTIONS AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, DOE/LX/07-2492&D1

Please find enclosed the *CY 2023 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (Fifth Synchronized Five-Year Review)*, DOE/LX/07-2492&D1. This five-year review encompasses activities associated with response actions from January 2018 through December 2022. Section XXX of the Federal Facility Agreement (FFA) for the Paducah Site includes requirements for synchronizing five-year reviews of remedial actions. The last five-year review at the Paducah Site was conducted in 2018 for the period of January 2013 through December 2017.

In accordance with Section XX of the FFA, the U.S. Environmental Protection Agency and the Kentucky Department for Environmental Protection have a 90-day review period. If the FFA Parties have no substantive comments, DOE requests a letter of concurrence.

If you have any questions or require additional information, please contact Richard Bonczek at (859) 321-7127.

Sincerely,

APRIL LADD Digitally signed by APRIL LADD
Date: 2023.07.11 14:19:39
-05'00'

April Ladd
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosure:
CY 2023 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (Fifth Synchronized Five-Year Review), DOE/LX/07-2492&D1

Administrative Record File—General Reference Compendium

cc w/enclosure:
abigail.parish@pppo.gov, PPPO
april.ladd@pppo.gov, PPPO
april.webb@ky.gov, KDEP
arcorrespondence@pad.pppo.gov
brian.begley@ky.gov, KDEP
bruce.ford@pad.pppo.gov, FRNP
bwhatton@tva.gov, TVA
dcnorman0@tva.gov, TVA
eric@pgdpcab.org, CAB
frnpcorrespondence@pad.pppo.gov
hjlawrence@tva.gov, TVA
joel.bradburne@pppo.gov, PPPO
kentuckyES@fws.gov
kristan.avedikian@TechLawInc.com, EPA
leanne.garner@pad.pppo.gov, FRNP
mac.mcrae@TechLawInc.com, EPA
megan.mulry@pad.pppo.gov, FRNP
myrna.redfield@pad.pppo.gov, FRNP
nathan.garner@ky.gov, KYRHB
nrepcdep-dwm-hwb-pgdp@ky.gov
pad.rmc@pad.pppo.gov
rebecca.goodman@ky.gov, KEEC
reinhard.knerr@pppo.gov, PPPO
richard.bonczek@pppo.gov, PPPO
sebenton@tva.gov, TVA
stephaniec.brock@ky.gov, KYRHB
testher@tva.gov, TVA
thhenry@tva.gov, TVA
timothy.kreher@ky.gov, KDFWS
todd.powers@pad.pppo.gov, FRNP
weeks.victor@epa.gov, EPA

DOE/LX/07-2492&D1
Secondary Document

CY 2023 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

(Fifth Synchronized Five-Year Review)

CLEARED FOR PUBLIC RELEASE

DOE/LX/07-2492&D1
Secondary Document

CY 2023 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

(Fifth Synchronized Five-Year Review)

Date Issued—July 2023

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

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

TABLES

FIGURES

ACRONYMS

AM	action memorandum
ARAR	applicable or relevant and appropriate requirement
BGOU	Burial Grounds Operable Unit
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CSOU	Comprehensive Site Operable Unit
D&D	decontamination and decommissioning
D&R	deactivation and remediation
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DPT	direct push technology
EISB	enhanced *in situ* bioremediation
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EQ	equalization
ERH	electrical resistance heating
ESD	explanation of significant differences
EU	exposure unit
EVO	emulsified vegetable oil
EW	extraction well
FFA	Federal Facility Agreement
FS	feasibility study
FY	fiscal year
GWOU	Groundwater Operable Unit
HAP	hazardous air pollutant
HI	hazard index
ICM	interim corrective measure
IRA	interim remedial action
ITR	independent technical review
KAR	*Kentucky Administrative Regulations*
KDEP	Kentucky Department for Environmental Protection
KDWM	Kentucky Division of Waste Management
KPDES	Kentucky Pollutant Discharge Elimination System
KRS	*Kentucky Revised Statutes*
LUC	land use control
LUCAP	land use control assurance plan
LUCIP	land use control implementation plan
MCL	maximum contaminant level
MIP	membrane interface probe
MOA	memorandum of agreement
MW	monitoring well
mZVI	microscale zero-valent iron
N/A	not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPCS	Northeast Plume Containment System
NESHAP	National Emission Standards for Hazardous Air Pollutants

NFA	no further action
NPL	National Priorities List
NSDD	North-South Diversion Ditch
NTCRA	non-time-critical removal action
NWPGS	Northwest Plume Groundwater System
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PFAS	per- and polyfluoroalkyl substances
PGDP	Paducah Gaseous Diffusion Plant
PHEA	public health and ecological assessment
POE	point of exposure
RA	remedial action
RACR	remedial action completion report
RAO	remedial action objective
RAWP	remedial action work plan
RCRA	Resource Conservation and Recovery Act
RDR	remedial design report
RDSI	remedial design support investigation
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SI	site investigation
SMP	site management plan
SVGTS	Soil Vapor and Groundwater Treatment System
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
TBC	to be considered
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
USCA	*United States Code Annotated*
USEC	United States Enrichment Corporation
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area group
WKWMA	West Kentucky Wildlife Management Area
ZVI	zero-valent iron

EXECUTIVE SUMMARY

The cleanup strategy under the site management plan (SMP) and required by the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant* (FFA) (EPA 1998), establishes operable units (OUs) to be accomplished to achieve delisting of the Paducah Site from the National Priorities List (NPL) and the decommissioning of the Paducah Gaseous Diffusion Plant (PGDP). These OUs include the C-400 Complex OU, the Groundwater OU (GWOU), the Surface Water OU (SWOU), the Soils OU, the Soils and Slabs OU, the Burial Grounds OU (BGOU), the Facility Decontamination and Decommissioning (D&D) OU, the Lagoons OU, the Depleted Uranium Hexafluoride (DUF_6) Footprint Underlying Soils OU, the Comprehensive Site OU (CSOU), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste Disposal Alternatives OU. Each OU leading up to the CSOU is scoped to remediate areas and media associated with the U.S. Department of Energy (DOE) Paducah Site.[1] A final CSOU evaluation will occur following the completion of the Facility D&D OU (of PGDP), the completion of the DUF6 Footprint Underlying Soils OU, and the completion of cleanup of each of the specific OUs. The specific scopes and further discussions for each OU and associated follow-up actions are addressed in the fiscal year (FY) 2023 SMP (DOE 2022a).

The U.S. Environmental Protection Agency (EPA) defines the following four types of five-year reviews: (1) statutory review, (2) policy review, (3) discretionary review, and (4) five-year review addendum (for deferred protectiveness). This document is a combination of statutory and discretionary reviews.

This fifth synchronized Five-Year Review encompasses the remedial actions (RAs) that DOE has taken under the respective OUs, plus the Water Policy removal action, surface water interim corrective measures (ICMs), and surface water on-site sediment removal.[2] The FFA for the Paducah Site includes requirements for synchronizing five-year reviews of RAs (Section XXX). The triggering action for this review is the five-year anniversary of the fourth synchronized Five-Year Review conducted at the Paducah Site in 2018 for activities associated with response actions from 2013 through 2017 [*CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah,* DOE/LX/07-2426&D2 (DOE 2019a)]. This fifth synchronized Five-Year Review encompasses activities associated with response actions from 2018 through 2022. A form summarizing the Paducah Site, issues from the review, recommendations, and protectiveness statements is presented in Table ES.1. This form is the updated 2011 version of the form from Appendix F of EPA guidance document *Comprehensive Five-Year Reviews Guidance* (EPA 2001).

---

[1] References in this report to the Paducah Site generally mean the property, programs, and facilities at or near PGDP for which DOE has the ultimate responsibility. The Paducah Site is located in a generally rural area of McCracken County, Kentucky, 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River. PGDP is on a 3,556-acre DOE site comprised of the following: approximately 1,450 acres utilized for site operations, 133 acres in acquired easements, and the remaining 1,973 acres licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area.

[2] As shown in Table 2.1, four individual OUs had five-year reviews conducted prior to the 2003 Five-Year Review.

Table ES.1. Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Paducah Gaseous Diffusion Plant		
EPA ID: KY8-890-008-982		
Region: 4	State: KY	City/County: Paducah/McCracken
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	Has the site achieved construction completion? No	
REVIEW STATUS		
Lead agency: Other Federal Agency If "Other Federal Agency" was selected above, enter Agency name: U.S. Department of Energy		
Author name (Federal or State Project Manager): Richard Bonczek, PhD		
Author affiliation: U.S. Department of Energy		
Review period: 01/01/2018–12/31/2022		
Date of site inspection: 12/05/2022–12/08/2022		
Type of review: Statutory and Discretionary		
Review number: Fifth Synchronized		
Triggering action date: 12/30/2018		
Due date (*five years after triggering action date*): 12/30/2023		

Table ES.1. Five-Year Review Summary Form (Continued)

Issues/Recommendations				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
SWOU and BGOU				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): Groundwater, Northwest Plume	**Issue Category:** Remedy Performance			
	Issue: The Northwest Plume [Solid Waste Management Unit (SWMU) 201] interim remedial action (IRA), designed to initiate hydraulic control of the high trichloroethene (TCE) concentration of the Northwest Plume, has achieved the IRA goals in the area of the original north extraction well (EW) wellfield (EW 228 and EW 229). TCE detections in the north wellfield now are consistently low (~ 5 ppb or less) and the contaminant trends indicate the Northwest Plume has migrated east of the north wellfield. The risk posed by the unused wells exceeds any potential benefit of future reuse of the wells.			
	Recommendation: Perform an evaluation of the north EW wellfield (EW 228 and EW 229) for deactivation and abandonment, and gain concurrence of the FFA parties.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No*	Yes*	Federal Facility	EPA/State	12/30/2027 (end of next five-year review period)

*The integrity of the EWs and MWs are maintained to ensure current protectiveness. Unless maintained in perpetuity, proper abandonment is needed to prevent the EWs and MWs from becoming future avenues of migration of surface contaminants to the Regional Gravel Aquifer.

OU(s): Groundwater, Northwest Plume	**Issue Category:** Remedy Performance			
	Issue: The C-612 groundwater treatment facility was constructed in 1995 pursuant to the Northwest Plume (SWMU 201) IRA. The facility was designed for a five-year life span and for the treatment of contaminant concentrations much higher than are currently present. Though some major components of the facility have been replaced since 1995, many components are nearly 30 years old,			
	Recommendation: Perform a comprehensive evaluation the C-612 groundwater treatment facility to determine the extent of modifications needed to optimize reliability and performance.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No*	No*	Federal Facility	EPA/State	12/30/2027 (end of next five-year review period)

*Although the issue does not affect the current or future protectiveness, the issue and recommended actions are an optimization to the current remedy established and are included as recommended by guidance.

Table ES.1. Five-Year Review Summary Form (Continued)

<table>
<tr><td rowspan="3">OU(s): Groundwater, Northeast Plume (SWMU 202)</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: NW and NE Plume systems are working as designed to increase TCE mass removal and enhance hydraulic capture of the plumes; however, the containment systems could be further optimized by installing additional EW(s) near the C-400 Complex.</td></tr>
<tr><td colspan="4">Recommendation: Perform an evaluation for installing additional EW(s) near the C-400 Complex, consistent with the groundwater flow modeling assessment completed as part of the RAWP (DOE 2018a).</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No*</td><td>No*</td><td>Federal Facility</td><td>EPA/State</td><td>12/30/2027 (end of next five-year review period)</td></tr>
</table>

*Although the issue does not affect the current or future protectiveness, the issue and recommended actions are an optimization to the current remedy established and are included as recommended by guidance.

<table>
<tr><td rowspan="3">OU(s): Water Policy</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: Information obtained during the last five years demonstrates that the technetium-99 (Tc-99) plume no longer exists at concentrations exceeding the Tc-99 MCL in areas off DOE property and that the TCE plumes have reduced concentrations and areal extent in areas off DOE property. Sources of relevant TCE and Tc-99 plume information that support these reductions are as follows: (1) results of monitoring plume concentrations and changes in those concentrations; (2) changes in plume extent as shown in biennial plume map reports; (3) information and findings on groundwater flow and concentration trends evaluated as part of the sitewide groundwater strategy; (4) insights developed from updates to the sitewide groundwater flow and fate and transport models; and (5) results of plume stability analyses.</td></tr>
<tr><td colspan="4">Recommendation: Develop a technical paper using relevant TCE and Tc-99 plume information to better understand the status of the Water Policy action and whether an optimization of the Water Policy action is warranted.</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No*</td><td>No*</td><td>Federal Facility</td><td>EPA/State</td><td>12/30/2027 (end of next five-year review period)</td></tr>
</table>

*Although the issue does not affect the current or future protectiveness, the issue and recommended actions are an optimization to the current remedy established and are included as recommended by guidance.

Table ES.1. Five-Year Review Summary Form (Continued)

Protectiveness Statement(s)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, Northwest Plume	Short-term Protective	N/A

Protectiveness Statement:

The IRA for the Northwest Plume (SWMU 201) is protective of human health and the environment in the short-term. Reduction in contaminant concentrations and reduction in the plume footprint have contributed to control or reduction in unacceptable risks. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plumes OU [see Appendix 3 of the FY 2023 SMP for a discussion of the scope of the Dissolved-Phase Plumes OU (DOE 2022a)], need to be evaluated for long-term protection. A recommendation was made for an evaluation to be performed of the north EW wellfield (EW 228 and EW 229) for deactivation and abandonment and to gain concurrence of the FFA parties.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, Northeast Plume	Short-term Protective	N/A

Protectiveness Statement:

The IRA for the Northeast Plume (SWMU 202) is protective of human health and the environment in the short-term. The Northeast Plume groundwater extraction system has been optimized to increase TCE mass removal, to enhance control of plume migration at the eastern edge of the PGDP industrial area. Reduction in contaminant concentrations and reduction in the plume footprint have contributed to control or reduction in unacceptable risks. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plumes OU [see Appendix 3 of the FY 2023 SMP for a discussion of the scope of the Dissolved-Phase Plumes OU (DOE 2022a)], need to be evaluated for long-term protection. A recommendation was made for an evaluation to be performed to install additional EW(s) near the C-400 Complex, which is consistent with the groundwater flow modeling assessment completed as part of the RAWP (DOE 2018a).

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, Cylinder Drop Test Area	Short-term Protective	N/A

Protectiveness Statement:

The IRA for the Cylinder Drop Test Area (SWMU 91) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled through DOE access controls. This project is not a final action and was not designed to return the areas to unrestricted use and unlimited exposure. A final TCE cleanup level providing long-term protection of groundwater has not yet been established. In order to establish long-term protectiveness, per the FFA, "…any necessary RA shall be selected and implemented…." as part of the CSOU.

Table ES.1. Five-Year Review Summary Form (Continued)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, Water Policy	Short-term Protective	N/A

Protectiveness Statement:

The removal action for the Water Policy currently protects human health and the environment by institutional controls, including administrative controls, in the short-term. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plumes OU, need to be evaluated for long-term protection [see Appendix 3 of the FY 2023 SMP for a discussion of the scope of the Dissolved-Phase Plumes OU (DOE 2022a)]. A recommendation was made to develop a technical paper using relevant TCE and Tc-99 plume information to better understand the status of the Water Policy action and whether an optimization of the Water Policy action is warranted.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, C-400 Electrical Resistance Heating (ERH)	Short-term Protective	N/A

Protectiveness Statement:

The IRA for the volatile organic compound (VOC) contamination at C-400 Cleaning Building is protective of human health and the environment in the short-term. In the interim, land use controls (LUCs) for this action include property record notices and deed restrictions, administrative controls, and access controls. This action, in combination with other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), has adequately addressed known exposure pathways that could result in unacceptable risks originating from C-400. In order to establish long-term protectiveness, an additional RA will be selected, under the C-400 Complex OU Record of Decision (ROD).

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, Southwest Plume Oil Landfarm	Protective	N/A

The final remedial action (RA) for VOC sources at the Southwest Plume Oil Landfarm (SWMU 1) is protective of human health and the environment. The collected data indicates that TCE contaminant levels in general have continued to decline following the completion of the action. As indicated in the ROD, a period of time is expected before attainment of RAO 3 is confirmed. RAO 3 states, "Reduce VOC migration from contaminated subsurface soils in the treatment areas at the Oil Landfarm and the C-720 Northeast and Southeast Sites so that contaminants migrating from the treatment areas do not result in the exceedance of MCLs in the underlying RGA groundwater." Interim LUCs consisting of placement of warning signs and DOE's excavation/penetration permit program are in place to prevent exposure to site contaminants until RAO 3 is attained. This action, in combination with other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), has addressed adequately known exposure pathways that could result in unacceptable risks originating from the Southwest Plume (SWMU 210).

Table ES.1. Five-Year Review Summary Form (Continued)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
GWOU, Southwest Plume, C-720 Building Northeast Spill Site (SWMU 211-A)	Protective	N/A

The final RA for VOC sources at the Southwest Plume C-720 Building Northeast Spill Site (SWMU 211-A) is protective of human health and the environment now and is expected to continue to be protective. Data collected currently indicates that bioremediation is occurring as expected. Also as expected and documented in the record of decision, a period of time also is needed before attainment of all RAOs. Interim LUCs consisting of placement of warning signs and DOE's excavation/penetration permit program are in place to prevent exposure to site contaminants. This action, in combination with other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), will address adequately known exposure pathways that could result in unacceptable risks originating from the Southwest Plume (SWMU 211-A).

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
SWOU, North-South Diversion Ditch Source Control	Protective	N/A

Protectiveness Statement:

The IRA for the North-South Diversion Ditch (NSDD) Source Control is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled. The remedy is functioning as intended per the definition of "protective." This project was not designed to return the areas to unrestricted use and unlimited exposure.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
SWOU, North-South Diversion Ditch Sections 1 and 2	Short-term Protective	N/A

Protectiveness Statement:

The IRA for the NSDD Sections 1 and 2 (SWMU 59) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk currently are being controlled. In order to establish long-term protectiveness, additional action will be evaluated and selected, as necessary, under the SWOU.

Table ES.1. Five-Year Review Summary Form (Continued)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
SWOU, C-746-K Sanitary Landfill	Protective	N/A
Protectiveness Statement:		
The RA for the C-746-K Sanitary Landfill (SWMU 8) is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled and the remedy is functioning as expected. This project was not designed to return the area to unrestricted use and unlimited exposure.		

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
SWOU, Fire Training Area	Short-term Protective	N/A
Protectiveness Statement:		
The RA for the Fire Training Area (SWMU 100) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled. This project was not designed to return the areas to unrestricted use and unlimited exposure. In order to establish long-term protectiveness, per the FFA, "…any necessary RA shall be selected and implemented…." as part of the CSOU. In March 2023, EPA proposed maximum contaminant levels (MCLs) for six per- and polyfluoralkyl substances (PFAS). As an emergent contaminant, PFAS was not considered as part of the scope of the WAGs 1 & 7 RI/FS or ROD. As discussed in the FY 2023 SMP, the presence of PFAS will be evaluated separately; if cleanup under CERCLA is required, a new remedial action project will be identified to address the contamination (DOE 2022a).		

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
Surface Water ICMs	Short-term Protective	N/A
Protectiveness Statement:		
The interim/institutional corrective/control measures for the Surface Water currently protects human health and the environment by institutional controls; however, additional actions under the SWOU need to be evaluated for long-term protectiveness.		

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
SWOU, On-site Sediment Removal	Short-term Protective	N/A
Protectiveness Statement:		
The Surface Water On-site Sediment Removal Action is protective of human health and the environment in the short-term due to excavation of contaminated sediment/soil and placement of clean soil to meet the cleanup goal. In order to establish long-term protectiveness, RAs will be evaluated and selected, as necessary, under the SWOU.		

Table ES.1. Five-Year Review Summary Form (Continued)

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
BGOU, C-749 Uranium Burial Ground	Short-term Protective	N/A
Protectiveness Statement: The IRA for the C-749 Uranium Burial Ground (SWMU 2) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled through DOE access controls. This remedy was not designed to fully address the risks to human health and the environment from the buried wastes nor return the areas to unrestricted use and/or unlimited exposure. A final RA will be selected under the BGOU to ensure long-term protectiveness.		

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination:	*Addendum Due Date (if applicable):*
N/A	N/A
Protectiveness Statement: N/A	

N/A = not applicable at this time, as the Paducah Site has not achieved construction completion.

The assessments of this fifth synchronized Five-Year Review find that DOE has implemented and operated the remedies in accordance with the requirements of the RODs or Action Memorandums (AMs). Table ES.2 is a list of the continuing or completed response actions by decision document, site or project name, and OU contained in this review.

Table ES.2. Decision Document and Site/Project Name Included in Fifth Synchronized Five-Year Review

Decision Document	Site or Project	Operable Unit
Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1143&D4, and *Explanation of Significant Differences to the Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0343&D2	Northwest Plume (SWMU 201)	GWOU
Explanation of Significant Differences for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1481&D2	Northwest Plume (SWMU 201)	GWOU
Record of Decision for Interim Remedial Action at the Northeast Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1356&D2	Northeast Plume (SWMU 202)	GWOU
Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-1291&D2/R2	Northeast Plume (SWMU 202)	GWOU
Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1527&D2	Cylinder Drop Test Area (SWMU 91) or Lasagna™	GWOU
Action Memorandum for the Water Policy at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1201&D2	Water Policy	GWOU
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, DOE/OR/07-2150&D2/R2	C-400 ERH	GWOU
Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0365&D2/R1	Southwest Plume	GWOU
Explanation of Significant Differences to the Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2480&D2	Southwest Plume	GWOU

Table ES.2. Decision Document and Site/Project Name Included in Fifth Synchronized Five-Year Review (Continued)

Decision Document	Site or Project	Operable Unit
Record of Decision for Interim Action Source Control at the North-South Diversion Ditch, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1213&D3	NSDD Source Control	SWOU
Record of Decision for Interim Remedial Action at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1948&D2	NSDD Sections 1 and 2 (SWMU 59)	SWOU
Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1470&D3	C-746-K Sanitary Landfill (SWMU 8)	SWOU
Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1470&D3	Fire Training Area (SWMU 100)	SWOU
Interim Measure Report for Institutional Control of Off-Site Contamination in Surface Water, DOE/OR/07-1206&D1	Surface Water ICMs	SWOU
Action Memorandum for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0119&D2/R1	Surface Water On-site Sediment Removal	SWOU
Record of Decision for Interim Remedial Action at Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1351&D1	C-749 Uranium Burial Ground (SWMU 2)	BGOU

The response actions are functioning as intended by the decision documents. Each of these projects had specific remedies cited in each applicable decision document (e.g., ROD or AM). This fifth synchronized Five-Year Review concludes, for completed response actions, that additional actions are not required to meet the remedial goals or RAOs of the decision documents.

THIS PAGE INTENTIONALLY LEFT BLANK

1. INTRODUCTION

The purpose of this fifth synchronized Five-Year Review is to determine whether the remedies at the U.S. Department of Energy (DOE) Paducah Site[3] remain protective of human health and the environment and to evaluate the implementation and performance of the selected remedies. The methods, findings, conclusions, and recommendations of the reviews of 13 projects are documented in this report.

DOE has conducted this fifth synchronized Five-Year Review pursuant to the Federal Facility Agreement (FFA) (EPA 1998) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 *U.S.C.A.* § 9621(c)]; the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 *CFR* § 300.430(f)(4)(ii)]; and the U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-03B-P (EPA 540-R-01-007) (EPA 2001). Additionally, this document meets guidance set forth in the "Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Review Guide," Office of Environmental Management, DOE, March 2002 (DOE 2002a) Assessing Protectiveness at Sites for Vapor Intrusion Supplement to the "Comprehensive Five-Year Review Guidance," OSWER 9200.2-84; Recommended Evaluation of Institutional Controls: Supplement to the Comprehensive Five-Year Review Guidance Five-Year Reviews, OSWER 9355.7-18; Frequently Asked Questions (FAQs) and Answers, Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews, OSWER 9355.7-21; and memorandum issued September 13, 2012, OSWER 9200.2.111. Per guidance, community involvement activities during the Five-Year Review should include notifying the community that the five-year review will be conducted. DOE published a public notice in the local newspaper on December 10, 2022, announcing that the five-year review had been initiated and requesting that any suggestions, issues, questions, or concerns regarding this review be provided from December 18 through December 31, 2022. No comments were received as a result of publishing the public notice.

CERCLA requires that reviews be conducted no less often than once every five years. The FFA, Section XXX, requires a five-year review for final remedial actions (RAs) for any operable unit (OU), "including selected alternatives entailing institutional controls with remedial action, result in Hazardous Substances, pollutants or contaminants, or Hazardous Wastes and Hazardous Constituents remaining at the Site above levels that allow for unlimited use and unrestricted exposure in accordance with Section 300.430(f)(4)(ii) of the NCP." EPA Guidance (OSWER 9355.7-21) defines the following four types of five-year reviews: (1) statutory reviews; (2) policy reviews; (3) discretionary reviews; and (4) five-year review addendum (for deferred protectiveness).

Statutory Reviews are conducted pursuant to CERCLA § 121(c) and 40 *CFR* § 300.430(f)(4)(ii) of the NCP and are conducted when the following conditions exist:

- Upon completion of the RA, hazardous substances, pollutants, or contaminants will remain at the site above levels that allow for unlimited use and unrestricted exposure; and

[3] References in this report to the Paducah Site generally mean the property, programs, and facilities at or near Paducah Gaseous Diffusion Plant (PGDP) for which DOE has ultimate responsibility. The Paducah Site is located in a generally rural area of McCracken County, Kentucky, 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River. PGDP is on a 3,556-acre DOE site comprised of the following: approximately 1,450 acres utilized for site operations, 133 acres in acquired easements, and the 1,973 acres licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA).

- The Record of Decision (ROD) for the site was signed on or after October 17, 1986, [the effective date of Superfund Amendments and Reauthorization Act (SARA)] and the RA was selected under CERCLA § 121.

Policy reviews generally are conducted for the following types of actions:

- A pre- or post-SARA RA that, upon completion, will not leave hazardous substances, pollutants, or contaminants on-site above levels that allow for unlimited use and unrestricted exposure, but requires five years or more to complete;

- A pre-SARA RA that leaves hazardous substances, pollutants, or contaminants on-site above levels that allow for unlimited use and unrestricted exposure; or

- A removal-only site on the National Priorities List (NPL) where a removal action leaves hazardous substances, pollutants, or contaminants on-site above levels that allow for unlimited use and unrestricted exposure and where no RA has or will take place.

Discretionary reviews are not required by statute or policy. These types of five-year reviews may be done at the discretion of the region or federal agency to help ensure the protectiveness of selected remedies. A five-year review addendum generally is completed for remedies where the protectiveness determination was deferred in a prior five-year review report in order to collect further information.

All the projects listed in Table 1.1 are undergoing a statutory five-year review with the exception of the following: Water Policy, Surface Water Interim Corrective Measures (ICMs), and Surface Water On-site Sediment Removal. Five-year reviews are being conducted for the Water Policy, Surface Water ICM, and Surface Water On-site Sediment Removal as discretionary reviews. For the Water Policy and C-400 electrical resistance heating (ERH), addendum reviews have been conducted based on findings from the previous Five-Year Review. The Water Policy addendum was approved in November 2017. The C-400 ERH addendum was submitted in May 2018 to EPA and the Kentucky Department for Environmental Protection (KDEP).

The Water Policy is a removal action that originally was implemented and currently is being maintained to eliminate and/or reduce potential exposure from contaminated groundwater at the Paducah Site. Various RA projects at the Paducah Site rely on the Water Policy to demonstrate protectiveness for the groundwater exposure pathway. The Surface Water ICM was conducted as a Resource Conservation and Recovery Act (RCRA) ICM intended to identify the areas of contamination through the posting of warning signs and to help restrict casual public access to the creeks. Proper monitoring and maintenance of these controls are necessary to demonstrate ongoing protectiveness for the surface water exposure pathway until such time that a final RA is implemented as part of the Surface Water OU (SWOU). The Surface Water On-site Sediment Removal Project was conducted as a removal action to remove on-site areas of elevated sediment contamination. The removal action reduced contaminant levels to within the acceptable CERCLA risk range based on the current and reasonably anticipated future land use (industrial, recreational), but did not achieve cleanup levels that would allow for unlimited use and unrestricted exposure.

This review encompasses the response actions listed in Table 1.1 by decision document, site/project name, and OU.

Table 1.1. Decision Document and Site/Project Name Included in Fifth Synchronized Five-Year Review

Decision Document	Site/Project Name Used in This Report	Operable Unit	Project Name Used in Previous Five-Year Reviews
Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1143&D4 and *Explanation of Significant Differences to the Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0343&D2	Northwest Plume [Solid Waste Management Unit (SWMU) 201]	Groundwater OU (GWOU)	Northwest Plume (SWMU 201)
Explanation of Significant Differences for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1481&D2	Northwest Plume (SWMU 201)	GWOU	Northwest Plume (SWMU 201)
Record of Decision for Interim Remedial Action at the Northeast Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1356&D2	Northeast Plume (SWMU 202)	GWOU	Northeast Plume (SWMU 202)
Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-1291&D2/R2	Northeast Plume (SWMU 202)	GWOU	Northeast Plume (SWMU 202)
Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1527&D2	Cylinder Drop Test Area (SWMU 91) or Lasagna™	GWOU	Cylinder Drop Test Area (SWMU 91) or Lasagna™
Action Memorandum for the Water Policy at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1201&D2	Water Policy	GWOU	Water Policy
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, DOE/OR/07-2150&D2/R2	C-400 ERH	GWOU	C-400 ERH
Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0365&D2/R1	Southwest Plume	GWOU	Southwest Plume
Explanation of Significant Differences to the Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2480&D2	Southwest Plume	GWOU	Southwest Plume

Table 1.1. Decision Document and Site/Project Name Included in Fifth Synchronized Five-Year Review (Continued)

Decision Document	Site/Project Name Used in This Report	Operable Unit	Project Name Used in Previous Five-Year Reviews
Record of Decision for Interim Action Source Control at the North-South Diversion Ditch, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1213&D3	North-South Diversion Ditch (NSDD) Source Control	SWOU	NSDD Source Control
Record of Decision for Interim Remedial Action at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky, DOE/OR/07-1948&D2	NSDD Sections 1 and 2 (SWMU 59)	SWOU	NSDD Sections 1 and 2 (SWMU 59)
Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1470&D3	C-746-K Sanitary Landfill (SWMU 8)	SWOU	C-746-K Landfill (SWMU 8)
Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1470&D3	Fire Training Area (SWMU 100)	SWOU	Fire Training Area (SWMU 100)
Interim Measure Report for Institutional Control of Off-Site Contamination in Surface Water, DOE/OR/07-1206&D1	Surface Water ICMs	SWOU	Surface Water ICMs
Action Memorandum for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0119&D2/R1	Surface Water On-Site Sediment Removal	SWOU	Surface Water On-Site Sediment Removal
Record of Decision for Interim Remedial Action at Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/06-1351&D1	C-749 Uranium Burial Ground (SWMU 2)	Burial Grounds OU (BGOU)	C-749 Uranium Burial Ground (SWMU 2)

The FFA includes provisions for combining Five-Year Reviews of RAs as stated in Section XXX:

> Consistent with Section 121(c) of CERCLA, 42 U.S.C. § 9621 (c), and in accordance with this Agreement, DOE agrees that if the selected, final RAs for any operable unit, including selected alternatives entailing institutional controls with remedial action, result in Hazardous Substances, pollutants or contaminants, or Hazardous Wastes and Hazardous Constituents remaining at the Site above levels that allow for unlimited use and unrestricted exposure in accordance with Section 300.430(f) (4) (ii) of the NCP, DOE will submit to EPA and KNREPC* a review of the RAs no less often than once every five (5) years (Five-Year Review) after the initiation of such RAs (i.e., date of issuance of final-ROD) for as long as the site remains on the NPL to assure that human health and the environment are being protected by the RAs being implemented. To facilitate the Five-Year Review process for multiple OUs, the Five-Year Reviews shall be synchronized as follows: reviews which are required for RA OUs will be conducted every five years starting from the initiation of the RA for the first OU. Every five years thereafter, all subject OU RAs which were started prior to the next Five-Year Review date, shall be included in the next Five-Year Review. For OU RAs which started after the most recent Five-Year Review, the level of the review shall be commensurate to the completeness of the RA and the quantity of operation and maintenance data collected.

> If, based on the Five-Year Review, it is the judgment of EPA or KNREPC that additional action or modification of a RA is appropriate in accordance with Sections 104, 106 or 120 of CERCLA, 42 U.S.C. §§ 9604, 9606, or 9620, the RCRA Permits or KRS 224 Subchapter 46, then EPA or KNREPC shall require DOE to submit a proposal to implement such additional or modified actions, which shall be subject to review and approval by EPA and KNREPC.
>
> *KNREPC now is called the Kentucky Energy and Environment Cabinet.

DOE is the lead agency for these response actions, and EPA and KDEP provide regulatory oversight pursuant to the FFA. This fifth synchronized Five-Year Review contains reviews of completed projects. The triggering action for this review is the five-year anniversary of the fourth synchronized Five-Year Review conducted at the Paducah Site [*Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2462&D2 (DOE 2019a)].

This fifth synchronized Five-Year Review is used to accomplish the following (DOE 2002a):

1. Evaluate whether the remedy is operational and functional;

2. Evaluate those assumptions critical to the effectiveness of remedial measures or the protection of human health and the environment (e.g., land use, site conditions, applicable standards) made at the time of the remedial decision to determine, given current information, whether these assumptions are still valid;

3. Determine what corrective measures are required to address any identified deficiencies; and

4. Evaluate whether there are opportunities to optimize the long-term performance of the remedy or reduce lifecycle costs.

EPA Region 4 issued a policy in April 1998 for assuring the long-term effectiveness of land use controls (LUCs) at federal facilities (Johnston 1998). The Paducah Site subsequently developed a site-specific Memorandum of Agreement (MOA) and Land Use Control Assurance Plan (LUCAP) (DOE 2000a). The Paducah Site LUCAP specifies that decision documents approved prior to the effective date of the MOA in which LUCs were selected as part of the remedy will be analyzed for the effectiveness of the LUCs during the ROD Five-Year Reviews. EPA issued guidance in 2011, OSWER Directive 9355.7-18 (EPA 2011), which provided recommendations for conducting Five-Year Reviews for the institutional control (i.e., LUC) component of remedies in a manner similar to the review of engineering or other remedy components. The effectiveness of the institutional controls or LUCs is addressed in this fifth synchronized Five-Year Review. The Paducah Site LUCAP also requires that DOE notify EPA and KDEP in writing of any major changes in land use at least 60 days prior to the initiation of such changes. This notification will include the following:

- An evaluation of whether the anticipated land use change will pose unacceptable risks to human health and the environment or negatively impact the effectiveness of the remedy;

- An evaluation of the need for any additional RA(s) resulting from the anticipated land use changes; and

- A proposal for any necessary changes to the selected RA and identification of documentation requirements [e.g., ROD amendments, ROD Explanation of Significant Differences (ESD), RCRA permit modification)] for the proposed changes.

Deed restrictions were verified at the McCracken County Courthouse in Paducah, Kentucky.

The review of the completed response actions was conducted during December 2022 through February 2023 for the period extending from January 2018 through December 2022. DOE and its deactivation and remediation (D&R) Contractor, Four Rivers Nuclear Partnership, LLC, conducted the reviews. Section 4 of this report identifies the locations of the actions that were reviewed. Components of this review are as follows and can be found in Appendices A, B, and C:

- Document review
- Data review
- Site inspection
- Interviews of personnel responsible for specific aspects of some of the response actions
- Five-year review report development and review

These components are described in more detail in Section 22.

Protectiveness statements are developed after the technical review is completed and the following questions are answered:

- Question A: Is the Remedy Functioning as Intended by the Decision Documents?

- Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives (RAOs) Used at the Time of the Remedy Selection Still Valid?

- Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

2. SITE CHRONOLOGY

Table 2.1 contains key dates that are important to the environmental response program of the Paducah Site.

Table 2.1. Chronology of Significant Site Events at the Paducah Site

Date of Action	Response Description	Site/Project Name	OU	WAG	SWMU	Media	Response Type
1952	PGDP begins enriching uranium for nuclear fuel reactors.	N/A	N/A	N/A	N/A	N/A	N/A
1964–1965, 1979	The Paducah Site conducts cylinder drop tests using trichloroethene (TCE) pit (later to be designated SWMU 91).	N/A	GWOU	N/A	91	Ground-water	N/A
Aug–1988	Off-site[a] groundwater contaminants are discovered in neighboring residential wells. DOE immediately provided a temporary water supply. Initiated construction activities to supply municipal water.	N/A	GWOU	N/A	N/A	Ground-water	N/A
Nov–1988	Agreed Consent Order is signed.	N/A	N/A	N/A	N/A	N/A	N/A
Aug–1991	Kentucky Hazardous Waste Management Permit and EPA Hazardous and Solid Waste Amendments Permits are first effective.	N/A	N/A	N/A	N/A	N/A	N/A
May–1993	The Paducah Site applies for listing on NPL.	N/A	N/A	N/A	N/A	N/A	N/A
Jul–1993	Implemented institutional controls (fencing/posting) for off-site contamination in surface water, outfalls, and lagoons.	Exterior Drainage Ditches	SWOU	18 and 25	58–69, 168, 171, 199	Surface water	ICM
Jul–1993	Issued ROD to initiate control of the source and mitigate the spread of the high concentration portion (TCE) of the Plume.	Northwest Plume	GWOU	26	201	Ground-water	Interim Remedial Action (IRA)
Mar–1994	Issued ROD that instituted action to treat certain facility effluent and control the migration of contaminated sediment associated with the NSDD.	NSDD	SWOU	25	59	Surface water	IRA
May–1994	The Paducah Site is placed on NPL.	N/A	N/A	N/A	N/A	N/A	N/A
Aug–1994	Action Memorandum (AM) approved for extended municipal water line to residents potentially affected by off-site groundwater contamination.	Water Policy	GWOU	26	201 and 202	Ground-water	Non-Time-Critical Removal Action (NTCRA)
Jun–1995	Issued ROD to initiate hydraulic control of high concentration area (TCE) within the Northeast Plume.	Northeast Plume	GWOU	26	202	Ground-water	IRA
Aug–1995	Northwest Plume Groundwater System (NWPGS) begins operation.	Northwest Plume	GWOU	26	201	Ground-water	IRA

Table 2.1. Chronology of Significant Site Events at the Paducah Site (Continued)

Date of Action	Response Description	Site/Project Name	OU	WAG	SWMU	Media	Response Type
Sept–1995	The ROD selected an impermeable cap to reduce leachate migration from surface infiltration, groundwater monitoring, and institutional controls. Through agreement of the parties, an impermeable cap was not constructed (WAG 22 Post-ROD Change, October 23, 1996). This change also will be documented in the Final Remedial Decision for the C-749 Uranium Burial Ground.	C-749 Uranium Burial Ground	BGOU	22	2	Soil and ground-water	IRA
Nov–1996	ESD to ROD was approved by EPA. The ESD proposed to eliminate activated carbon filters (proposal was later withdrawn in response to public comment). The ESD reversed the sequence of two treatment units (ion exchange unit and air stripper) and eliminated the iron filings treatability study.	Northwest Plume	GWOU	26	201	Ground-water	IRA
Feb–1997	Northeast Plume Groundwater System begins operation.	Northeast Plume	GWOU	26	202	Ground-water	IRA
Feb–1998	FFA is signed with EPA and KDEP.	N/A	N/A	N/A	N/A	N/A	N/A
Jul–1998	First Five-Year Review is completed for Northwest Plume Action.	Northwest Plume	GWOU	26	201	N/A	IRA
Aug–1998	First Five-Year Review is completed for Water Policy.	Water Policy	GWOU	26	201 and 202	N/A	N/A
Aug–1998	Issued ROD for *in situ* treatment of TCE-contaminated soils using the Lasagna™ technology.	Cylinder Drop Test Area	GWOU	27	91	Soil	IRA
Aug–1998	Issued ROD for installation of rip-rap along creek bank to prevent direct contact, implementation of institutional controls, and long-term monitoring and enhancement of existing cap to reduce leachate migration from surface infiltration.	C-746-K Sanitary Landfill	SWOU	1 & 7	8	Surface water and sediment	IRA
Aug–2000	First Five-Year Review is completed for BGOU.	Burial Ground	BGOU	22	2 and 3	Soil and ground-water	N/A
Aug–2000	First Five-Year Review is completed for SWOU.	Surface Water	SWOU	[b]	[b]	Surface water	N/A
Dec–2001	Lasagna™ or Cylinder Drop Test Area remedial operations are completed.	Cylinder Drop Test Area	GWOU	27	91	Soil	IRA
Aug–2002	Initiated removal of process equipment and piping for C-410 decontamination and decommissioning (D&D).	C-410 Infrastructure Removal	Facility D&D	30	478	Building structures	NTCRA

Table 2.1. Chronology of Significant Site Events at the Paducah Site (Continued)

Date of Action	Response Description	Site/Project Name	OU	WAG	SWMU	Media	Response Type
Sep–2002	RA for Sections 1 and 2 of the NSDD.	NSDD	SWOU	25	59	Sediment and soil	IRA
Dec–2003	First synchronized Five-Year Review is issued.	All Applicable Projects	Applies to all activities associated with all OUs.				
Aug–2005	Issued ROD for *in situ* treatment of TCE source areas in the Upper Continental Recharge System (UCRS) and Regional Gravel Aquifer (RGA) located in the southeast and southwest corners of the C-400 Cleaning Building using ERH technology.	C-400 ERH	GWOU	6	11 and 533	Ground-water	IRA
Dec–2005	Initiate removal, characterization, and disposal of building structure and contents.	C-402 Limehouse, C-405 Incinerator	Facility D&D	30	480 and 55	Building structures	NTCRA
Nov–2008	Second synchronized Five-Year Review is issued.	All Applicable Projects	Applies to all activities associated with all OUs.				
Apr–2009	AM approved for the removal of contaminants associated with sediment in Sections 3, 4, and 5 of the NSDD and Kentucky Pollutant Discharge Elimination System (KPDES) Outfalls 001, 008, 010, 011, and 015, and associated internal ditches and areas of the Paducah Site.	Surface Water On-site Sediment Removal	SWOU	N/A	58, 63, 66–69, and associated internal ditches and areas (including SWMUs 92 and 97)	Sediment and soil	NTCRA
May–2009	AM approved for the removal of lead-contaminated soil at the C-218 Firing Range (SWMU 181); removal of contamination within the respective SWMU boundaries of C-410-B (SWMU 19); and removal of contamination within the respective SWMU boundaries of C-403 (SWMU 40).	Soils Inactive Facilities Removal	Soils	N/A	19, 40, and 181	Soil	NTCRA
Nov–2009	Issued addendum to document a change in scope of the C-410 removal action to (1) expand the scope of the existing NTCRA to include facility structure demolition to the slabs and disposition of demolition debris, and (2) allow the nonprocess systems to remain in place and to remove these systems at the same time the building is demolished using heavy equipment such as an excavator with shears.	C-410 Infrastructure Removal	Facility D&D	30	478	Building structures	NTCRA

Table 2.1. Chronology of Significant Site Events at the Paducah Site (Continued)

Date of Action	Response Description	Site/Project Name	OU	WAG	SWMU	Media	Response Type
May–2010	Issued the AM for the decommissioning of the C-340 Metals Plant and C-746-A East End Smelter, which includes the demolition of C-340-A, -B, and -C structures as well as the C-746-A East End Smelter. The slabs and soils underlying these structures will be addressed in future CERCLA response actions.	C-340 Decommissioning and C-746-A, East End Smelter	Facility D&D	N/A	477 and 137	Building structures	NTCRA
Sept–2010	Issued an ESD to the ROD for the IRA of Northwest Plume to increase contaminant mass removal and enhance capture near the southern extraction wells (EWs) that were closer to the sources. The NWPGS was optimized by placing existing southern EWs on standby and installing two new EWs east of original southern extraction field.	Northwest Plume	GWOU	26	201	Ground-water	IRA
Mar–2012	Issued ROD for: Oil Landfarm—*In situ* source treatment using deep soil mixing with interim LUCs. C-720 Building Northeast Spill Site—*In situ* source treatment using enhanced *in situ* bioremediation (EISB) with interim LUCs or long-term monitoring with interim LUCs based upon remedial design support investigation (RDSI) results. C-720 Building Southeast Spill Site—*In situ* source treatment using EISB with interim LUCs or long-term monitoring with interim LUCs based upon RDSI results.	Southwest Plume	GWOU	N/A	1, 211-A, and 211-B	Soil	RA
Aug–2013	Third synchronized Five-Year Review is issued.	All Applicable Projects	Applies to all activities associated with all OUs.				
Nov–2015	Issued an ESD to the ROD for the IRA of the Northeast Plume. The Northeast Plume Containment System (NEPCS) was optimized by replacing the two existing EWs with two new EWs in the upgradient high concentration portion of the plume and installing new treatment units to remove volatile organic compounds (VOCs) from the extracted groundwater.	Northeast Plume	GWOU	26	202	Ground-water	IRA

Table 2.1. Chronology of Significant Site Events at the Paducah Site (Continued)

Date of Action	Response Description	Site/Project Name	OU	WAG	SWMU	Media	Response Type
Sep–2016	Issued remedial action completion report (RACR) for Oil Landfarm RA—*in situ* source treatment using deep soil mixing with interim LUCs.	Southwest Plume	GWOU	N/A	1	Soil	IRA
Sep–2016	Removed liquid and sludge to the extent practicable within the acid neutralization tank. Filled the tank with flowable fill.	Soils Inactive Facilities Removal	Soils	N/A	27	Liquid and sludge	Time-critical removal action
Aug–2017	Reprioritization of DOE mission-related activities at the Paducah Site.	C-400	C-400 Complex OU	6	11, 40, 47, 98, 203, 480, and 533	Ground-water and soil	MOA
May–2018	Determined path forward for SWMUs 211-A and 211-B	Southwest Plume	GWOU	N/A	211-A and 211-B	Soil	RA
Jul–2018	Issued RACR for Phases I and IIa ERH RAs in the UCRS and upper RGA.	C-400 ERH	GWOU	6	11 and 533	Ground-water	IRA
May–2019	Fourth synchronized Five-Year Review is issued.	All Applicable Projects	Applies to all activities associated with all OUs.				
Aug–2019	Proceeded with the C-400 Complex OU Remedial Investigation/Feasibility Study (RI/FS) project and suspended the NTCRA for the C-400 Cleaning Building	C-400	C-400 Complex OU	6	11, 40, 47, 98, 203, 480, and 533	Ground-water and soil	MOA
Mar–2022	Began *in situ* source treatment using EISB with interim LUCs for SWMU 211-A	Southwest Plume	GWOU	N/A	211-A	Soil	RA
Dec–2022	Issued an ESD to the ROD for the VOC sources of the Southwest Plume.	Southwest Plume	GWOU	N/A	211-A and 211-B	Soil	RA

N/A = not applicable
[a] Off-site is defined as off DOE property, unless otherwise noted.
[b] The 2000 Five-Year Review for SWOU addresses the surface water associated with 39 SWMUs.

THIS PAGE INTENTIONALLY LEFT BLANK

3. BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

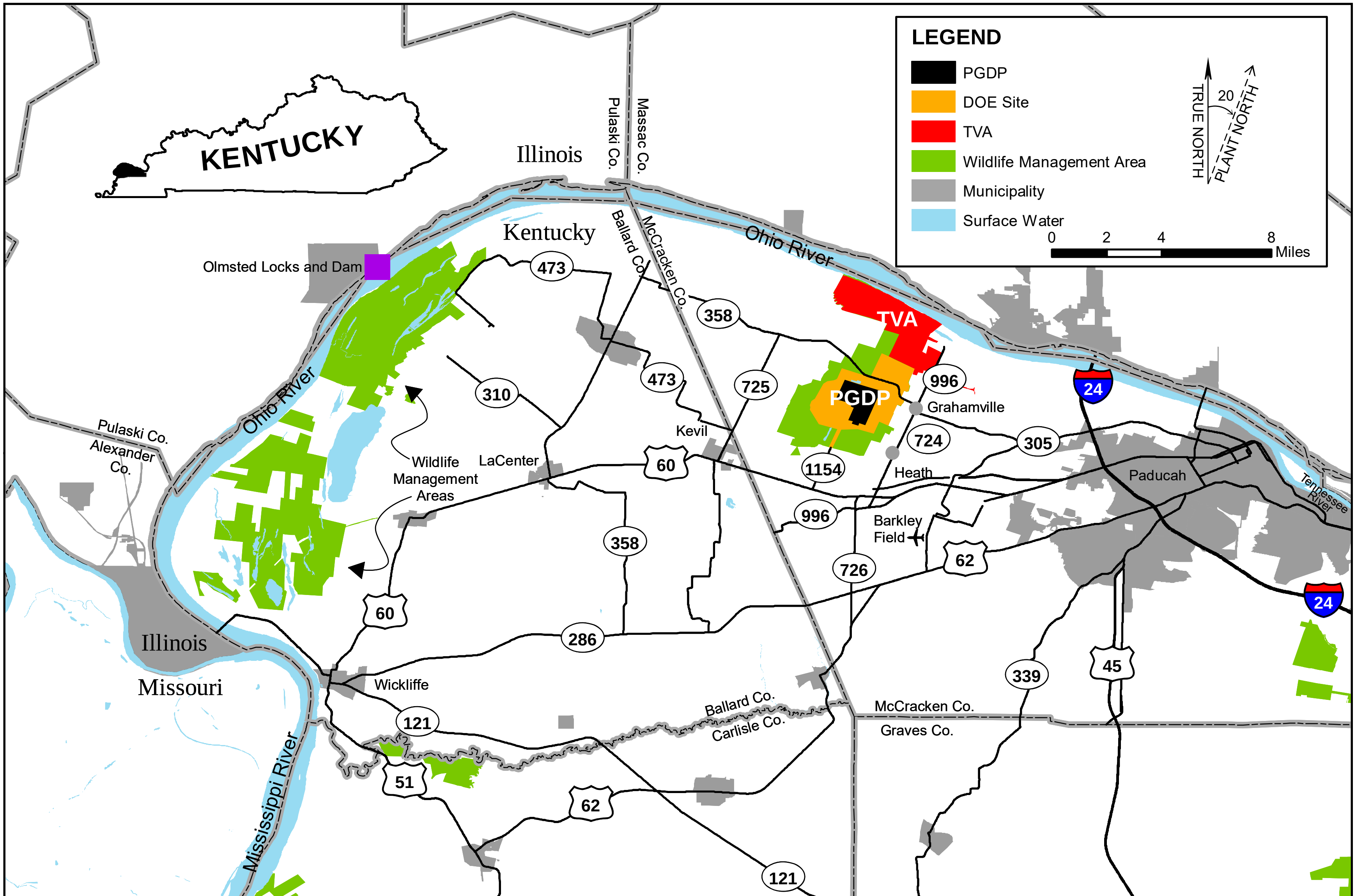
The Paducah Site is located in western Kentucky, approximately 10 miles west of the city of Paducah, and approximately 3.5 miles south of the Ohio River (Figure 3.1). The total acreage of land held by DOE at the Paducah Site is 3,556 acres. The industrial portion of the Paducah Site is approximately 1,450 acres. Surrounding the industrial portion of the reservation is the WKWMA.

PGDP is situated near the New Madrid Seismic Zone, which is a seismically active region. Geophysical investigations of the Paducah Site identified that the south extension of the high-angle northeast-trending faulting in the bedrock beneath the Paducah Site is likely 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 passes under or near PGDP (on the east side). Another Southern Illinois fault zone that might 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 were conducted at the Paducah Site. These area field studies were completed at the site of a potential CERCLA waste disposal facility, called Site 3A, (DOE 2004) and 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 2004) and the C-746-U Landfill is located 1 mile north of the PGDP security-fenced area, (KRCEE 2006). These two field studies identified subsurface faulting, which exhibited both normal and reverse displacement from the carbonate bedrock and extended upward into the Continental Deposits, in both locations.

The Site 3A investigation (DOE 2004) identified a series of faults beneath Site 3A. 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, form either 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 of the investigation sites (FRNP 2018a).

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

Several groundwater-bearing zones are present in the area of the Paducah Site. The primary water-bearing units, in order of increasing depth, are the UCRS, the RGA, and the McNairy Formation (Figure 3.2). The RGA has been identified as the uppermost aquifer at the Paducah Site (MMES 1992). The RGA is the dominant groundwater flow system at the Paducah Site and contains the on-site and off-site contaminant plumes.



MAP SOURCE INFORMATION
Map Generation Date and Location-- G:\GIS\ARCVIEWS\PROJECTS\ASER\Site_Location_20220328.mxd
Roads Layer-- G:\GIS\iPEGASIS.gdb\AllRds (Query: "ROUTE_NBR" IN ('1154','121','286','305','310','339','358','473','724','725','726','996') OR ("ROUTE_TYPE" = 'US'), …\fe_2007_21145_edges (Query: "FULLNAME" = 'Interstate Hwy 24')
County Lines Layer-- G:\GIS\iPEGASIS.gdb\County_Line_1z, …\fe_2007_us_state, …\counties_line (Query: "NAME" = 'Pulaski' OR "NAME" = 'Massac')
Surface Water Layer-- G:\GIS\iPEGASIS.gdb\tgr29133wat (Query: "LANDNAME" = 'Mississippi River'), …\fe_2007_21039_areawater (Query: "FULLNAME" = 'Mississippi Riv'),
…\fe_2007_21007_areawater (Query: "FULLNAME" <> ' 'OR "HYDROID" = '110223194147'), …\fe_2007_21145_areawater (Query: "HYDROID" IN ('110198428441','110198428305','110198428335')
OR ("FULLNAME" IN ('Metropolis Lk','Ohio Riv','Tennessee Riv','Bayou Crk')
Dams Layer-- https://services2.arcgis.com/FiaPA4ga0iQKduv3/arcgis/rest/services/NID_v1/FeatureServer (Query: "RIVER" = 'Ohio')
PGDP Boundary Layer-- G:\GIS\iPEGASIS.gdb\pgdpbnd; TVA Boundary Layer-- G:\GIS\iPEGASIS.gdb\tvabnd_official
DOE Boundary Layer-- G:\GIS\iPEGASIS.gdb\doebnd
Wildlife Management Area Layer-- G:\GIS\iPEGASIS.gdb\Public_hunting_areas, …\Wildlife_Management_Areas
Municipality Layer-- G:\GIS\iPEGASIS.gdb\tl_2015_21_place, …\tl_2015_17_place (Query: "NAME" IN ('Brookport','Joppa','Metropolis','Cairo','Olmsted')

Figure 3.1. Paducah Site Location

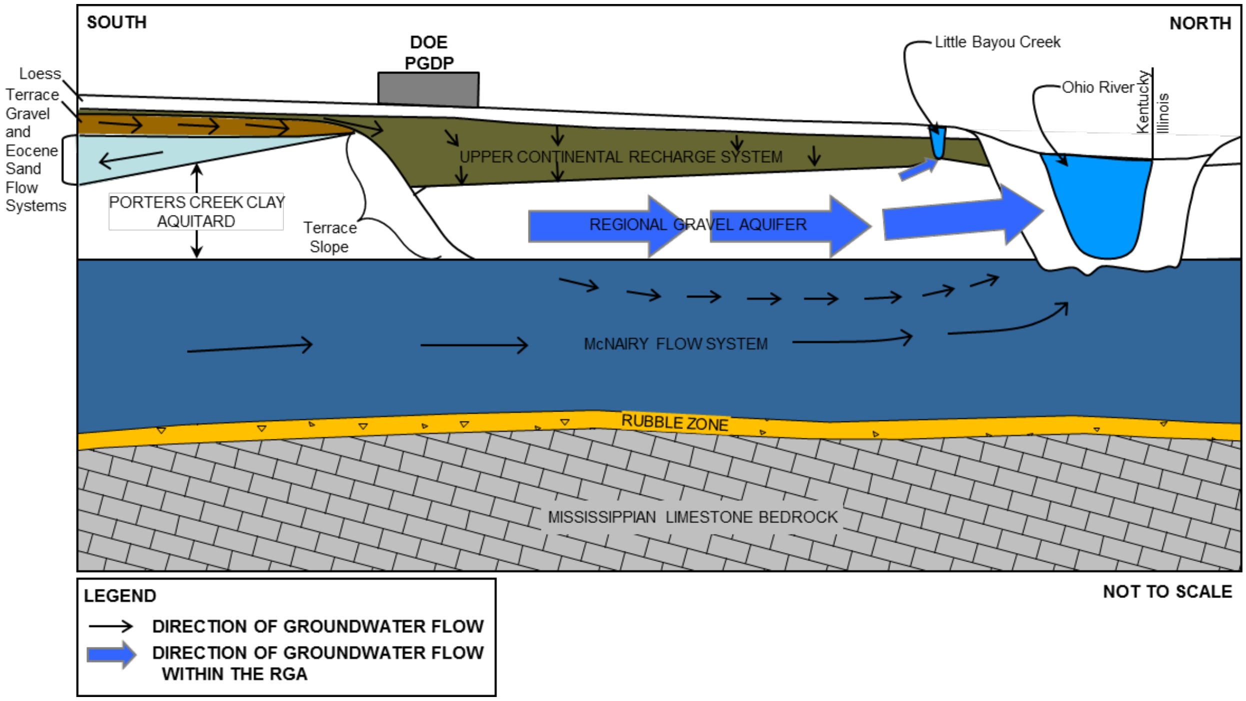


Figure 3.2. Water-Bearing Zones of the Paducah Site

Groundwater flow is predominately vertically downward in the UCRS, providing recharge to the RGA. Rainfall infiltration and leakage from the Paducah Site water utilities account for most of the recharging water. In general, the depth to the UCRS water table is less than 20 ft in the western half of the Paducah Site industrial area (as shallow as 5 ft in some areas and as much as 40 ft in the northeastern corner).

The RGA typically has a relatively high hydraulic conductivity and serves as the dominant flow system in the area. Hydraulic gradients direct groundwater flow in the RGA laterally to the north where the regional groundwater systems discharge into the Ohio River. Additionally, discharges of contaminated groundwater to surface water occur at seeps in Little Bayou Creek. The groundwater in these seeps contains contaminants associated with the Northwest Plume.

Silts and fine sands of the McNairy Formation, found beneath the RGA sediments, form the lower confining unit to the shallow aquifer system. The regional groundwater flow direction in the McNairy Formation is toward the Ohio River. Vertical hydraulic gradients in the McNairy Formation are downward beneath the Paducah Site industrial area, but upward near the Ohio River. The Porters Creek Clay is a confining unit to groundwater flow south of the Paducah Site industrial area. A shallow water table flow system (the Terrace Gravel flow system) is developed in gravels that overlie the Porters Creek Clay south of the Paducah Site industrial area and underlies the C-746-K Sanitary Landfill. Discharge from the Terrace Gravel flow system provides baseflow to Bayou Creek and underflow to the UCRS under the Paducah Site industrial area.

3.2 LAND AND RESOURCE USE

Uranium enrichment operations began at the Paducah Site in 1952, and the complex became fully operational in 1955. Hazardous, nonhazardous, and radioactive wastes have been generated, stored, and disposed of at the Paducah Site. The industrial portion of the Paducah Site, designated as secured (i.e., fenced and patrolled) industrial land use, includes numerous buildings and offices, support facilities, equipment storage areas, and active and inactive waste management units. The Depleted Uranium

Hexafluoride (DUF_6) Conversion Project located at the Paducah Site converts DUF_6 stored at the Paducah Site into a more stable chemical form suitable for beneficial reuse or disposal. The United States Enrichment Corporation (USEC) leased site facilities from DOE and operated PGDP from 1992 to 2013. In 2014, USEC terminated its lease agreement with DOE for operation of PGDP and returned the leased facilities to DOE. DOE retains ownership of all facilities and retains responsibility for managing the disposition of legacy waste material and environmental cleanup. DOE currently holds a license with the Commonwealth of Kentucky for certain portions of WKWMA. Portions of both the DOE Reservation and WKWMA occupy land that once was part of the Kentucky Ordnance Works, a trinitrotoluene production facility that was in operation from 1942 to 1946. The entire WKWMA covers approximately 6,823 acres. The land licensed to WKWMA is designated as recreational and is used extensively for outdoor recreation such as hunting and fishing. DOE property not leased to WKWMA and outside the security area is classified as on-site, unsecured (i.e., not fenced) industrial. Figure 3.3 is a map showing the land use areas surrounding the Paducah Site.

North of the DOE Reservation and WKWMA is the Shawnee Fossil Plant, operated by the Tennessee Valley Authority (TVA). This TVA property is designated as industrial.

Private property surrounds the DOE Reservation, WKWMA, and TVA. This property is mostly rural and agricultural. Residents and businesses in the surrounding area are served by a municipal water supply and private wells (if not subject to restriction under DOE's Water Policy). The municipal water supply is serviced by Paducah Water. The district's water source is the Ohio River upstream of DOE Reservation.

As noted above, the Paducah Site is located approximately 10 miles west of Paducah, Kentucky, in the western part of McCracken County [population approximately 67,875 (DOC 2020)]. Based on preliminary population data from the 2020 census, the total population within a 50-mile radius of the Paducah Site is approximately 325,000. Approximately 112,000 people live within 20 miles of the Paducah Site and homes are scattered along rural roads around the perimeter of the site. The population of Paducah, based on the 2020 U.S. Census, is 27,137. The closest communities to the Paducah Site are the unincorporated towns of Grahamville and Heath which are 1.24 and 1.86 miles east of the PGDP, respectively. The nearest schools are Heath Elementary and Middle Schools. These are 1.86 miles southeast of PGDP near the Heath community. The nearest hospitals are located in Paducah. The Paducah Site is near the following major roads: U.S. Highway 60 and Kentucky Highways 358, 725, and 996. Additional major roads at greater distance are Interstate 24 and U.S. Highway 62. A rail spur serves the Paducah Site and connects to the Illinois Central Gulf Railroad. The nearest airport is Barkley Regional Airport located approximately 3.7 miles southeast of the Paducah Site. Metropolis, Illinois, and Kevil, Kentucky, are the nearest municipal areas and are shown as urban residential land use (Figures 3.1 and 3.3).

The Ohio River is navigable along its entire length, and near the Paducah Site has a downstream connection to the Mississippi River and an upstream connection to the Tennessee River. The Olmsted Locks and Dam (which began operations on September 6, 2018) controls the Ohio River stage at the Paducah Site (Figure 3.1). In addition, the Kentucky Lock and Dam is located on the Tennessee River near its confluence with the Ohio River. The Paducah Site is located 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.

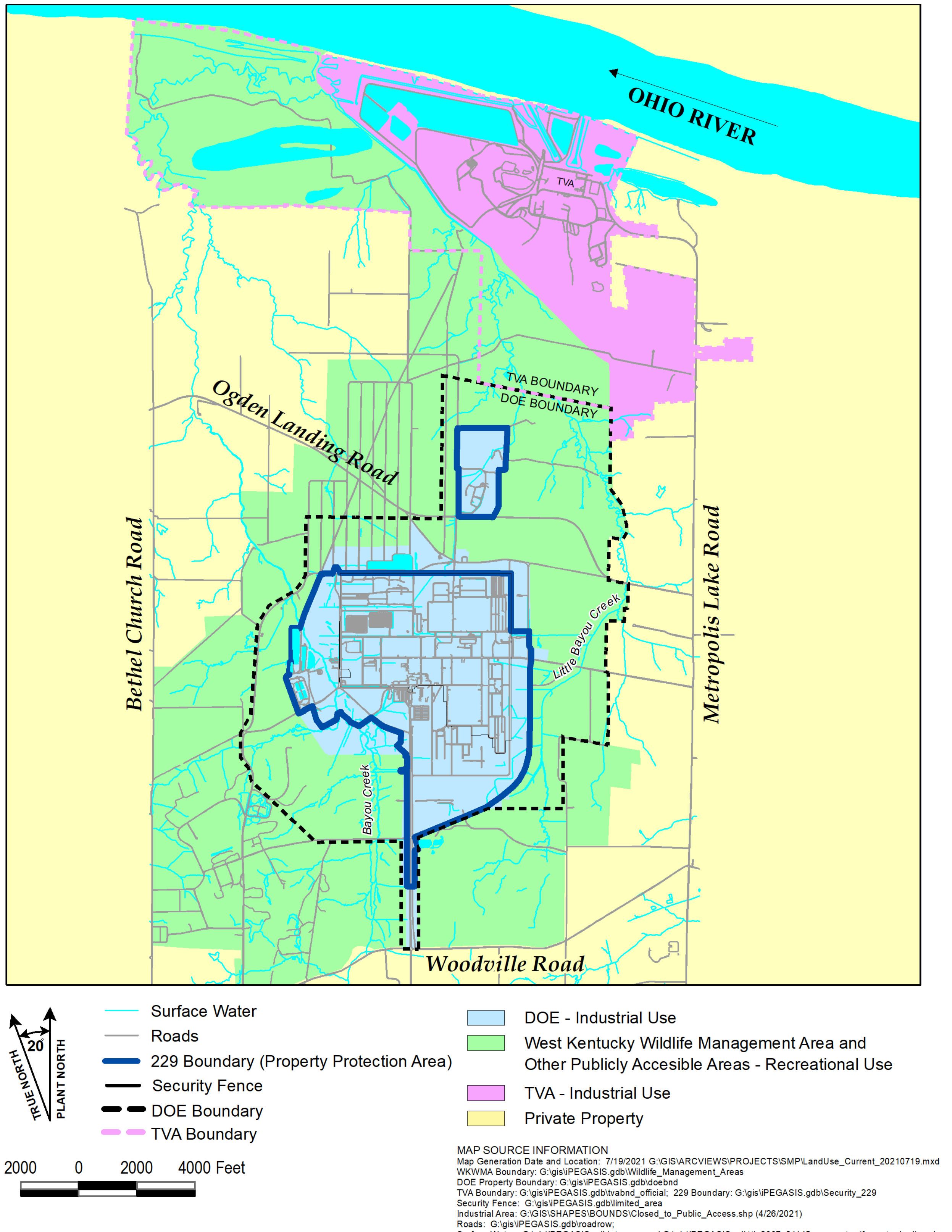


Figure 3.3. Land Use in Proximity to the Paducah Site

PGDP is situated on the divide between Little Bayou Creek and Bayou Creek (Figure 3.4). Bayou Creek is a perennial stream on the western boundary of PGDP that flows generally northward to the Ohio River. Little Bayou Creek becomes a perennial stream at the east outfalls of the Paducah Site industrial area and extends northward to the Ohio River. Most of the flow within Bayou and Little Bayou Creeks is from process effluents or surface water runoff from the Paducah Site industrial facility.

3.3 HISTORY OF CONTAMINATION

Historical activities at the Paducah Site have generated various nonhazardous, hazardous, and radioactive wastes that have been managed, stored, and/or disposed of by different methods. These activities have, in some cases, resulted in the release of contaminants to the environment. The primary contaminants of concern (COCs) at the Paducah Site are technetium-99 (Tc-99), TCE, polychlorinated biphenyls (PCBs), and uranium.

In August 1988, TCE, an organic solvent, and Tc-99, a beta-emitting radionuclide, were detected in four private wells north of the Paducah Site. DOE placed the potentially affected residences and businesses on alternate water supplies and began an intensive monitoring and investigation program to define the extent and temporal variations of the groundwater contaminant plumes. Since that time, several investigations and response actions have taken place (see Table 2.1 for listing of significant site events).

The contaminant, Tc-99, is a man-made radionuclide created as a by-product of the fission of uranium. Initially, Tc-99 was introduced to PGDP in 1953 as a contaminant in feed material during a program in which spent nuclear reactor fuel was fed into the gaseous diffusion processes.

TCE had been used as a cleaning solvent at uranium enrichment plant since its construction. In the C-400 Cleaning Building, process piping and equipment from the cascade system were cleaned with TCE. In 1986, TCE was found to have been discharged inadvertently (apparently for many years) from a sump pump in the degreaser area of C-400 to a storm sewer and was found to have leaked into the soil. Other potential sources of TCE releases at the Paducah Site are the TCE degreaser at the C-720 Maintenance and Storage Building and switchyard transformers that were washed with TCE. Reportedly, TCE also was used in the Kellogg Building during PGDP construction. Waste TCE was disposed of in on-site landfills and in a historical landfarming operation. In the Paducah Site cylinder drop tests, TCE was placed into a pit and used as a refrigerant in tests to determine cylinder integrity (Section 7). The Paducah Site ceased use of TCE in 1993.

PCBs have been found in sediment and fish downstream of the Paducah Site. PCBs have been used extensively as an insulating, nonflammable, thermally conductive fluid in electrical capacitors and transformers at the Paducah Site. The large switchyards that service the process buildings included PCB-filled transformers. PCBs also have been used as flame retardants (on the gaskets of diffusion cascades in other sections of the plant), as a hydraulic fluid, and are used in paints on equipment that is subject to high temperatures. PCBs have been released to the environment from spill sites throughout the industrial complex that resulted from specific transformer ruptures and as part of general operations over the years.

Uranium, thorium, and transuranic elements (i.e., plutonium and neptunium) were detected in off-site sediments near the Paducah Site in 1988 (MMES 1989). Results ranged from approximately 2.5 to over 200 times background. Many of these sediments have been removed (Section 16) (DOE 2011a). Sources of uranium releases are general plant operations.

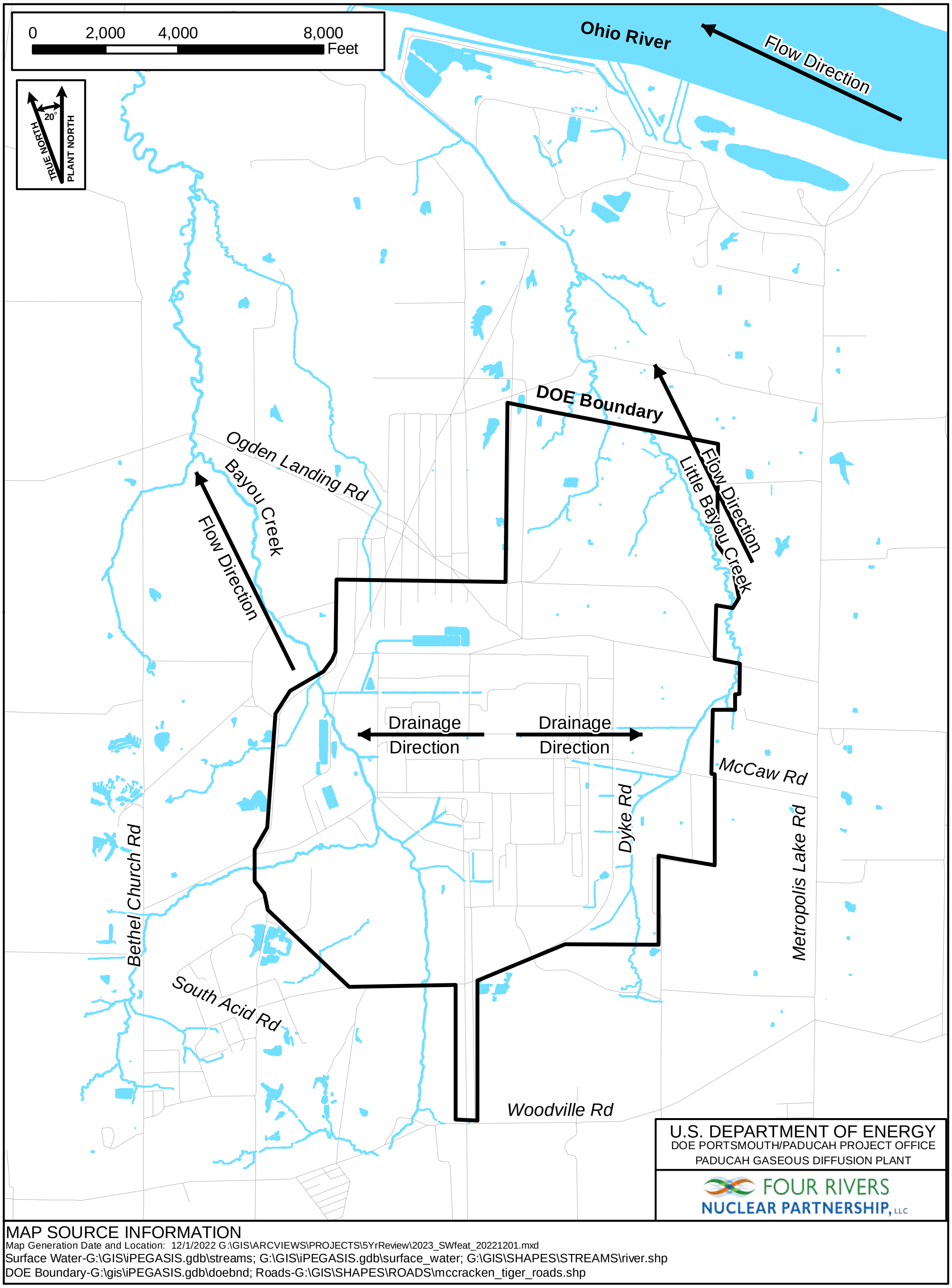


Figure 3.4. Surface Water Features in the Vicinity of the Paducah Site

3.4 INITIAL RESPONSE

After the discovery of groundwater contamination in 1988, DOE placed potentially affected residences and businesses on an alternate water supply and began an intensive monitoring and investigation program to define the extent of contamination. The Paducah Site was proposed for the NPL on May 10, 1993, and listed on May 31, 1994.

DOE's first objective was to reduce immediate risks to off-site residents. DOE implemented plume control actions at the NWPGS and the NEPCS, and surface water institutional controls to further reduce the risks posed to human health and environment by releases from the Paducah Site.

After addressing immediate off-site risks, DOE identified potential areas of contamination at the Paducah Site (e.g., burial grounds, spill sites, and container storage areas) as SWMUs and areas of concern. DOE then grouped most of the SWMUs and areas of concern into waste area groupings (WAGs), based upon common characteristics such as similar contaminants or type of media affected and gave highest priority to those WAGs with the greatest potential for contributing to off-site contamination. Subsequently, DOE began conducting response activities to address the contamination.

In August 1998, DOE, EPA, and the Commonwealth of Kentucky agreed to restructure the remedial strategy for the Paducah Site. This restructuring reflected the accomplishment of sitewide remedial objectives through an OU approach based on the primary exposure pathways and applied to the site Environmental Remediation Program.

Site cleanup activities were divided into three scopes: (1) pre-PGDP shutdown scope, (2) post-PGDP shutdown scope, and (3) Comprehensive Site OU (CSOU) scope. The pre-PGDP shutdown scope was associated with media-specific OUs initiated prior to shutdown of uranium enrichment operations (i.e., pre-PGDP shutdown activities). The source areas for the pre-PGDP shutdown scope were grouped into five media-specific OUs:

- Facility D&D OU
- GWOU
- BGOU
- SWOU
- Soils OU

In October 2014, USEC terminated its lease agreement for operation of PGDP and returned the leased facilities to DOE. Some of these previously leased facilities contain SWMUs that had not been readily accessible during USEC operation. Because DOE now has control of the formerly leased facilities, DOE has reassessed site cleanup priorities to identify areas offering the greatest opportunity to address significant sources of environmental media contamination. As a result, in 2016, DOE identified a comprehensive characterization and final response action of the C-400 Cleaning Building and its adjacent areas, hereafter referred to as the C-400 Complex, as its highest cleanup priority at the site. The C-400 Complex contains numerous SWMUs and is the largest source of off-site TCE groundwater contamination. The implementation of the C-400 Complex as the highest cleanup priority at the DOE Paducah Site has resulted in the resequencing of other cleanup work at the site to align with the new cleanup priorities and the revised time frames projected for implementation. The FFA senior managers signed an MOA for the C-400 Complex under the FFA for the Paducah Site, on August, 8, 2017, to document key aspects of the new strategy.

The new strategy from the MOA includes the following:

- The addition of the C-400 Complex OU with enforceable milestones and planning dates for all the CERCLA activities under the OU, including the out-year enforceable milestone for the C-400 RA field start;

- The integration of pre- and post-PGDP shutdown projects and schedules into the overall cleanup scope of the FFA;

- The continuation of the C-720 Building Northeast Spill Site (SWMU 211-A) groundwater RA; and

- The resequencing of all other projects (e.g., CERCLA Waste Disposal Alternatives, BGOU, Soils OU, Dissolved-Phase Plumes OU, SWOU, and CSOU).

Under the new strategy, the site cleanup OUs are integrated and no longer distinguish between pre- and post-PGDP scope. Completion of these OUs is required to achieve delisting of the site from the NPL and the decommissioning of the plant. Prior to final deletion from the NPL, partial delisting may occur if conditions are met to support potential property transfers. The currently defined OUs (DOE 2022a) consist of the following:

- C-400 Complex OU
- GWOU
- SWOU
- Soils OU
- Soils and Slabs OU
- BGOU
- Facility D&D OU
- Lagoons OU
- DUF_6 Footprint Underlying Soils OU
- CSOU
- CERCLA Waste Disposal Alternatives OU

The site management plan (SMP) identifies the actions that have been reviewed as part of this fifth synchronized Five-Year Review as IRAs or removal actions (with the exception of Southwest Plume). Each of these interim actions will be subject to further evaluation to support the long-term protectiveness for future final decisions. The final action to support NPL delisting will consist of the CSOU, which will evaluate residual risks and ensure all actions taken to date, when considered collectively, are protective of human health and the environment from a sitewide perspective. The actions reviewed under this fifth synchronized Five-Year Review will have these follow-up actions:

Five-Year Review Actions	**Follow-on Actions**
GWOU: Northwest Plume	Dissolved-Phase Plumes OU
GWOU: Northeast Plume	Dissolved-Phase Plumes OU
GWOU: Cylinder Drop Test Area	Dissolved-Phase Plumes OU
GWOU: Water Policy	Dissolved-Phase Plumes OU
GWOU: C-400	C-400 Complex OU
GWOU: Southwest Plume	Dissolved-Phase Plumes OU
SWOU: NSDD Source Control	SWOU
SWOU: NSDD Sections 1 and 2	SWOU
SWOU: C-746-K Sanitary Landfill	CSOU
SWOU: Fire Training Area	CSOU
SWOU: ICM	SWOU
SWOU: On-site Sediment	SWOU
BGOU: C-749 (SWMU 2)	BGOU (SWMUs 2 and 3) Final Action

The timing and sequencing for the implementation of activities associated with OUs are based on regulator expectations, risk-based decision-making, compliance with other programs, technical considerations that are associated with PGDP transition/turnover, funding projections, mortgage reduction, and demonstrated progress toward the completion of the environmental management mission. The SMP documents the schedule of actions for OUs.

The objective of grouping the sources and areas of contamination into these OUs is to provide a more comprehensive framework to assess sitewide risks, identify and prioritize response actions, and develop integrated cleanup solutions that will reduce any unacceptable risk across the primary exposure pathways through which human health and the environment may be affected. To support implementation of this strategy, the source areas and affected media within each OU have been subjected to a binning process to further segregate the source areas into various categories, including candidate areas designated as a high priority for a response action, areas requiring additional characterization/risk evaluation, and source areas associated with Paducah Site operations. Current examples of actions for high-priority areas include the ongoing implementation of the Water Policy; and the source action for TCE and other VOC contamination at the C-400 Cleaning Building area, which is now identified as the C-400 Complex OU.

In order to keep residents and the community informed of the remedial efforts taking place at the Paducah Site, DOE established a Citizens Advisory Board (CAB) in September 1996. This board is composed of people who reflect the diversity of gender, race, and interests of the persons surrounding the Paducah Site. The mission statement of CAB, as stated in *Paducah Gaseous Diffusion Plant Citizens Advisory Board Operating Procedures* (adopted on November 18, 2021), is as follows:

> The mission of the Environmental Management (EM) Site-Specific Advisory Board (the Board or Citizens Advisory Board [CAB]) at the Paducah Gaseous Diffusion Plant (PGDP) is to provide meaningful opportunities for collaborative dialogue among the appointed Board members, EM, and the U.S. Department of Energy (DOE) Portsmouth Paducah Project Office (PPPO). The Board is chartered under the EM Site-Specific Advisory Board Federal Charter. Serving at the request of the Assistant Secretary or the Deputy Designated Federal Official (DDFO), the Board is tasked to provide advice and recommendations concerning the following EM site-specific issues: clean-up standards and environmental restoration, waste management and disposition, stabilization and disposition of non-stockpile nuclear materials, excess facilities, future land use and long term stewardship, risk assessment and management, and clean-up science and technology activities. The Board may also be asked to provide advice and recommendations on any other EM project or issue. The Board promotes early ongoing dialogue with the community that improves the quality of the decision making process of EM.

The full CAB meets on odd numbered months to hear from persons working on relevant environmental efforts, listen to and discuss input from concerned citizens, form advice and recommendations to submit to DOE, and formulate recommendations to DOE about how to conduct cleanup actions. CAB has working sessions on even numbered months. All meetings are open to the public in accordance with the organization's bylaws. The Paducah Community Relations Plan describes how DOE will provide opportunities for the public to become involved in FFA-related decisions at PGDP and outlines how the parties to the agreement will coordinate public participation prescribed by the FFA (DOE 2022b).

3.5 BASIS FOR TAKING ACTION

Exposures to soil, sediment, surface water, and groundwater are associated with risks that exceed EPA's risk management criteria either for industrial or residential exposure scenarios. Prior to implementation of the DOE Water Policy the risks were highest for exposures to contaminants in private wells. Other risks were due to recreational exposures in creek sediments and industrial exposures to process drainages.

Additional information regarding the potential risks associated with potential areas of contamination at the Paducah Site, contaminants by media, and results of site investigations (SIs) are included in the following sections. Table 3.1 contains the COCs by media addressed by the actions included in this fifth synchronized Five-Year Review.

Table 3.1. COCs by Media

Groundwater	
Organics	*Radionuclides*
1,1-Dichloroethene (DCE)	Tc-99
cis-1,2-DCE	
Chloroform	
TCE	
Vinyl chloride	
Soils/Sediment and Surface Water	
Metals	*Organics*
Aluminum	Total polycyclic aromatic hydrocarbons (PAHs)
Antimony	Total PCBs
Arsenic	
Barium	*Radionuclides*
Beryllium	Americium-241
Cadmium	Cesium-137
Chromium	Neptunium-237
Copper	Plutonium-239/240
Iron	Tc-99
Lead	Thorium-230
Manganese	Thorium-232
Mercury	Uranium-234
Nickel	Uranium-235
Selenium	Uranium-238
Silver	
Thallium	
Uranium	
Vanadium	

THIS PAGE INTENTIONALLY LEFT BLANK

4. RESPONSE ACTIONS

The 13 sites with response actions that require five-year reviews, the OU with which each site is associated, and the name used in previous five-year reviews are listed in Table 4.1. The location of each action reviewed within this document is shown on Figure 4.1, along with the latest available plume map, which shows the TCE plumes based on 2020 data.

Table 4.1. Site/Project with Response Actions Taken at the Paducah Site

Section	Site/Project Name Used in This Report	Operable Unit	Project Name Used in Previous Five-Year Reviews
5	Northwest Plume	GWOU	Northwest Plume
6	Northeast Plume	GWOU	Northeast Plume
7	Cylinder Drop Test Area or Lasagna™	GWOU	SWMU 91
8	Water Policy	GWOU	Water Policy
9	C-400 Electrical Resistance Heating	GWOU	GWOU C-400 ERH
10	Southwest Plume	GWOU	Southwest Plume
11	NSDD Source Control	SWOU	NSDD Source Control
12	NSDD Sections 1 and 2	SWOU	NSDD Sections 1 and 2
13	C-746-K Sanitary Landfill	SWOU	WAGs 1 and 7, SWMU 8
14	Fire Training Area	SWOU	WAGs 1 and 7, SWMU 100
15	Surface Water ICMs	SWOU	Surface Water ICMs
16	Surface Water On-site Sediment Removal	SWOU	Surface Water On-site Sediment Removal
17	C-749 Uranium Burial Ground	BGOU	WAG 22, SWMU 2

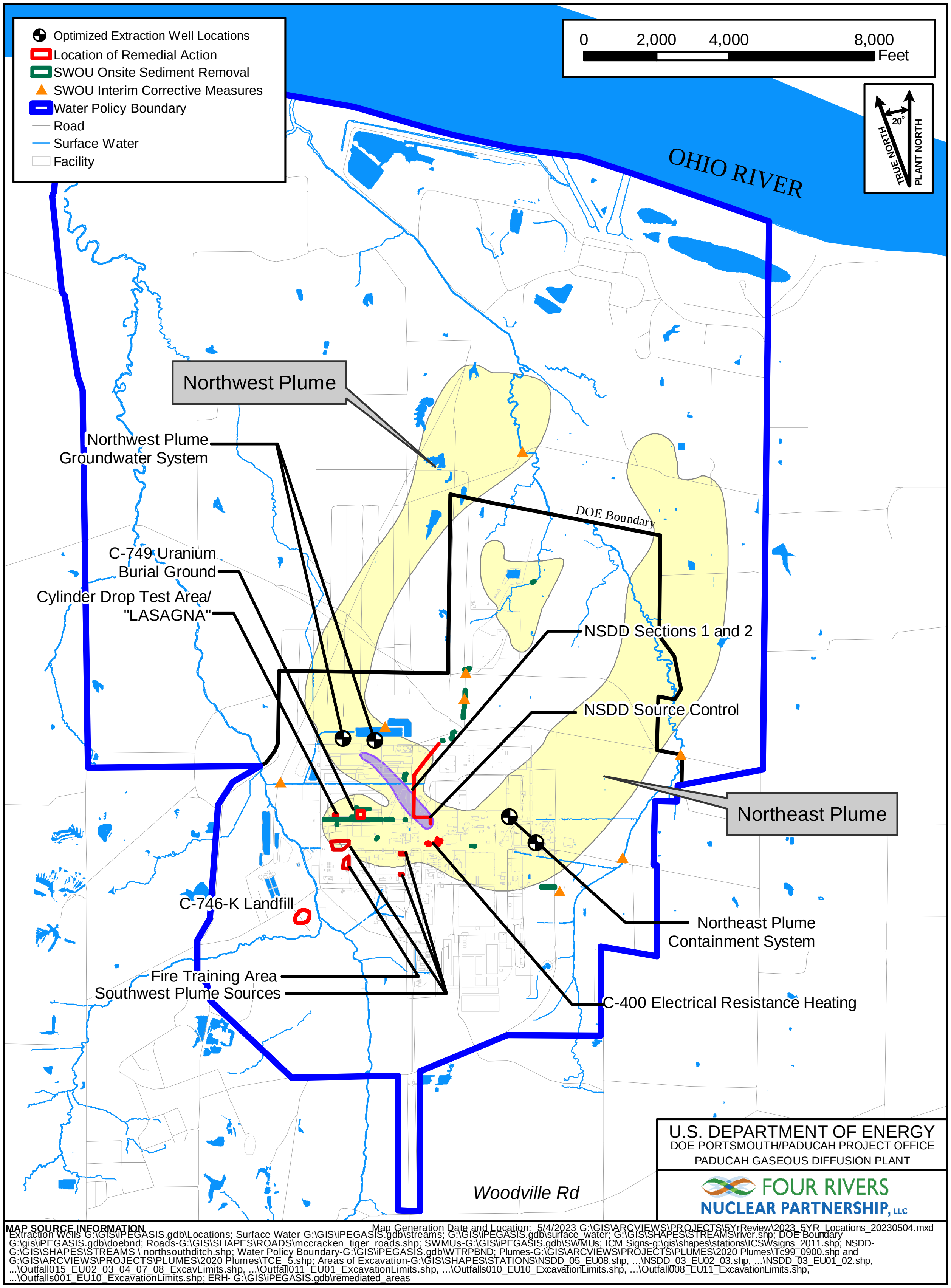


Figure 4.1. 2023 CERCLA Five-Year Review Project Locations

5. NORTHWEST PLUME

After the initial discovery of off-site contamination at the Paducah Site in August 1988, DOE conducted an SI to identify the nature and extent of the contamination. The investigation, documented in the results of the site investigation (Phase I, Phase II), determined that the groundwater contamination is spreading generally northward toward the Ohio River in multiple plumes (CH2M HILL 1991, CH2M HILL 1992). The most prominent of the plumes, containing both TCE and Tc-99, is the Northwest Plume (SWMU 201).

Outside of the immediate vicinity of its source areas on DOE property, the Northwest Plume is restricted to the RGA, which occurs in a thick gravel unit and adjacent thin sands at depths of approximately 60 to 100 ft over most of the length of the plume. The extent of the Northwest Plume (and Northeast and Southwest Plumes, SWMUs 202 and 210) is well known through several DOE investigations. DOE maintains a monitoring well (MW) network to detect trends in the plume. The Northwest Plume underlies land licensed by DOE to WKWMA, land owned by TVA, and privately owned land that is sparsely populated. Some contaminated groundwater from the Northwest Plume discharges in seeps in Little Bayou Creek on TVA property. The Ohio River is the regional discharge point for groundwater flow in the RGA.

The overlying soils consist of thick silt units with lesser interbedded sand and gravel deposits that isolate the plume from potential human and ecological exposure. A vapor intrusion study of the downgradient Northeast and Northwest Plume areas determined that vapor intrusion does not pose a concern for area residences (DOE 2016a). DOE maintains a Water Policy (evaluated in Section 8) that controls access to the groundwater. Physically, access is controlled, for example, by padlocks on wells. Administratively, access is controlled through a license agreement process with landowners with and without residential wells in the area of the plume. DOE provides access to municipal water and pays reasonable municipal water bills for a majority of the residents, which further limits any access to the contamination of the Northwest Plume.

Figure 5.1 illustrates the extent of the off-site Northwest Plume; the two EW wellfields, which began operation in 1995 for the NWPGS; and an optimized EW field (consisting of two wells), which began operation in 2010. Figure 5.2 is a comparison of the plumes between 2002 and 2020, which is the latest available plume map (FRNP 2021a). The downgradient limit of the Northwest Plume is near the Ohio River and at seeps in Little Bayou Creek.

5.1 REMEDY SELECTION

EPA and DOE, with the concurrence of the Commonwealth of Kentucky, agreed to a ROD for an IRA for the Northwest Plume on July 22, 1993 (DOE 1993a). This IRA consisted of the installation and maintenance of two EW fields (consisting of four EWs) for a period of two years to initiate control of the high-concentration zone of TCE and Tc-99 in the Northwest Plume. A water treatment facility was constructed to treat effluent from the EWs. The NWPGS has continued to operate since August 1995.

The *Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1143&D4, delineated the RA as follows (DOE 1993a):

- The contaminated groundwater will be extracted at two locations. The first location, immediately north of the plant on DOE property, is intended to control the source. The second groundwater extraction location is off site of the DOE reservation at the northern tip of the most contaminated portion of the plume [greater than 1,000 µg/L of TCE.

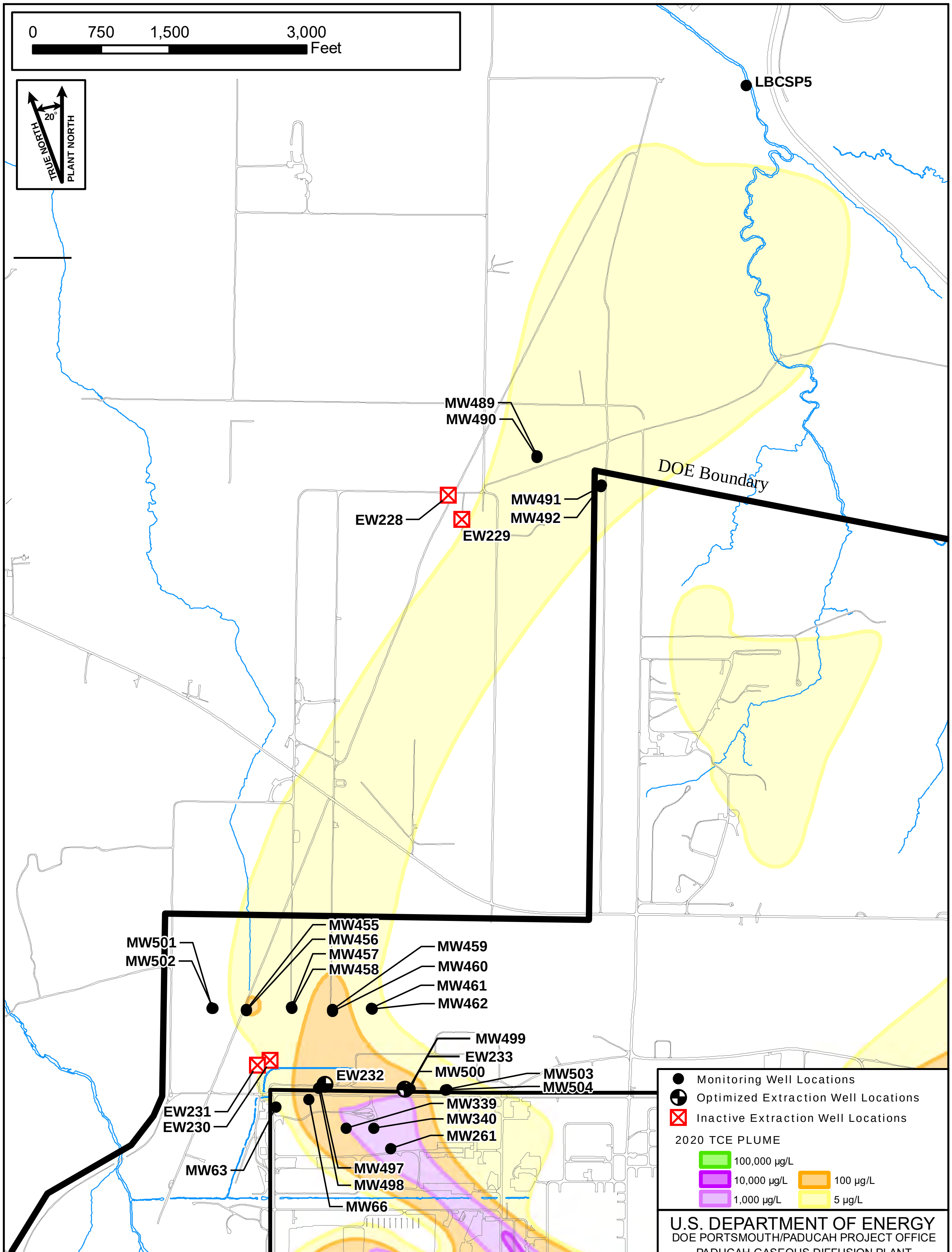


Figure 5.1. NW Plume EW Fields with 2020 TCE Plume Map*

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

MAP SOURCE INFORMATION
Map Generation Date and Location: G:\GIS\ARCVIEWS\PROJECTS\5YrReview\2023_5YR_NWPlumeEWField.mxd 2/8/2023
Locations Layer, DOE Boundary, PDGP Boundary, Roads Layer, Streams Layer-- G:\GIS\iPEGASIS.gdb\Locations, ...\doebnd, ...\pgdpbnd, ...\roadrow, ...\streams
2020 Plumes Layer-- G:\GIS\ARCVIEWS\PROJECTS\PLUMES\2020 Plumes\TCE_100000.shp, ...\TCE_10000.shp, ...\TCE_1000.shp, ...\TCE_100.shp, ...\TCE_5.shp

*Note: Only those MWs discussed in Section 5 are shown on this figure. Additional MWs are sampled on a continuing basis under the Northwest Plume operations and maintenance program.

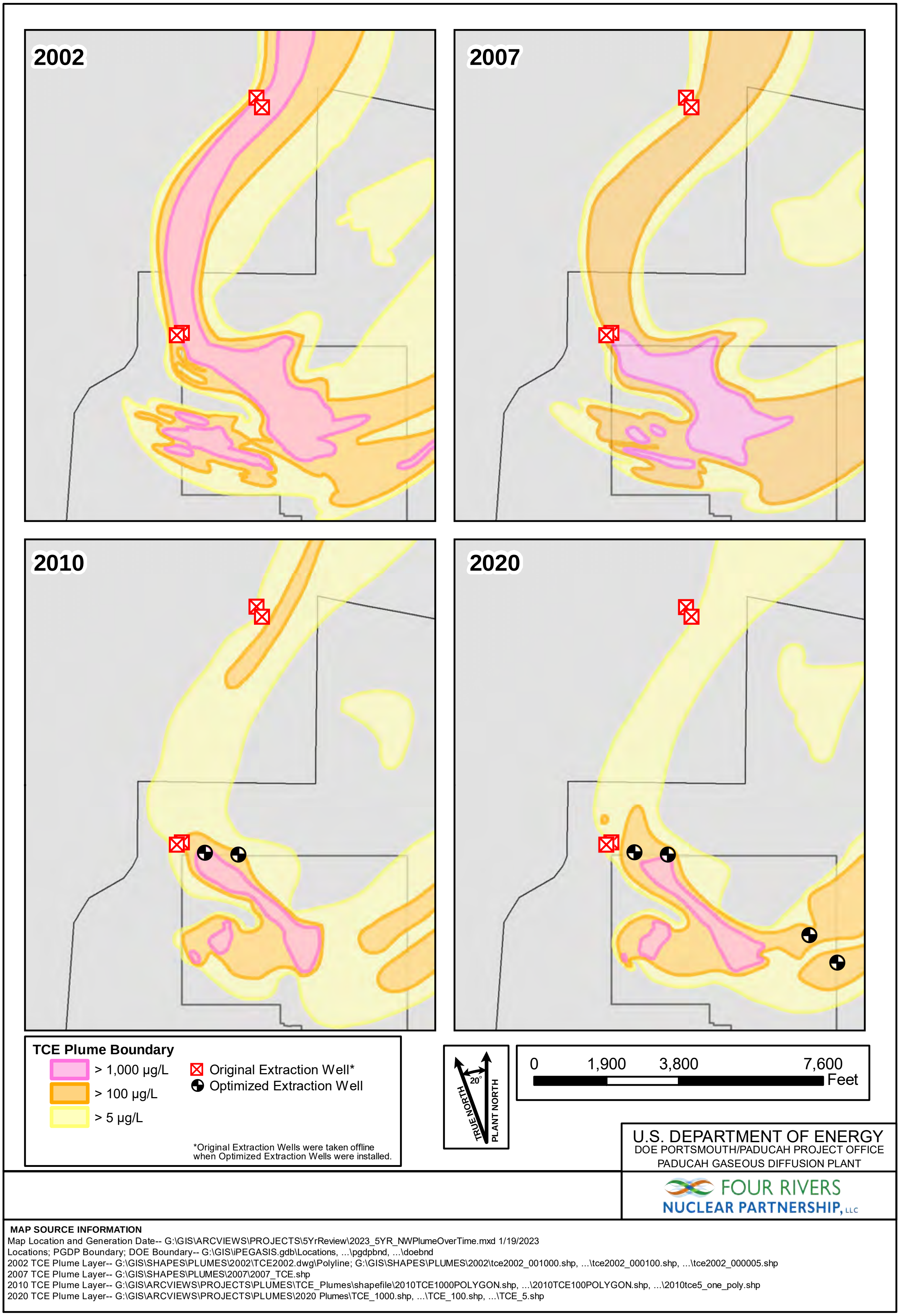


Figure 5.2. TCE Plumes as Interpreted for 2002, 2007, 2010, and 2020

- The contaminated groundwater will be pumped at a rate to reduce further contribution to contamination northwest of the plant without changing hydraulic gradients enough to mobilize dense non aqueous-phase liquids (DNAPLs) or significantly affect other plumes. This pumping rate may be modified during operation to optimize hydraulic containment by adjusting flow from the extraction wells and to support subsequent actions.

- The extracted groundwater will be collected in a manifold and piped to the treatment system, which will consist of two ion exchange units in parallel followed by an air stripper with treatment for off gas emissions. This technology provides the treatment to the COCs (TCE and Tc-99). The target level for treatment of TCE is 5 ppb and 900 pCi/L for Tc-99.

- The amount of treated water discharged will be limited by the flow capacity of the skid mounted treatment units. The treated water will be discharged through KPDES Outfall 001.

- The interim action also includes implementation of a treatability study to evaluate an innovative technology. The innovative technology to be studied involves the potential utilization of iron filings as a viable alternative to pump and treat technology for ground water treatment.

- The remedy does not address source remediation, however; the remedy will address continuing release from a DNAPL principal threat source area.

Cleanup levels and RAOs are not specifically stated because the principal goal of this interim action is to decrease the risk by mitigating the spread of the high concentration portion of the Northwest Plume, retarding the migration of the contaminants emanating from the source area.

5.2 REMEDY IMPLEMENTATION

The remedial design was issued in May 1993 (MMES 1993a), and the remedial action work plan (RAWP) was issued one year later (DOE 1994a). The construction of the facility was performed in two phases. The first phase was the installation of MWs and EW fields. The second phase of work was the installation of the treatment facility and all internal equipment, and the subsurface pipelines to transport the contaminated water through the WKWMA to the treatment system. All of the construction was completed in May 1995, with calibration and operational preparedness completed on August 27, 1995. The NWPGS began pump-and-treat operations on August 28, 1995.

The interim action, construction completed in 1995, included the following:

- Four EWs and the associated monitoring network with two EWs located at the north end of the high concentration zone and two EWs located immediately north of the Paducah Site facility;

- Double-walled subsurface pipelines with leak detection equipment to transport the contaminated water to the treatment facility;

- Active treatment equipment located in the facility including an equalization (EQ) tank, dual sand filter unit, low-profile air stripper, activated carbon treatment units, two double ion exchange units, and an on-line volatile organic analyzer; and

- Support equipment installed in the facility including backwash tank, settling tank, sludge handling equipment, air compressor, and filter press.

DOE issued an *Explanation of Significant Differences for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1481&D2, in August 1996 that proposed modifying the original RA (DOE 1996a). The three propositions in the document were as follows: (1) elimination of the activated carbon filters, (2) reversal of the sequence of the two treatment units (ion exchange unit and air stripper), and (3) elimination of the iron filings treatability study (DOE 1996a). At that time, DOE determined that the remedy would remain protective of human health and the environment and would meet the applicable or relevant and appropriate requirements (ARARs) identified in the ROD and additional ARARs introduced by the modifications. The additional ARARs triggered by the reversal of the treatment units are identified in the ESD document, and approved by EPA on November 18, 1996. The Northwest Plume RA continues to comply with these ARARs. Although removing the carbon filters would not result in violation of Clean Air Act standards, DOE withdrew its proposal to eliminate the carbon filters in response to public comments.

In February 2006 and March 2006, DOE Headquarters conducted a sitewide remedy review at the Paducah Site. The sitewide remedy review report recommended that DOE expand the monitoring and characterization program, provide for an independent assessment to optimize the Northwest Plume and Northeast Plume IRAs, and evaluate natural attenuation processes further. At DOE's request, the U.S. Army Corps of Engineers led a remediation system evaluation of the Northeast and Northwest Plume extraction systems in October 2006. The review team concluded that the Northwest Plume IRA should be modified to terminate extraction at the two northern EWs and increase total extraction in the vicinity of the southern EWs. DOE issued *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0343&D2, in December 2010 to document the agreement of the FFA parties to discontinue pumping in the northern EWs and the construction of two new EWs to the east of the original extraction locations in the south well field to capture more efficiently contaminant mass associated with the Northwest Plume (DOE 2010). The new EWs began operation in August 2010.

5.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

Operation and maintenance (O&M) for the NWPGS is conducted in accordance with the *Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2469&D2 (DOE 2021a). The latest revision (October 2021) was prepared to update routine and preventive maintenance requirements in accordance with the *Paducah Plume Operations Maintenance, Sampling and Analysis Calibration and Testing Plan*, CP2-ER-0046 (FRNP 2022a).

Since operations began on August 28, 1995, the frequency of repair to the system has been normal and routine. The Northwest Plume treatment system had processed approximately 2,728,368,258 gal of water, as of December 31, 2022. Mass balance evaluations indicate that the treatment system has removed approximately 48,343 lb (3,992 gal) of TCE as of December 31, 2022.

Beginning in August 2010, as part of the optimization of the NWPGS, withdrawal switched from the original four EWs (with a combined withdrawal of approximately 220 gal/minute) to withdrawal from two new EWs (operating at a pumping rate of approximately 100 gal/minute each).

The activated carbon units are changed routinely due to contaminant loading. Other than a modernization project in 2015 and 2016, few other major modifications to the C-612 Treatment Facility (i.e., replacement of primary equipment) have been needed.

The costs associated with the O&M of the NWPGS and the NEPCS (discussed in Section 6) are tracked jointly and have been since fiscal year (FY) 2002. The cost of both systems for the Five-Year Review reporting period is $5.08M, or an average of $1.02M per year. This average annual O&M cost of $1.02M is less than the combined original estimates of $1.5M to $2.0M for the NWPGS and $240K for the NEPCS; the reduction is due primarily to efficiencies gained through continued long-term operation. The total operation cost for both the NWPGS and the NEPCS was $37.12M by the end of December 2022.

5.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The 2018 Five-Year Review contained the following statement of protectiveness for the Northwest Plume IRA (DOE 2019a).

> The remedy for the Northwest Plume is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plumes OU, need to be evaluated for long-term protection.
>
> The objective of this IRA is to initiate control of the source and mitigate the spread of contamination in the Northwest Plume. The optimization of the Northwest Plume IRA is intended to increase VOC mass removal and enhance the contaminant capture in the vicinity of the existing south wellfield located immediately north of the plant. In addition, successful control of the plume, in combination with existing controls (alternate water supply, monitoring, etc.), ensures protection during the period of the interim response.

The 2018 Five-Year Review contained the following recommendation: "EW pump placement and pumping rates should be evaluated to optimize capture of the Northwest Plume." A recommendation was made for an evaluation of EW pump placement and pumping rates to optimize capture of the Northwest Plume in response to increasing TCE levels in downgradient MW460.

Appendix D summarizes a review of contaminant trends upgradient, downgradient, and within the optimized EW wellfield to assess the capture of contamination in the Northwest Plume. The review determined that the NWPGS is performing as intended and that no adjustment of pump placement or pumping rate is required.

DOE has continued to evaluate the effectiveness of the NWPGS. Downgradient TCE and Tc-99 levels in the Northwest Plume have decreased in some MWs and increased in others in response to the adjusted pumping centers. In general, the extent of dissolved-phase TCE greater than the maximum contaminant level (MCL) (5 µg/L) has declined. The long-term benefit of the optimization of the IRA will require additional time to be evaluated fully.

5.5 SITE INSPECTION

A site inspection of the Northwest Plume Pump-and-Treat System was conducted on December 5, 2022. Participants included the facility manager, the O&M manager, members of the five-year review team, representatives from DOE's support contractor, and KDEP.

The currently active system includes the C-612 Treatment Facility and the south, optimized wellfield (EW232/EW233). The treatment facility is located just outside the northwest corner of the PGDP security-fence of the Paducah Site industrial area, but within the Property Protection Area. The EW232/EW233 field is located east of the treatment facility (just north of the facility perimeter fence, within the Property Protection Area, and close to the C-616-E and C-616-F lagoons.

The C-612 Treatment Facility is a pre-engineered metal building with one vehicular entrance and two pedestrian entrances. The exterior of the building appears in good condition, with no signs of damage, rust, or deterioration. The area around the building is well maintained, including timely mowing and weed trimming. A chain-link security fence that is in good condition encloses the building.

All treatment process equipment is located within the building and an adjacent treatment trailer. Groundwater treatment equipment inside includes a sand filter unit, an air stripper, and a carbon filtration unit. The four ion exchange columns are located in the treatment trailer. The interior of the building and the treatment trailer is clean, free of clutter and debris, and well maintained. Access-controlled areas within the building and trailer are clearly marked and identified. Process piping in the facility is identified properly as to content and flow direction, adequately supported, and in a well-maintained condition. There are no signs of leaks or deterioration. Process control panels are well maintained, with all components clearly identified and labeled. All electrical power and control panels are labeled properly. The building contains a wet-type fire sprinkler system that is monitored constantly via a supervisory control and data acquisition system by FRNP Fire Services.

Well vaults for both the currently operating EWs and the original south wellfield EWs (in standby mode) are maintained properly. In general, the optimization EWs are operating as intended, with minimal maintenance required. An electricity spike associated with a storm event in the summer of 2022 resulted in the failure of the west EW pump (EW232) operation for 61 days. The long downtime was due, in large part, to supply chain issues associated with the COVID-19 pandemic. During this fifth synchronized Five-Year Review period, other than the replacement of the pump in EW232 in 2022, there has been no need for downhole maintenance (e.g., video inspection or rehabilitation) in the EWs.

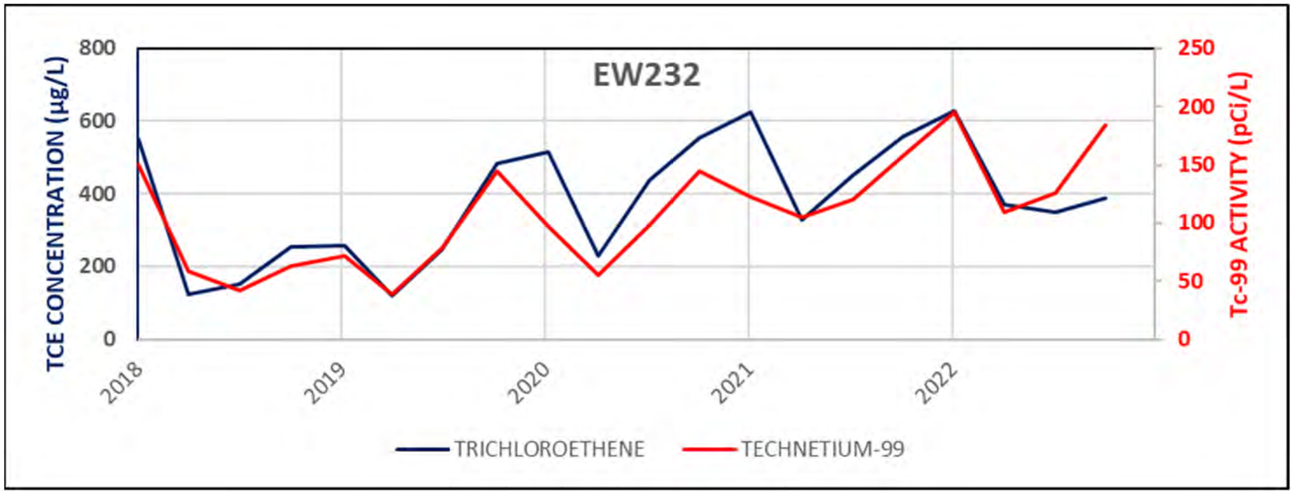
5.6 TECHNICAL ASSESSMENT

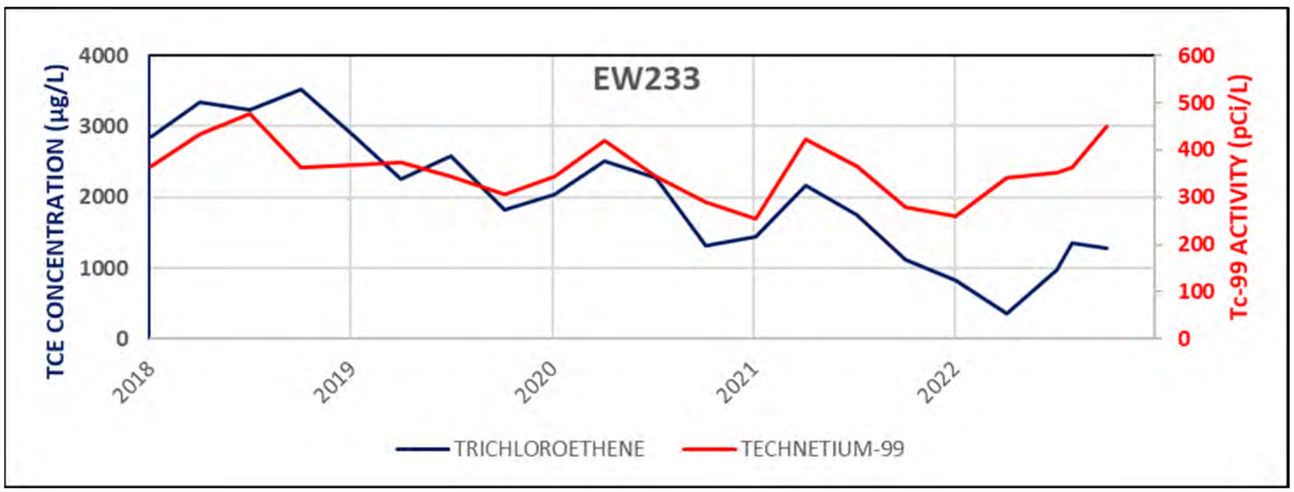
The primary objective of the Northwest Plume IRA is to initiate an action to mitigate the spread of the high concentration zone of TCE and Tc-99 contamination of the Northwest Plume. Monitoring data indicate that this RA has reduced contaminant concentrations in the Northwest Plume since operations began in 1995. The action described in the ROD is not intended or expected to return groundwater quality to MCLs.

5.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The original north and south EW fields operated nearly continuously since the start of pumping on August 28, 1995, through August 27, 2010, when operation of the new south EW field (EW232 and EW233) began. Other than the EW232 downtime in the summer of 2022, the optimized EWs have operated nearly continuously. Influent and effluent monitoring of the aboveground groundwater treatment system shows that the treatment system is effectively reducing the contaminant levels of the extracted water to target levels that are approved for release to surface water. Even during the 61-day period of failure of the EW pump in EW232 in the summer of 2022, the withdrawal rate of the EW pump in EW233 was increased and the NWPGS maintained capture of the Northwest Plume.

Figure 5.3 shows contaminant level trends in each of the optimization EWs. Targets for the average levels of TCE and Tc-99 in effluent continue to be met (Table 5.1). The target concentrations for these contaminants are 5 μg/L TCE and 900 pCi/L Tc-99.





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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 5.3. Contaminant Trends in the Optimization Wellfield EWs (EW232 and EW233)

Table 5.1. NWPGS Influent and Effluent Concentrations for the Period 2018 through 2022

	TCE (µg/L)			Tc-99 (pCi/L)		
	High	Low	Average	High	Low	Average
Influent	2,070	566	1,227	391	187	229
Effluent	6.2[a]	< 1[b]	1.6	101	-15 [b]	17.8

[a] Single analysis > 5 µg/L. Next highest value is 3.7 µg/L.
[b] The values denoted are below the detection limit.

Groundwater flow modeling for the optimization study predicted 99.99% capture of the mass of TCE flux in the Northwest Plume at the PGDP security-fence using the optimization EWs that were installed in 2010. Comparison of groundwater analyses of TCE and Tc-99 for the 2018 through 2022 period from upgradient MWs MW261 and MW340 (upgradient lower RGA MWs with the highest TCE and Tc-99 levels) and from downgradient MWs MW458, MW460, and MW462 (downgradient lower RGA MWs with highest TCE levels and high Tc-99 levels) demonstrate that the EWs have reduced contaminant levels significantly in the RGA (Figure 5.4). Table 5.2 summarizes TCE and Tc-99 levels in the optimization wellfield for 2010, when groundwater extraction began at EW232 and EW233, compared with levels reported during the current five-year review period.

Table 5.2. Summary of Contaminant Levels at the Optimization EW Field (EW232 and EW233)

	TCE Concentration (µg/L)				Tc-99 Activity (pCi/L)			
		2018–2022				2018–2022		
Well	Max 2010	Average	Max	Reduction Trend?	Max 2010	Average	Max	Reduction Trend?
MW63[a]	74	6.7	13.6	No. Stable	26.5	21	40.3	No. Stable
MW66[a]	2,600	573	861	No	853	221	438	No
MW497	17	365	588	Uncertain	6.8	126	216	Uncertain
MW498	9,900	124	658	Uncertain	1,190	59	332	Uncertain
MW499	180	670	956	No	484	307	363	No
MW500	160	487	701	No	339	335	405	No
MW503	240	12	30.4	Yes	22.2	216	317	Uncertain
MW504	1.4	1.6	6.01	No. Stable	19.6	0.2	8.5[b]	No. Stable

[a] Upgradient well
[b] All Tc-99 analyses for the period of 2018-2022 were nondetect, with the highest nondetect result of 8.47 pCi/L reported.

MW261 and MW340 are located in the core of the Northwest Plume and upgradient of both the original and optimized EW fields (Figure 5.1). TCE levels in both MW261 and MW340 were generally less than the levels during the previous five-year review period, ranging from 1,080 to 4,910 µg/L during the 2018 through 2022 period (Figure 5.4). Tc-99 levels in both wells declined through 2018 and then increased significantly beginning in 2019 (rising from a low of 204 pCi/L to a high of 2,230 pCi/L). See Section 9.7.1 for a discussion of the trend of Tc-99 concentrations in the upgradient source area at C-400.

Downgradient MWs for the optimization wellfield (EW232/EW233) (Figure 5.1) document reduced contaminant levels, overall, in the core of the Northwest Plume, as intended by the ROD. Higher TCE levels in downgradient MW460 likely indicates limited plume bypass between the optimization EWs.

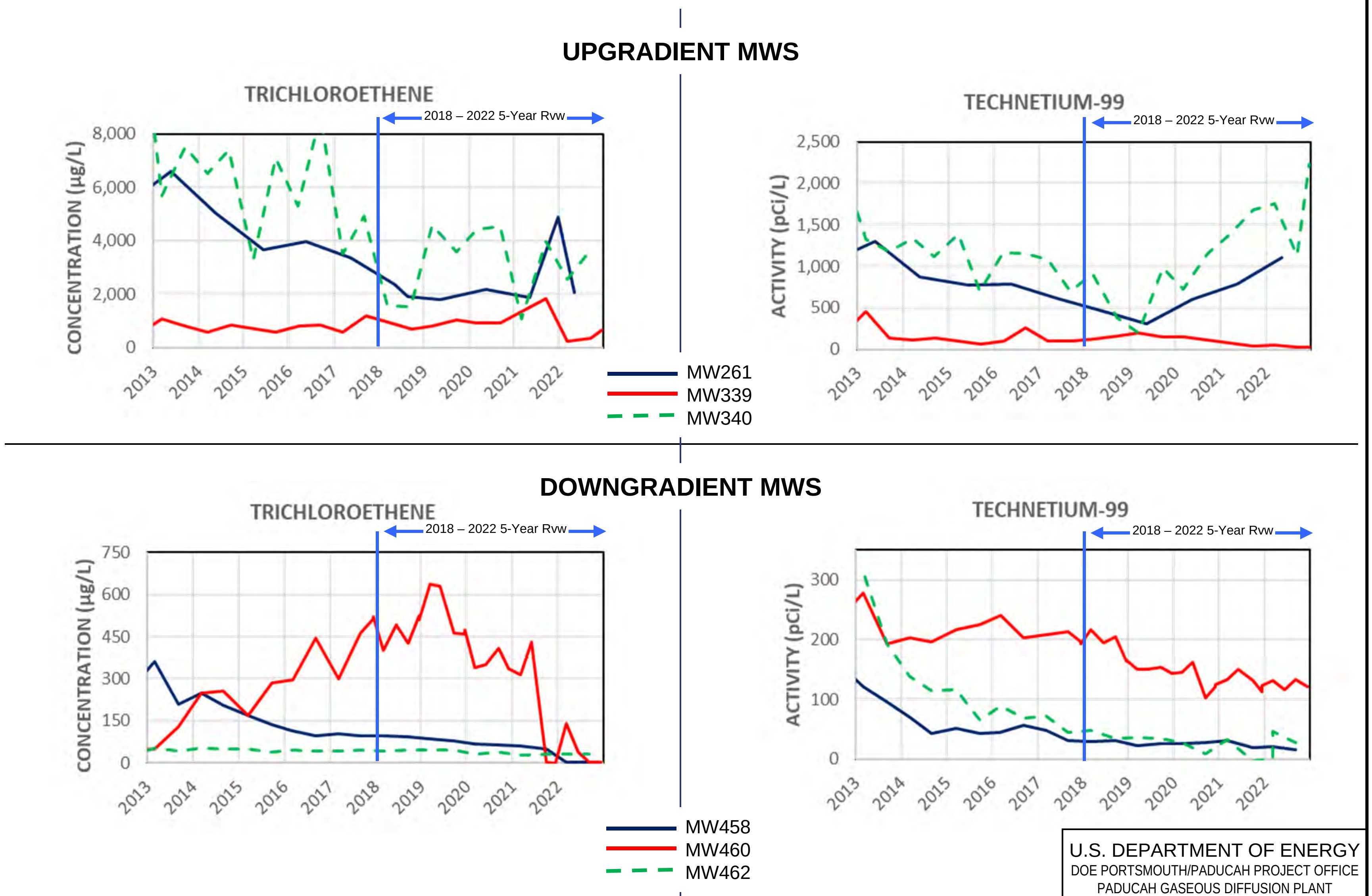


Figure 5.4. Upgradient vs Downgradient Contaminant Levels

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

DOE performed a MW upgrade project during the period of October 2009 through February 2010, which resulted in the installation of 38 new MWs in the area of the Northwest Plume. A membrane interface probe (MIP) was used to characterize the location of the centroid of the Northwest Plume along four transects and optimize the location of many of these wells. Results of a MIP transect to the east of the north wellfield, which began operation in 1995 (EW228/EW229 wellfield), documented that the centroid of the Northwest Plume had migrated to the east of the north wellfield. RGA MW cluster MW489/MW490 was placed in the centroid of the Northwest Plume (in 2009) and MW cluster MW491/MW492 was placed to the east of the centroid (Figure 5.1). The analyses of groundwater samples from these wells document the contaminant trends in the area of the former north wellfield.

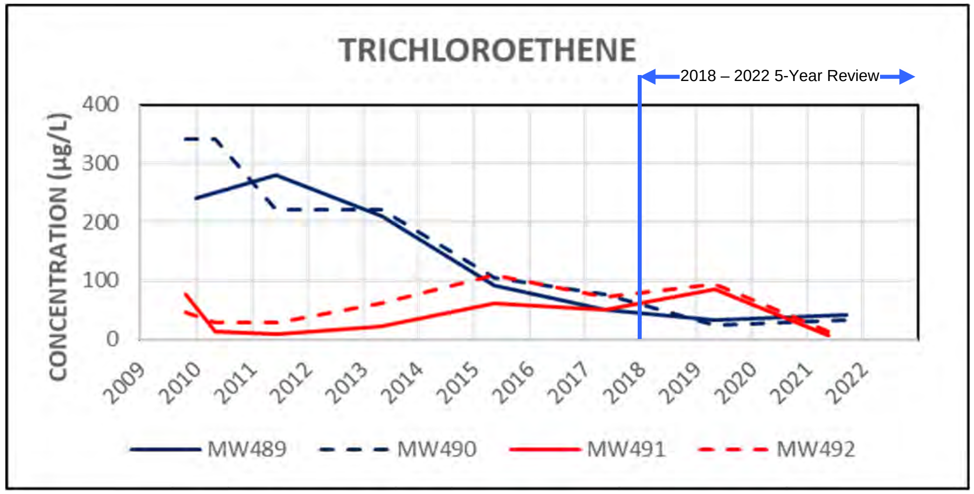
Contaminant levels east of the north wellfield generally declined or stabilized during the 2018 to 2022 five-year review period. The highest TCE levels shifted from MW491/MW492 to MW489/MW490 in late 2021. The highest Tc-99 levels occurred in MW491/MW492. Table 5.3 and Figure 5.5 document the contaminant trends in the area east of the north wellfield.

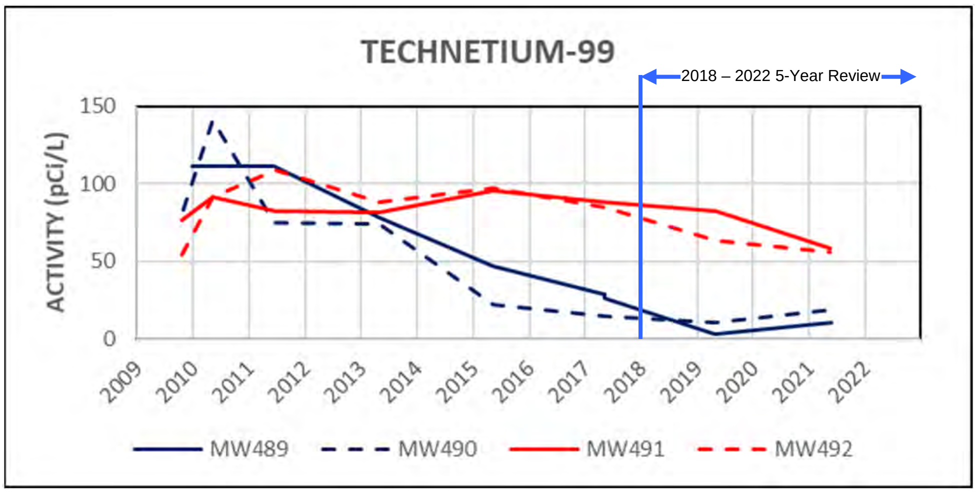
Table 5.3. Summary of Contaminant Levels in the Area of the North EW Field (EW228 and EW229) for the Periods 2009, 2017, and 2021

Well	Maximum Levels [a] 2009	2017	2021[b]	Contaminant Trends 2009–2017	2019–2021
	TCE Concentration (µg/L)				
MW489	240	50	42	Steady reduction	Stable
MW490	340	76	33.3	Steady reduction	Stable
MW491	76	51	6	Reduction, then increase	Increase, then reduction
MW492	47	72	13	Slight reduction, then increase	Increase, then reduction
	Tc-99 Activity (pCi/L)				
MW489	111	29	10U[c]	Steady reduction	Not detectable
MW490	83	15U	19U	Near steady reduction	Not detectable
MW491	77	88	59	Slight increase	Stable, then reduction
MW492	54	84	56	Rise, then slight decline	Continued reduction

[a] Data rejected by validation or assessment are not included.
[b] These MWs are sampled in odd CYs. The last available samples for these MWs for this five-year review are from 2021.
[c] U = analyte analyzed for, but not detected at or below, the lowest concentration reported.

The thick interval of relatively low-permeability silt that overlies the Northwest Plume reduces the potential for transport of VOC vapors from the Northwest Plume to the surface. A vapor intrusion study of the downgradient Northeast and Northwest Plume areas determined that vapor intrusion does not pose a concern for area residences (DOE 2016a). Moreover, the NWPGS has significantly reduced the VOC levels in the off-site plume and is anticipated to reduce off-site contaminant levels further with continued operation. While operation of the NWPGS is an interim action with no established cleanup levels, the NWPGS is effectively protective in conjunction with other Paducah Site actions (notably the Water Policy, discussed in Section 8). The optimized wellfield appears to have maintained the effectiveness of the Northwest Plume IRA. O&M of the NWPGS continues to be efficient because costs are lower than anticipated in the Northwest Plume Interim ROD. Contaminant trends in the MW transect located downgradient of the optimized EWs document a significant reduction of contaminant levels in the main centroids of dissolved TCE and Tc-99 but with limited bypass occurring in the basal RGA between the two EWs. There are no other indicators of potential issues for the system. Institutional controls associated with the Northwest Plume Interim ROD are DOE's Water Policy (evaluated in Section 8) and Surface Water ICM (evaluated in Section 15). The Water Policy and Surface Water ICM effectively limit exposure to the downgradient Northwest Plume.





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

Figure 5.5. Contaminant Trends in MWs Located to the East of the EW228/EW229 Wellfield

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

RAs are scheduled to be implemented beginning June 29, 2025, to minimize further migration from the C-400 Complex (source area). Remaining contaminant plumes will be addressed in the Dissolved-Phase Plumes OU. Reviews of documents, groundwater monitoring data, and the results of the site inspection all indicate the EW fields are retarding the migration of contaminants emanating from the source area; therefore, its function is consistent with the objective in the ROD. The treatment system is functioning as designed and the extent of the Northwest Plume is retracting.

5.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The exposure assumptions used to develop the Public Health and Ecological Assessment (PHEA) included both the current exposures (industrial worker) and the potential future exposures (future resident using groundwater and future industrial worker). The MCL for TCE remains 5 µg/L, as it was during the original remedy selection; however, the original remedy was intended only to control high concentration portions of the plume and was based on the assumption that there is no current exposure pathway because institutional controls restrict access to the contaminated groundwater. There are no risk-based cleanup levels or MCLs required for this project. There have been no changes to the exposure pathways due to institutional controls that restrict access to the contaminated groundwater; therefore, the exposure assumption (no exposure) is still valid.

Cleanup levels and RAOs are not specifically stated because the principal goal of this interim action is to decrease the risk by mitigating the spread of the high concentration portion of the Northwest Plume, thus retarding the migration of the contaminants emanating from the source area.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy during this five-year review period; however, on December 21, 2022, EPA issued a final rule revising Subpart GGGGG regulations for the National Emission Standards for Hazardous Air Pollutants (NESHAP) of the Clean Air Act (40 *CFR* Part 63). This regulatory revision in part, removed the exemption for CERCLA site remediation projects that generate and/or emit hazardous air pollutants (HAPs) above certain threshold quantities. While this project, in conjunction with other currently active sources and the Paducah Site do not cumulatively generate/emit HAPs that exceed the threshold amounts specified by regulation, nor impact the protectiveness of this remedy, this new NESHAP regulation will need to be evaluated as a potential new ARAR in future five-year reviews as new remediation projects are implemented at the Paducah Site.

The Northwest Plume underlies land controlled by DOE and the TVA Shawnee Fossil Plant, and the sparsely populated areas between the two reservations. DOE maintains a Water Policy (evaluated in Section 8) that controls access to the groundwater. Physically, access is controlled, for example, by padlocks on wells. Administratively, access is controlled through a license agreement process with landowners with and without residential wells in the area of the plume. DOE provides access to municipal water and pays reasonable municipal water bills for a majority of the residents, which further limits access to contamination in the Northwest Plume. Exposure assumptions used in the ROD regarding future domestic use of groundwater off DOE property remain valid. There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected.

The current groundwater data indicate that assumptions underlying the remedy selection in the ROD remain valid. There have been no new contaminants or new understanding of geologic conditions identified in the downgradient area of the Northwest Plume.

5.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

Since the institution of the IRA, seeps of contaminated water originating from the Northwest Plume have been identified in Little Bayou Creek. The Surface Water ICM (evaluated in Section 15) limits human access to the contaminated water. TCE levels in the seeps are declining (with a maximum detected level of 1.38 µg/L during the 2018 through 2022 period in LBCSP5). Tc-99 levels are less than 25 pCi/L in the latest seep samples that were collected in 2020.[4] The ecological risks associated with the seeps have not been fully evaluated.

No other information has come to light that would call into question the protectiveness of the remedy.

5.6.4 Technical Assessment Summary

The operational data and the site inspection indicate that the mechanical components of the remedy are functioning as intended by the ROD.

The Northwest Plume IRA now consists of groundwater extraction at one location immediately outside the north PGDP security-fenced. This EW field is intended to control the source of groundwater contamination to the Northwest Plume. Contaminant levels in the area of the previous north EW field (EW228/EW229) and further to the east have decreased significantly since the initiation of the Northwest Plume IRA, and they are continuing to decline with the operation of the optimization EW field (EW232/EW233). The remedy remains protective.

5.7 ISSUES

The Northwest Plume (SWMU 201) IRA, designed to initiate hydraulic control of the high TCE concentration of the Northwest Plume, has achieved the IRA goals in the area of the original north EW wellfield and, therefore, deactivation and abandonment of the north EW wellfield should be performed. The FFA parties should confer and mutually agree that the north wellfield (EW) is no longer needed and deactivation and abandonment of the north wellfield (EWs and most MWs) should occur.

The C-612 groundwater treatment facility was constructed in 1995 pursuant to the Northwest Plume (SWMU 201) IRA. The facility was designed for a five-year life span and the treatment of contaminant concentrations much higher than those that are currently present. Though some major components of the facility have been replaced since 1995, many components are nearly 30 years old. Some aspects of the design and operations of the C-612 facility are fundamentally inconsistent with those associated with groundwater treatment facilities subsequently constructed to treat the Northeast Plume. The recommendation is to perform a comprehensive evaluation of the C-612 groundwater treatment facility to determine the extent of modifications needed to optimize reliability and performance.

---

[4] The seeps were last sampled for Tc-99 on August 20, 2020. Samples were collected from seeps LBCSP2, LBCSP3, LBCSP4, LBCSP8, LBCSP9, and LBCSP10.

6. NORTHEAST PLUME

After the initial discovery of contamination at the Paducah Site in August 1988, DOE conducted an SI to determine the extent of contamination. The investigation, documented in the results of the site investigation (Phase I, Phase II), determined that the groundwater contamination is spreading generally northward toward the Ohio River in multiple plumes (CH2M HILL 1991, CH2M HILL 1992). Results of a follow-up groundwater monitoring investigation presented in the *Northeast Plume Preliminary Characterization Summary Report*, DOE/OR/07-1339V1&D2, delineated numerous plumes within the RGA that coalesce to form the Northeast Plume (SWMU 202) (DOE 1995a). One of these plumes was a zone of high TCE concentration (TCE concentrations exceeding 1,000 µg/L) that emanates from the eastern portion of the facility and extends off DOE property. Figure 6.1 depicts the aerial extent of the Northeast Plume based on the latest available plume map from 2020 (FRNP 2021) and shows the original EW field (consisting of two wells), which began operation in 1997 for the NEPCS, and an optimized EW field, which began operation in 2017. Figure 6.2 is a comparison of the plume between 2002 and 2020.

6.1 REMEDY SELECTION

Because of the risks related to off-site migration from on-site contaminant sources, DOE initiated an IRA for the Northeast Plume. DOE signed the Northeast Plume ROD on June 13, 1995, and EPA signed on June 15, 1995 (DOE 1995b). KDEP conditionally concurred with the selected remedy on June 5, 1995. The ROD identified the selected remedy, outlined the performance objectives, and provided rationale for the remedy selection.

The following are the major components of the selected RA.

- Installation of EWs and transfer pumps that were to be located at the northern end of the high-concentration TCE portion of the Northeast Plume. At the time of the ROD's preparation, the high-concentration portion had a TCE concentration greater than 1,000 µg/L. The pumping rate selected in the ROD was approximately 100 gallons per minute (gpm), which was enough to initiate hydraulic control, but not enough to change groundwater gradients.

- Implementation of a treatment system that consisted of process water cooling towers that already were located at the Paducah Site facility and would be used to volatilize the TCE and DCE before the treated water was discharged to KPDES Outfall 001. The water was to be collected and pumped to the top of the tower and trickle down over slats that increased the surface area of the water and transit time spent in contact with the atmosphere. This resulted in volatilization of contaminants, while the temperature of the water approached that of the ambient atmosphere.

- Two treatability studies also were included to evaluate the use of photo catalytic oxidation for the treatment of TCE in vapor phase and *in situ* treatment of TCE-contaminated groundwater.

Although the Northeast Plume ROD does not identify RAOs for the action, the ROD documents the following goal.

"The primary objective of this interim remedial action is to implement a first-phase remedial action as an interim action to initiate hydraulic control of the high concentration area within the Northeast Plume that extends outside the plant security fence."

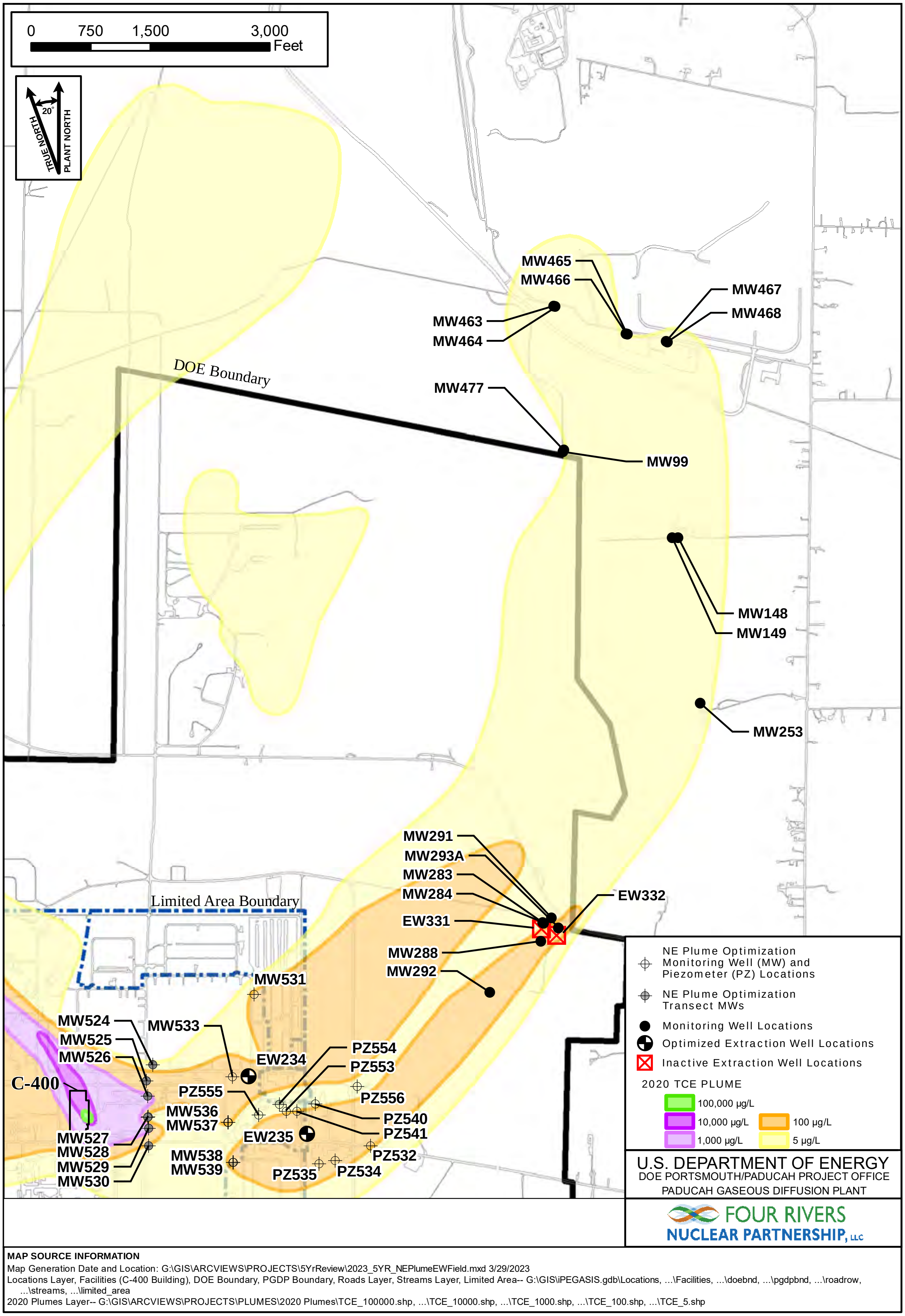


Figure 6.1. Northeast Plume EW Field with 2020 TCE Plume Map

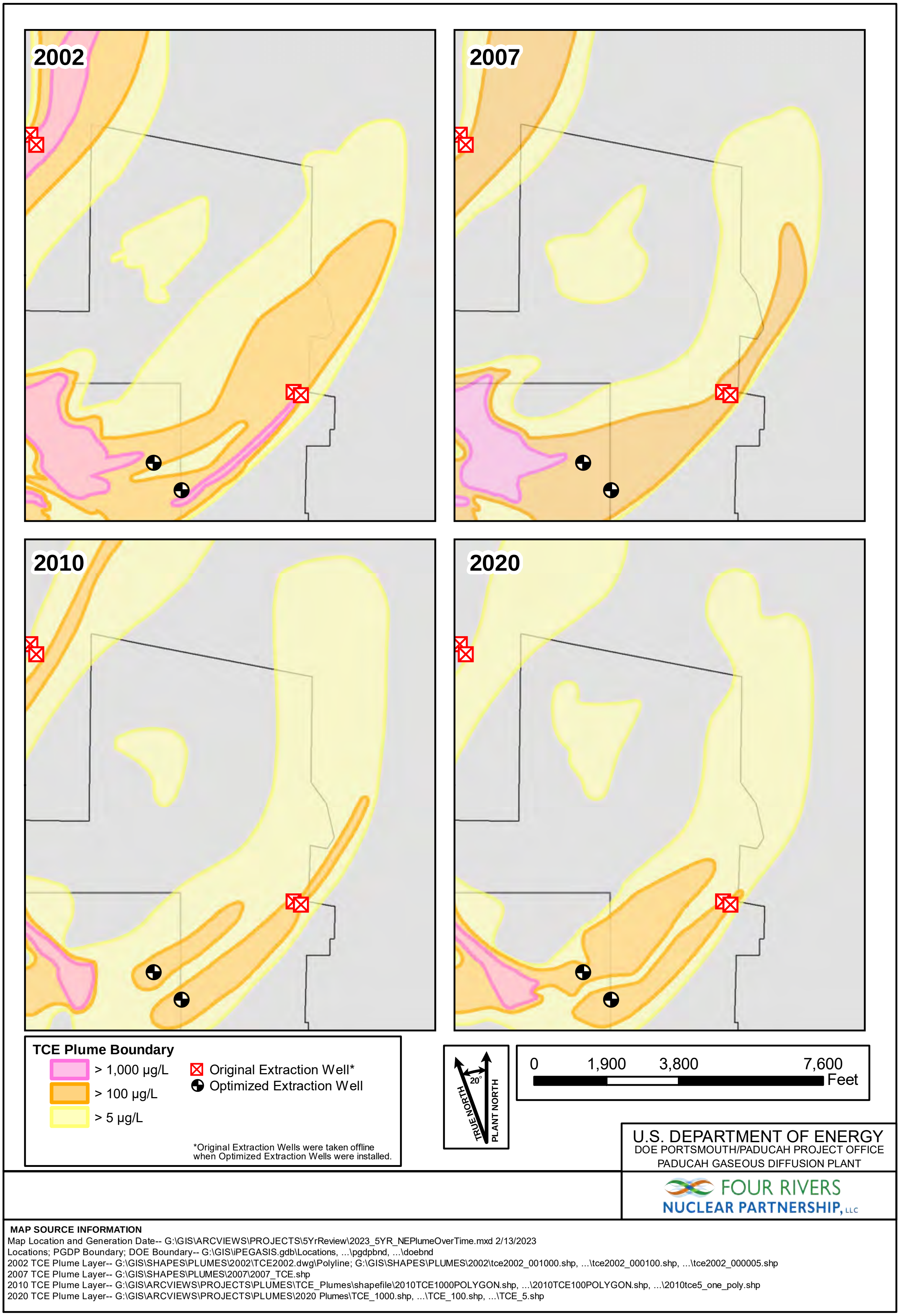


Figure 6.2. TCE Plume as Interpreted for 2002, 2007, 2010, and 2020

The ROD was supported by a PHEA. In the PHEA, TCE is listed as the primary Paducah Site-related contaminant found in groundwater off DOE property. The *Summary of Comparative Analysis of the Interim Alternatives* (Section 2.8 of the ROD) discusses risk relative to nearby communities and workers associated with the construction and operation of the source control systems. No cleanup levels were identified in the ROD.

The *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-1291&D2, (DOE 2013a) expanded the goal as follows:

> The Northeast Plume IRA optimization project is to continue to serve as an interim measure to remove TCE and 1,1-DCE mass and enhance capture of the Northeast Plume contamination in the vicinity of the eastern edge of PGDP industrial facility to reduce further migration off-site.

This goal was reiterated in a 2015 update of the ESD (DOE 2015a).

6.2 REMEDY IMPLEMENTATION

Following the signing of the ROD on June 15, 1995, DOE began the remedial design process for the selected remedial alternative. Minor modifications to the RA were required during the design phase. These minor modifications included the following:

- Removing the sand filter;
- Adding an EQ tank;
- Increasing pumping rate from 100 gpm to 170 gpm; and
- Postponing indefinitely the two treatability studies.

The rationale for removing the sand filtration system was based on the lack of suspended solids in the groundwater. Should suspended solids increase, the treatment system configuration would allow for the addition of a sand filter. No sand filter was needed. An EQ tank was added to equalize water flow.

DOE issued a Notice to Proceed with construction on April 5, 1996, and construction of the original Northeast Plume pump-and-treat system was completed in December 1996. Major equipment installed for this project included two EWs capable of producing a combined maximum discharge of 260 gpm, a 20,000-gal underground fiberglass-reinforced plastic EQ tank, and a submersible transfer pump capable of producing a maximum discharge of 263 gpm. This process equipment was installed along with associated piping, valves, and fittings. The construction of the facilities was documented in the *Postconstruction Report for the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky*, DOE/OR/07-1555&D1, and was issued February 7, 1997 (DOE 1997a). Operation of the NEPCS began February 28, 1997.

In February 2006 and March 2006, DOE Headquarters conducted a sitewide remedy review at the Paducah Site. The sitewide remedy review report recommended optimization of the Northeast Plume and Northwest Plume IRAs (DOE 2006). At the request of DOE, the U.S. Army Corps of Engineers led a remediation system evaluation of the Northeast and Northwest Plume extraction systems at the Paducah Site in October 2006 (DOE 2007a). The review team concluded that the interim goal of the Northeast Plume IRA, to control migration of water contaminated by > 1,000 µg/L TCE, had been achieved. The review team's main recommendation concerning the NEPCS was that the system be placed in standby mode, with continued detection monitoring to assess the potential reappearance of TCE concentrations above 1,000 μg/L.

Cessation of uranium enrichment operations at the Paducah Site by USEC in May 2013 resulted in the loss of operation of the C-637 Cooling Towers that acted as the air stripper and provided further need to optimize the NEPCS with the use of an alternate treatment unit that could air strip the VOC contamination. Installation of the alternate treatment unit was completed on September 4, 2013, when routine operations were initiated. Installation of the treatment unit resulted in a new CERCLA outfall discharge point (CERCLA Outfall 001) located downstream of KPDES Outfall 002.

The FFA parties evaluated the sitewide remedy review recommendation and related conclusions in the following:

- The 2003, 2008, and 2013 CERCLA five-year reviews (DOE 2003a, DOE 2009a, and DOE 2014a);

- *Review Report: Groundwater Remedial System Performance Optimization at PGDP, Paducah, Kentucky* (DOE 2007a); and

- The FY 2012 SMP (DOE 2012a).

The base design for the optimization of the NEPCS was developed in the *Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2018a) (RAWP). This RAWP included groundwater flow modeling to assess design and evaluation of the optimized EW system (RAWP Appendix C). The proposed design, based on modeling, included pumping from two new EWs located near the east security fence and a third EW located at the north side of C-400.

The parties agreed to an optimization of the NEPCS, which was documented in a MOA for Resolution (DOE 2015b). Primary initiatives of the MOA for Resolution were as follows:

- Upgradient relocation of the two EWs and operation of two treatment units;[5]

- Construction of up to two new CERCLA outfalls for discharge of the treated groundwater (one treatment unit and CERCLA outfall already were in use); and

- Construction and maintenance of an optimized MW network, including a transect of MWs located approximately 600 ft east of the C-400 Cleaning Building. These transect MWs were to be used to assess the impact of the optimized NEPCS on contaminant migration from source areas, including impacts to the groundwater flow divide located east of the C-400 Cleaning Building.

The optimized NEPCS consists of the two new EWs (EW234 and EW235), the two associated treatment units (using one CERCLA outfall), and installation of an additional 14 MWs and 8 piezometers to evaluate the performance and the effectiveness of the optimized EWs. Included in the system of 14 MWs, with single screens, were 7 new RGA MWs in a north-south transect located approximately 600 ft east of the C-400 Cleaning Building (Figure 6.3). Sampling results from the transect MWs were used to establish baseline TCE and Tc-99 levels in the area of their installation and will be used to assess impacts of the EWs on contaminant migration from source areas, including impacts to the groundwater divide east of the

[5] The extraction of the Northeast Plume mass from the new EWs (EW234 and EW235), located upgradient of the former EWs (EW331 and EW332) and in the vicinity of the eastern boundary of the facility, is intended to remove VOC mass in the contaminated groundwater from the higher concentration portion of the Northeast Plume and control the amount of plume mass migrating off-site. The proposed EW located north of C-400 in the model-based design of the RAWP was deferred.

C-400 Cleaning Building. The transect MWs were installed first (August 2016) to expedite the collection of baseline (preoperation) monitoring results. Based on the first 2 quarters of monitoring data, the FFA parties concurred on proceeding with construction of the remaining project components. Existing EWs, pipelines, and facilities not utilized as part of the optimized NEPCS were placed into a standby condition. EW331 and EW332 are being kept in standby condition until the FFA parties agree that maintenance no longer is necessary, and final disposition (including well abandonment) is determined.

6.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

For the 2018 through 2022 period, O&M activities for the NEPCS were conducted in accordance with the *Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2470&D1, (DOE 2021b). The O&M Plan provides an overview of the activities required to operate and maintain the treatment system to meet DOE, EPA, and Commonwealth of Kentucky policies and statutes. Since operation began, the NEPCS has processed approximately 2,175,384,677 gal of water as of December 31, 2022. The treatment system has removed approximately 4,792 lb (371 gal) of TCE.

The costs associated with the O&M of the NEPCS and the NWPGS are tracked jointly and have been since FY 2002. The combined cost for both systems for the five-year reporting period is $5.08M, or an average of $1.02M per year. This average annual O&M cost of $1.06M is lower than the combined original estimates of $1.5M to $2.0M for the NWPGS and $240K for the NEPCS; but the average annual cost increased since the 2013 to 2017 review period ($645K). Increased O&M costs for the optimized NEPCS, with its two treatment facilities, resulted in a baseline shift for this reporting period. Table 6.1 crosswalks the combined yearly costs and downtime for EWs of the NEPCS and the NWPGS. As evidenced in the table, periods of significant EW downtime in 2019 and 2022 relate to additional O&M costs. The total operation cost for both the NEPCS and the NWPGS was $37.12M at the end of December 2022.

Table 6.1. Summary of Annual O&M Costs and EW Downtime (Greater than 24 Hours) for the Combined NEPCS and NWPGS

Year	O&M Cost	Days of Extended Unplanned EW Downtime*
FY 2018 (10/1/2017–9/30/2018)	$799K	22
FY 2019 (10/1/2018–9/30/2019)	$1.19M	94
FY 2020 (10/1/2019–9/30/2020)	$810K	0
FY 2021 (10/1/2020–9/30/2021)	$830K	28
FY 2022 (10/1/2021–9/30/2022)	$1.45M	128

*One EW remained operational during the extended periods of EW downtime for both the NEPCS and NWPGS during the 2018 through 2022 review period.

Overall, the optimized Northeast Plume IRA treatment system operated as intended, with a combined operational efficiency of 90.7% over this five-year review period.

6.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The 2018 Five-Year Review states the following (DOE 2019a):

> The remedy for the Northeast Plume (SWMU 202) is protective of human health and the environment in the short-term. The Northeast Plume groundwater extraction system is being optimized to increase TCE mass removal, to enhance control of plume migration at the eastern edge of the PGDP industrial area. Exposure pathways that could result in

> unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plume OU…, need to be evaluated for long-term protection.

Previously, the FFA parties recommended optimization of the NEPCS to increase TCE and 1,1-DCE mass removal and to enhance the contaminant capture in the Northeast Plume in the vicinity of the eastern edge of the Paducah Site facility. Moreover, an evaluation of the results of the optimization of the NEPCS with field testing and the use of the sitewide groundwater flow model was needed to understand the performance of the new EWs.

Construction of the optimized NEPCS was completed during the period of the previous (fourth synchronized) five-year review and routine operation began on October 10, 2017, with a combined extraction rate of 270 gpm to 275 gpm. Field tests of the hydraulic containment of the NEPCS were performed from February 15, 2018, to April 2, 2018, and from April 19, 2018, to May 10, 2018. Based on the results of the field tests and with FFA agreement, the withdrawal rates were reduced to 175 gpm on June 14, 2018. DOE issued the D2/R1 version of the postconstruction report for the Northeast Plume Optimization on June 28, 2018 (DOE 2018b). There were significant planned shutdowns for both EWs of the optimized NEPCS over extended periods during February 2018 and March 2018 for the first of the field tests of hydraulic containment. Otherwise, the EWs collectively have maintained a monthly operational efficiency of 91% or greater for each month of the five-year review period.

6.5 SITE INSPECTION

A site inspection of the NEPCS facilities was made on December 5, 2022. Participants included the facility manager, the O&M manager, members of the five-year review team, representatives from DOE's support contractor, and KDEP.

The standby facility, which consists of the two original EWs, a pumping station, associated piping, electrical power and control systems, security fencing and gates, and interconnecting gravel access roads, is located south and west of the intersection of Ogden Landing Road (Kentucky Highway 358) and Little Bayou Creek and northeast of the Paducah Site (Figure 6.3).

For the standby facility, the main access road into the area is secured by a chain-link gate. The gate is in good condition and serves its intended function. All the roads in the area appear to be well maintained and are in good condition.

The two standby EWs are located approximately 200 ft apart. Each well is located in an underground concrete vault with a hinged aluminum lid. A chain-link security fence surrounds each well, with an access gate that is locked to prevent unauthorized entry. The vaults are in good condition and are free of foreign debris. The security fences around each well are also in good condition. The immediate area around each fenced location was mowed and is well maintained. During this inspection, both wells appeared to be functional, if needed.

The pipeline pumping station for the original well field, which consists of a large underground EQ tank, a discharge pump and associated piping, and electrical power and control panels, also is enclosed completely in a chain-link security fence, with an access gate at one end. All aboveground piping is insulated to prevent freezing. All of the exposed piping and insulation and electrical power and control panels are in good condition and properly labeled.

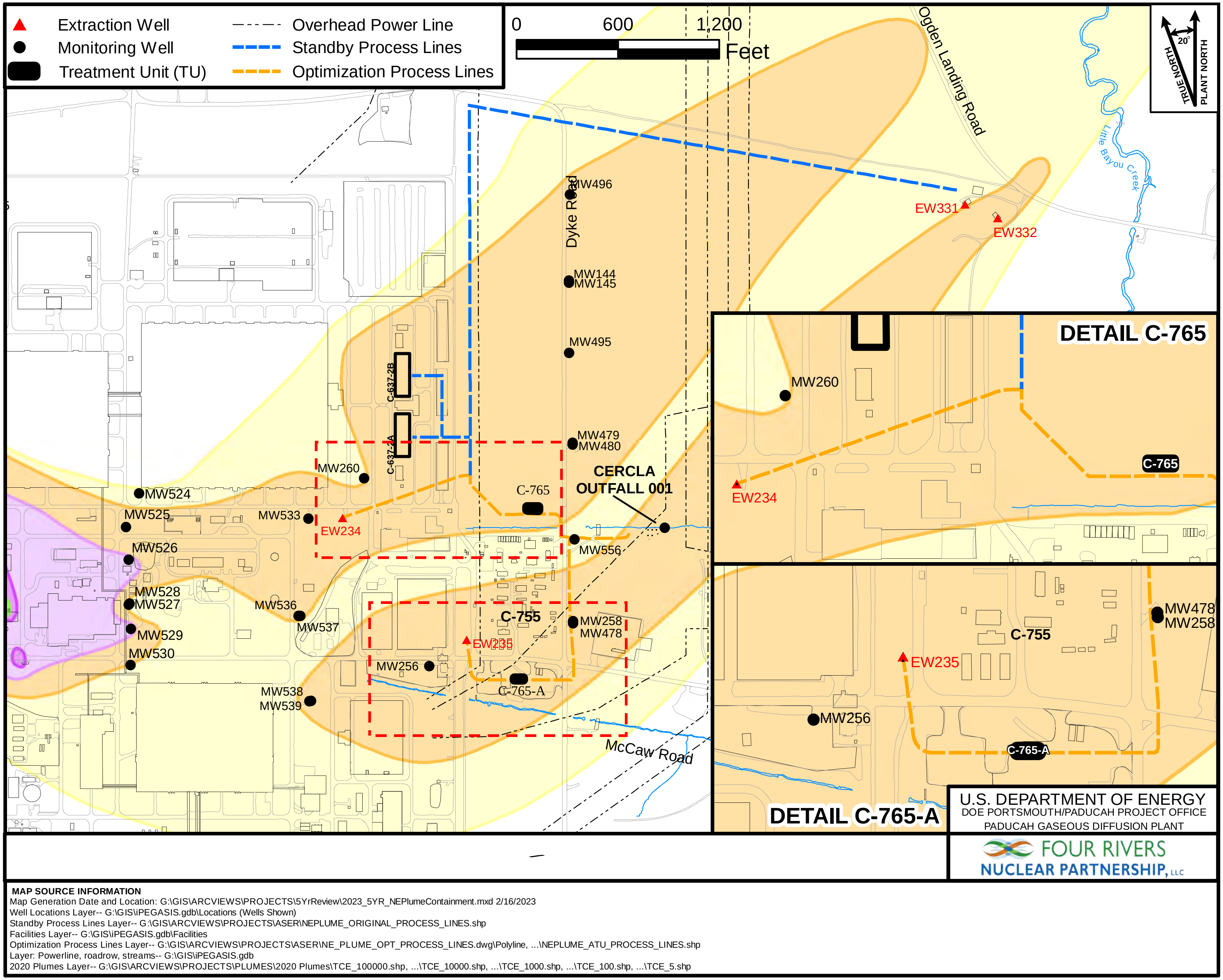


Figure 6.3. Location of MWs, EWs, and the Optimized NEPCS Relative to the Paducah Site

The optimized NEPCS consists of two EWs (EW234 and EW235) and two associated treatment units. EW234 is located within the PGDP security-fence, near the intersections of 20th Street and Vermont Avenue. Its treatment unit (C-765) is located outside the PGDP security-fenced area and east of EW234, off Dyke Road. EW235 is located immediately outside the security fence and immediately north of McCaw Road. Its treatment unit (C-765-A) is located in a graveled staging area immediately to the south of EW235 and McCaw Road. Both treatment units discharge to a facility effluent ditch through CERCLA Outfall 001, which is downstream of KPDES Outfall 002. Figure 6.3 shows the location of the NEPCS components.

At both operating EWs (EW234 and EW235), the wells, with their valves and sample ports, are housed in a locked concrete well vault with a hinged aluminum lid. The well vaults are in good condition and free of foreign debris. Components are labeled. Above ground electrical power and control panels are adjacent to each well vault. Access roads and grounds are well maintained.

The two treatment units are similar, each housing piping and valves, bag filters, and an air stripping treatment unit. System controls and communication equipment is also located in the treatment trailers. All components are well organized and labeled. The facilities are kept clean and neat.

Operation of the optimized NEPCS began October 11, 2017. By October 30, 2017, the EWs and treatment systems were in continuous operation. While the optimized NEPCS has remained in near continuous operation during the assessment period,[6] there have been 7 occurrences of pump failure over extended periods. Table 6.2 summarizes periods of pump and system failures lasting over 24 hours. Downtime in 2021 and 2022 was significantly extended because of supply-chain issues related to the COVID-19 pandemic.

Table 6.2. Summary of Unplanned Down Time (Greater than 24 Hours) for the NEPCS

Period	Event
12/22/2018–1/16/2019	EW235 pump failure
2/20/2019–3/8/2019	EW234 pump failure
6/9/2019–7/9/2019	EW234 pump failure
7/20/2019–8/20/2019	EW235 pump failure
7/7/2020–7/9/2020	C-765 shut down for repair
10/3/2020–10//15/2020	EW234 pump failure
9/14/2021–11/3/2021	EW234 pump failure
12/14/2021–3/28/2022	EW234 pump failure

Assessments of the pump failures identified problems with potentially harsh voltage conditions from the supplied electrical power to the pump motors and the sizing of the pumps (after pumping rates were reduced following the tests of hydraulic containment in 2018). Corrective measures have been implemented and the EW pumps are operating with good efficiency.

6.6 TECHNICAL ASSESSMENT

The NEPCS is an IRA to control the high concentration area of the Northeast Plume that extends outside the PGDP security-fence and to track contaminant migration to assess the IRA's performance. The optimization of the system is intended to increase TCE mass removal, and to enhance control of plume

[6] Meaning one or both EWs and treatment facilities in operation.

migration at the eastern edge of the PGDP industrial area. Monitoring data indicate that this RA has reduced contaminant concentrations in the Northeast Plume since operations began in 1997 and the optimization has increased TCE mass removal. The action described in the ROD is not intended or expected to return groundwater quality to MCLs.

6.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The original EWs (EW331 and EW332) began operation on February 28, 1997; the optimization EWs (EW234 and EW235) began operation on October 11, 2017. Trends of TCE concentrations in groundwater of the original Northeast Plume EW field monitoring system demonstrated that TCE levels were being reduced by the pump-and-treat system. For the optimized NEPCS, TCE levels of the EW234 and EW235 wellfields are evidence of declining trends beginning in 2021 (Figure 6.4), with the exception of MW533. MW533 is located immediately upgradient of EW234 and is located in a centroid of TCE contamination that is migrating to EW234 from a TCE source zone in the vicinity of C-400 area. See Section 9.7.1 for a discussion of TCE trends at the northwest corner of C-400.

Figure 6.5 illustrates the TCE trends in EW234, EW235, and MW533. For the period of 2018 through 2022, TCE levels in EW234 have ranged between 110 and 493 µg/L with a median value of 198 µg/L.[7] The TCE level generally increased beginning in 2019 and 2020, then decreased over the latter half of 2022. For the same 2018 through 2022 period, TCE levels in EW235 have ranged between 106 and 205 µg/L with a median value of 142 µg/L.[8] The TCE level in EW235 has generally decreased. The TCE removal rate for this five-year review period has increased more than 36% over the previous five-year review period (Table 6.3).

In general, TCE levels along the eastern edge of the PGDP industrial area, downgradient of the optimized NEPCS EWs, have remained near-steady or slightly declined during the 2018 through 2022 period (Figure 6.6). MWs with the highest TCE levels began to show a decline beginning in 2021/2022.

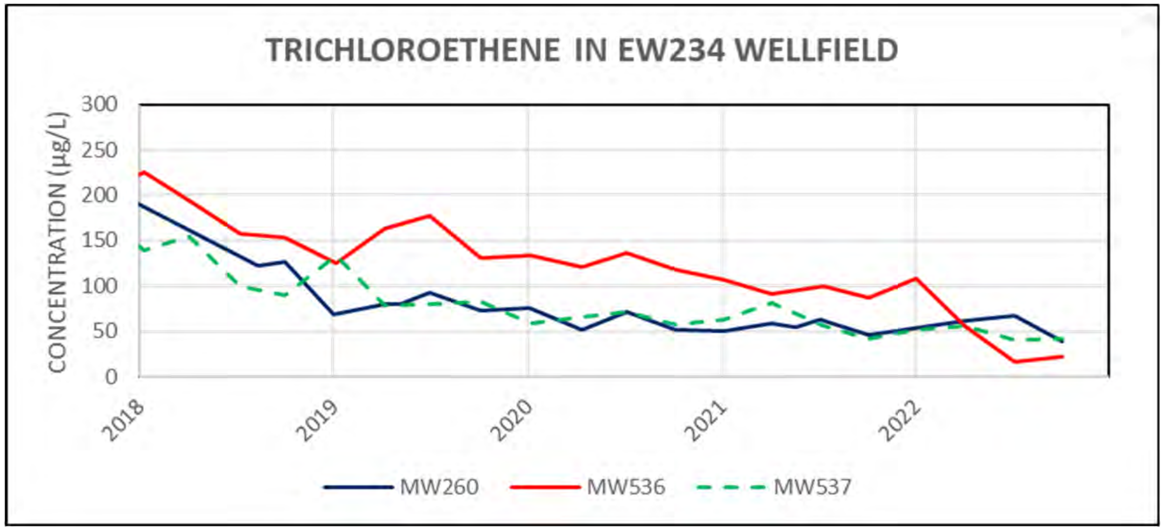
The sum of the data indicates that the EWs are being effective at controlling the high-concentration core of the Northeast Plume and that the TCE levels in the downgradient Northeast Plume are declining. TCE levels in the effluent of the optimized treatment system are meeting the target levels (Table 6.4).

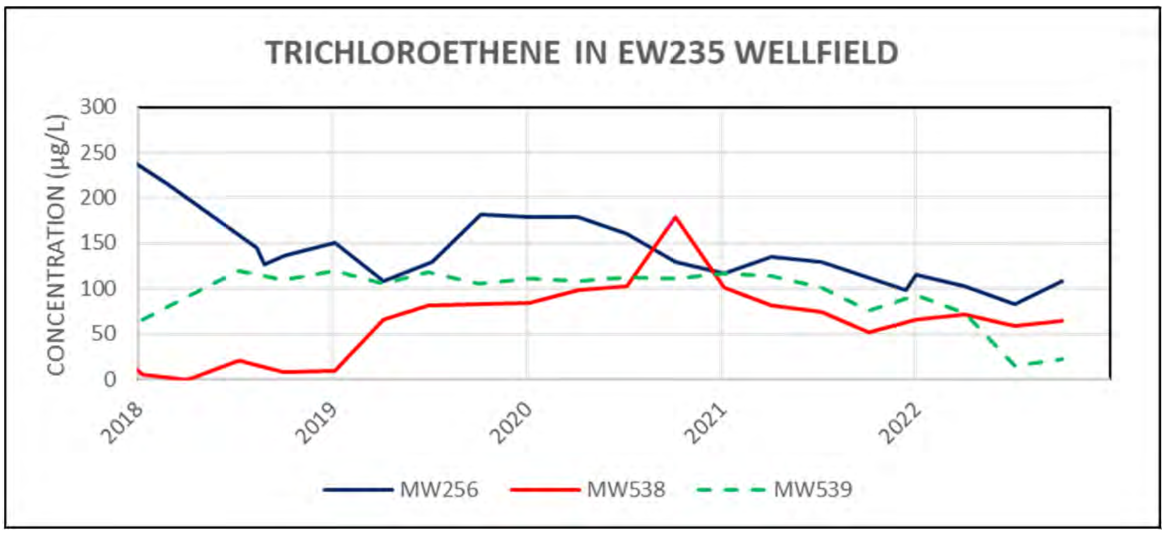
This review of data and the site inspection indicate that the remedy as implemented by the optimized EWs is meeting the RAOs as described in the ROD (DOE 1995b) and MOA (DOE 2015b). No changes in the physical conditions of the site have occurred that would affect the value of the remedy. The action inherently benefits downgradient areas by limiting the advance of the plume. Reviews of groundwater monitoring data and the results of the site inspection all indicate that the NEPCS has functioned as designed. The optimization of the NEPCS has increased the rate of contaminant mass removal by the remedial system.

---

[7] Excluding an uncharacteristic TCE concentration of 64.9 µg/L in a sample collected on October 10, 2022.

[8] Excluding uncharacteristic TCE concentrations of 53.7 and 55.4 µg/L in samples collected on October 10, 2022.

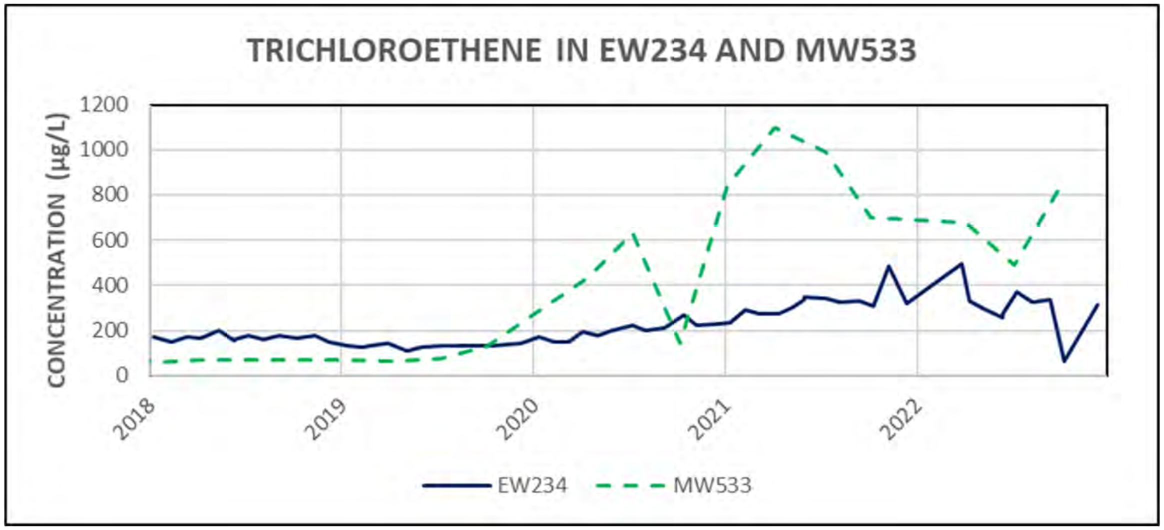


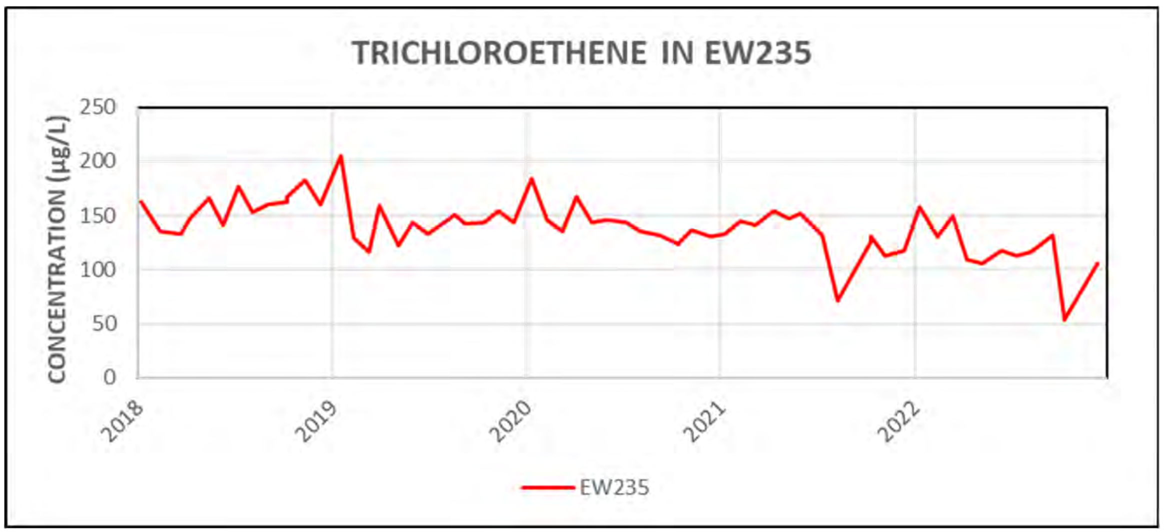


U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

Figure 6.4. Trichloroethene Trends in the Optimized NEPCS Extraction Wellfields





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

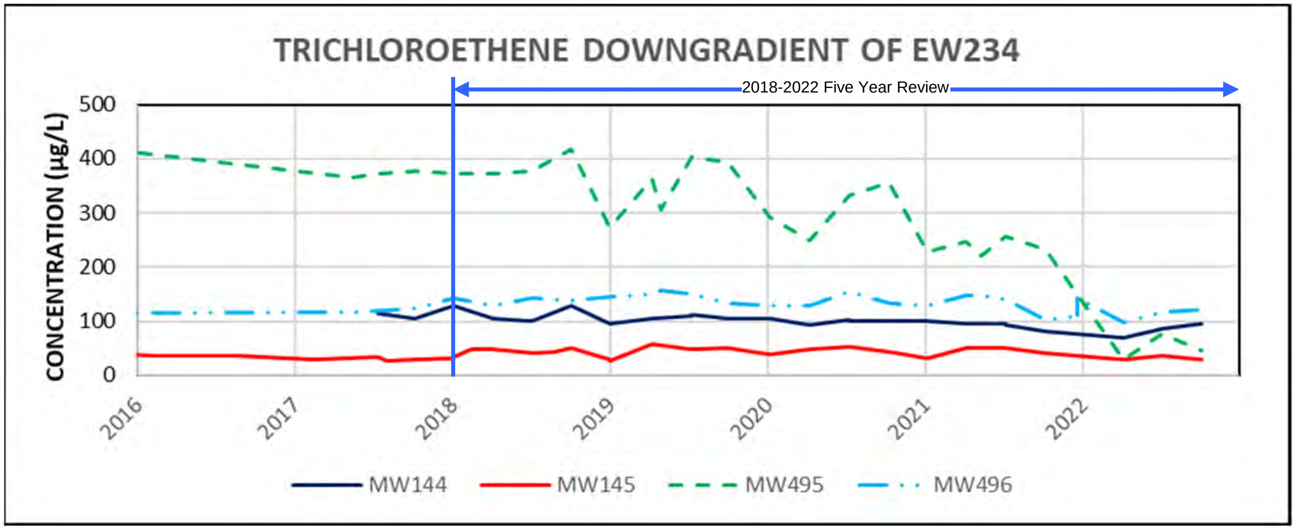
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

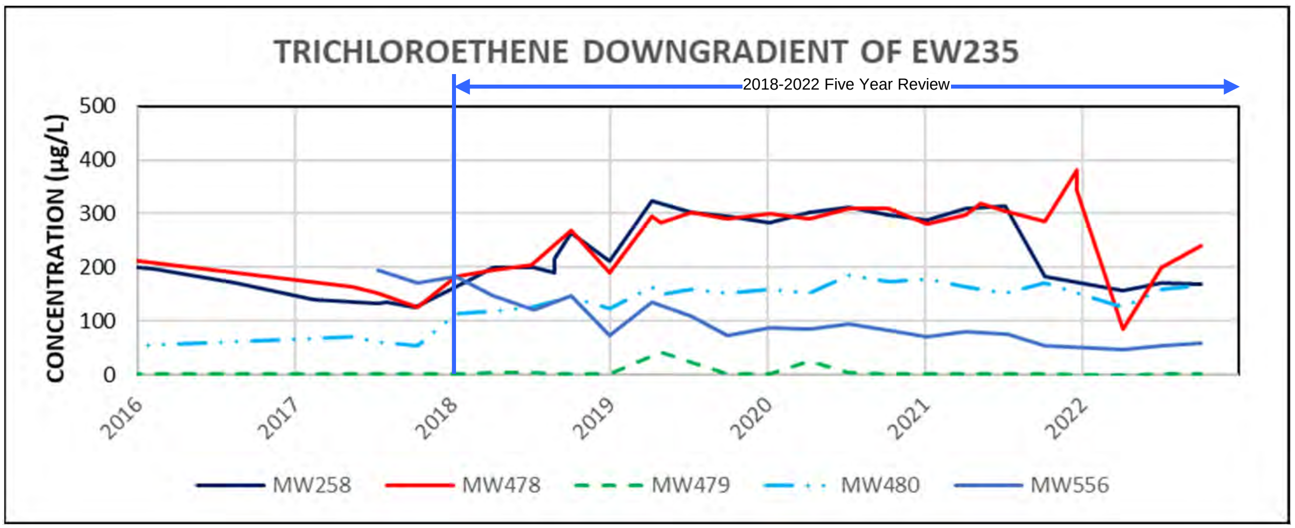
Figure 6.5. Trichloroethene Trends in the NEPCS Extraction Wells and MW533

Table 6.3. Northeast Plume IRA TCE Removal

<table>
<tr><th></th><th>Calendar Year</th><th>TCE Removal (gal)</th><th>Cumulative TCE Removal (gal)</th></tr>
<tr><td></td><td>2013</td><td>5</td><td>284</td></tr>
<tr><td></td><td>2014</td><td>9</td><td>293</td></tr>
<tr><td></td><td>2015</td><td>8</td><td>301</td></tr>
<tr><td></td><td>2016</td><td>9</td><td>310</td></tr>
<tr><td></td><td>2017*</td><td>8</td><td>318</td></tr>
<tr><td rowspan="5">Current Five-Year Review Period</td><td>2018</td><td>11</td><td>329</td></tr>
<tr><td>2019</td><td>8</td><td>337</td></tr>
<tr><td>2020</td><td>10</td><td>347</td></tr>
<tr><td>2021</td><td>13</td><td>360</td></tr>
<tr><td>2022</td><td>11</td><td>371</td></tr>
</table>

*Start of optimized NEPCS EWs: October 11, 2017.





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

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

Figure 6.6. TCE Trends iin Monitoring Wells Downgradient of the Optimized NEPCS EWs

Table 6.4. NEPCS TCE Effluent Concentrations at CERCLA Outfall 001 for the Period of 2018 through 2022

	TCE (µg/L)		
	High	**Low**	**Average***
Effluent	2.03	0.34	0.99

*Average is calculated as an arithmetic average using the detection limit where the TCE level was nondetect.

6.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The exposure assumptions used to develop the PHEA included both the current exposures (industrial worker) and the potential future exposures (future resident using groundwater and future industrial worker). The MCL for TCE remains 5 µg/L as it was during the original remedy selection; however, the original remedy was intended to control only high concentration portions of the plume and was based on the assumption that there is no exposure pathway because the Water Policy (as discussed in Section 8) prevents access to the contaminated groundwater. There are no risk-based cleanup levels or MCLs required for this project. There have been no changes to the exposure pathways due to the Water Policy (as discussed in Section 8) that restricts access to the contaminated groundwater; therefore, the exposure assumption (no exposure) is still valid.

The goals identified for the Northeast Plume, to initiate hydraulic control of the high concentration area that extends outside the facility security fence (from the ROD) and to remove TCE and 1,1-DCE mass and enhance capture of the Northeast Plume in the vicinity of the eastern edge of PGDP industrial facility and to reduce further migration off-site [from ESD (DOE 2015b)], remain valid.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. The ROD identified a chemical-specific ARAR for discharge of TCE to Little Bayou Creek of 81 µg/L, as controlled by the KPDES Permit; however, the water quality criterion was lowered to 30 µg/L. The 2015 ESD (DOE 2015a) established up to two CERCLA outfalls for discharge of TCE to the creek with the same 30 µg/L water quality criterion. The discharges from the Northeast Plume treatment never have exceeded this lower value; therefore, this change in standards has no impact on the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy during this five-year review period; however, on December 21, 2022, EPA issued a final rule revising Subpart GGGGG regulations for NESHAP of the Clean Air Act (40 *CFR* Part 63). This regulatory revision in part, removed the exemption for CERCLA site remediation projects that generate and/or emit HAPs above certain threshold quantities. While this project, in conjunction with other currently active sources and the Paducah Site do not cumulatively generate/emit HAPs that exceed the threshold amounts specified by regulation, nor impact the protectiveness of this remedy, this new NESHAP regulation will need to be evaluated as a potential new ARAR in future five-year reviews as new remediation projects are implemented at the Paducah Site.

The Paducah Site's Northeast Plume underlies land controlled by DOE and sparsely populated areas northeast of the facility and borders on residences (to the east) located along Metropolis Lake Road. DOE maintains a Water Policy (evaluated in Section 8) that controls access to the groundwater in the area of the plume through a license agreement process with landowners and by providing household water supply to the area residents. Exposure assumptions used in the ROD regarding future domestic use of groundwater off DOE property remain valid. There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected.

The current groundwater data indicate that assumptions underlying the remedy selection in the ROD still are valid. There have been no new contaminants or new understanding of geologic conditions identified in the downgradient area of the Northeast Plume.

6.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

6.6.4 Technical Assessment Summary

The operational data and the site inspection indicate that the mechanical components of the remedy are functioning as intended by the ROD.

The optimized Northeast Plume IRA consists of groundwater extraction from two EWs located within and near the facility security fence and in the high concentration cores of contamination of the Northeast Plume. This optimized EW field is intended to control migration of the high-concentration core of TCE contamination off the DOE property and to maximize VOC mass recovery. The NEPCS 2015 update of the ESD requires the following (DOE 2015a).

- Installation (at a minimum) of five new RGA monitoring wells in a north-south transect approximately 600 feet east of C-400 Building (exact locations to be determined by the FFA parties as part of the finalization of the RAWP). These transect monitoring wells will be used to assess the impact of groundwater extraction wells on contaminant migration from source areas, including impacts to the groundwater divide east of C-400 Building.

- If contaminant concentrations in any transect well's quarterly samples are determined to be increasing and may double above the established baseline within a year of the quarterly samples showing an increase, then potential changes in groundwater flow or source impacts (e.g. rising contaminant concentrations in the NE Plume, source migration, etc.) will be further examined and the FFA parties will consider adjustments (e.g. adjusting extraction well pumping rates) for the optimized NE Plume interim action to minimize these potential impacts.

- If the measures taken by the FFA parties (e.g. adjusting extraction well pumping rates) do not result in decreased or stabilized concentrations at the transect monitoring wells, or if such adjustments reduce the effectiveness of the optimized extraction wells or if Tc-99 concentrations continue to increase and are detected at twice their baseline concentration in any one (or more) of the transect wells for two consecutive quarters, then DOE must notify EPA and KDEP within 30 days of receiving sampling results or one of the other aforementioned conditions occurring. After EPA and KDEP have been notified, the FFA parties will discuss and evaluate options to address continued increase of groundwater concentrations and plume expansion.

- Within 1 year from the notification, DOE shall submit an ESD and RAWP Addendum as the Primary documents to undertake modification to the existing CERCLA Interim Remedial Action pursuant to the FFA to address the contaminated groundwater plume expansion and to prevent Tc-99 at levels above the MCL from further being pulled within the NE Plume.

- The FFA parties will discuss whether to temporarily suspend operation of one or both of the extraction wells while determining the modifications to the CERCLA Interim Remedial Action to prevent further plume expansion.

- If a determination is made to shut down the optimized pump and treat system either before a modification to the Interim Remedial Action or as part of a modification to the Interim Action, then DOE shall reinstate implementation of the NE Plume Interim Remedial Action (Interim ROD 1995). DOE shall keep the extraction wells associated with the NE Plume Interim Remedial Action in good working condition until the FFA parties agree the maintenance is no longer necessary.

The FFA parties have reviewed TCE and Tc-99 trends of the MW transect on a quarterly basis. After an adjustment to the pumping rates in June 2018, no further adjustments have been required.

Figure 6.7 summarizes the TCE and Tc-99 trends for the MW transect. TCE trends identify two centroids of contamination emanating from the C-400 vicinity, a north TCE source associated with the NSDD (see Section 9.7.1, discussion of trends of the northwest corner of C-400) and migrating through MW525 and MW526, and a south source, the VOC source in the Phase IIb area (see Section 9.7.1, discussion of trends of the southeast C-400 area), and migrating through MW529. The NEPCS treatment systems are well equipped to address TCE at these levels. The Tc-99 contamination remains well below levels that would require treatment.

Contaminant levels downgradient of the EW field have decreased since the initiation of the Northeast Plume IRA and are continuing to decline. The thick interval of relatively low-permeability silt that overlies the Northeast Plume should reduce the potential for transport of VOC vapors from the Northeast Plume to the surface. A vapor intrusion study of the downgradient Northeast and Northwest Plume areas determined that vapor intrusion does not pose a concern for area residences (DOE 2016a). While operation of the NEPCS is an interim action, it is effectively protective in conjunction with other Paducah Site programs (notably the Water Policy).

6.7 ISSUES

The RAWP for the optimization of the Northeast Plume identified a need for an EW on the north side of the C-400 Complex to halt the unintended spread of dissolved contamination to the Northeast Plume EWs (DOE 2018a). A technical paper to further assess an EW on the north side of C-400, which is consistent with the groundwater flow modeling completed as part of the RAWP, is recommended.

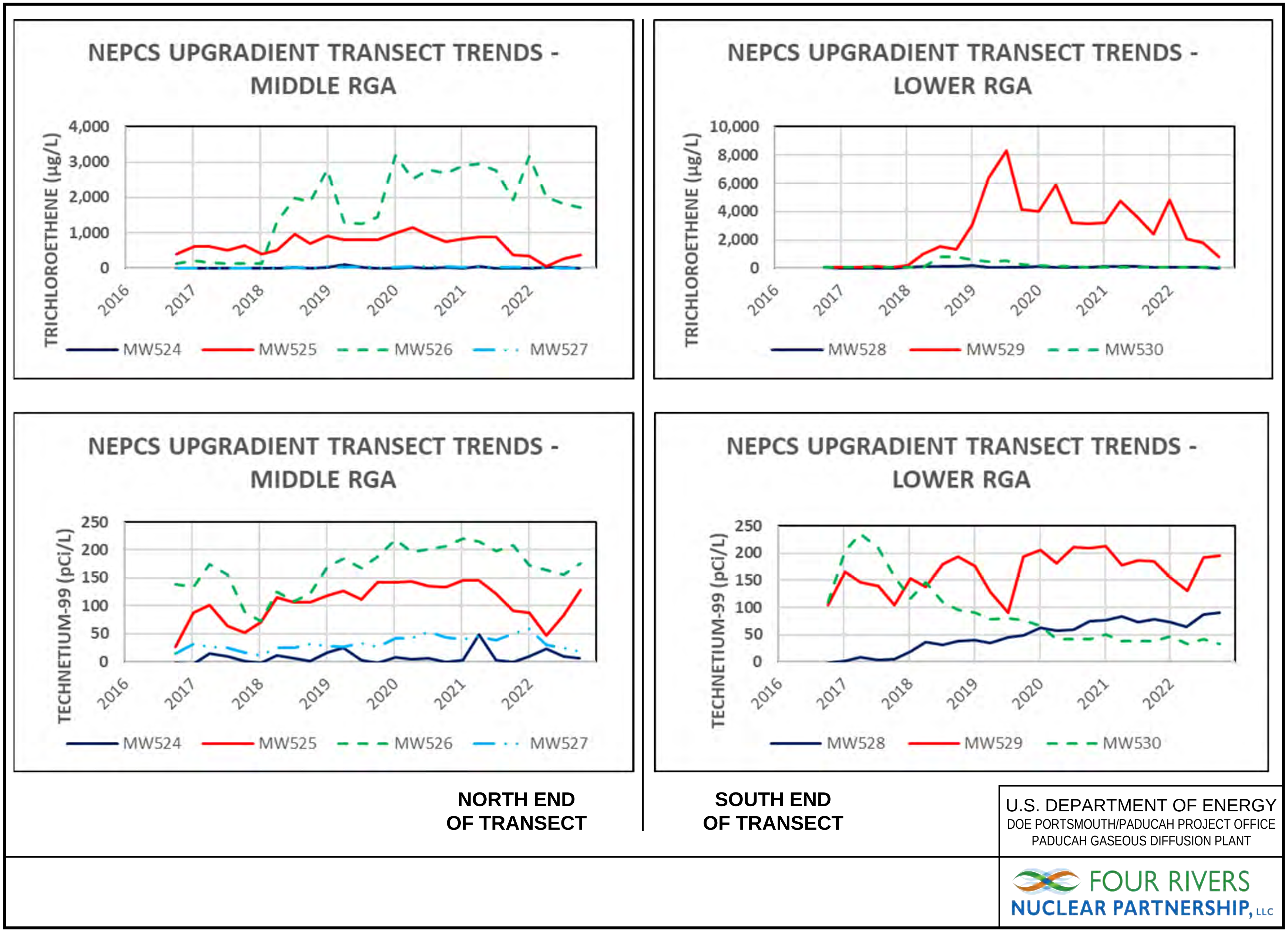


Figure 6.7. Trends in the Upgradient MW Transect

7. CYLINDER DROP TEST AREA OR LASAGNA™ TECHNOLOGY DEMONSTRATION

The Cylinder Drop Test Area (SWMU 91) encompasses approximately 1.7 acres and is located in the extreme west-central area of the facility on the southern edge of the C-745-B Cylinder Yard. Figure 7.1 illustrates the location of the Cylinder Drop Test Area. Drop tests were conducted from late 1964 until early 1965 and in February 1979. These tests were used to demonstrate the structural integrity of the steel cylinders that were used to store and transport uranium hexafluoride (UF_6). Prior to the drop test, the cylinders were cooled by immersing them in a solution of dry ice and TCE that was in an open below-ground-surface pit. After the cylinders were chilled, a crane lifted and then dropped them onto a concrete and steel pad to simulate worst-case transportation accidents. The TCE was not removed from the pit after the tests and eventually vaporized or leaked into the surrounding shallow soil and groundwater. The likely maximum quantity lost to the surrounding soil is approximately 1,635 L (430 gal). Additional information regarding the nature and extent of contamination is presented in the *Results of the Site Investigation, Phase II*, KY/SUB/13B-97777C, P-03 1991/1 (CH2M HILL 1992), and the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128 (LMES 1996a).

Results of the initial investigations conducted at the Cylinder Drop Test Area indicated that organic contaminants were present in both the soil and groundwater at the unit. The maximum concentration of TCE in subsurface soil was 1,523 mg/kg, and in shallow groundwater it was 943 mg/L. The area of TCE contamination was approximately 6,000 ft^2, and the average TCE concentration was 84 mg/kg. The sampling results indicated that TCE had migrated below the water table in the UCRS, but had not fully penetrated the aquitard above the RGA. Contamination was present in the subsurface soils to an approximate depth of 45 ft below ground surface (bgs).

7.1 REMEDY SELECTION

In 1993, the Cylinder Drop Test Area was selected as the site of an innovative technology demonstration. The technology, known as Lasagna™, uses electroosmosis to move shallow groundwater and contaminants contained in fine-grained or clayey soils. Contaminants are treated by passing contaminated groundwater through in-ground treatment cells. The success of the initial 120-day demonstration (Phase I), which began in January 1995, led to a full-scale demonstration (Phase IIA) that was conducted from August 1996 through July 1997. Sampling and analytical results from the Phase I study are reported in the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128 (LMES 1996a). During the second phase of the technology demonstration, the average TCE concentration in the demonstration area soil was reduced by 95%. Post-test soil sampling conducted for the Phase IIA demonstration indicated that Lasagna™ would achieve the cleanup goals. The results of the Phase IIA demonstration are discussed further in the *Lasagna™ Soil Remediation: Innovative Technology Summary Report* [LMES 1996b (unnumbered)].

DOE then selected Lasagna™ for the full-scale remediation of the Cylinder Drop Test Area and documented this decision in the *Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1527&D2 (DOE 1998a), with EPA approval and KDEP concurrence, September 1998. The ROD identified the selected remedy, outlined the performance objectives, and provided rationale

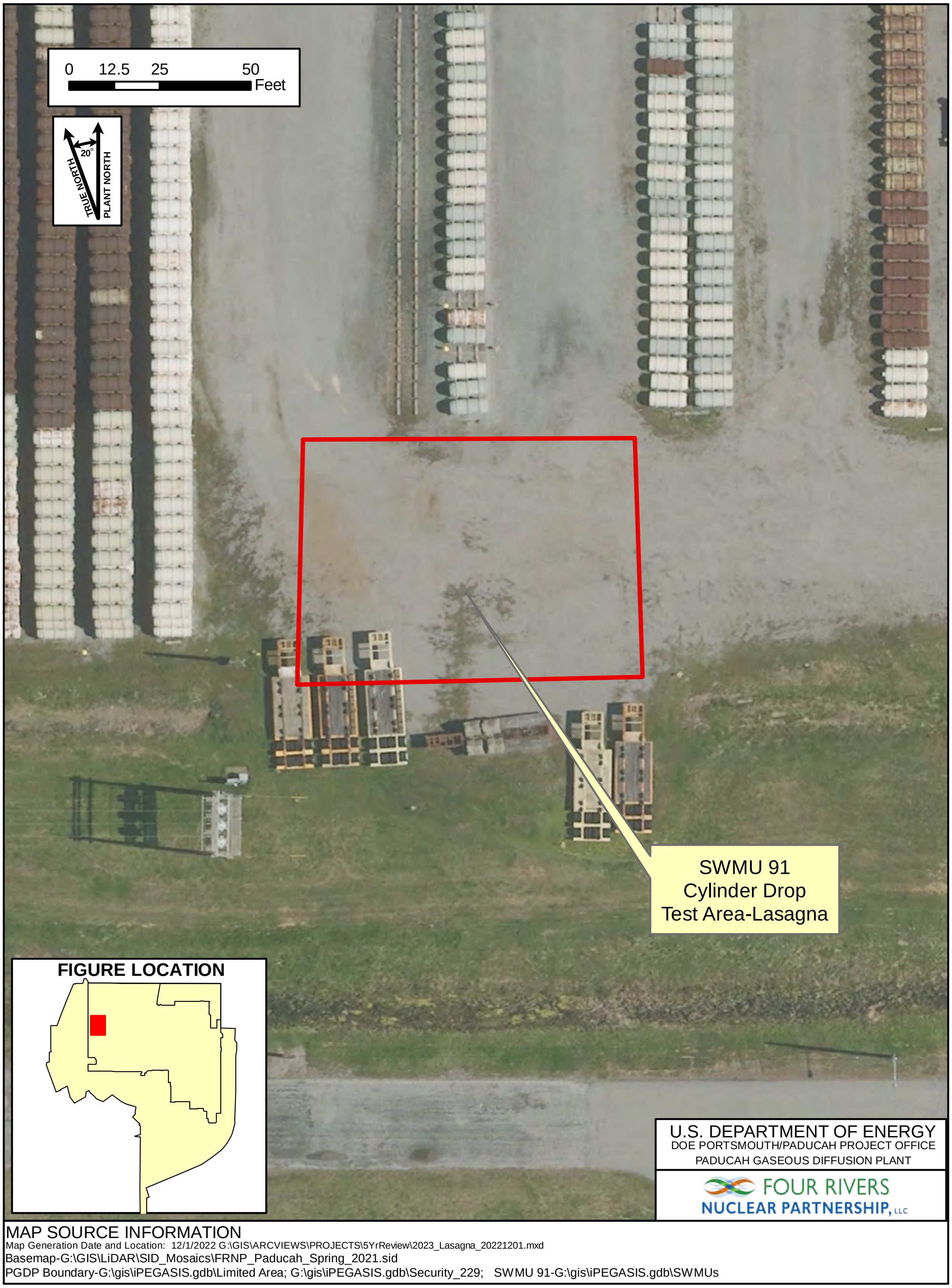


Figure 7.1. Location of Cylinder Drop Test Area

for the remedy selection. The remedy consisted of the treatment of contaminated soil pore water by the Lasagna^{TM} electroosmosis technology. The RAO was to mitigate migration of TCE beyond the SWMU boundary through the groundwater by the soil leaching pathway. Reduction of the concentration of TCE in soil to at least 5.6 mg/kg, reduced the potential for future releases to groundwater that could pose a threat to human health and the environment at the nearest point of exposure (POE) in groundwater. The following are the specific components of the selected remedy (DOE 1998a).

- Treatment zones that contain reagents that either decompose the TCE to nontoxic products or adsorb the TCE and make it immobile.

- Electrodes (a cathode and an anode) that, when energized, move contaminants (i.e., TCE) into or through the treatment zones and heat the soil. The contaminated water in the soil pores flows from the anode, through treatment zones, and toward the cathode.

- A water management system that recycles and returns the water that accumulates at the cathode back to the anode for acid-base neutralization.

The ROD specified that the Lasagna^{TM} system operate for two years, but, if necessary to meet the cleanup objectives, the operation might be continued until cleanup levels are reached. The ROD also included a contingency action to use *in situ* enhanced soil mixing in the event that the Lasagna^{TM} technology by itself was incapable of achieving cleanup objectives. Additional information regarding the selected remedy is presented in the ROD for the Cylinder Drop Test Area (DOE 1998a).

7.2 REMEDY IMPLEMENTATION

All phases of the Lasagna^{TM} technology demonstration have been completed. In March 1999, a contract was awarded for the installation and operation of the full-scale remediation (Phase IIb) using the Lasagna^{TM} technology. The remedial design report (RDR) to support construction was issued in May 1999 and construction began in August 1999. The construction was completed and operations began in December 1999. The *Post-Construction Report for the Lasagna^{TM} Phase IIb In-situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1856&D1, documents the remedial construction process (DOE 2000b). The construction phase also included collection of soil samples to establish a baseline of contamination in the system area prior to remediation.

The remedial system operated from December 1999 through December 2001. The results of post-cleanup verification sampling indicated the average concentration of TCE was 0.38 mg/kg, with a maximum concentration of 4 mg/kg. The Lasagna^{TM} RA reduced the TCE soil concentrations well below the RAO of 5.6 mg/kg average concentration.

The system operated continuously for the first several months. After the soil temperature reached 194°F, the system was put into pulse mode to prevent overheating of the soil. Pulse-mode operations consisted of energizing the system for one to four days and then shutting it down for several days to allow the soil to cool. Soil samples were collected in August 2000 and in August 2001. Due to mechanical problems, the system was shut down for approximately eight weeks beginning in August 2001. A number of additional operational problems were encountered during the operational phase and are detailed in the *Final Remedial Action Report for Lasagna^{TM} Phase IIb In-situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2037&D1 (DOE 2002b). The Commonwealth of Kentucky and EPA approved the final RA report on October 31, 2002.

Lasagna™ verification sampling and analysis were conducted in April 2003 and confirmed that the remediation objective was met. Details of the Lasagna™ verification sampling and analysis are included in the *Addendum to the Final Remedial Action Report for Lasagna™ Phase IIb In-Situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2037&D1/R1 (DOE 2003b).

The Lasagna™ equipment and site were demobilized on September 30, 2002. The remediation site has been returned to its original condition. The total cost of the implementation of the Lasagna™ remediation (i.e., post-ROD activities) was $3.96M (DOE 2002b).

7.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

There is no O&M for this remedy.

7.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The remedy for the Cylinder Drop Test Area remains protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk, such as groundwater, are being controlled [e.g., Water Policy (DOE 1994b)].

There were no issues or recommendations for the Cylinder Drop Test Area in the 2018 Five-Year Review. The site remains unchanged since the performance of the 2018 Five-Year Review, and no new actions have occurred.

7.5 SITE INSPECTION

A site inspection was conducted on December 6, 2022, by the five-year review team, the facility manager, and a representative from DOE's support contractor. The site includes bare ground with some grass area south of the C-745-B Cylinder Yard: part of the area underlies a portion of the gravel cylinder yard. No construction or operations activities were being conducted at the time of the site inspection, and no erosion or disrepair was noted for the area.

7.6 TECHNICAL ASSESSMENT

The remedy was designed to be protective of future groundwater use (from the RGA) at the fence line of the facility by meeting the TCE MCL value of 5 μg/L. The MCL for TCE remains at 5 μg/L.

The residual concentrations of TCE in soil (post-remediation verification sampling) were an average 0.38 mg/kg, less than one-tenth of the original level calculated to be protective of groundwater in the ROD, with a maximum of 4.5 mg/kg (DOE 2002b); therefore, the remedy employed is protective. No additional post-remediation sampling and analysis have been performed since the completion of the RA.

7.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy is functioning as designed. The reduction of TCE concentrations in soil is protective of future groundwater use at the nearest POE.

In 2011, EPA revised the cancer slope factors and toxicity data for TCE. The 2011 Paducah Site NFA level was based on a more conservative KDEP cancer slope factor and had an industrial screening value of 0.0619 mg/kg for the excavation worker at 1E-06 (DOE 2011b). Using these screening levels, the mean concentration corresponds to 6E-06 risk using the Paducah Site/KDEP value. The maximum value at the Cylinder Drop Test Area corresponds to 6.5E-06 risk using this same value. Based on a comparison of the 2022 Paducah Site screening values (i.e., 2.26 mg/kg for toxicity and 30.9 mg/kg for cancer using the EPA slope factor and excavation worker exposure factors) and the measured concentrations of TCE in soil after the remediation was completed, the effectiveness of the remedy for soil remains protective for future groundwater use at the fence line of the facility.

7.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. DOE remains in control of the property that the Cylinder Drop Test Area encompasses, and the land use remains industrial with no groundwater use on DOE property. The facility's excavation/penetration permit program requires formal authorization prior to performance of all excavations and other intrusive activities; therefore, the exposure assumptions used in the ROD remain valid.

The soil cleanup level (Table 7.1) established in the ROD to be protective of groundwater at the POE was met.

Table 7.1. Chemical-Specific Standards for the Cylinder Drop Test Area LasagnaTM Technology Demonstration

Contaminant	Media	Cleanup Level	Basis
TCE	Soil	5.6 mg/kg	MCL of 5 μg/L at POE

There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected (see Section 7.6.1).

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in advisories, criteria, or guidance identified as to be considered (TBC) in the ROD that impact the protectiveness of the remedy.

The RAO used at the time of remedy selection still is valid.

7.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

There have been no new contaminants or new understanding of geologic conditions identified. No other information has come to light that would call into question the protectiveness of the remedy.

7.7 ISSUES

None.

THIS PAGE INTENTIONALLY LEFT BLANK

8. WATER POLICY

Upon detecting TCE and Tc-99 in private wells located north of the Paducah Site in August 1988, DOE immediately placed potentially affected residences/businesses on alternate water supplies and began an intensive monitoring and investigation program to define the extent and temporal variations of the groundwater contaminant plumes. DOE developed the Paducah Site Water Policy in accordance with the *Engineering Evaluation/Cost Analysis for the Water Policy at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1142&D3, (DOE 1993b), and the *Action Memorandum for the Water Policy at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/06-1201&D2 (DOE 1994b).

The actions associated with the remedy selections of the Northwest and Northeast Plumes (SWMUs 201 and 202, respectively) mitigate the continued migration of the higher concentration portion of the plumes. The Water Policy response action is to minimize the potential threat to human health and welfare resulting from exposure to the chemical and radiological contaminants in the groundwater.

No significant changes have occurred during the 2018 through 2022 period.

8.1 REMEDY SELECTION

The Paducah Site Water Policy states, "It is the intent of the PGDP Environmental Restoration Program to offer municipal water service in accordance with this Policy to all existing private residences and businesses within the projected migration area of the contaminated groundwater originating at PGDP (affected area)." With the adoption of the Water Policy, DOE focused its groundwater monitoring program on the Water Policy Box and adjacent areas that might be affected if and when the plume migrates or expands. Figure 8.1 is a map of the 5 µg/L TCE groundwater contaminant plume boundaries (adapted from the 2022 *Water Policy Educational Fact Sheet* mailer) and the Water Policy Box affected area as of 2022.

In June 1994, DOE signed the AM for the Water Policy (DOE 1994b). The AM contains the following regarding the purpose of the Water Policy:

> The purpose of long-term remedial action is to eliminate, reduce, or control risks to human health and the environment. Implementation of this removal action is consistent with that purpose. Potential threats to public health require attention prior to initiation of long term remediation. This action prohibits exposure to contaminated water from residential wells until a permanent remedy has been successfully completed, or other actions have formally been deemed appropriate.[9]

The AM included the following conditions.

- DOE offered to provide municipal water to all existing residences and businesses within the affected area surrounding the Paducah Site. They also offered to pay for installation of water supply mains and connection of those residences and businesses that were not connected to a public water supply at that time. These residences and businesses were responsible for cooperating and working with Paducah Water to connect the water supply.

[9] It should be noted that signing of the agreement is voluntary, and that 81% of parcels in the Water Policy Box affected area are covered by a Water Policy license agreement that specifies that the property owner will not drill new water supply wells or use existing water wells.

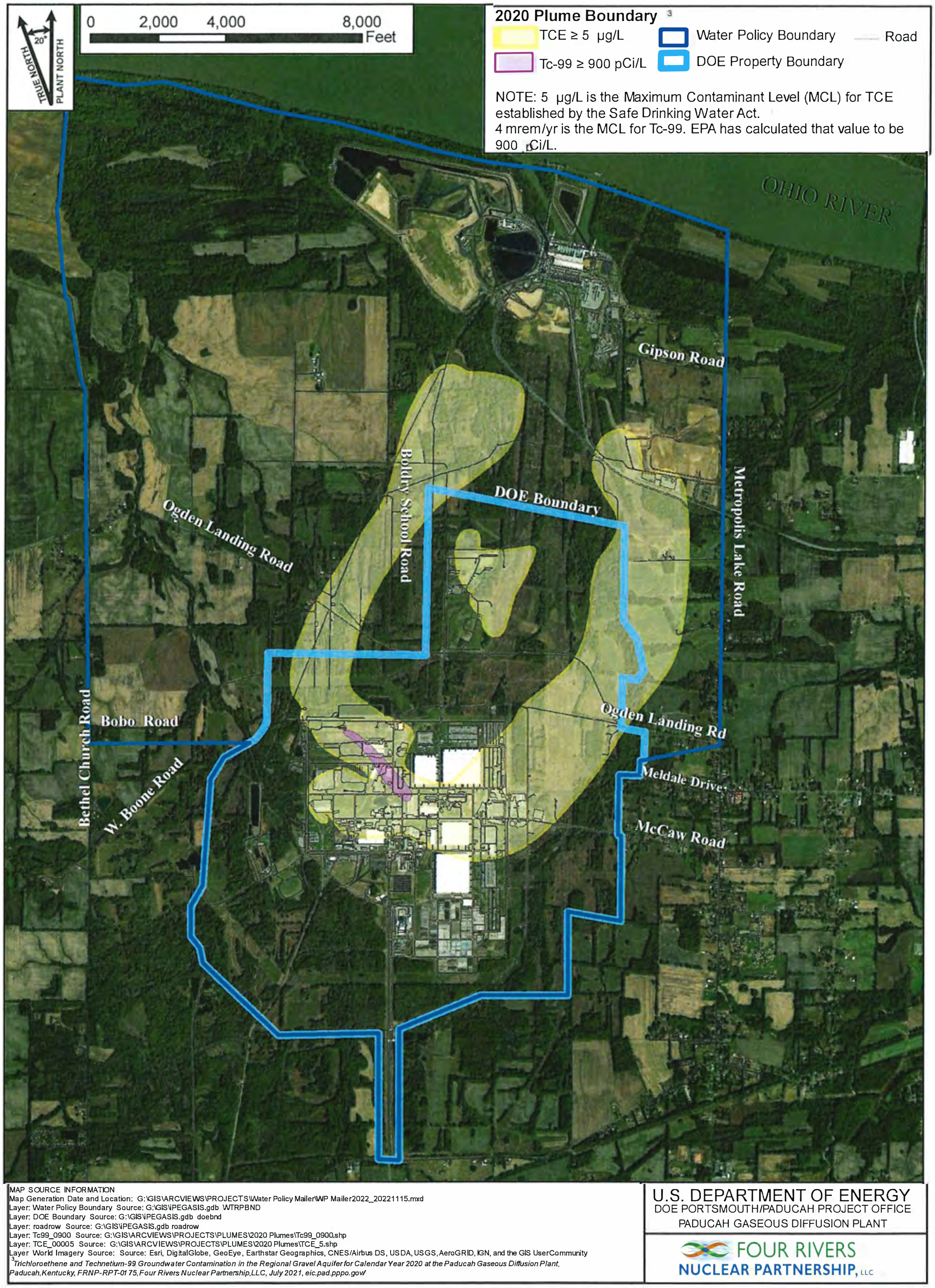


Figure 8.1. Location of Water Policy Boundary Relative to DOE Site and Contaminant Plumes

- DOE offered to pay the reasonable costs of water bills in the affected area. The definition of "reasonable cost of water consumption" for residents was based on the historical usage of each owner's well. Water usage increases caused by increases in agricultural water use, livestock water use, or subdivision of property were not to have been reimbursed.

- Each household or business in the Water Policy Box (affected area) was asked to sign a water policy license agreement with DOE that delineated the responsibilities of each property owner and DOE. The agreements specify that the property owner will not drill new water supply wells or use existing water wells, and that Paducah Site personnel are permitted access to the property for sampling purposes. Paducah Site personnel installed locks to prevent unauthorized use of the existing water wells.

- DOE samples existing residential water supply wells and MWs to track migration of groundwater contaminant plumes. Additional MWs are installed as required for other environmental restoration programs.

The engineering evaluation/cost analysis also specified the need to conduct a five-year review (DOE 1993b).

8.2 REMEDY IMPLEMENTATION

DOE has obtained Water Policy license agreements covering 81% of the parcels located within the Water Policy Box affected area. Paducah Water records indicate that all residents have chosen to use municipal water; however, some property owners have chosen not to sign the water policy license agreements. The following approach was implemented to manage the DOE Water Policy.

- Water bills are reviewed monthly looking for abnormal bills and property owners are notified by mail of any water bills that are considered to be above reasonable water cost.

- A comprehensive review of the parcels in the Water Policy Box affected area is conducted twice a year using the website for the McCracken County Property Valuation Administrator's office. The website is also accessed several times per year to determine property ownership and recent sales.

- An inspection program of the caps and locks installed on residential wells on properties with a license agreement verifies the wells are nonoperational.

- As license agreements are set to expire, property owners are contacted prior to the expiration date to request a renewal of the license agreement.

- At this time, DOE has approved all requests from new residents/business within the Water Policy Box affected area for DOE to pay water bills. The AM states that new residences and businesses that are offered access to a municipal water supply at their own expense within the affected area will not be provided free water under this policy, and that exceptions to this policy may be made on a case-by-case basis.

8.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

DOE paid for water supply line extensions of the West McCracken Water District, which is Paducah Water as of February 2022, into the Water Policy Box. Total capital construction cost for implementation of the Water Policy was $1,027,781. The average annual cost to implement the Water Policy program is $175K.

This includes an average of $88K for annual water bill payments, $90K for annual management of the program, and $12K for land access and/or monitoring rights for sampling wells on private property. This sampling is for monitoring groundwater inside the Water Policy Box via DOE-owned and installed groundwater MWs or sampling of privately owned residential wells that are located outside the Water Policy Box affected area. The estimated annual cost for sampling associated with this remedy is approximately $37K.

DOE regularly collects groundwater samples from the area in the Water Policy Box and expanded the residential well monitoring from 2008. Seven northeastern residential wells are sampled annually; and 8 northwestern residential wells and 14 northwestern MWs are sampled quarterly (DOE 2021a, DOE 2021b). The interval of sampling of each well within the Water Policy Box affected area has been adjusted to characterize temporal variations within the plumes and to confirm migration paths near the northwestern and northeastern boundaries. DOE reports the results of groundwater monitoring in its Annual Site Environmental Report.

8.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

In the *Memorandum of Agreement for Resolution of the Informal Dispute Concerning US. Environmental Protection Agency and Kentucky Department for Environmental Protection Requirements for Additional Actions or Modifications Regarding the CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2426&D2*, the FFA parties agreed that the protectiveness determination for Water Policy would be re-evaluated as part of the 2023 Five-Year Review (DOE 2020). The following eight issues and recommendations were addressed in response.

1) Issue: DOE written commitment to expansion of the Water Policy Education Fact Sheet distribution list for the next (2Q FY 2020) annual mailing, and in subsequent years, beyond the residents and businesses in the Water Policy to include trusted individuals and information sources in the broader community.

   Resolution: DOE established a revised distribution list for the Water Policy Education Fact Sheet that will be utilized for future updates of the fact sheet that included the following information. Additionally, a direct link to the most current Water Policy Education Fact Sheet has been provided on the Environmental Information Center website (https://eic.pad.pppo.gov/) to enhance accessibility for the public. The revised distribution list (effective 2Q FY 2020) now includes the following:

   - All residences and businesses within the Water Policy affected area;
   - Owners of property within the Water Policy affected area who do not reside at the property;
   - Paducah CAB members (contact list provided through the CAB office);
   - Local elected officials and city contact (see Community Relations Plan, Appendix C); and
   - PGDP Reading File maintained by the McCracken County Library Special Collections.

2) Issue: DOE provision (as Official Use Only) of the annual Water Policy Due Diligence Report by December 30, 2019, to EPA and KDEP for review and subsequent DOE

provision of a briefing on the report to the regulatory agencies no later than January 30, 2020.

Resolution: DOE added a Water Policy section to the FFA Semiannual Progress Report for communication and documentation of activities related to the Water Policy. The FFA Semiannual Progress Report is updated every six months (April and October) and will include Water Policy reporting starting in April 2020.

3) Issue: DOE preparation and submittal of a Water Policy removal action work plan proposing a revised residential well and MW sampling proposal for EPA and KDEP review.

   Resolution: DOE will incorporate elements of the Water Policy boundary monitoring currently conducted under the Paducah Site Environmental Monitoring Plan into the Northeast and Northwest Plumes O&M plans and submit the revised documents to EPA and KDEP in FY 2020 in lieu of developing a removal action work plan for the Water Policy. Data generated in support of Water Policy monitoring will be made available in the PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS) and a summary reported in the FFA Semiannual Progress Report for use in evaluating continued protectiveness in support of future Five-Year Reviews.

4) Issue: Provide appropriate documentation to demonstrate that efforts have been made to contact households in the Water Policy affected area and to document well usage status. This documentation should be updated on a regular basis.

   Resolution: DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE implementation, and regulatory agency understanding, of the Water Policy, in support of future Five-Year Reviews. The documentation and discussion satisfied the condition.

5) Issue: Consider cost offsets.

   Resolution: During dispute resolution discussions, KDEP and EPA were advised that the DOE Portsmouth-Paducah Project Office is actively pursuing license agreements for payment of monthly water bills to all residential and business addresses in the Water Policy affected area. It was also discussed that some residents refuse for DOE to pay their water bills and/or refuse to sign license agreements. These discussions satisfied the condition.

6) Issue: Implement a Public Awareness Campaign that employs multiple communication efforts (such as well lock contact tags), especially for residents that have not signed license agreements, to verify that existing wells are not being used for primary or secondary sources.

   Resolution: DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE's implementation, and regulatory agency understanding, of the Water Policy and to support future Five-Year Reviews. See also the resolutions to EPA additional actions. This documentation and discussion satisfied the condition.

7) Issue: Compile a consolidated Water Policy Occupant list that includes the property owner(s), license status, municipal water costs offset status, and shortest distance to the TCE plume by December 31, 2019.

Resolution: DOE compiled and shared lists of addresses and license status to enhance regulatory agency understanding of DOE's implementation of the Water Policy and to support future Five-Year Reviews. This documentation and discussion satisfied the condition.

8) Issue: Develop a consolidated, management-approved, standard set of procedures that will be followed to ensure that exposure to contaminated groundwater is not occurring.

   Resolution: DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE's implementation, and regulatory agency understanding, of the Water Policy and to support future Five-Year Reviews. This documentation and discussion satisfied the condition.

DOE has completed the following actions.

- The annual *Water Policy Educational Fact Sheet* mailer was mailed to all residents and businesses within the Water Policy affected area; owners of property within the Water Policy affected area who do not reside on the property; Paducah CAB members; local elected officials and city contacts; and the PGDP Reading File maintained at the McCracken County Library. The *Water Policy Educational Fact Sheet* mailer was sent to the expanded distribution list in March 2020, 2021, and 2022. Additionally, a direct link to the most current *Water Policy Educational Fact Sheet* mailer has been provided on the Environmental Information Center website (https://eic.pad.pppo.gov/) to enhance accessibility for the public.

- DOE and its D&R contractor conducted a briefing on the Water Policy Due Diligence report on December 18, 2019, and the Water Policy program has been included in the FFA Semiannual Report since April 2020.

- DOE incorporated elements of the Water Policy boundary monitoring currently conducted under the Paducah Site Environmental Monitoring Plan into the Northeast and Northwest Plumes O&M plans. Data generated in support of Water Policy monitoring has be made available in PEGASIS and a summary reported in the FFA Semiannual Progress Report for use in evaluating continued protectiveness.

- Procedures have been drafted to describe the implementation of the Water Policy program. These procedures include CP4-ES-1013, *Water Policy Management*, and CP1-ES-0065, *Guidelines to Manage Water Bills for Water Policy Landowners*.

- The list of properties and property owners within the Water Policy affected area were reviewed and will continue to be reviewed semiannually to look for any changes in parcels or property owners.

- Multiple Water Policy license agreements were distributed; the percentage of parcels covered by a Water Policy license agreement increased to 81%.

8.5 SITE INSPECTION

The site inspection was conducted December 7, 2022, by members of the Five-Year Review team, representatives from DOE's support contractor, and KDEP. A drive through the Water Policy affected area looking for any changes or observances of possible water well usage was performed. None were noted.

8.6 TECHNICAL ASSESSMENT

The primary objective of the removal action is to minimize the potential threat to human health and welfare resulting from exposure to the chemical and radiological contaminants in the groundwater.

The removal action is supported by municipal water service being offered to all existing residences and businesses within the Water Policy Box affected area and provisions included in the Water Policy license agreements that specify that the resident or business may not install new water supply wells or use existing water wells. This provision in the Water Policy license agreements is supported by the residential well cap and lock program which monitors for unauthorized use of the existing water wells.

- A license agreement review was conducted as part of the technical assessment. One hundred of 124 parcels of land are covered by a Water Policy license agreement. There are 24 parcels without a license agreement, explained as follows.

  — Four parcels have new property owners.
  — One property owner declined DOE payment of the water bill.
  — Four parcels have property owners who have declined license agreement.
  — One parcel is a former church site.
  — One parcel is a cemetery
  — One parcel is owned and managed by the Kentucky Nature Preserves Commission.
  — Three parcels are vacant lots.
  — Nine parcels have unresponsive property owners.

- Water meters within the Water Policy Box affected area were reviewed with Paducah Water to determine if residences were using municipal water. All residences within the Water Policy Box affected area are using municipal water.

- As stated in Section 8.4, the *Water Policy Educational Fact Sheet* mailer was sent out in March 2018, 2019, 2020, 2021, and 2022. The mailer was sent to the expanded distribution list in March 2020, 2021, and 2022.

- The residential well inspection program was maintained to ensure that wells are not used as a source of water in the Water Policy Box affected area. An inspection program checks residential wells on properties that have a license agreement to ensure that they remain nonoperational.

- Water bills were reviewed monthly to identify any changes in usage per procedure. Water bills were reviewed to identify any decrease in usage that could suggest a resident's change from use of municipal water to groundwater. A review of water bill data shows continuing use of municipal water and no decrease that would suggest a resident's use of groundwater for all potentially affected properties.

- For properties situated over the 5 μg/L or greater TCE plumes, records were reviewed to determine whether those parcels had residential wells, DOE caps and locks, and/or license agreements.

- The Kentucky water well database was reviewed to ensure no additional groundwater wells had been installed. No installations of new wells have been reported within the Water Policy Box affected area. The database may be accessed using the following link: http://kgs.uky.edu/kgsweb/datasearching/Water/WaterWellSearch.asp. The monitoring of groundwater in and around the Water Policy Box affected area confirms that the groundwater plumes have not migrated beyond the current Water Policy Box at the MCL for the COCs and indicates that the current Water Policy still is protective.

8.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The Water Policy removal action is meeting the objectives specified in the AM by providing municipal water to the residents of the Water Policy Box affected area. The action continues to eliminate the exposure pathway to the groundwater, which is supported by monthly water usage data provided by Paducah Water, indicating that residents are utilizing the municipal water. An annual *Water Policy Educational Fact Sheet* mailer is sent to all addresses within the Water Policy Box affected area to ensure that all residents and property owners are educated about the potential contamination in their groundwater.

8.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. The exposure assumptions used in the AM remain valid. There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected. There have been no new contaminants identified.

The current groundwater data indicate that assumptions underlying the remedy selection still are valid.

No cleanup levels were established in the AM because the scope of the removal action was to supply potable water to residences and businesses within the area surrounding the Paducah Site that could be affected by migration of groundwater contamination originating from the facility. The purpose of this action is to reduce any potential public health hazard that might result from exposure to groundwater contaminants.

There are no changes in standards identified as ARARs in the AM that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in TBCs identified in the AM that impact the protectiveness of the remedy.

The RAO used at the time of remedy selection still is valid.

8.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No. The remedy remains protective by providing municipal water to the residents of the Water Policy Box affected area. Monitoring data demonstrate that the plume has not migrated beyond the Water Policy Box.

No other information has come to light that would call into question the protectiveness of the remedy.

8.6.4 Technical Assessment Summary

The Water Policy Box eliminates potential pathways of exposure to the public by providing municipal water to potentially affected residents and businesses within the Water Policy Box affected area. The Water Policy remains effective for the purpose for which it was intended.

8.7 ISSUES

Information obtained during the last five years demonstrates that the Tc-99 plume no longer exists at concentrations exceeding the Tc-99 MCL in areas off of DOE property and that the TCE plumes have reduced concentrations and areal extent in areas off of DOE property. Sources of relevant TCE and Tc-99 plume information that support these reductions are as follows: (1) results of monitoring plume concentrations and changes in those concentrations; (2) changes in plume extent as shown in biennial plume map reports; (3) information and findings on groundwater flow and concentration trends evaluated as part of the sitewide groundwater strategy; (4) insights developed from updates to the sitewide groundwater flow and fate and transport models; and (5) results of plume stability analyses. DOE will develop a technical paper using relevant TCE and Tc-99 plume information to better understand the status of the Water Policy action and whether an optimization of the Water Policy action is warranted.

THIS PAGE INTENTIONALLY LEFT BLANK

9. C-400 ELECTRICAL RESISTANCE HEATING

The C-400 Cleaning Building is located near the center of the industrial section of the Paducah Site. The building 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 9.1 shows the location of the C-400 Cleaning Building and immediate area.

Historically, some of the primary activities associated with the C-400 Cleaning Building have been cleaning machinery parts, decontaminating the interiors of used UF_6 cylinders, disassembling and testing cascade components, and laundering work clothes. The building also has housed various other processes and activities, including recovery of precious metals and treatment of radiological waste streams.

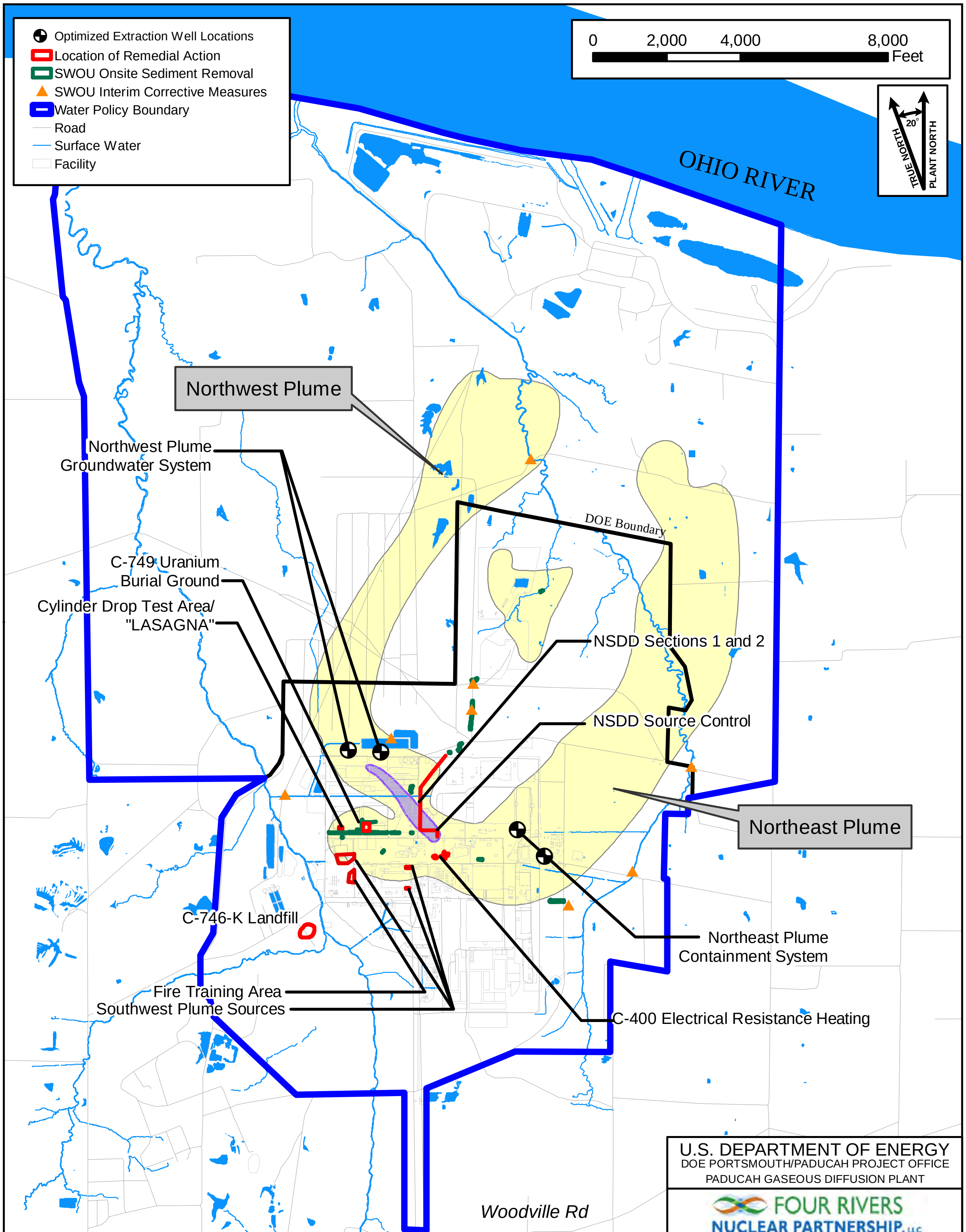
In June 1986, a routine construction excavation along the 11th Street storm sewer revealed TCE soil contamination. The cause of the contamination was determined to be a leak in a storm sewer that received drainage from the C-400 Cleaning Building's basement sump. The area of contamination became known as the C-400 TCE Leak Site and was given the designation of SWMU 11. The C-400 TCE Leak Site and the C-400 Cleaning Building has been the subject of several investigations since then. Significant occurrences of TCE-contaminated soil and groundwater were detected in 1997 during the WAG 6 RI. A second RI of the C-400 area (the C-400 Complex OU RI) occurred from 2019 through 2021, which fully delineated the C-400 TCE source zones (DOE 2022c). Some results indicated the presence of TCE as DNAPL. TCE was identified in three hydrostratigraphic units: the UCRS, the RGA, and the upper part of the underlying McNairy Formation. At C-400, the UCRS extends from surface to approximately 46 ft to 61 ft bgs. The RGA extends from the bottom of the UCRS to the top of the McNairy, with a thickness range of approximately 30 ft to 45 ft.

After the discovery of the C-400 TCE Leak Site in June 1986, some of the soils were excavated in an attempt to reduce the contamination in the area. Approximately 12 yd^3 of TCE-contaminated soil was drummed for off-site disposal. The excavation was backfilled with clean soil, and the area was capped with a layer of clay. A 2003 Six-Phase Heating Treatability Study removed over 22,000 lb of TCE (approximately 1,900 gal) from the subsurface in a 43-ft diameter treatment area near the southeast corner of the C-400 Cleaning Building (Figure 9.2). Approximately 5,378 yd^3 of contaminated soil and subsurface aquifer were treated.

9.1 C-400 CLEANING BUILDING REMEDIATION ACTIVITIES

The success of the Six-Phase Heating Treatability Study conducted in 2003 resulted in an interim ROD, signed in 2005, which required mass removal of TCE source material within the UCRS and RGA using ERH. The scope of the interim remedy for the C-400 source action was limited to accessible areas located around the outside perimeter of the east and southwest portions of the C-400 Cleaning Building due to ongoing USEC operations at that time that occupied the C-400 Cleaning Building.

Implementation of the ERH remedy was designed using a two-phase approach. Phase I was completed in 2010 and focused on selected treatment areas around C-400 (east and southwest areas) where the majority of the TCE was confined to the UCRS. Phase I removed a combined total of approximately 6,525 lb of TCE (535 gal) from the east and southwest treatment areas (Figure 9.2).



MAP SOURCE INFORMATION
Map Generation Date and Location: 5/4/2023 G:\GIS\ARCVIEWS\PROJECTS\5YrReview\2023_5YR_Locations_20230504.mxd
Extraction Wells-G:\GIS\iPEGASIS.gdb\Locations; Surface Water-G:\GIS\iPEGASIS.gdb\streams; G:\GIS\iPEGASIS.gdb\surface_water; G:\GIS\SHAPES\STREAMS\river.shp; DOE Boundary-G:\gis\iPEGASIS.gdb\doebnd; Roads-G:\GIS\SHAPES\ROADS\mccracken_tiger_roads.shp; SWMUs-G:\GIS\iPEGASIS.gdb\SWMUs; ICM Signs-g:\gis\shapes\stations\ICSWsigns_2011.shp; NSDD-G:\GIS\SHAPES\STREAMS \ northsouthditch.shp; Water Policy Boundary-G:\GIS\iPEGASIS.gdb\WTRPBND; Plumes-G:\GIS\ARCVIEWS\PROJECTS\PLUMES\2020 Plumes\Tc99_0900.shp and G:\GIS\ARCVIEWS\PROJECTS\PLUMES\2020 Plumes\TCE_5.shp; Areas of Excavation-G:\GIS\SHAPES\STATIONS\NSDD_05_EU08.shp, ...\NSDD_03_EU02_03.shp, ...\NSDD_03_EU01_02.shp, ...\Outfall015_EU02_03_04_07_08_ExcavLimits.shp, ...\Outfall011_EU01_ExcavationLimits.shp, ...\Outfalls010_EU10_ExcavationLimits.shp, ...\Outfall008_EU11_ExcavationLimits.shp, ...\Outfalls001_EU10_ExcavationLimits.shp; ERH- G:\GIS\iPEGASIS.gdb\remediated_areas

Figure 9.1. Location of C-400 Cleaning Building

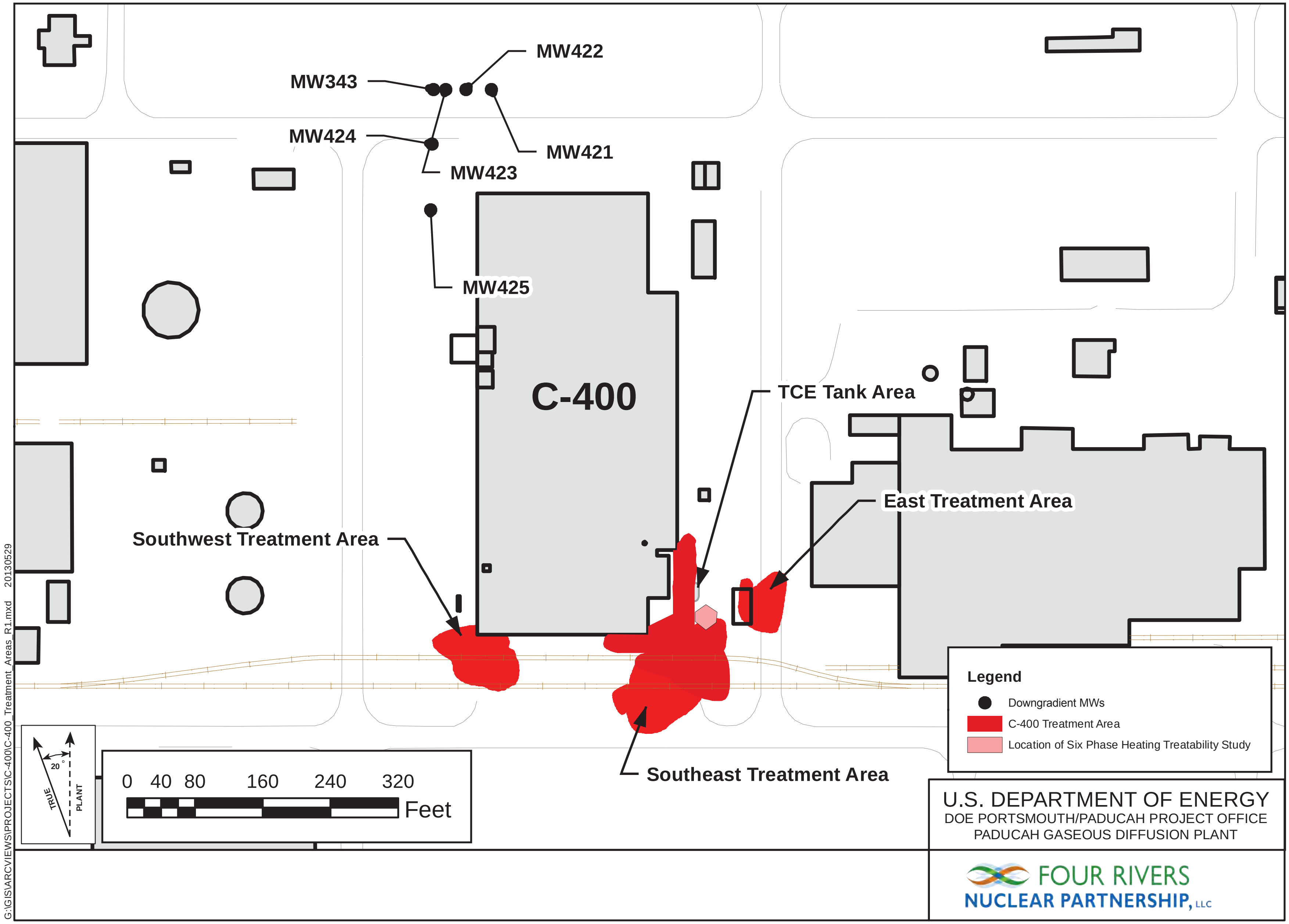


Figure 9.2. C-400 Treatment Areas

An important objective of Phase I was to evaluate the heating performance of the ERH design in the underlying RGA down to the McNairy Formation in the southwest treatment area. During implementation of Phase I, temperature goals were not attained in the lower RGA in the southwest treatment area. Because of the inability of ERH to reach target temperatures in the lower RGA without significant changes to the base design, the FFA parties agreed to divide Phase II (southeast area) 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 successfully in fall of 2014. Phase IIa removed approximately 13,871 lb of TCE (1,137 gal) from the southeast treatment area.

To help evaluate applicable technologies for potential use in the lower RGA in the Phase IIb area, a steam treatability study was performed in 2015 to obtain data specific to understanding the behavior of steam injected into the RGA under variable injection scenarios. The steam treatability study report—*Treatability Study Report for the C-400 Interim Remedial Action Phase IIb Steam Injection Treatability Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2202&D2, (DOE 2016b)—demonstrated that the technology would be technically implementable in the hydrogeological conditions tested, although several uncertainties remained regarding the full nature and extent of the Phase II source area, particularly whether a portion of the source extends beneath the C-400 Cleaning Building and whether contamination was mobilized upgradient or downgradient of the study area.

Prior to moving forward with the implementation of the IRA, DOE approached EPA and the Commonwealth of Kentucky Energy and Environment Cabinet and proposed reprioritization of the DOE mission at the Paducah Site based on the return of the enrichment facilities (including C-400); the need to perform work in a comprehensive manner at the C-400 Complex; and the expected impacts of anticipated future funding limitations across the DOE Complex. In June 2016, DOE provided a written proposal for the entire C-400 Complex that included acceleration of the investigation and cleanup of the C-400 Complex for all sources of contamination associated with and underlying the C-400 Cleaning Building. This action would address the remaining VOC source in the Phase IIb area.

On August 8, 2017, the FFA senior managers signed an MOA for the C-400 Complex that is being implemented as a separate OU identified as the C-400 Complex OU (DOE 2017a).

On September 28, 2017, the FFA senior managers signed a second MOA agreeing that the C-400 Cleaning Building IRA ROD was complete, resolving a 2016 formal dispute (DOE 2017b). As a result, the prior work performed under the C-400 IRA for Phase I and Phase IIa was documented in a RACR for the C-400 IRA (DOE 2018c).

9.2 REMEDY SELECTION

Following the WAG 6 RI (DOE 1999a) and the GWOU FS (DOE 2001a), a ROD was finalized for an IRA at C-400, *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*, DOE/OR/07-2150&D2/R2 (DOE 2005a). The ROD determined that TCE (as DNAPL and dissolved-phase) is present in the UCRS and the RGA within the footprint of the C-400 Cleaning Building area, and is considered a principal threat source material. The ROD also documented the selection of ERH as the preferred technology to address the source area contaminated with TCE and other VOCs.

The C-400 ERH action included the design, installation, operation, and subsequent decommissioning of ERH systems to heat discrete (vertical and horizontal) intervals of the subsurface source zone resulting in volatilization, removal, and recovery of VOCs from the C-400 treatment area. The remediation goal for this interim action, as documented in the ROD, was to operate the ERH system until monitoring indicated that heating had stabilized in the subsurface and that recovery of TCE, as measured in the recovered vapor, diminished to a point at which the recovery rate was constant (i.e., recovery is asymptotic) (DOE 2005a). The following were the major components of the selected remedy:

- An RDSI to delineate further the areal and vertical extent of the contamination in the C-400 Cleaning Building area to optimize design of the remedial system;

- Removal and treatment of TCE and other VOCs from the contaminant source zone in the UCRS and RGA at the C-400 Cleaning Building area using ERH. The operation of ERH would cease when monitoring indicates that heating had stabilized in the subsurface and when recovery diminished to a point at which the rate of removal of TCE, as measured in the recovered vapor, became asymptotic; and

- Implementation, maintenance, enforcement, and reporting of LUCs on the C-400 Cleaning Building area; and continuation of groundwater monitoring of the free-phase DNAPL and dissolved-phase plumes because some contamination would remain in place following the IRAs.

The ERH technology consisted of installing electrodes in the subsurface, energizing them, and heating the subsurface to volatilize contaminants in the groundwater and soil. The volatilized contaminants were captured by aboveground equipment and processed for disposal as hazardous waste.

The ROD stipulated that the LUCs include the following activities:

- Placement of Property Record Notices to alert anyone searching property records to the information about contamination and the interim response action for the C-400 Cleaning Building area. The language comprising the Property Record Notice would be filed with the McCracken County Clerk, in accordance with state law, within 120 days of regulatory approval of the Land Use Control Implementation Plan (LUCIP);

- Deed restrictions (1) to limit use of the property to industrial activities, (2) to prevent exposure of groundwater to industrial workers, and (3) to restrict drinking or other interest(s) being created in the DOE property that is the subject of this interim action, including but not limited to, liens, mortgages, leases, easements, licenses, profits, servitudes, covenants or life estates; or before any actual transfer of such property. Deed restrictions were to be recorded with the McCracken County Clerk, in accordance with applicable state and federal law;

- Administrative controls in the form of an "excavation/penetration permit program" that would require a worker to obtain formal authorization prior to excavating or performing other intrusive activities in the C-400 Cleaning Building area; and

- Access controls, as necessary, to ensure protectiveness following the RA.

The RAOs in the ROD were as follows:

- Prevent exposure to contaminated groundwater by on-site industrial workers through institutional controls (e.g., excavation/penetration permit program);

- Reduce VOC contamination (primarily TCE and its breakdown products) in UCRS soil at the C-400 Cleaning Building area to minimize the migration of these contaminants to RGA groundwater and to off-site points of exposure; and

- Reduce the extent and mass of the VOC source (primarily TCE and its breakdown products) in the RGA in the C-400 Cleaning Building area to reduce the migration of the VOC contaminants to off-site points of exposure.

9.3 REMEDY IMPLEMENTATION

The RDSI was completed in August 2006 and, coupled with data from previous investigations, delineated the areas of high TCE concentration more accurately, thereby allowing the design team to optimize placement of ERH electrodes, vapor recovery wells, and other subsurface components (DOE 2005b).

In 2007, DOE commissioned an independent technical review (ITR) of the C-400 90% RDR (ITR 2007). The 2007 ITR team consisted of subject matter experts from DOE, the environmental remediation field, and EPA. The ITR team published its report in October 2007, *Review Report: Building C-400 Thermal Treatment 90% Remedial Design Report and Site Investigation, PGDP, Paducah, Kentucky*, WSRC-STI-2007-00427 (ITR 2007). Observations and recommendations from ITR team members helped shape the final design and led to the phased deployment strategy.

Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, 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, DOE/LX/07-0005&D2/R1, was issued in July 2008 (DOE 2008a).[10] The design incorporated two phases to mitigate the risks and uncertainties associated with large-scale deployment of ERH in the highly permeable RGA.

Construction of Phase I was initiated in December 2008 and was completed in December 2009. Testing concluded in March 2010 and normal remedial operations were initiated. Operations continued through September 2010 when TCE concentrations in recovered vapor had dropped to asymptotic levels, at which time pulsed operations were initiated. Pulsed operations ended in October 2010 and power to the electrodes was turned off. Vapor extraction continued for approximately five weeks to facilitate subsurface cooling.

Phase I targeted the shallow UCRS formation (20–60 ft bgs) in the east and southwest treatment areas (Figure 9.2) with ERH and also served as a pilot test, in the southwest treatment area, to determine if ERH would be a viable technology to heat the lower RGA formation to the TCE/water co-boil target temperatures required to remediate source zones in the lower RGA.

Phase I data indicated that ERH was ineffective in treating the lower RGA based on the RDR criteria and that modifying the ERH design to overcome design deficiencies would be cost prohibitive (DOE 2008a). Therefore, the FFA parties decided to divide Phase II (Southeast Treatment Area) into two subphases (Phase IIa and Phase IIb). Phase IIa would target the UCRS and upper RGA soils (20–60 ft bgs) for ERH thermal treatment and Phase IIb would target the lower RGA for an alternate treatment technology to be based on future treatability studies.

Phase IIa construction began in September 2012 and was substantially complete in May 2013; at that time, start up and shakedown testing began. Testing was completed and operations commenced at the end of July 2013. Heating operations ceased (soil vapor extraction continued) in early October 2014, and all system operations ended on November 5, 2014.

[10] The C-400 LUCIP was issued in February 2008 and was included as an appendix to the C-400 RDR (DOE 2008a).

9.4 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

Phase IIa drilling and subsurface completion of ERH components (electrodes, multiphase EWs, temperature monitoring strings, vacuum piezometers, and water-level monitoring instruments) were completed in March 2013 (refer to Figure 9.3 for ERH well locations). The Soil Vapor and Groundwater Treatment System (SVGTS) modifications were completed in May 2013. System testing concluded on July 22, 2013, and normal operations began.

Normal operations continued until November 2013, at which time operational difficulties were experienced with the newly installed, steam-regenerated, carbon adsorption skid unit and unseasonably cold weather. Freezing temperatures resulted in extensive damage to system process piping, instrument sensing lines, valves, fitting, and other items, necessitating replacement or repair. Normal operations resumed January 14, 2014, and continued through July 2014 when TCE concentrations in recovered vapor had dropped to asymptotic levels.

Pulsed operations were initiated on July 28, 2014. The strategy for the pulsing operations was to maximize removal of the remaining contaminants from the Phase IIa treatment area by maximizing extraction from the wells and by varying the pressure levels within the subsurface. To maximize the extraction from individual wells, a pattern was initiated that consisted of operating half of the wells while the remaining half was shut down. To vary subsurface pressures, the extraction rates were reduced or increased concurrently with varying the power levels to the electrodes. The process then was repeated for two cycles. Pulsed operations ended on September 14, 2014, and power to the electrodes was turned off on October 9, 2014, to allow the subsurface to cool down. The SVGTS remained operational to continue mass removal during the cool down period. The SVGTS continued to operate through November 5, 2014, at which time operations ceased, and the RA portion of Phase IIa project was considered complete.

O&M activities during Phase IIa were conducted in accordance with the *Operations and Maintenance Plan for Phase IIa of 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/07-1285&D2 (2013b). The Phase IIa treatment system removed approximately 13,871 lb (1,137 gal) of TCE, at a cost of approximately $26.7M.

Phase IIa heating continued over a 341-day period prior to the commencement of pulsed operations. During that time, operation of the electrodes was interrupted (power failures and other system problems) for approximately 61 days (18% of the time). Temperature plots in the treatment areas document that the three most significant downtime events, occurring in September 2013, December 2013/January 2014, and February 2014, had an impact on heating and extended the time needed to reach target temperatures. Operation of the SVGTS was interrupted for approximately 125 days (37% of the time), primarily because of mechanical failure of system components due to freeze damage as a result of unseasonably cold weather events that occurred in late 2013/early 2014.

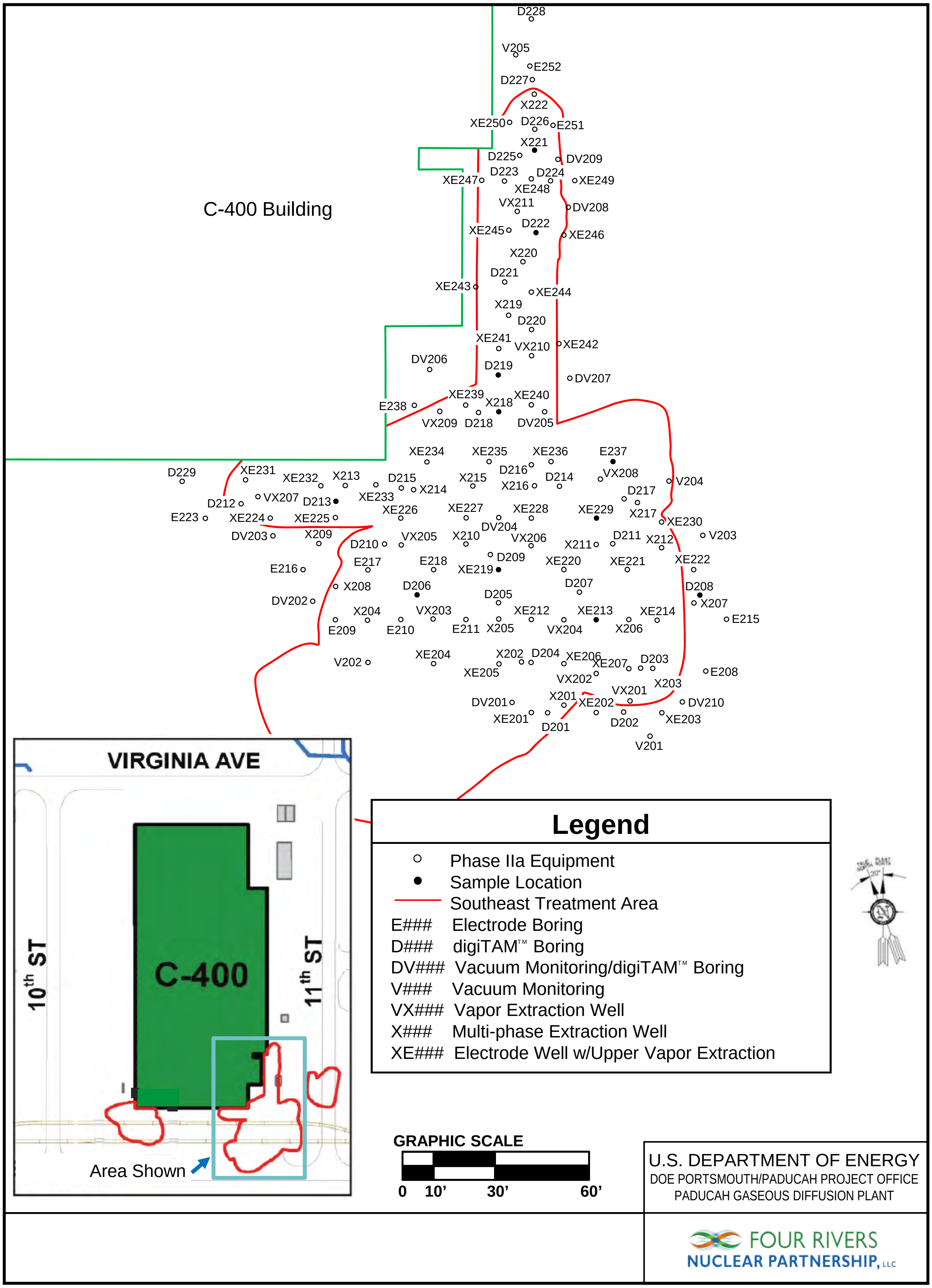


Figure 9.3. Southeast Area ERH Well Location Map

DOE completed the C-400 IRA remedy by executing the Phase IIa RA in the UCRS and upper RGA. In addition, DOE plugged and abandoned all ERH wells installed during Phase I and IIa. EWs and contingency wells were abandoned by over-drilling, extracting the well casing, and grouting the borehole from the bottom to the surface. All other ERH wells were abandoned by removing sensors, where present, and grouting the casing from the bottom to within 5 ft bgs with high-temperature cement grout. Where the ERH wells were constructed with fiberglass pipe, the shallow fiberglass pipe was pulled or perforated prior to grouting the well.

Electrodes were abandoned in place (per an EPA-approved Class IV Underground Injection Control well plugging procedure modification variance) by filling the upper 2 ft of the electrode boring with grout and cutting off the electrode water injection and return lines 2 ft bgs and plugging the lines with stainless steel screws.

Because Phase I showed that ERH was unable to reach target temperatures in the lower RGA without extensive changes to the base design, DOE, with the participation of the other FFA parties, conducted a steam treatability study to evaluate whether steam is a viable remedial alternative to treat the lower RGA (DOE 2013b). USEC shut down enrichment operations and returned control of the Paducah Site leased facilities to DOE in October 2014 and opened the door to performing a full RA at the C-400 Complex. The FFA parties agreed to terminate the IRA and initiate a full RA of the C-400 Complex OU, as outlined in the 2017 MOA (DOE 2017a).

9.5 PROGRESS SINCE LAST FIVE-YEAR REVIEW

A RACR was prepared in July 2018 that detailed the completion of Phase I and Phase IIa ERH activities (DOE 2018c). The RACR provides affirmation that Phase I and Phase IIa of the IRA were completed successfully and the RAOs from the ROD (DOE 2005a) were met.

Subsequent actions (not addressed by the 2005 C-400 IRA ROD and not within the scope of this Five-Year Review) include the performance of deactivation of the C-400 Cleaning Building (2017–2020), the field work for the C-400 Complex OU RI/FS (2019–2021), and the development of the D1 version of the RI/FS report. The start of fieldwork for the C-400 Complex OU Final RA is scheduled for 2025.

9.6 SITE INSPECTION

A site inspection of the C-400 IRA area was conducted on December 7, 2022. The inspection was conducted by the five-year review team, the facility manager, KDEP, and representatives from DOE's support contractor.

The inspection involved a walkdown and drive-by assessment of the grounds. No issues were noted during the walkdown inspection. The overall appearance of the grounds and treatment system was good.

In August 2022, the D&R Contractor performed a LUCIP inspection of the C-400 ERH IRA area. The inspection revealed no evidence of land use changes or prohibited activities (e.g., unauthorized groundwater well installation, use of groundwater, trenching, or other excavation other than that approved by DOE's excavation/penetration permit program). The C-400 area Property Record Notice was filed with the McCracken County Clerk in 2009. DOE has not transferred any of the property covered by the C-400 ROD (previously or during the five-year review period), so deed restrictions were not applicable.

9.7 TECHNICAL ASSESSMENT

The C-400 ROD is an IRA to reduce the mass of TCE and other VOCs in the source soils and groundwater in the UCRS and RGA at the C-400 area. Monitoring data indicate that this RA has reduced the contaminant mass in the Phase I and Phase IIa areas by implementation of ERH in the UCRS and upper RGA. Phase I data show that ERH, as currently configured, is ineffective in the lower RGA.

With the return of the enrichment facilities to DOE in October 2014 and the completion of the Phase I and Phase IIa remedial activities in November 2014, the project has transitioned from an IRA confined to the accessible areas outside of the C-400 Cleaning Building to a comprehensive RA for the entire C-400 Complex OU.

9.7.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Phase IIa ERH removed approximately 13,871 lb of TCE (1,137 gal), which was a small fraction of the original RDR estimate of TCE in the southeast treatment areas (631,984 lb/51,802 gal) (DOE 2008a). The original estimate of TCE for the southeast treatment areas was based on a faulty conceptual model and overestimated the amount of TCE that was present. The Phase IIa RDR revised the estimated volume of TCE DNAPL in the southeast treatment areas to 7,320–85,400 lb (600–7,000 gal), approximately 7.5 times less than originally postulated (DOE 2012b). Phase IIa accounted for only a portion of the Phase II TCE DNAPL zone. Phase IIb lower RGA TCE DNAPL volumes now will be addressed by the C-400 Complex OU ROD.

Phase IIa baseline operational and postoperational soil and groundwater samples were collected to support analysis of the efficiency of removal of TCE by the ERH RA. The difference in soil baseline and postoperational TCE (and TCE breakdown products) levels was intended to be a direct measure of the percent reduction of TCE. Soil samples were collected during installation of the ERH wells [electrode, digital temperature sensor (digiTAM™), and EW borings], along with locations between electrodes and EWs, in order to characterize pretreatment soil TCE levels. Postoperational samples were collected from locations adjacent to baseline soil borings to characterize residual TCE levels subsequent to the operation of the ERH electrodes.

Soil baseline and postoperational samples were collected from 18 locations, with 104 paired soil sampling sets, in the southeast treatment area (refer to Table 9.1 and Figure 9.4). Comparing the baseline to the postoperational soil sample results shows a 99.8% reduction in concentration, shifting the average TCE concentration of 93,918 µg/kg to 200 µg/kg. Groundwater baseline and postoperational samples were collected from 10 locations (10 paired groundwater sampling sets) in the southeast treatment area (refer to Table 9.2 and Figure 9.4). Comparing the baseline to the postoperational groundwater sample results shows a 99.3% reduction in TCE concentration, shifting the average concentration of 107,740 µg/L to 709 µg/L. These data demonstrate significant mass reduction within the UCRS and upper RGA in the southeast treatment area and achievement of the second and third RAOs.

Table 9.1. Southeast Treatment Area Baseline and Postoperational Soil Sampling TCE Results[a,b]

Location	Depth (ft bgs)	Baseline Result (µg/kg)[c]	Postoperational Result (µg/kg)[c]	Baseline—Post-operational (µg/kg)	Reduction[d] (%)
D206	0–10	29	1	28	96.6
D206	10–20	127	1	126	99.2
D206	20–30	1,140	1	1,139	99.9
D206	30–40	966	< 2	964	99.8
D206	40–52	8,190	4	8,186	100.0
D206	52–60	579	2	577	99.7

Table 9.1. Southeast Treatment Area Baseline and Postoperational Soil Sampling TCE Results[a,b] (Continued)

Location	Depth (ft bgs)	Baseline Result (µg/kg)[c]	Postoperational Result (µg/kg)[c]	Baseline—Post-operational (µg/kg)	Reduction[d] (%)
D208	0–10	< 6	< 1	5	83.3
D208	10–20	118	10	108	91.5
D208	20–30	674	79	595	88.3
D208	30–40	6,170	51	6,119	99.2
D208	40–52	1,080	385	695	64.4
D208	52–60	156	17	139	89.1
D213	0–10	3,950	4	3,946	99.9
D213	10–20	5,520	2	5,518	100.0
D213	20–30	13,300	1	13,299	100.0
D213	30–40	1,750	< 1	1,749	99.9
D213	40–52	9,660	23	9,637	99.8
D213	52–60	723	26	697	96.4
D214	0–10	2,790	233	2,557	91.6
D214	10–20	77,770	85	77,685	99.9
D214	20–30	31,700	9	31,691	100.0
D214	30–40	87,900	11	87,889	100.0
D214	40–52	47,000	3	46,997	100.0
D214	52–60	994,000	1	993,999	100.0
D216	0–10	73	164	-91	-124.7
D216	10–20	135	5	130	96.3
D216	20–30	1,410	1	1,409	99.9
D216	30–40	320	8	312	97.5
D216	40–50	6,220	84	6,136	98.6
D216	50–60	68,900	10,100	58,800	85.3
D219	0–10	2,450	5	2,445	99.8
D219	10–20	4,800	2	4,798	100.0
D219	20–30	874	< 95	779	89.1
D219	30–40	264	2	262	99.2
D219	40–52	15,000	4	14,996	100.0
D219	52–60	461	3	458	99.3
D221	0–10	2,110	21	2,089	99.0
D221	10–20	861	< 1	860	99.9
D221	20–30	256	1	255	99.6
D221	30–40	356	< 1	355	99.7
D221	40–52	5,420	11	5,409	99.8
D221	52–60	23,800	43	23,757	99.8
D222	0–10	1,850	15	1,835	99.2
D222	10–20	471	2	469	99.6
D222	20–30	1,510	1	1,509	99.9
D222	30–40	2,030	1	2,029	100.0
D225	0–10	13	2	11	84.6
D225	10–20	9	< 1	8	88.9
D225	20–30	3	1	2	66.7
D225	30–40	161	1	160	99.4
E213	0–10	1,100	3	1,097	99.7
E213	10–20	1,400	1	1,399	99.9
E213	20–30	790	1	789	99.9
E213	30–40	2,300	1	2,299	100.0
E213	40–52	300	1	299	99.7
E213	52–60	< 1	4	-3	-300.0
E219	0–10	1,400	85	1,315	93.9
E219	10–20	3,500	7	3,493	99.8

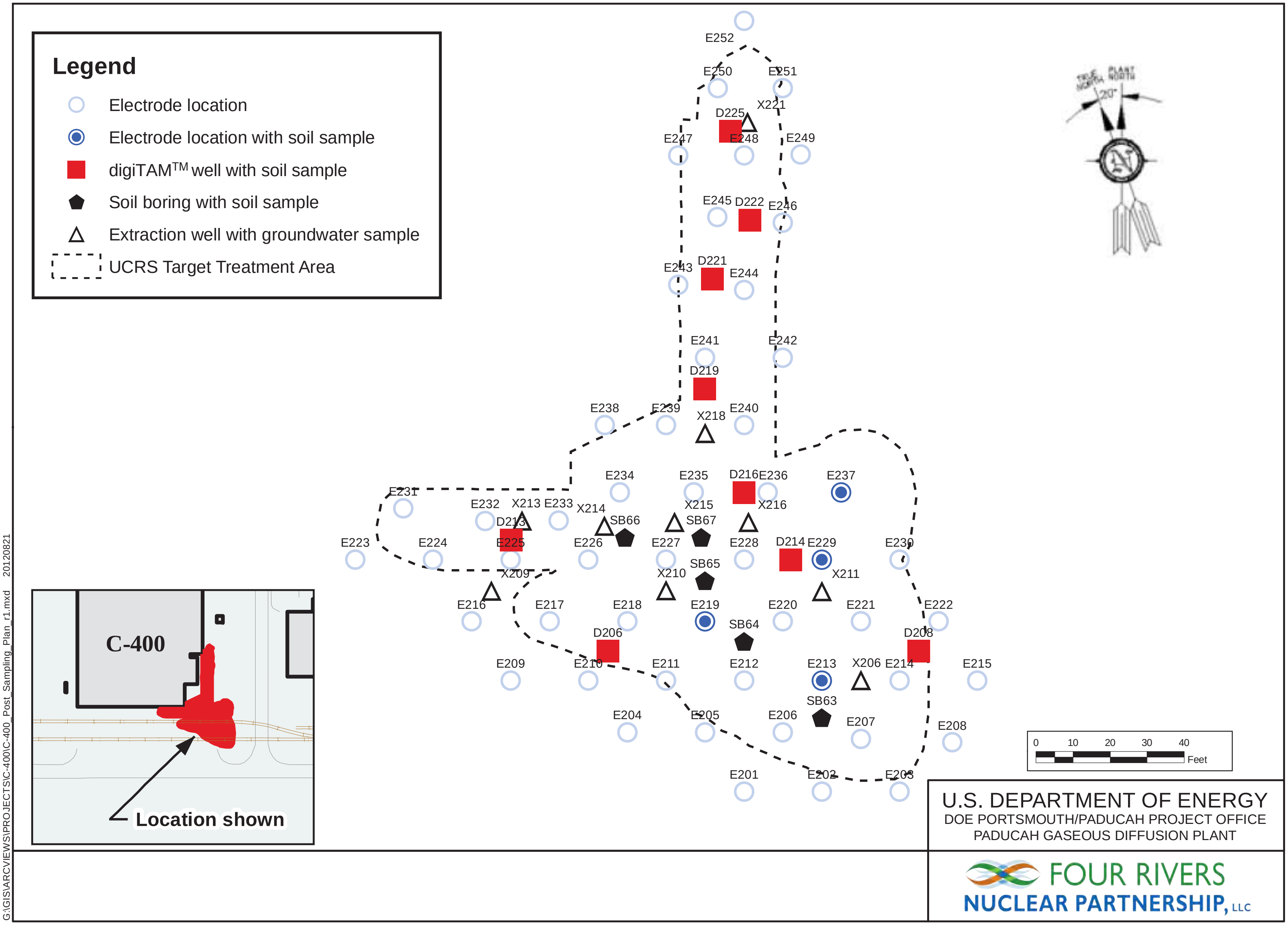
Table 9.1. Southeast Treatment Area Baseline and Postoperational Soil Sampling TCE Results[a,b] (Continued)

Location	Depth (ft bgs)	Baseline Result (µg/kg)[c]	Postoperational Result (µg/kg)[c]	Baseline—Post-operational (µg/kg)	Reduction[d] (%)
E219	20–30	6,400	38	6,362	99.4
E219	30–40	21,000	< 1	20,999	100.0
E219	40–52	88,000	8	87,992	100.0
E219	52–60	32,000	54	31,945	99.8
E229	0–10	140,000	7,850	132,150	94.4
E229	10–20	57,700	19	57,681	100.0
E229	20–30	45,500	1	45,499	100.0
E229	30–40	5,620,000	5	5,619,995	100.0
E229	40–52	156,000	1	155,999	100.0
E229	52–60	21,600	31	21,569	99.9
E237	0–10	21,400	< 1	21,399	100.0
E237	10–20	18,500	148	18,352	99.2
E237	20–30	11,900	2	11,898	100.0
E237	30–40	7,380	77	7,303	99.0
E237	40–52	975	5	970	99.5
E237	52–60	56,000	12	55,988	100.0
SB63	0–10	6	1	5	83.3
SB63	10–20	18	< 1	17	94.4
SB63	20–30	133	1	132	99.2
SB63	30–40	164	2	162	98.8
SB63	40–52	10	< 1	9	90.0
SB63	52–60	2,620	1	2,619	100.0
SB64	0–10	1,650	69	1,581	95.8
SB64	10–20	2,080	3	2,077	99.9
SB64	20–30	13,300	3	13,297	100.0
SB64	30–40	22,100	3	22,097	100.0
SB64	40–52	8,820	1	8,819	100.0
SB64	52–60	286,000	406	285,594	99.9
SB65	0–10	7,610	15	7,595	99.8
SB65	10–20	2,700	2	2,698	99.9
SB65	20–30	19,700	3	19,697	100.0
SB65	30–40	4,500	< 1	4,499	100.0
SB65	40–52	6,320	9	6,311	99.9
SB65	52–60	30,500	54	30,446	99.8
SB66	0–10	5,880	18	5,862	99.7
SB66	10–20	70,900	54	70,846	99.9
SB66	20–30	90,100	97	90,003	99.9
SB66	30–40	7,370	1	7,369	100.0
SB66	40–52	1,800	1	1,799	99.9
SB66	52–60	411,000	4	410,996	100.0
SB67	0–10	3,910	158	3,752	96.0
SB67	10-20	161	1	160	99.4
SB67	20–30	732	4	728	99.5
SB67	30–40	7,190	< 1	7,189	100.0
SB67	40–52	548,000	1	547,999	100.0
SB67	52–60	462,000	22	461,978	100.0
count		104	104		
average (µg/kg)		93,918	200	Average Reduction % = 99.8[e]	
minimum (µg/kg)		1	1		
maximum (µg/kg)		5,620,000	10,100		
count < 70 µg/kg		9	89		
counts nondetectable		2	13		

Table 9.1. Southeast Treatment Area Baseline and Postoperational Soil Sampling TCE Results[a,b] (Continued)

Location	Depth (ft bgs)	Baseline Result (µg/kg)[c]	Postoperational Result (µg/kg)[c]	Baseline—Post-operational (µg/kg)	Reduction[d] (%)

[a] Data represented in this table were derived from the C-400 IRA RACR (DOE 2018c).
[b] Only the locations that have both a baseline and postoperational sample are included.
[c] Nondetectable included at stated detection level.
[d] Reduction percentage = (baseline result-postoperations result)/baseline result × 100.
[e] This value is based on the average result values.



Modified from RAWP, DOE/LX/07-1271&D2/R3

Figure 9.4. C-400 Phase IIa Postoperations Soil and Groundwater Sample Location Map

Table 9.2. Phase IIa Southeast Treatment Area Baseline and Postoperations Groundwater Sampling Results

LOCATION ID	SAMPLE INTERVAL (Upper RGA)			
	Baseline TCE Results (µg/L)	Post-operations TCE Results (µg/L)[a]	Baseline Minus Post-operational (µg/L)	Reduction %
X206	100,000	1,800[b]	98,200	98.2
X209	5,900	110	5,790	98.1
X210	6,500[b]	69	6,431	98.9
X211	350,000	440	349,560	99.9
X213	23,000	270	22,730	98.8
X214	75,000	37	74,963	99.9
X215	100,000	140	99,860	99.9
X216	260,000	2,500	257,500	99.0
X218	120,000	1,200	118,800	99.0
X221	37,000	520	36,480	98.6
average (µg/L)	107,740	709	Average Reduction % = 99.3[c]	
minimum (µg/L)	5,900	37		
maximum (µg/L)	350,000	2,500		
count < 70 µg/L	0	2		
counts nondetectable	0	0		

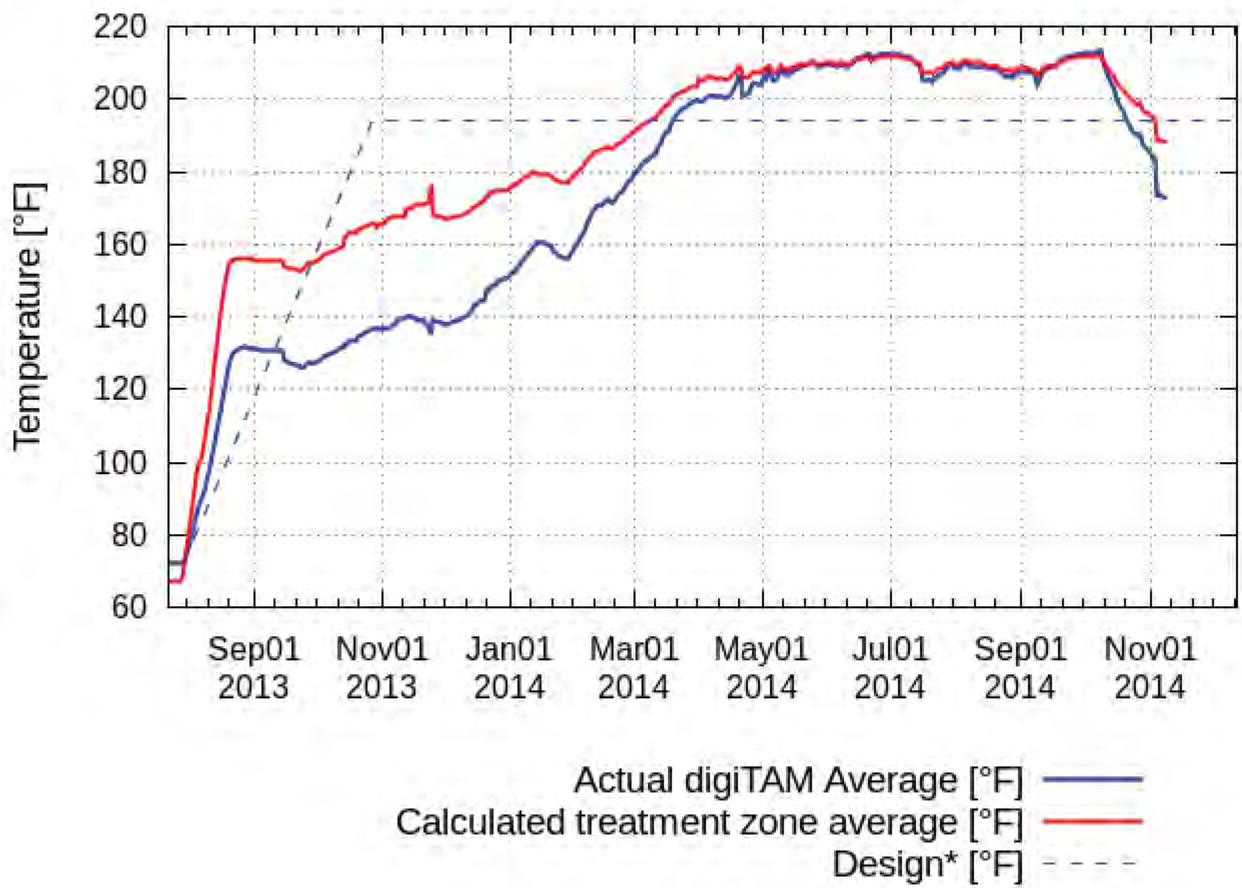
[a] Groundwater pump raised from 68 ft bgs to 60 ft bgs for collection of postoperations groundwater samples per RAWP (DOE 2013c).
[b] The greater of the regular result and field duplicate result is presented.
[c] This value is based on the average result values.

Target temperatures were attained in the southeast treatment area at depths targeted for VOC removal, indicating that the ERH design was adequate for thermal treatment of the UCRS and upper RGA. Figures 9.5 and 9.6 summarize actual-verses-design temperature curves and average digiTAM™ temperatures by depth as documented during Phase IIa operations.

TCE is the primary groundwater concern in the southeast C-400 area. Six RGA groundwater MWs provide characterization of TCE levels near the Phase II source zones southeast of the C-400 Cleaning Building (Figure 9.7). The MWs can be divided into two groups by location: the Six-Phase Heating Treatability Study multi-screen wells MW405, MW406, MW407, and MW408; and previously installed MWs of the Phase II SI located adjacent to 11th Street, MW155 (lower RGA) and MW156 (upper RGA).

Long-term records of TCE levels in the Six-Phase Heating Treatability Study area are only available for MW405 Port 5 (middle RGA), MW406 Port 5 (middle RGA), MW407 Port 4 (upper RGA), and MW408 Port 5 (middle RGA). Figure 9.8 presents the TCE trends, beginning in 2003. The Six-Phase Heating Treatability Study significantly reduced TCE levels, from a high of 1,000,000 µg/L to 210,500 µg/L and less. Subsequently, TCE levels rebounded (as high as 1,400,000 µg/L in MW408 Port 5). The follow-on Phase IIa IRA, which bordered the Six-Phase Heating Treatability Study area, resulted in reduced TCE levels in the MWs (with sustained levels less than 20,000 µg/L[11]).

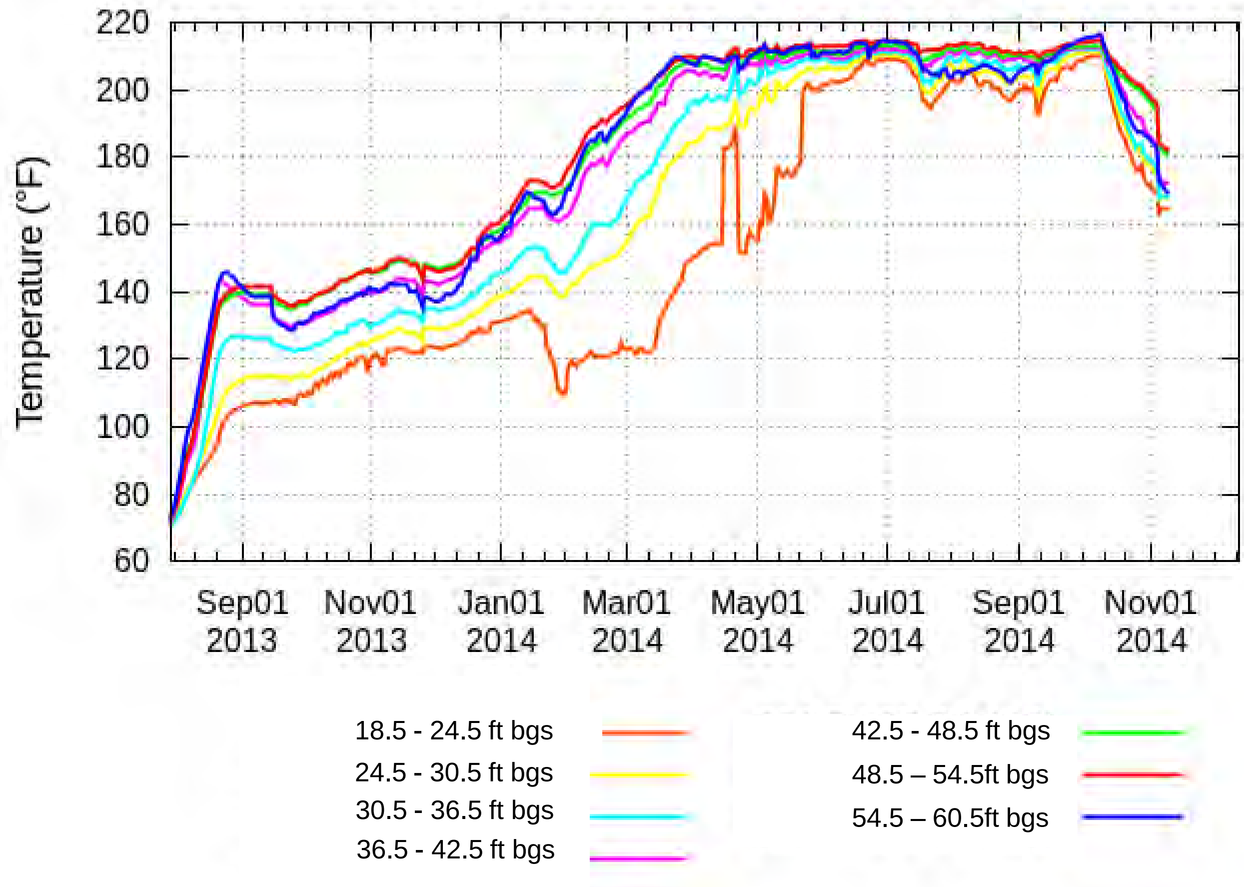
[11] The lone exception is a TCE concentration of 41,600 µg/L in a sample collected from MW408 Port 5 in December 2019.



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

Figure 9.5. C-400 Phase IIa Actual and Design Temperature Curves

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC



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

Figure 9.6. C-400 Phase IIa Average digiTAM™ Temperature by Depth

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

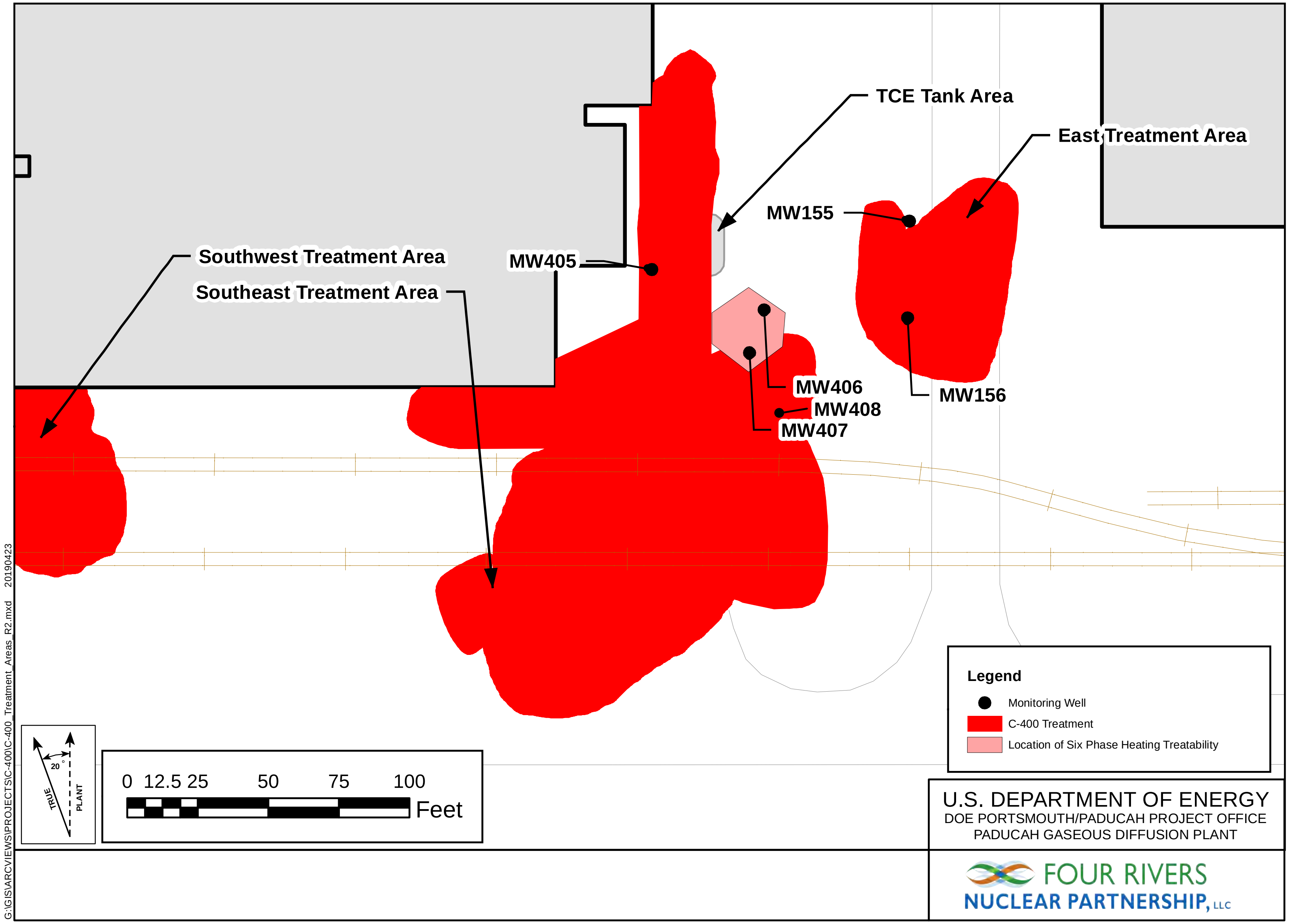
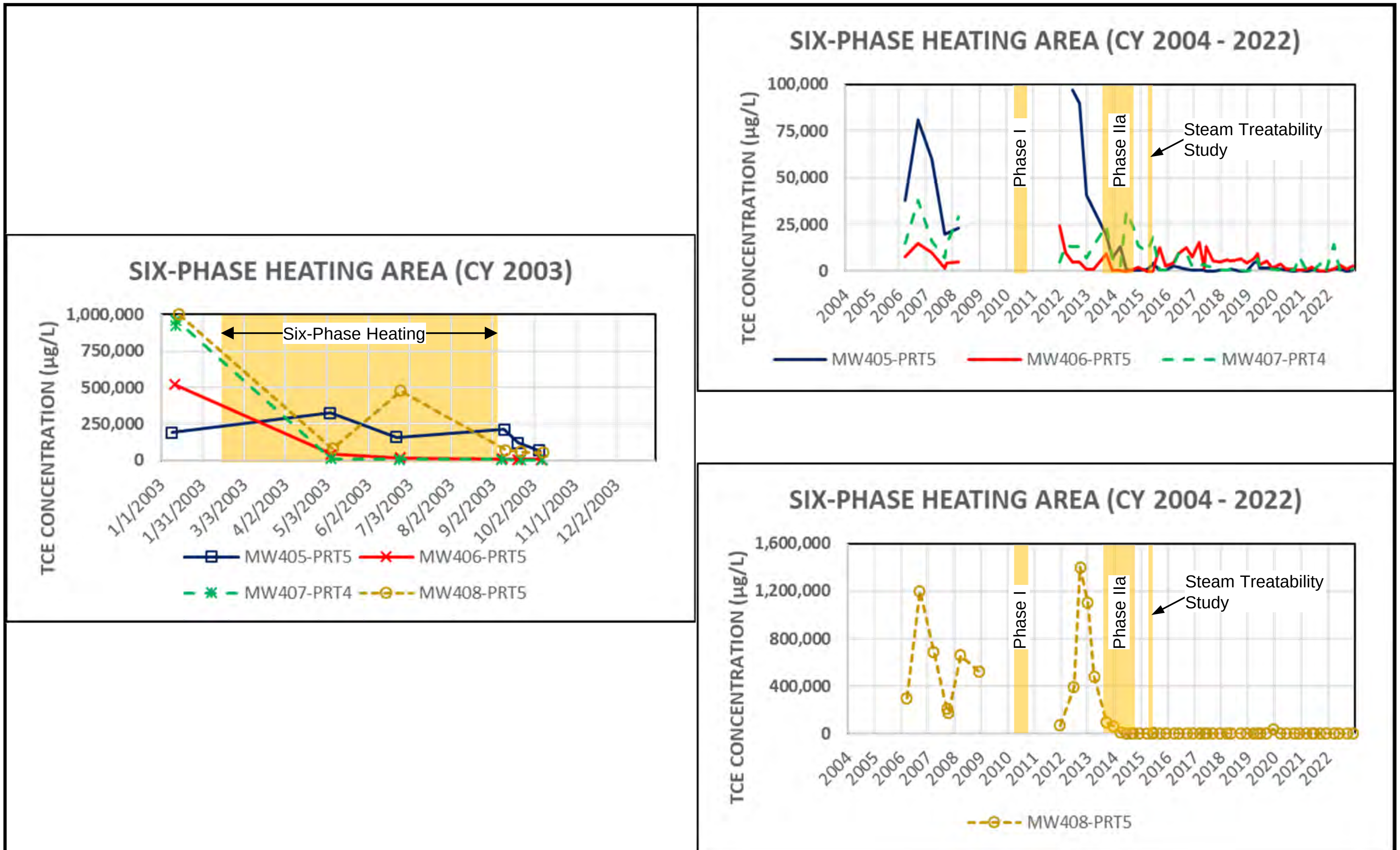


Figure 9.7. MWs near the Phase II Source Zones



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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 9.8. Six-Phase Heating Area TCE Trends

MW155 and MW156 are located east of the Six-Phase Heating Treatability Study area. The TCE trend in the upper RGA (MW156) is a near-steady decline for the period of 1991 (high of 550,000 µg/L) through 2002 (low of 150,000 µg/L), followed by a steep decline after the Six-Phase Heating Treatability Study (2003) (Figure 9.9). TCE levels rebounded in MW156 starting in 2007 (as high as 83,000 µg/L in June 2011) and declined to current levels (as low as 925 µg/L) following the Phase IIa IRA.

MW155 TCE levels are comparatively low (390 to 2,500 µg/L through 2002[12]) with some opposing trends (Figure 9.9). TCE levels sharply increased in MW155 following the Six-Phase Heating Treatability Study (2003) with a high of 23,000 µg/L in March 2007, then sharply dropped following the Phase I IRA (2010). Subsequently, MW155 TCE levels increased (range of 1,690 µg/L to 10,300 µg/L) following the Phase IIb Steam Treatability Study (2015) and the start of the optimized NEPCS operations (2017).

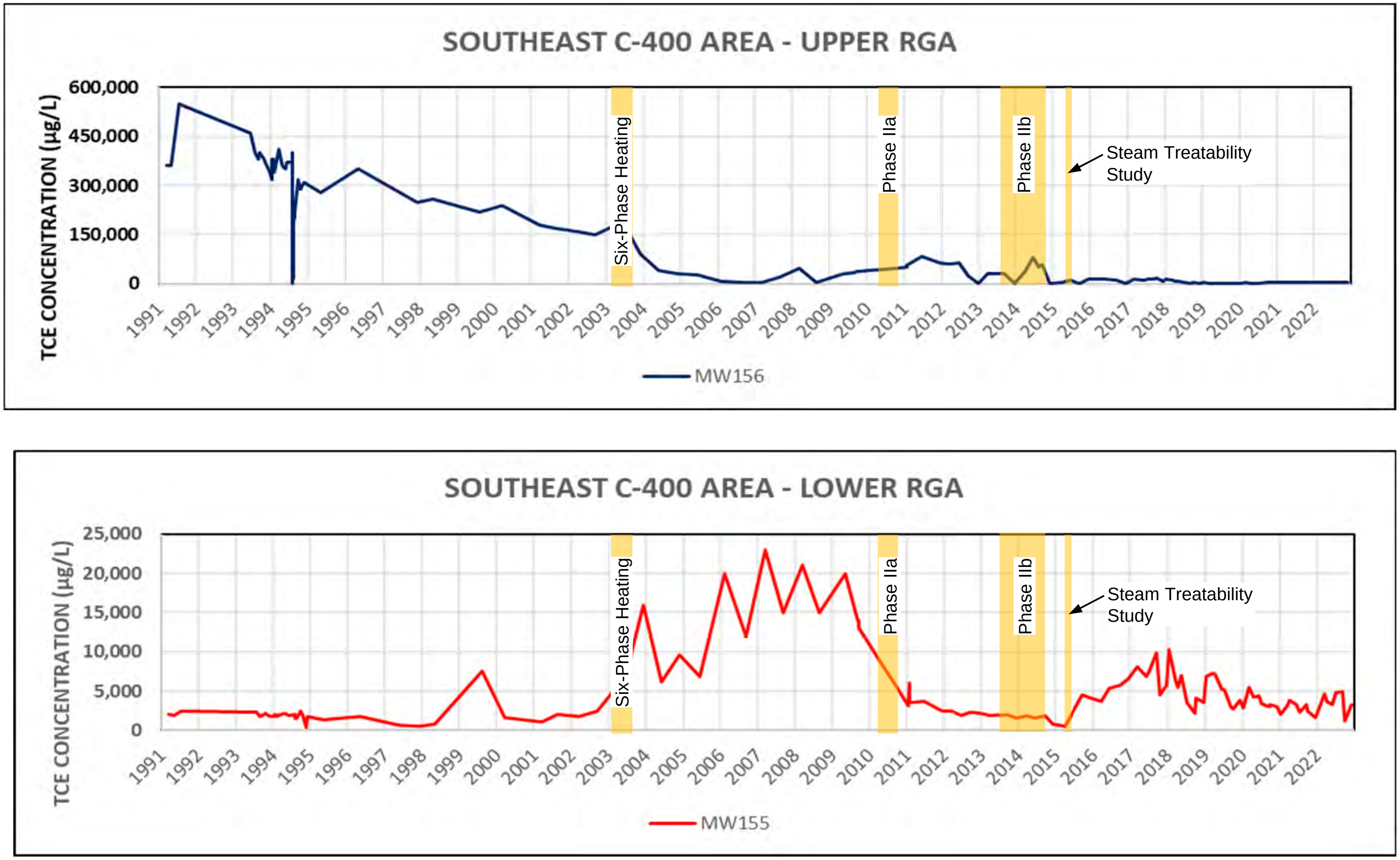
For the period of this review (2018 through 2022), TCE trends have remained stable in the area of the southeast C-400 Phase II TCE source zones (MW155, MW156, MW405 Port 5, MW406 Port 5, MW407 Port 4, and MW408 Port 5) with dissolved TCE levels of 14,500 µg/L and less.[13]

DOE installed five nested MWs—MW421, MW422, MW423, MW424, and MW425 (refer to Figure 9.2 for well locations)—across the northwest corner of the C-400 Cleaning Building in June 2009. The wells were screened in the middle and lower RGA intervals to monitor dissolved contaminant trends from C-400 source areas(s). In general, the level of dissolved TCE is greatest at the base of the RGA (Port 3/lower screen in each of the well nests). Levels of Tc-99 commonly are greatest in the Port 1/top screen of the well nests.

Figure 9.10 graphically compares the MW analytical data for the northwest corner of the C-400 area from the 2009–2017 period versus the current review period (2018–2022). TCE levels are commonly highest in MW421 (Port 3), and Tc-99 levels are commonly highpest in MW422 and MW423 (Port 1).

[12] The lone exception is a TCE concentration of 7,500 µg/L in a sample collected in August 1999.

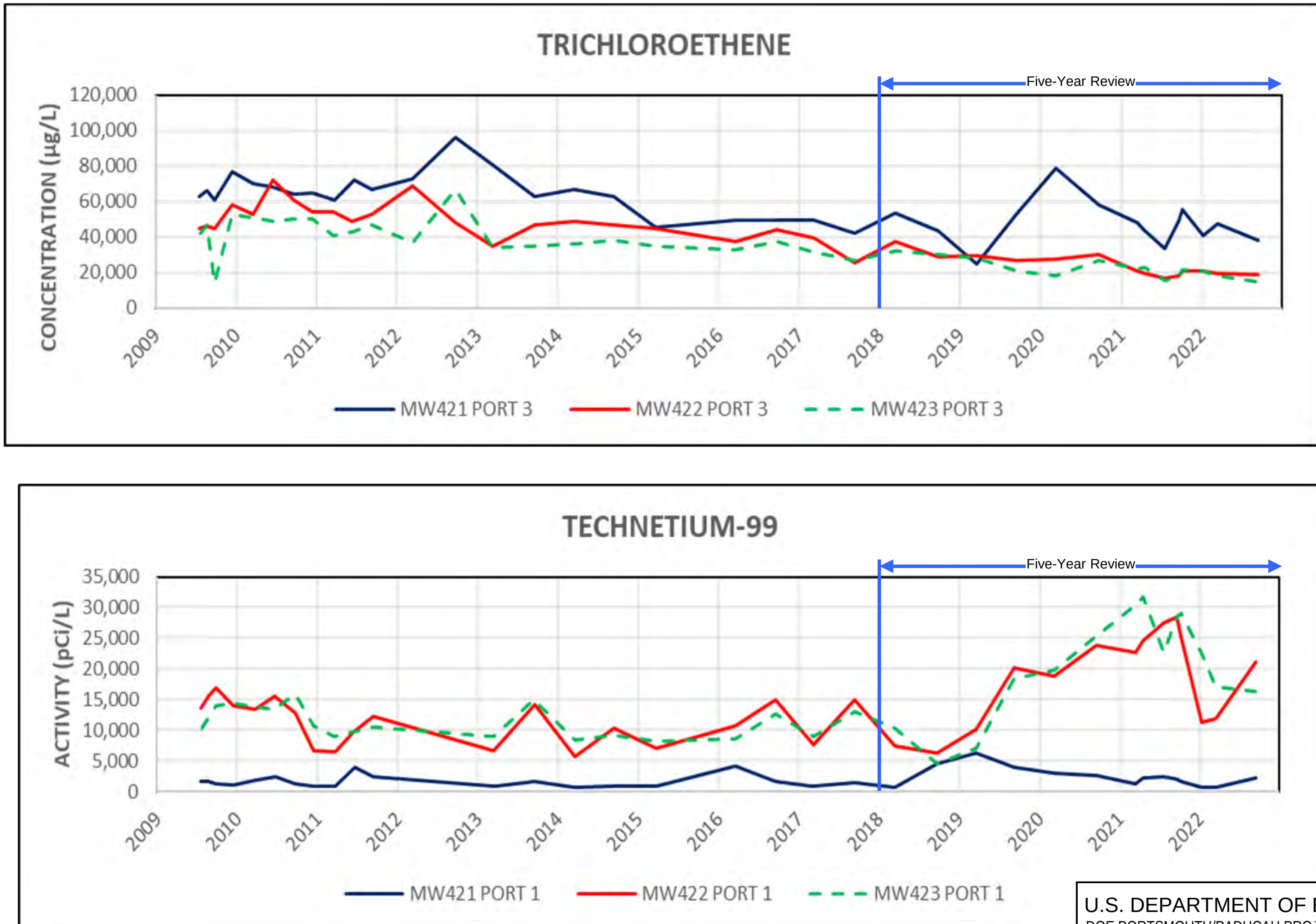
[13] This excludes one uncharacteristic result for MW408-PRT5 of 41,600 µg/L.



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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 9.9. TCE Trends East of the Six-Phase Heating Treatability Study



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

Figure 9.10. Contaminant Trends in MWs Located on the North Side of C-400

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

The overall TCE trend has been a decline, from peak levels in 2012 (96,000 µg/L in MW421; 69,000 µg/L in MW422; and 67,000 µg/L in MW423). This trend of declining TCE levels continued in MW422 and MW423 through the current review period (down to approximately 20,000 µg/L). The TCE level in MW421 during the current review period spiked in early 2020 (to 78,700 µg/L) and has remained at approximately 40,000 µg/L through 2022. This TCE spike in MW421 is attributed to eastward groundwater flow induced by the growing influence of the optimized NEPCS (which started operation in 2017). A suspected TCE DNAPL zone associated with the NSDD (located to the west of MW421) is the apparent source of the higher dissolved TCE levels.

Tc-99 levels routinely were highest in MW422 and MW423 through 2017, at approximately 10,000 pCi/L. In 2018, Tc-99 levels declined in MW422 and MW423 and increased in MW421 to a common level of approximately 5,000 pCi/L. Tc-99 levels in MW421 have declined since early 2019 to less than 3,000 pCi/L. Beginning in 2019, Tc-99 levels increased in MW422 and MW423 to 18,500 pCi/L and greater, followed by a decline beginning in 2022.

The C-400 Complex OU RI/FS (fieldwork conducted from 2019 to 2021) discovered a discrete zone of Tc-99 soil contamination under the west-central footprint of the building. The spike in Tc-99 levels in MW422 and MW423 beginning in early 2019 likely is related to the disturbance of this primary Tc-99 source zone under C-400 during the deactivation of the C-400 Cleaning Building, preceding the C-400 Complex OU RI/FS.

9.7.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The exposure assumptions used to develop the risk assessment included both the current exposures (on-site industrial and excavation worker and off-site recreational) and the potential future exposures (future on-site resident and off-site resident using groundwater at the DOE property boundary). The objective at the C-400 project is to reduce VOC source mass to the extent practicable, and no specific risk-based level or MCL was established as a cleanup criterion for the project.

The goals identified for the C-400 ROD remain valid: (1) to implement institutional controls to prevent on-site industrial worker exposure, and (2) to reduce source mass of TCE and other VOCs to reduce migration to off-site points of exposure.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy.

Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy.

C-400 is located within the facility security fence and administrative controls prevent unauthorized access to the site. Exposure controls identified in the ROD remain valid regarding current restrictions on use of groundwater within DOE property. Changes to the risk assessment methodology have been made but the protectiveness of the remedy was not affected.

The current groundwater data indicate that assumptions underlying the remedy selection in the ROD remain valid for the groundwater contamination under the south portion of the C-400 Complex area. The identification of new contaminants and the refined understanding of geologic conditions from the C-400 Complex OU RI/FS (DOE 2022c) will be addressed in the forthcoming C-400 Complex OU ROD.

9.7.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

The C-400 Complex OU RI/FS confirmed TCE is the primary groundwater risk driver at C-400 (DOE 2022c). Additional TCE source zones and principal contaminants were identified. The forthcoming C-400 Complex OU ROD will address all contaminant sources.

9.7.4 Technical Assessment Summary

The Phase IIa ERH action effectively prevents on-site industrial worker exposure and removed UCRS and upper RGA VOC (primarily TCE and its breakdown components) mass in the east, southeast, and southwest treatment areas associated with historical TCE releases as documented in the WAG 6 RI. This IRA is protective of the site worker.

DOE, with the participation of the other FFA parties, has initiated a C-400 Complex OU, which includes selection of a remedy for the Phase IIb Scope.

9.8 ISSUES

None.

10. SOUTHWEST PLUME

The Southwest Plume source areas consist of groundwater in the RGA contaminated primarily with TCE and are located in the southwestern portion of PGDP and south of the larger groundwater contamination area identified as the Northwest Plume (SWMU 201). Sources to the Southwest Plume included in this action are the Oil Landfarm (SWMU 1), the C-720 Building TCE Northeast Spill Site (SWMU 211-A), and the C-720 Building TCE Southeast Spill Site (SWMU 211-B) (Figures 10.1, 10.2, and 10.3).

DOE conducted an SI of the Southwest Plume and four potential source areas in 2004 [*Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1 (DOE 2007b)]. Then a focused FS for the Southwest Groundwater Plume VOC sources (Oil Landfarm and C-720 Building Northeast and Southeast TCE Spill Sites) was developed (DOE 2011c).

The scope of this project is to implement selected remedies for three of the known VOC sources to the Southwest Plume. This project is included in this fifth synchronized Five-Year Review with summaries of activities consistent with the progress of the project up to the date of the review. The ROD was signed in March 2012 (DOE 2012c).

The RA implementation at the Oil Landfarm was completed in 2017, with approval of the *Remedial Action Completion Report for In Situ Source Treatment by Deep Soil Mixing of the Southwest Groundwater Plume Volatile Organic Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1), at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2405&D2 (DOE 2017c).

The FFA parties agreed to implement EISB with interim LUCs at SWMU 211-A in 2018. The field implementation of the bioremediation was performed in 2022. In August 2017, the FFA parties signed the *Memorandum of Agreement on the C-400 Complex under the Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky* (DOE 2017f), which established that all projects, with the exception of the C-400 Complex and Southwest Plume SWMU 211-A, would be resequenced in the FY 2018 SMP (DOE 2017d).

Consistent with the *Explanation of Significant Differences to the Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2022d), the RA for SWMU 211-B will be re-evaluated for implementation in conjunction with actions to be taken for the C-720 Building and surrounding area, as described in the FY 2023 SMP (DOE 2022a). Because of this, SWMU 211-B will not be discussed further within this fifth synchronized Five-Year Review.

The field implementation of RAs at SWMU 211-A (C-720 Building TCE Northeast Spill Site) and SWMU 1 (Oil Landfarm) have been completed. Both of these SWMUs are currently in the monitoring phase where the reduction in contaminant concentrations is being monitored. Interim LUCs continue to remain in place for all three Southwest Plume Sources locations (SWMU 1, SWMU 211-A, and SWMU 211-B).

10.1 REMEDY SELECTION

The response actions were selected in the ROD to provide for timely remediation of VOCs at the Southwest Plume sources (DOE 2012c). Deep soil mixing with interim LUCs was selected for the Oil Landfarm to volatilize contaminants in the UCRS groundwater and UCRS soils. After further characterization, EISB with interim LUCs was selected for SWMU 211-A.

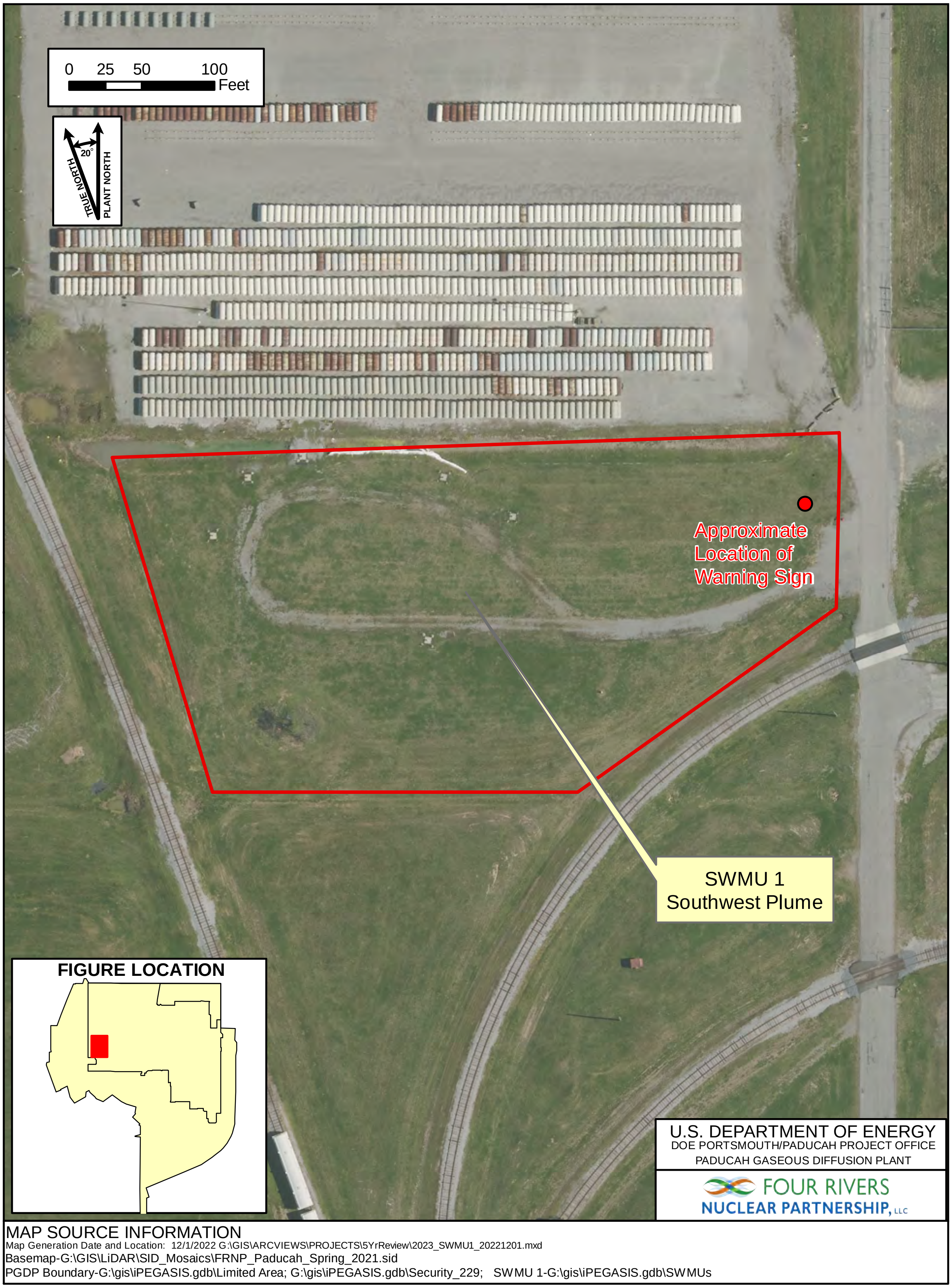


Figure 10.1. Location of the Oil Landfarm (SWMU 1)

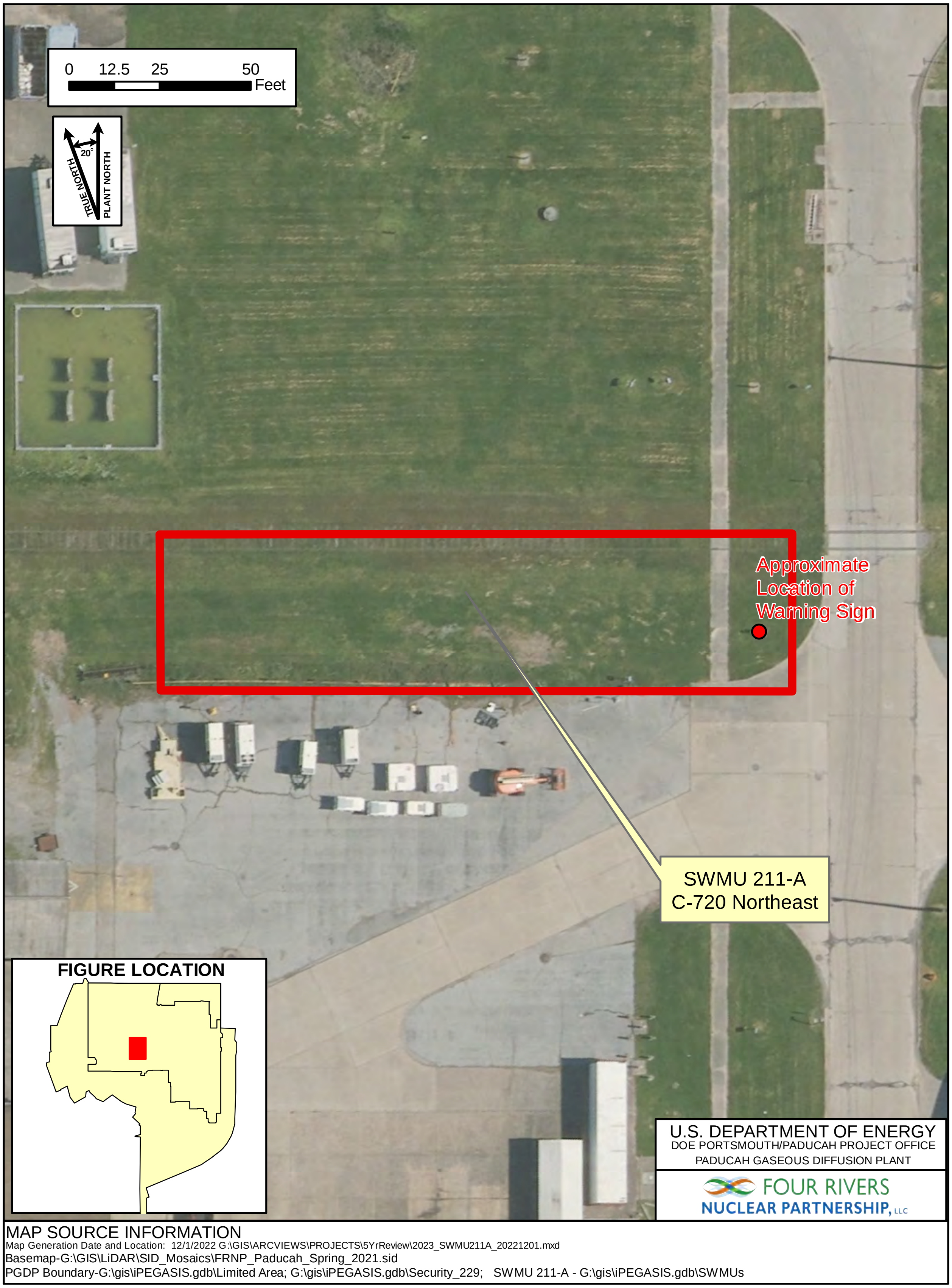
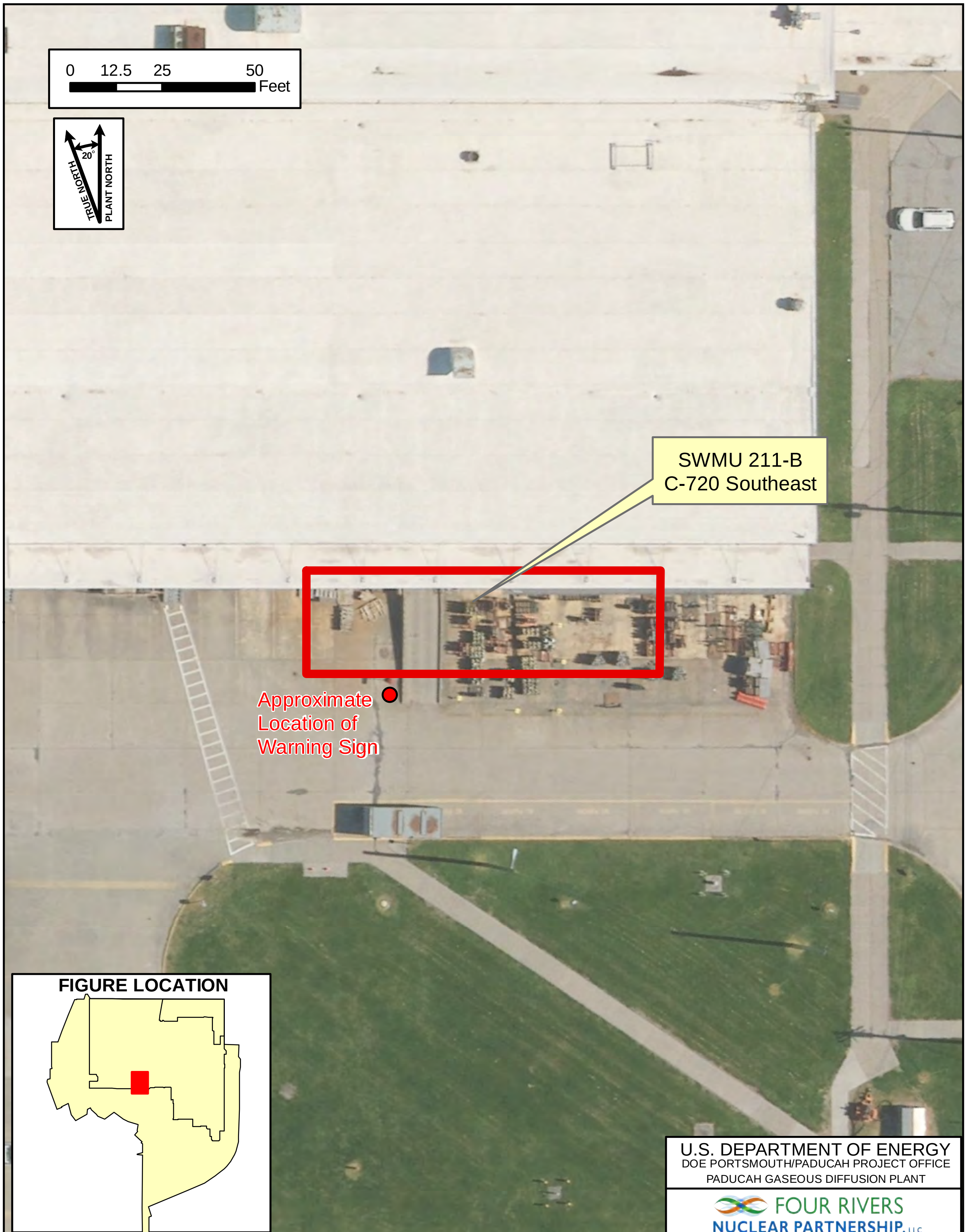


Figure 10.2. Location of the C-720 Building Northeast Spill Site



MAP SOURCE INFORMATION
Map Generation Date and Location: 12/1/2022 G:\GIS\ARCVIEWS\PROJECTS\5YrReview\2023_SWMU211B_20221201.mxd
Basemap-G:\GIS\LiDAR\SID_Mosaics\FRNP_Paducah_Spring_2021.sid
PGDP Boundary-G:\gis\iPEGASIS.gdb\Limited Area; G:\gis\iPEGASIS.gdb\Security_229; SWMU 211-B - G:\gis\iPEGASIS.gdb\SWMUs

Figure 10.3. Location of the C-720 Building Southeast Spill Site

The ROD designated the high concentration TCE soils and residual TCE DNAPL as principal threat waste (DOE 2012c). The following are the RAOs in the ROD (DOE 2012c).

1. Treat and/or remove the principal threat waste consistent with the NCP.

2a. Prevent exposure to VOC contamination in the source areas that will cause an unacceptable risk to excavation workers (< 10 ft).

2b. Prevent exposure to non-VOC contamination and residual VOC contamination through interim LUCs within the Southwest Plume source areas (i.e., SWMU 1, SWMU 211-A and SWMU 211-B) pending remedy selection as part of the Soils OU and the GWOU.

3. Reduce VOC migration from contaminated subsurface soils in the treatment areas at the Oil Landfarm and the C-720 Northeast and Southeast Sites so that contaminants migrating from the treatment areas do not result in the exceedance of MCLs in the underlying RGA groundwater.

Oil Landfarm

The ROD for the Oil Landfarm implemented *in situ* source treatment using deep soil mixing with interim LUCs. The ROD also required an RDSI, which was implemented in 2012 to collect additional soil samples to determine the extent and distribution of VOCs in the UCRS for treatment and supported completing the remedial design (DOE 2012c).

The Oil Landfarm RA included, in addition to the RDSI, the implementation of deep soil mixing with the injection of steam and zero-valent iron (ZVI), confirmatory sampling, site restoration, and groundwater monitoring. The remediation goal for TCE (the primary VOC) and other COCs for this Oil Landfarm action, as documented in the ROD (DOE 2012c), was to reduce average VOC levels in the UCRS soil to below the following cleanup goals.

VOC	**UCRS Soil Cleanup Level (µg/kg)**
TCE	73
1,1-DCE	130
cis-1,2-DCE	600
trans-1,2-DCE	1,080
Vinyl chloride	34

The interim LUCs for the Oil Landfarm consisted of DOE's excavation-penetration permit program and placement of warning signs.

C-720 Building TCE Northeast Spill Site (SWMU 211-A)

From the additional data collected during a final characterization of SWMU 211-A, the FFA parties selected either EISB with interim LUCs or long-term monitoring with interim LUCs as the remedy for SWMU 211-A. The interim LUCs consisted of DOE's excavation/penetration permit program and warning signs.

The selection of the RA for the C-720 Building TCE Northeast Spill Site was based upon the results collected in the final characterization/RDSI, a comparison of current and historical VOC contaminant levels, and an estimation of the time required to achieve cleanup goals. The remediation goal for TCE (again, the primary VOC) and other VOCs for the actions at the C-720 Building TCE Northeast Spill Site was to reduce average VOC levels in the UCRS soil to below the following levels to achieve cleanup goals.

VOC	UCRS Soil Cleanup Level (µg/kg)
TCE	75
1,1-DCE	137
cis-1,2-DCE	619
trans-1,2-DCE	5,290
Vinyl chloride	570

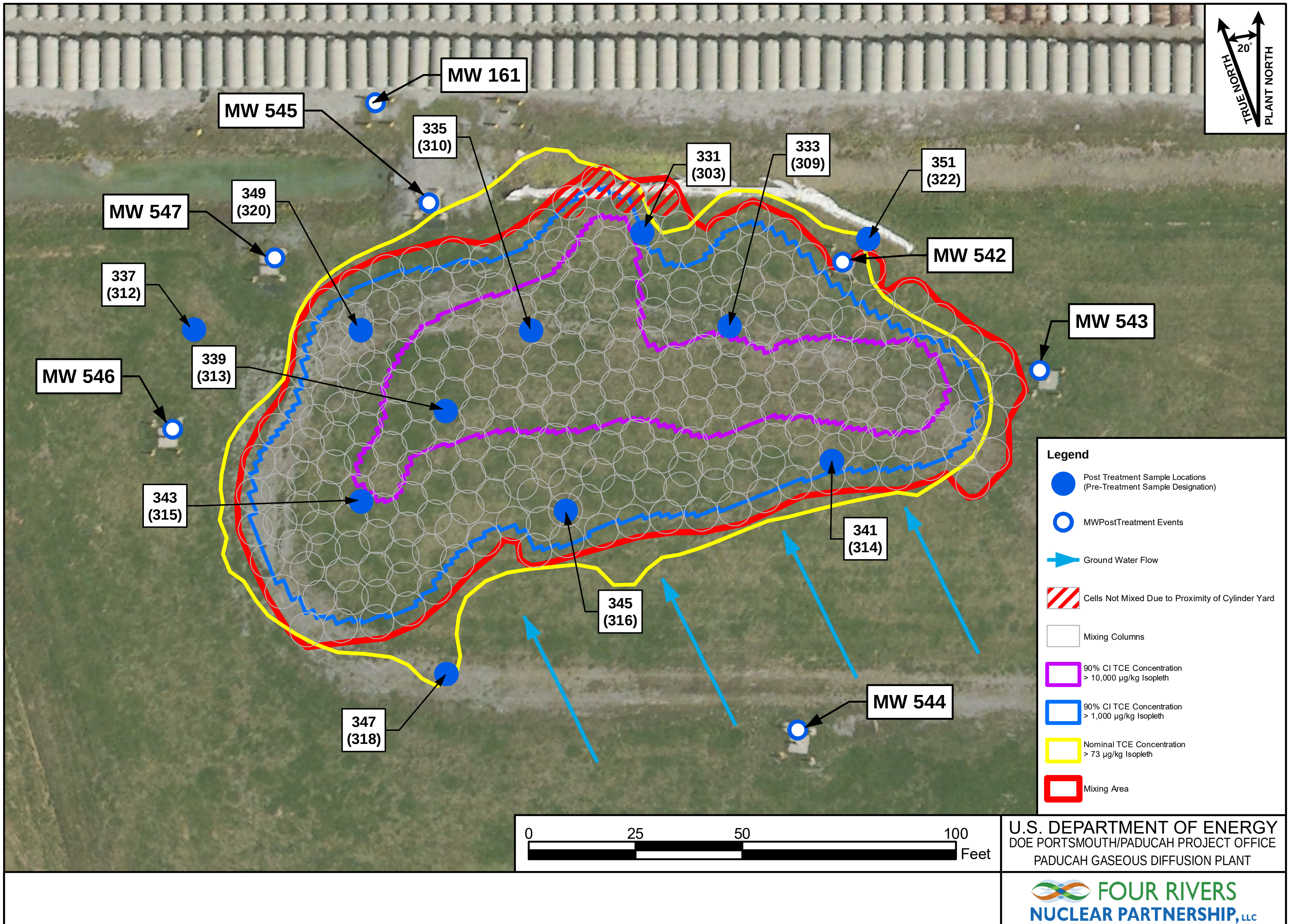
10.2 REMEDY IMPLEMENTATION

Oil Landfarm

The Oil Landfarm RDSI was the initial task performed in implementing the RA. It was performed in 2012 just prior to the start of this reporting period in accordance with the RDSI Characterization Plan contained in the *Remedial Design Support Investigation Characterization Plan for the C-747-C Oil Landfarm and C-720 Northeast and Southeast Sites at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0350&D1 (DOE 2012d). The RDSI data collected was used to complete development and attain approval of the remedial design for the soil mixing RA contained in *Remedial Design Report In Situ Source Treatment Using Deep Soil Mixing for the Southwest Groundwater Plume Volatile Organic Compound Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1) at the Paducah Gaseous Diffusion Plant, Paducah Kentucky*, DOE/LX/07-1276&D2/R1 (DOE 2013d). The *Remedial Action Work Plan for In Situ Source Treatment by Deep Soil Mixing of the Southwest Groundwater Plume Volatile Organic Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1287&D2/A1/R1, (DOE 2014b) provided additional implementation requirements.

The field implementation of the RA began on April 10, 2015. The *in situ* source treatment performed was by deep soil mixing of 258 soil columns (8-ft diameter) supplemented by hot air/steam injection with vapor extraction and vapor-phase treatment, followed by ZVI and guar gum injection. Contaminants treated as part of the RA included TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE, and vinyl chloride. The RA recovered an estimated 24 ± 12 gal of solvents total with a 95% confidence interval. In addition to that quantity recovered, the action left ZVI (estimated at 958,395 lb) in place to continue to provide passive treatment for any remaining VOC contamination. The recovered VOC contamination was captured on approximately 20,000 lb of activated carbon that was regenerated by the manufacturer for reuse. Lime soil stabilization, grading, and restoration of the excavated site; management and disposition of accrued waste; and post-remedial field sampling were performed following soil mixing.

Post-remedial field sampling included 11 soil borings that were sampled for VOCs at 5-ft intervals (Figure 10.4). Eight soil borings were drilled in the soil-mixed treatment area to assist in determining attainment of soil cleanup values for the UCRS soils mixed. The TCE cleanup level for the RA is 73 ppb. The TCE concentrations for the 8 pre- and post-mixing borings in the mixed zone show the cleanup level was attained for all of those borings, with a 99.3% overall arithmetic average reduction (excluding duplicates) in TCE soil contamination. Those results are shown graphically in Figure 10.5. Figure 10.6



MAP SOURCE INFORMATION
Map Generation Date and Location: G:\GIS\ARCVIEWS\PROJECTS\5YrReview\CERCLA_5YEAR_PostTreatmentSoilBorings.mxd 3/29/2023
Locations Layer-- G:\GIS\iPEGASIS.gdb\Locations
GW Flow Layer (12/9/2016); VOC Data (10/15/2015); 90% CI TCE Concentration > 10,000 µg/kg Isopleth (5/20/2013); 90% CI TCE Concentration > 1,000 µg/kg Isopleth (5/20/2013); Nominal TCE Concentration > 73 µg/kg Isopleth (6/3/2013);
Mixing Area (10/30/2013)-- G:\GIS\SHAPES\Project-Specific\SWMU_1\GW_FLOW.shp, ...\VOC_DATA.shp, ...\c90_10k_ppb.shp, ...\c90_1k_ppb.shp, ...\c50_73_ppb.shp, ...\Mixing_Area.shp
Image-- G:\GIS\LiDAR\SID_Mosaics\FRNP_Paducah_Spring_2021.sid

Figure 10.4 Post-Treatment Soil Borings and MW Locations

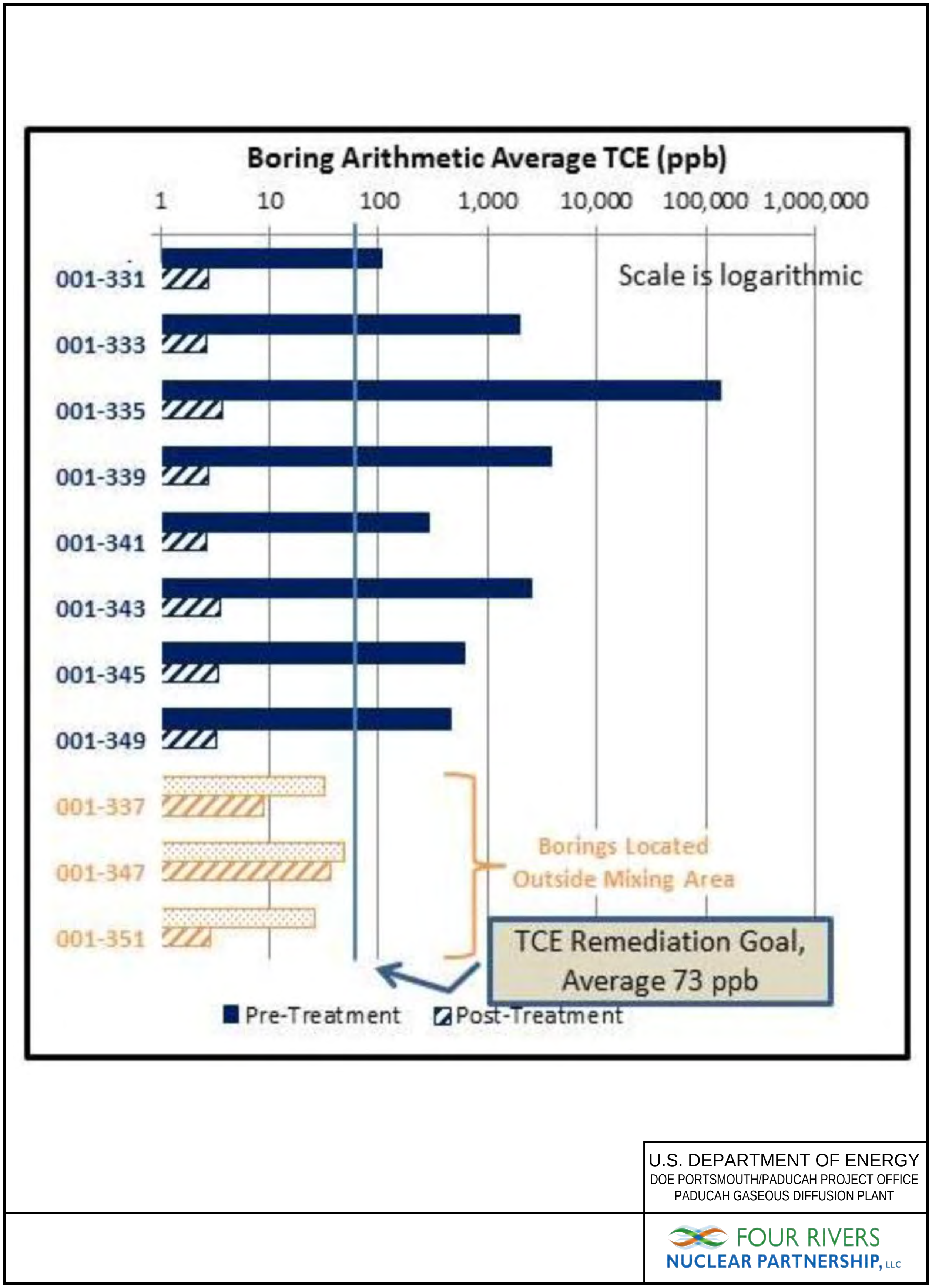
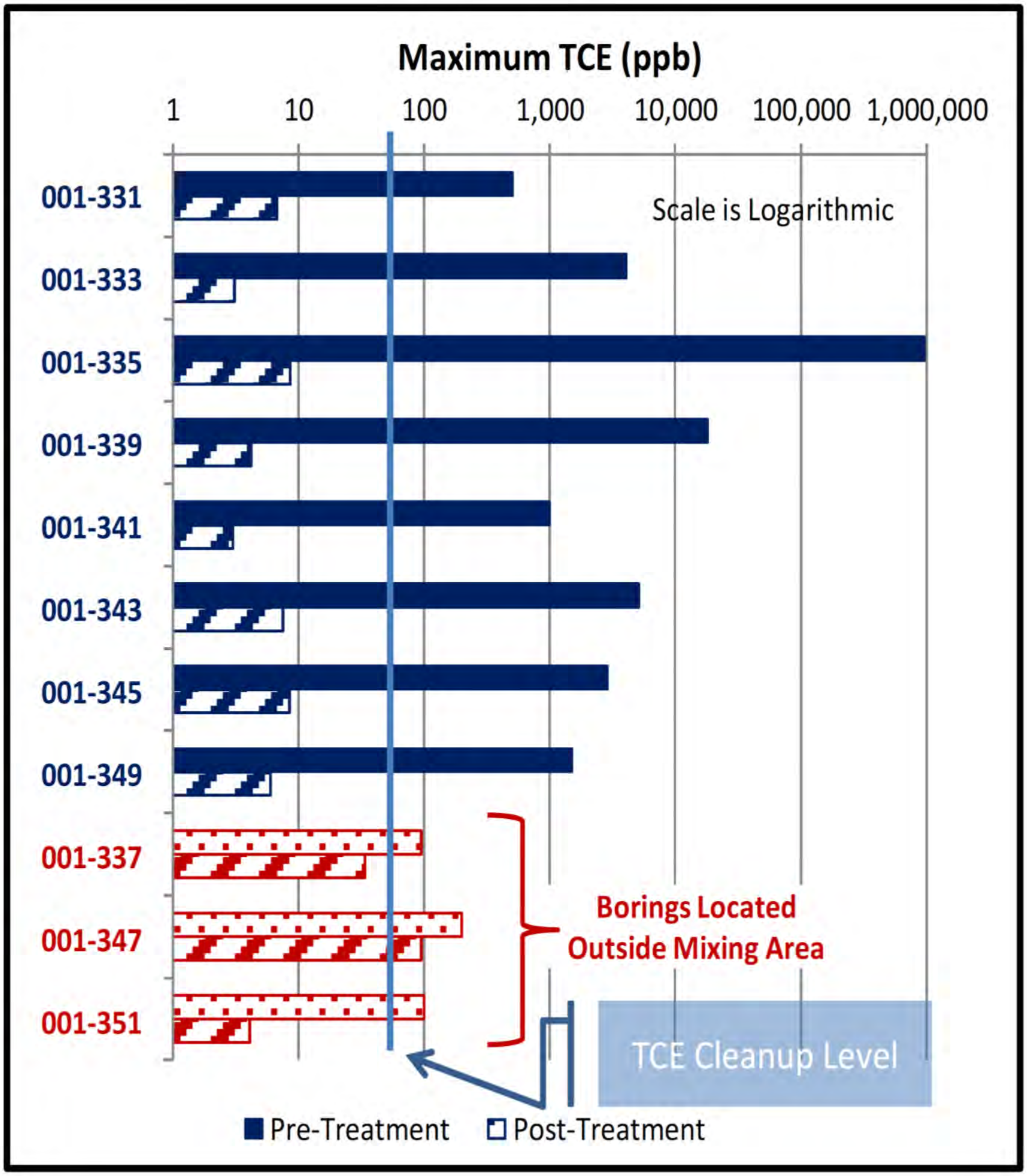


Figure 10.5. Arithmetic Average TCE Concentrations in Pre- and Post-Mixing Soil Borings (DOE 2017h)



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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 10.6. Maximum TCE Concentrations in Pre- and Post-Mixing Soil Borings (DOE 2017h)

shows the maximum TCE soil concentrations pre-treatment versus post-treatment. Six MWs also were constructed adjacent to the treatment area to provide long-term monitoring to determine the effectiveness of the remedy. A more detailed analysis of the field implementation of the soil mixing RA, field changes, lessons learned, and test results is contained in the RACR for the project, *Remedial Action Completion Report for In Situ Source Treatment by Deep Soil Mixing of the Southwest Groundwater Plume Volatile Organic Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1), at Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2405&D2 (DOE 2017c). Deep soil mixing of the final (258th) soil column was completed on October 8, 2015, while complete field demobilization along with waste disposal was completed in September 2016.

The Oil Landfarm RA also includes interim LUCs that consist of the excavation/penetration permit program and placement of warning signs to provide notice and warning of environmental contamination. The interim LUCs portion of the RA was implemented in 2012 just prior to the RDSI.

<u>C-720 Building TCE Northeast Spill Site (SWMU 211-A)</u>

Implementation of the selected RA for SWMU 211-A was designed and implemented during this fifth synchronized Five-Year Review reporting period. Prior to the implementation at SWMU 211-A, well installation and soil sampling for the final characterization/RDSI, as required by the ROD, were completed in the fall of 2012. A D1 *Final Characterization Report for the Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Source for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D1, (DOE 2013e) was developed to document the findings and to support the remedy selection as required by the ROD. Additional evaluation by the FFA parties resulted in the development of a D2 final characterization report (DOE 2013f). DOE issued a letter notification, *Final Characterization Notification for Solid Waste Management Unit 211-A and Solid Waste Management Unit 211-B at the Paducah Gaseous Diffusion Plant, Paducah Kentucky*, PPPO-02-1979222-13B, on July 10, 2013 (DOE 2013g). This final characterization notification identified DOE's recommendation for the remedy selection for both of the C-720 Building TCE Northeast and Southeast Spill Sites as long-term monitoring with interim LUCs (Alternative 2).

EPA requested additional groundwater data for the RGA to support the basis for the final selected remedy (EPA 2013). EPA issued an additional work request (EPA 2014), as provided for in the FFA, to collect the additional groundwater data as a follow-on phase of the RDSI. Negotiations among DOE, Kentucky Division of Waste Management (KDWM), and EPA followed to determine the type and location of groundwater sampling required to address the remaining concerns. A series of decision rules was developed by the FFA parties to provide a framework for analyzing the sample results upon collection and analysis. The additional sampling and analysis plan was documented in Appendix C of the *Addendum to the Remedial Design Work Plan for Solid Waste Management Units 1, 211-A, and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Sampling and Analysis Plan*, DOE/LX/07-1268&D2/R2/A1 (DOE 2015c). The groundwater sample collection and analysis were performed in 2015.

Following collection of additional groundwater data, the results of that effort were included in the *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2/A1 issued in December 2015 (DOE 2015d). After additional evaluation by the FFA parties, the *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/071288&D2/A1/R1 (DOE 2016c) was issued in April 2016. EPA issued letter FFS-16-0251 on May 25, 2016 (EPA 2016), indicating that EPA is not able to approve the *Addendum to the Final*

Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-1288&D2/A1/R1.

At the close of the reporting period for the fourth synchronized Five-Year Review, the FFA parties had not reached agreement for implementing either Alternative 2 or Alternative 8, as contained in the ROD, for either of the C-720 Building TCE Northeast or Southeast Spill Sites. Interim LUCs, however, are included in both possible alternatives. The interim LUCs that consist of the excavation/penetration permit program and placement of warning signs to provide notice and warning of environmental contamination have been implemented.

On May 23, 2018, early in the reporting period for the fifth synchronized Five-Year Review, the FFA parties discussed and arrived at implementing EISB with interim LUCs (Alternative 8) at SWMU 211-A (DOE 2018d). In preparation for field implementation, the *Certified for Construction Remedial Design Report for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2019b), and *Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2021), were developed and approved by the FFA parties.

Implementation of the remedy was initiated in March 2022 and was completed in October 2022. EISB consisted of jet injection hydraulic fracturing with direct push technology (DPT), and bioamendment and bioaugmentation injections. Following completion of bioaugmentation injection, a network of performance wells was installed to monitor the continued effectiveness of EISB. In addition, long-term MWs were installed to assess progress toward achieving cleanup goals.

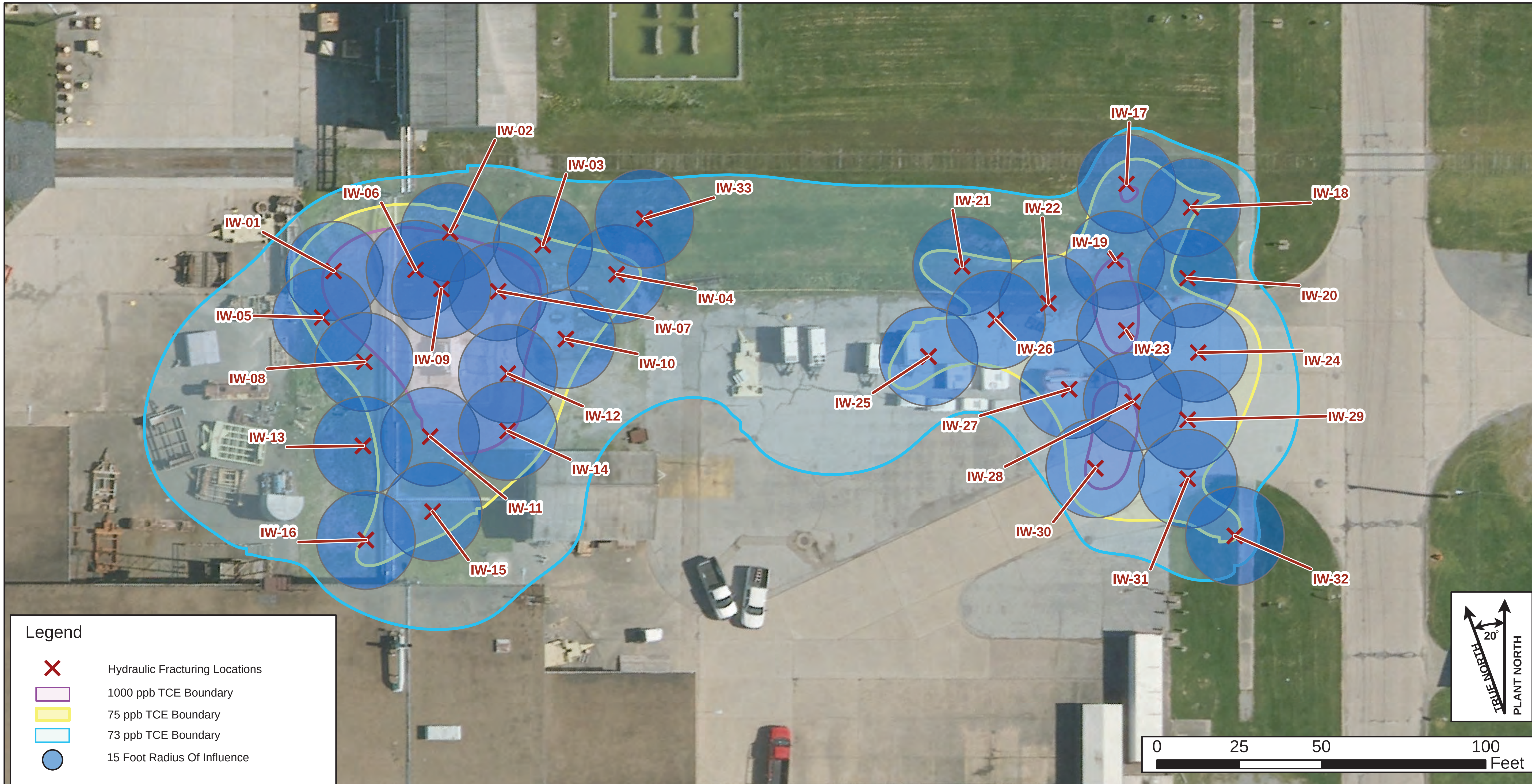
DPT Jet Injection fracturing occurred at 33 locations and utilized DPT drilling methods to produce horizontal fractures at pre-planned depths with an estimated radius of 15 ft (Figure 10.7). The fractures were injected with a mixture of guar gum, sand, microscale ZVI (mZVI), and an enzyme breaker. The sand and mZVI proppant helped expand targeted fractures and acted as support, holding the fractures open after injection activities ceased, which enhanced permeability to facilitate the subsequent delivery of amendments. Shortly after the conclusion of the proppant injections, the guar gum biodegrades with the assistance of the enzyme breaker. In total, the following amounts of materials were placed during the fracturing:

- mZVI—445,334 lb
- Proppant sand—221,674 lb
- Guar Gum gel—66,240 gal

In addition, the mZVI will continue to degrade TCE and its degradation products via abiotic processes.

EISB injection well drilling, and bioamendment and bioaugmentation injections followed the placement of the fractures. A total of 85 injection wells were drilled and constructed in the 33 fracture areas. The bioamendment activities involved the injection of emulsified vegetable oil (EVO) in conditioned water [dissolved oxygen-reduced] through each injection well into the UCRS to support the bioremediation process of reductive dechlorination of TCE and its degradation products to ethene. The emulsion allowed the bioamendment to be injected further into the UCRS to allow treatment of a larger radius up to 15 ft with each injection well location. An estimated total injection of 154,436 gal of EVO solution was injected into the treatment area, which exceeded the RDR target of 130,000 gal. During the injection of EVO, *Dehalococcoides ethenogenes* bacteria also was injected into the subsurface to support the dechlorination

THIS PAGE INTENTIONALLY LEFT BLANK



Map Source Information
Map Location/Date: G:\GIS\ARCVIEWS\PROJECTS\5YrReview\SWMU_211_A.aprx 2/14/2023
Hydraulic Fracturing Well Locations: G:\GIS\iPEGASIS.gdb\Locations
Injection Radius: G:\GIS\ARCVIEWS\PROJECTS\SWMU 211-A\SWMU_211_A.gdb\InjectionRadius_Buffer
TCE Boundaries: G:\GIS\ARCVIEWS\PROJECTS\SWMU 211-A\commondata\swmu_211_a_b1
--1000 ppb (\211A_1Kppb_90ci.shp); --75 ppb (\211A_75ppb_Nominal_Bezier.shp) -- 73 ppb (\211A_73ppb_90ci_Bezier.shp)

Figure 10.7. SWMU 211-A DPT Jet Injection Hydraulic Fracturing Injection As-Built Locations

THIS PAGE INTENTIONALLY LEFT BLANK

of contaminants. A total of 215 L of *Dehalococcoides ethenogenes* bacteria were injected into the treatment area. Completion of the injections provided the needed subsurface conditions for bioremediation to occur.

Long-term and performance MW networks were installed as part of the RA. See Tables 10.1 and 10.2 and Figure 10.8 for details concerning the well networks. The performance well network provides data to support evaluating whether bioremediation is continuing to occur. The long-term well network provides data to support evaluating the effectiveness in meeting the RAOs. The selected RA for SWMU 211-A achieves the RAOs by removing TCE and other VOCs in the subsurface soils using EISB. The RAOs for the action are provided in Section 10.1.

Table 10.1. Installed Performance Monitoring Wells

Well ID	Screen Location	Well Diameter (inches)	Screened Interval (ft bgs)	Total Depth (ft bgs)
PW001	RGA (upper)	4	65–70	71.5
PW002	UCRS (lower)	4	55–60	61.5
PW003	UCRS (middle)	4	45–50	51.5
PW004	RGA (upper)	4	65–70	71.5
PW005	UCRS (lower)	4	55–60	61.5
PW006	UCRS (middle)	4	45–50	51.5
PW007	RGA (upper)	4	65–70	71.5
PW008	UCRS (lower)	4	55–60	61.5
PW009	UCRS (middle)	4	45–50	51.5
PW010	RGA (upper)	4	65–70	71.5
PW011	UCRS (lower)	4	55–60	61.5
PW012	UCRS (middle)	4	45–50	51.5
PW013	RGA (upper)	4	65–70	71.5
PW014	UCRS (lower)	4	55–60	61.5
PW015	UCRS (middle)	4	45–50	51.5
PW016	RGA (upper)	4	65–70	71.5
PW017	UCRS (lower)	4	55–60	61.5
PW018	UCRS (middle)	4	45–50	51.5

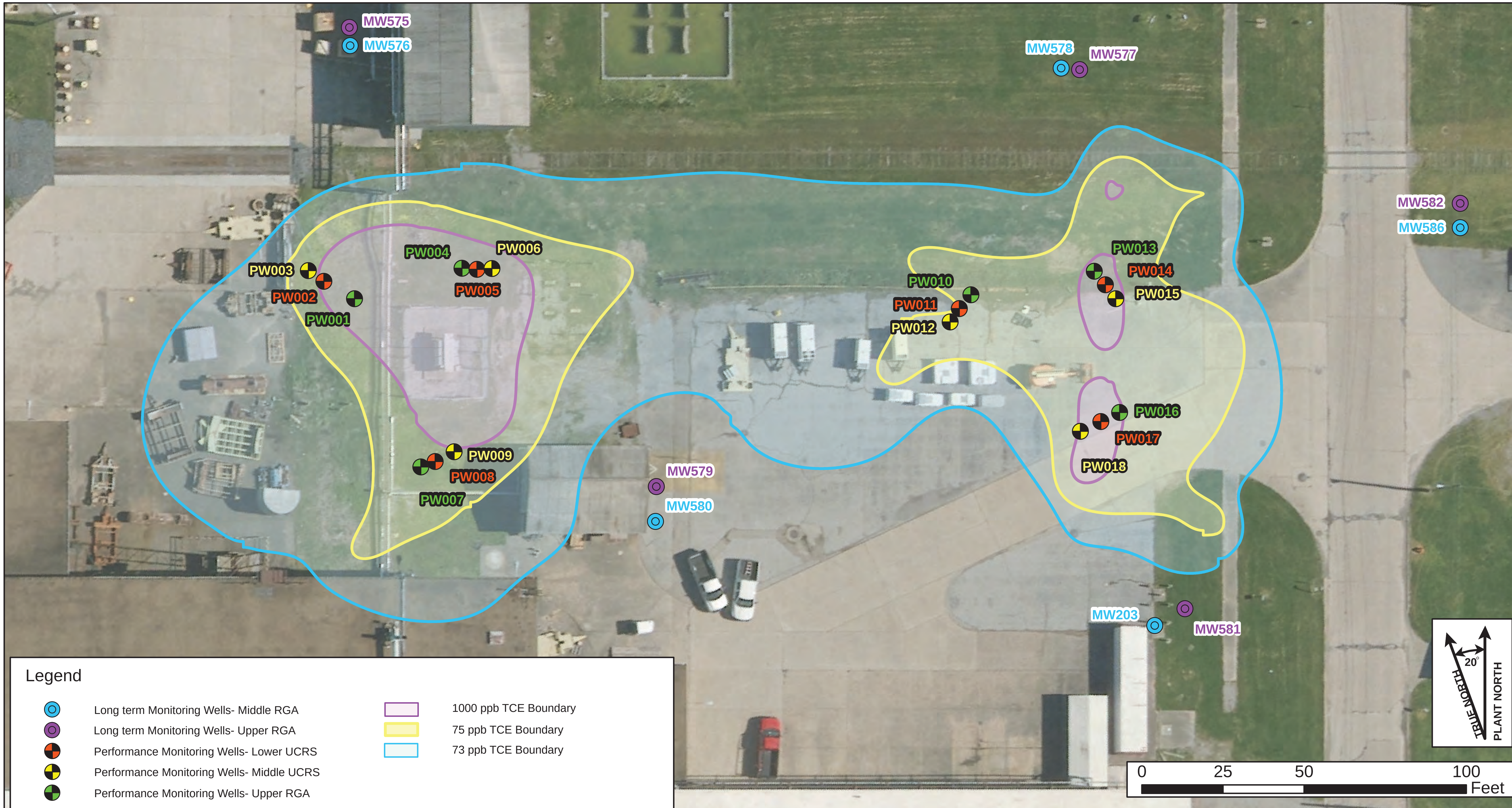
Note: MWs constructed with a 1.5-ft sump below the screened interval.

Table 10.2. Installed Long-Term Monitoring Wells

Well ID	Screened Zone	Well Diameter (in)	Screened Interval (ft bgs)	Total Depth (ft bgs)	Monitoring Position with Respect to SWMU 211-A (gradient)
MW575	RGA (upper)	4	65–70	71.5	Downgradient
MW576	RGA (middle)	4	70–75	76.5	Downgradient
MW577	RGA (upper)	4	65–70	71.5	Downgradient
MW578	RGA (middle)	4	70–75	76.5	Downgradient
MW579	RGA (upper)	4	65–70	71.5	Upgradient
MW580	RGA (middle)	4	70–75	76.5	Upgradient
MW581	RGA (upper)	4	65–70	71.5	Upgradient
MW582	RGA (upper)	4	65–70	71.5	Crossgradient
MW586	RGA (middle)	4	70–75	76.5	Crossgradient

Note: MWs constructed with a 1.5-ft sump below the screened interval.

THIS PAGE INTENTIONALLY LEFT BLANK



Map Source Information
Map Location/Date: G:\GIS\ARCVIEWS\PROJECTS\5YrReview\SWMU_211_A.aprx 2/14/2023
Long-term and Performance Monitoring Well Locations:G:\GIS\iPEGASIS.gdb\Locations
TCE Boundaries: G:\GIS\ARCVIEWS\PROJECTS\SWMU 211-A\commondata\swmu_211_a_b1
--1000 ppb (\211A_1Kppb_90ci.shp); --75 ppb (\211A_75ppb_Nominal_Bezier.shp) -- 73 ppb (\211A_73ppb_90ci_Bezier.shp)

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

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

Figure 10.8. SWMU 211-A Long-Term and Performance Monitoring Well Locations

THIS PAGE INTENTIONALLY LEFT BLANK

The field implementation of EISB at SWMU 211-A has been detailed in an interim RACR (DOE 2023).

10.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

Oil Landfarm

The ROD documents the estimated time frame for attaining the groundwater protection remediation goal within the Oil Landfarm and outside the treatment area to be approximately 68 years (DOE 2012c). The soil mixing with ZVI RA is an *in situ* treatment system that is complete after the mixing action has been performed and the ZVI attenuates COCs. Beyond the ZVI attenuation, the RA does include a period of O&M after the soil mixing ceases and contaminant levels continue to dissipate. Two periodic items that were included in the ROD are continuing requirements:

1. Periodic sampling of groundwater MWs, as listed in the RAWP (DOE 2014b); and

2. Inspect interim LUCs (signs) annually until a final remedy is selected as part of a subsequent OU that addresses the relevant media.

MW Sampling Analytical Results

The RAWP included direction for the installed MW network for the soil mixed area to be sampled on a quarterly schedule for the first year following installation, semiannually for the second year following installation, and then continues semiannual sampling beyond the second year. At the time of production of this fifth synchronized Five-Year Review, the Oil Landfarm MW network consists of the following 7 MWs (Figure 10.4).

- MW161 (middle RGA)
- MW542 (upper RGA)
- MW543 (upper RGA)
- MW544 (upper RGA)
- MW545 (upper RGA)
- MW546 (upper RGA)
- MW547 (upper RGA)

Figures 10.9 through 10.13 present the VOC contaminant levels in each MW as sampled during this reporting period. The field RA was competed in 2015. Two MWs, MW543 and MW544, are upgradient to the soil mixing area (Figure 10.4). Wells MW542, MW545, MW546, MW547 and MW161 are located downgradient to the soil mixing area. Since the implementation of the field RA, all MWs have seen decreased levels of all COCs over time. This is an indication that the RA has been generally effective. During the last two years of this five-year reporting period, contaminants in upgradient wells have remained generally at or near the required groundwater MCL levels for each VOC. Downgradient wells are exhibiting contaminant levels at levels near to or above the groundwater MCL contaminant levels for TCE, *cis*-1,2-DCE, and vinyl chloride. As such, the downgradient wells are not exhibiting groundwater contaminant levels that would allow attainment of RAO 3 to be declared. As indicated in the ROD, however, the attainment of the groundwater protection remediation goal is expected to require approximately 68 years. As of the end of this reporting period, approximately six years have passed since soil mixing was completed.

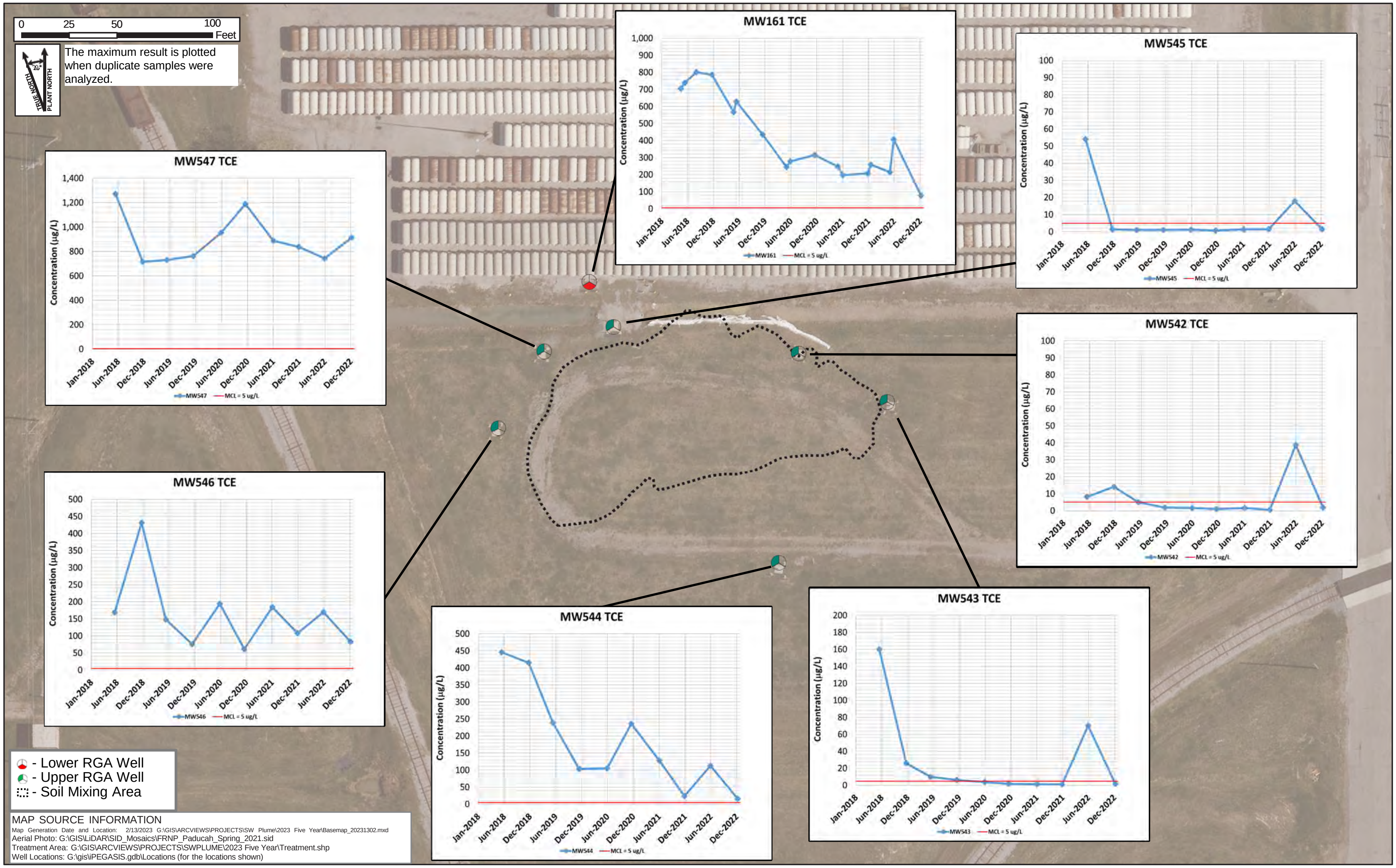


Figure 10.9. SWMU 1 - TCE Trends

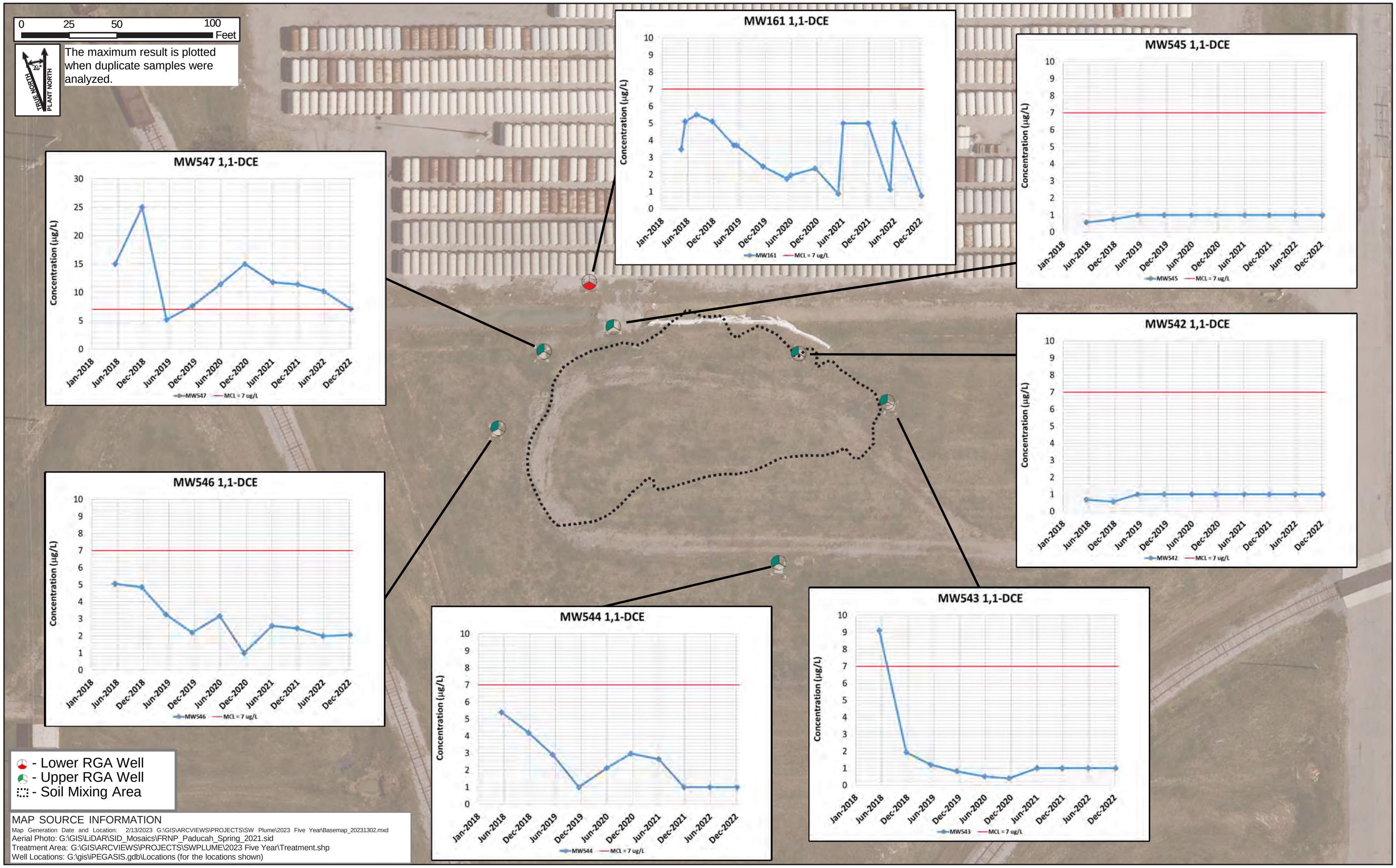


Figure 10.10. SWMU 1 - 1,1-Dichloroethene Trends

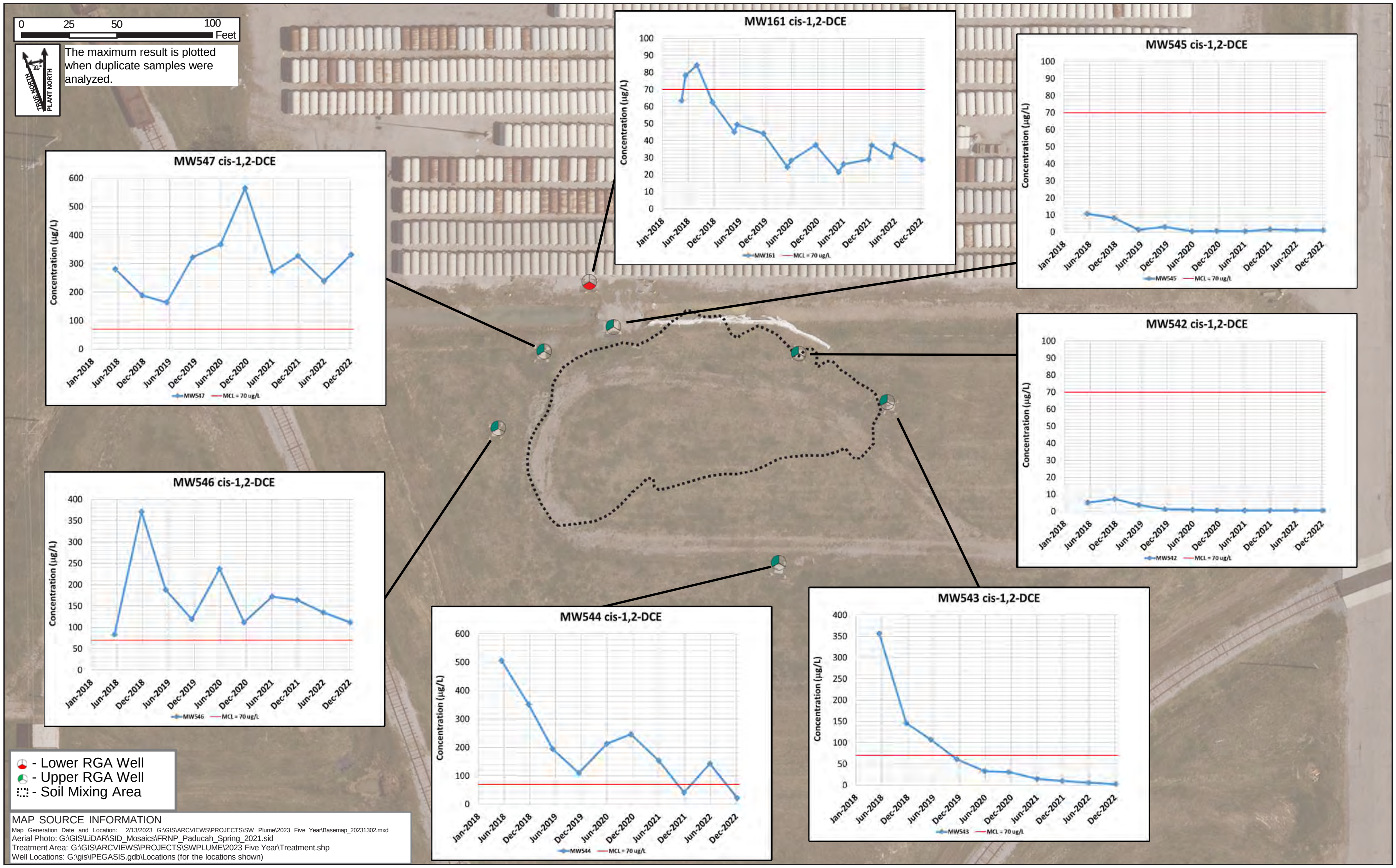


Figure 10.11. SWMU 1 - *cis*-1,1Dichloroethene Trends

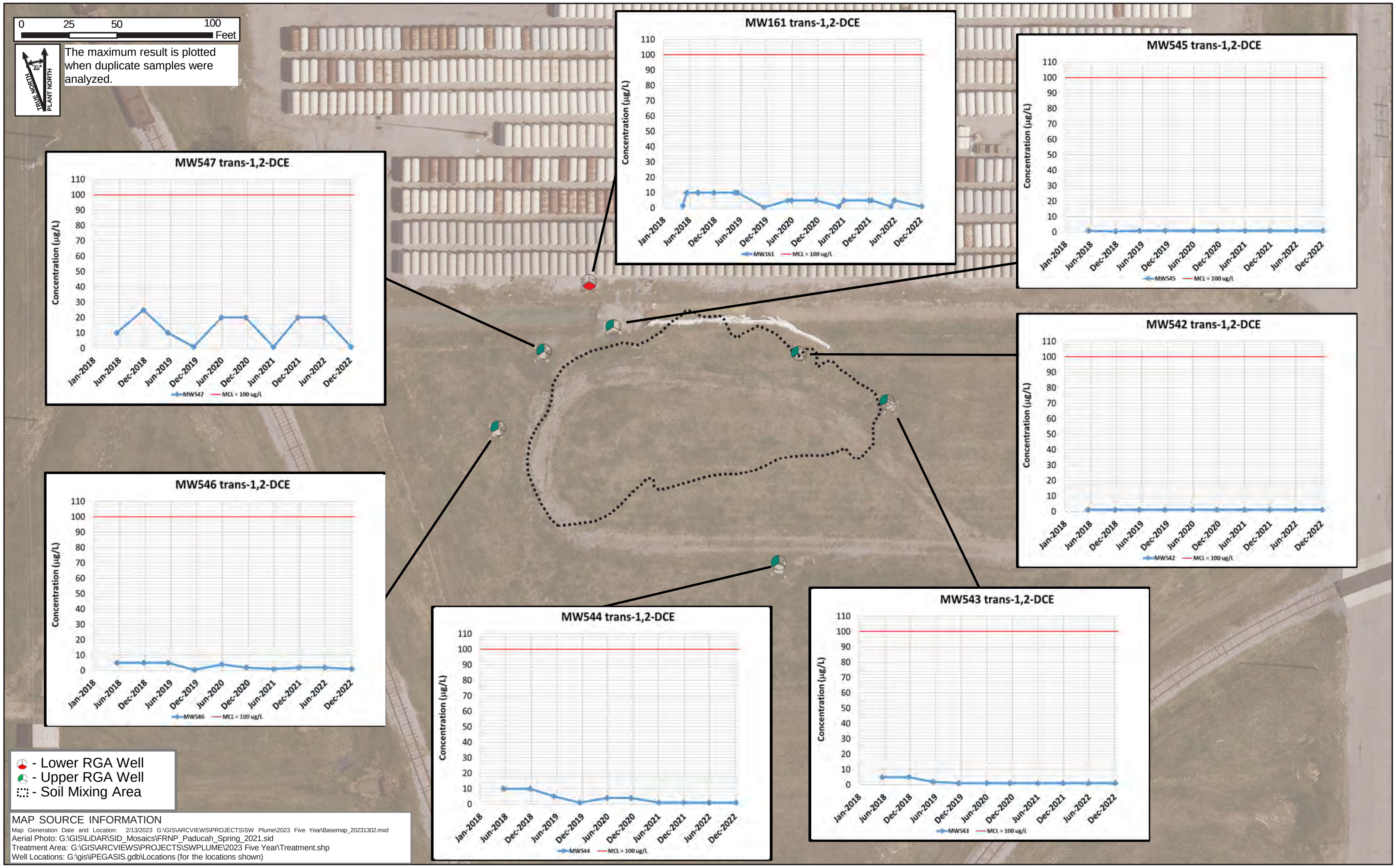


Figure 10.12. SWMU 1 - *trans*-1,2-Dichloroethene Trends

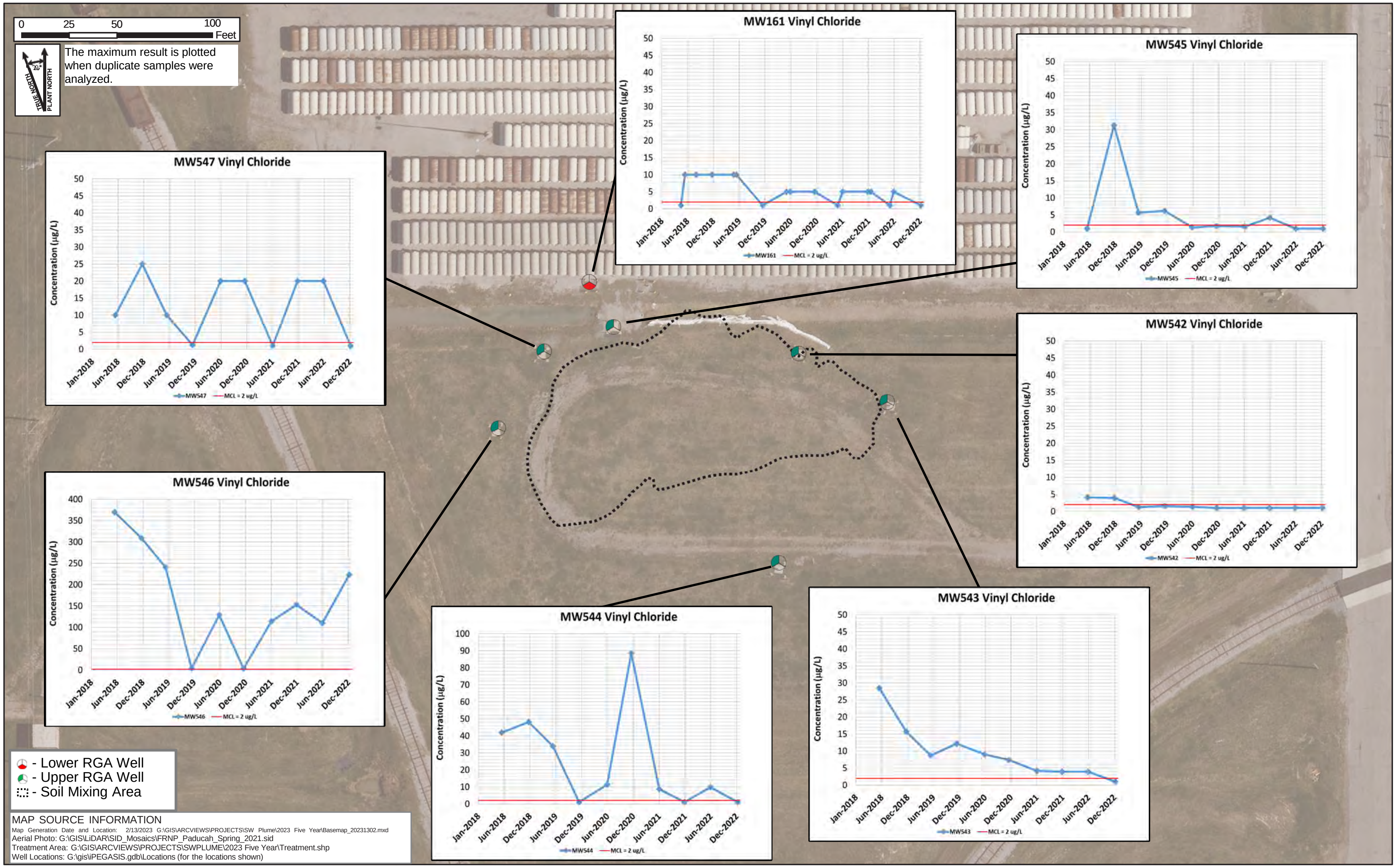


Figure 10.13. SWMU 1 - Vinyl Chloride Trends

C-720 Building TCE Northeast Spill Site (SWMU 211-A)

O&M cannot be assessed at this time for the C-720 Building TCE Northeast Spill Site (SWMU 211-A) as the field implementation was just completed at the end of the fifth synchronized Five-Year Review reporting period and operational data is limited. Only the baseline sampling of the long-term well network was available at the time of evaluation. The baseline VOC results were for samples collected just before initiation of bioamendment injection and are shown in Table 10.3. As scheduled, only one round of performance well samples was collected after the field injection and just before the end of the reporting period. Also, due to high volumes of vegetable oil being present in the performance wells and the resulting damage to the field parameter testing equipment, the field parameters were not collected for the initial monthly samples following treatment. Alternate methods are being planned for future collection of field parameters to prevent equipment damage. Also, due to radiological safety issues with the *Dehalococcoides ethenogenes* laboratory, the laboratory could not evaluate bacteria levels. Additional equipment is being installed to not impact future sample analyses. The VOC results of the first performance well sampling are shown in Table 10.4. As all performance wells are located within the area of occurring bioremediation, all wells show the presence of contamination. The presence of TCE degradation products at elevated levels were also identified in the first month samples. As little to no degradation was occurring at SWMU 211-A prior to the field implementation, the presence of the degradation products is a positive indication that bioremediation is occurring. Because there has been only one sampling event, a comparative analysis over time is not feasible. The interim LUCs were in place and operating at the close of the reporting period.

The results of the baseline sampling of the long-term MW network, as expected, indicate the presence of VOC contaminants above MCLs. As expected, with the contaminant concentrations exceeding the MCLs, RAO 3 has not been attained at this time.

10.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

Oil Landfarm

The RACR for the Oil Landfarm RA was approved by the FFA parties in January 2017. The site has entered into a period of monitoring and attenuation needed to attain the remaining RAOs. As shown and discussed in Section 10.3, there has been a considerable reduction in the contaminant levels present in the MW network; however, the level of contaminants in the wells screened in the RGA have not been reduced below MCLs; therefore, RAO 3 has not been attained at this time. The interim LUCs were in place and operating at the close of the reporting period.

C-720 Building TCE Northeast Spill Site (SWMU 211-A)

During this fifth synchronized Five-Year Review, SWMU 211-A was active. The decision was made by the FFA parties that EISB with interim LUC would be the RA to be implemented. The RDR and the RAWP for the RA were developed and approved. Implementation of the remedy was initiated in March 2022 and was completed in October 2022. EISB consisted of jet injection hydraulic fracturing with DPT, and bioamendment and bioaugmentation injections. Following the completion of bioaugmentation injections, a network of performance wells was installed to monitor the continued effectiveness of EISB. In addition, long-term MWs were installed to assess progress toward achieving RAO 3. The remedy was entering the long-term and performance monitoring period just following fieldwork at the end of the five-year reporting period. As such, sufficient monitoring data is not available to allow a complete determination of the effectiveness of the remedy. The containment concentrations in the underlying RGA groundwater exceed the MCLs; therefore, RAO 3 has not been attained at this time. However, the presence of TCE degradation products is indicative of bioremediation occurring. The interim LUCs were in place and operating at the close of the reporting period.

Table 10.3. Baseline VOC Groundwater Data for Long-Term Monitoring Wells

Location ID		MW203	MW575	MW575*	MW576	MW577	MW578	MW579	MW580	MW581	MW582	MW586
Parameter	**Units**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**
1,1-DCE	µg/L	3.34	1,530	1,500	3,530	15.8	34.3	5.89	5.5	0.39 J	22.6	75.4
cis-1,2-DCE	µg/L	9.76	39.1	40.1	83.3	1.41	14	3.88	4.58	3.95	14.6	39.5
TCE	µg/L	38.9 Y1	1,060 Y1	1,100 Y1	3,760 Y1	138 Y1	80.8 Y1	22.3 Y1	14.7 Y1	14.9 Y1	76 Y1	900 Y1
trans-1,2-DCE	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.43 J
Vinyl chloride	µg/L	1 U	2.55	2.66	7.04	1 U	1 U	1 U	1 U	1 U	1 U	1 U

U = analyte analyzed for, but not detected at or below, the lowest concentration reported
J = indicates an estimated value
Y1 = matrix spike/matrix spike duplicate recovery outside acceptance criteria
* = duplicate

Table 10.4. Baseline VOC Groundwater Data in Long-Term Performance Wells (12/2022)

Location ID		PW001	PW002	PW003	PW004	PW005	PW006	PW007	PW008	PW009
Parameter	**Units**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**
1,1-DCE	µg/L	769 Y1Y2	24,800 Y1Y2	19,000 Y1Y2	9,760 Y1Y2	23,800 Y1Y2	13,000 Y1Y2	1,180 Y1Y2	5,910 Y1Y2	335 Y1Y2
cis-1,2-DCE	µg/L	632 Y1Y2	13,800 Y1Y2	5,780 Y1Y2	5,650 Y1Y2	7,070 Y1Y2	7,860 Y1Y2	868 Y1Y2	7,100 Y1Y2	23.3 Y1Y2
trans-1,2-DCE	µg/L	10 U	500 U	250 U	200 U	250 U	200 U	25 U	100 U	5 U
TCE	µg/L	67.9	3080	128 J	200 U	7,990	106 J	63.8	390	322
Vinyl chloride	µg/L	35.5	500 U	113 J	1,180	4,030	3,630	65.5	615	5 U

Location ID		PW010	PW011	PW012	PW013	PW014	PW015	PW016	PW017	PW018
Parameter	**Units**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**	**12/14/2022**
1,1-DCE	µg/L	100 Y1Y2	328 Y1Y2	424 Y1Y2	73.9 Y1Y2	9 Y1Y2J	8.6 Y1Y2J	20 Y1Y2U	30.6 Y1Y2	5.1 Y1Y2J
cis-1,2-DCE	µg/L	53.2 Y1Y2	18.2 Y1Y2J	18 Y1Y2	353 Y1Y2	887 Y1Y2	751 Y1Y2	198 Y1Y2	3,120 Y1Y2	526 Y1Y2
trans-1,2-DCE	µg/L	5 U	20 U	5 U	5 U	20 U	10 U	20 U	20 U	10 U
TCE	µg/L	29	1,200	345	33.4	10 J	18.4	25.6	413	12.5
Vinyl chloride	µg/L	5 U	20 U	5 U	5.9	20 U	6.7 J	20 U	20 U	14.5

U = analyte analyzed for, but not detected at or below, the lowest concentration reported
J = indicates an estimated value
Y1 = matrix spike/matrix spike duplicate recovery outside acceptance criteria
Y2 = matrix spike/matrix spike duplicate relative percent difference outside acceptance criteria

10.5 SITE INSPECTION

Oil Landfarm

Site inspection of the Oil Landfarm was made on December 7, 2022, by the five-year review team, the facility manager, KDEP, and representatives from DOE's support contractor. The site was grass-covered with no significant erosion. The access road was in good repair but was highly covered in grass. There was no construction or other operational activities being conducted at the Oil Landfarm at the time of the inspection. The inspection revealed no major changes to physical site conditions since the completion of RA field operations, and there were no changes to land use or expected land use at the Oil Landfarm. Interim LUCs consisting of the placement of warning signs and DOE's excavation/penetration permit program were in place to prevent exposure to the site contaminants.

C-720 Building TCE Northeast and Southeast Spill Sites

C-720 Building TCE Northeast Spill Site: A site inspection was conducted on December 7, 2022. The C-720 Building TCE Northeast Spill Site includes a slightly covered grassy area, with a former railroad bed located to the north and a concrete/asphalt drive to the south that abuts the north side of the C-720 Building. No construction or operations activities were being conducted at the time of the site inspection; however, the SWMU had undergone heavy construction and drilling during the previous eight months due to the implementation of the RA (March 2022–November 2022). No erosion or disrepair was noted for the area. Interim LUCs consisting of the placement of warning signs and DOE's excavation/penetration permit program were in place to prevent exposure to the site contaminants. Additionally, portions of the injection areas had been surrounded by concrete barriers to prevent well damage from other plant activities in the area.

C-720 Building TCE Southeast Spill Site: The site inspection of the southeast spill site also was conducted on December 7, 2022. The C-720 Building TCE Southeast Spill Site includes a concrete parking area directly adjacent to the south edge of the C-720 Building. No construction or operations activities were being conducted at the time of the site inspection. Little to no plant activities or equipment were present in the area as the plant had discontinued use of portions of the C-720 Building adjacent to the SWMU. Interim LUCs consisting of the placement of warning signs and DOE's excavation/penetration permit program were in place to prevent exposure to the site contaminants.

10.6 TECHNICAL ASSESSMENT

Oil Landfarm

During this Five-Year Review reporting period, the RA implemented at SWMU 1 has been monitored using the long-term MW network. After the first year of operation, the well network has been sampled on a semiannual basis. As described in Section 10.3, during the last two years of the five-year reporting period, contaminants in upgradient wells have remained generally below or at the required groundwater MCL. Downgradient wells are exhibiting contaminant levels of TCE, *cis*-1,2-DCE, and vinyl chloride at levels above the groundwater MCL levels. As such, the long-term MWs are not exhibiting groundwater contaminant levels that allow attainment of RAO 3. As indicated in the ROD, however, the attainment of the groundwater protection remediation goal is expected to require approximately 68 years. As of the end of this reporting period, it has been approximately six years since soil mixing was completed. Interim LUCs were in place and operating at SWMU 1 during this reporting period.

C-720 Building TCE Northeast Spill Site (SWMU 211-A)

The remedial activities for the C-720 Building TCE Northeast Spill Site during the period of this fifth synchronized Five-Year Review included completion of the remedial design, RAWP, and the field implementation of the EISB RA. The fieldwork was completed at the end of the reporting period. As described in the RAWP and the RDR, the performance and long-term MW networks will provide the data needed to ascertain the effectiveness of the RA during each reporting period. However, one round of results from performance wells were available at the time of document production. The presence of TCE degradation products at elevated levels were also identified in the first month samples. As little to no degradation was occurring at SWMU 211-A prior to the field implementation, the presence of the degradation products is a positive indication that bioremediation is occurring. Interim LUCs were in place and operating at SWMU 211-A during this reporting period.

10.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Oil Landfarm

The soil mixing with ZVI action has been completed for approximately six years. Based on the postremediation soil sampling and the groundwater sampling performed thus far, the remedy appears to be functioning as intended. The ZVI is expected to continue to treat residual VOC contamination that may be migrating with groundwater to the RGA. Interim LUCs are in place and are functioning to control exposures.

C-720 Building TCE Northeast Spill Site (SWMU 211-A)

The remedy for the Southwest Plume VOC sources at the C-720 Building TCE Northeast Spill Site had just completed being implemented at the close of this reporting period; therefore, the function of this portion of the remedy cannot be completely assessed at this time. Quarterly sampling is scheduled for the first year following implementation, which, once completed, will supply the needed information to determine the function of the remedy. However, one round of results from performance wells were available at the time of document production. The presence of TCE degradation products at elevated levels were also identified in the first month samples. As little to no degradation was occurring at SWMU 211-A prior to the field implementation, the presence of the degradation products is a positive indication that bioremediation is occurring. Interim LUCs, however, are in place and are functioning to control exposures.

10.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The exposure assumptions used to develop the risk assessment included both the current exposures (on-site industrial and excavation worker and off-site recreational) and the potential future exposures (future on-site resident using groundwater at the SWMU boundary). The MCL for TCE remains 5 µg/L (and the MCLs for other COCs, *cis*- and *trans*-1,2-DCE, vinyl chloride, and 1,1-DCE remain unchanged) as it was during the original remedy selection. The basis and the numerical cleanup levels established in the Southwest Plume ROD are included in Table 10.5 for both the Oil Landfarm and the C-720 Building TCE Northeast and Southeast Spill Sites.

Table 10.5. Chemical-Specific Standards for the Southwest Plume UCRS Soil

Contaminant*	Media	Cleanup Level-Oil Landfarm	Cleanup Level-C-720 Building TCE Northeast and Southeast Spill Sites	Basis
TCE	UCRS Soil	73 µg/kg	75 µg/kg	Calculated soil cleanup levels protective of groundwater at POE.
1,1-DCE	UCRS Soil	130 µg/kg	137 µg/kg	Calculated soil cleanup levels protective of groundwater at POE.
cis-1,2-DCE	UCRS Soil	600 µg/kg	619 µg/kg	Calculated soil cleanup levels protective of groundwater at POE.
trans-1,2-DCE	UCRS Soil	1,080 µg/kg	5,290 µg/kg	Calculated soil cleanup levels protective of groundwater at POE.
Vinyl chloride	UCRS Soil	34 µg/kg	570 µg/kg	Calculated soil cleanup levels protective of groundwater at POE.

*Chloroform was a COC, but no cleanup level was established.

The RAOs identified for the Southwest Plume VOC sources ROD remain valid for the targeted sources.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy.

The Southwest Plume VOC source zones are located within the facility security fence and other administrative controls that prevent unauthorized access to the site. Exposure assumptions used in the ROD regarding current restrictions on use of groundwater within DOE property remain valid.

The current groundwater data indicate that assumptions underlying the remedy selection in the ROD still are valid for the targeted sources.

10.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

Oil Landfarm

No other information has come to light that would call into question the protectiveness of the remedy implemented at the Oil Landfarm.

C-720 Building TCE Northeast Spill Site

No other information has come to light that would call into question the expected protectiveness of the remedy implemented at the SWMU 211-A.

10.7 ISSUES

None.

11. NSDD SOURCE CONTROL

The NSDD originates within the north central portion of the Paducah Site industrial area and joins with Little Bayou Creek to the north of the facility. Figure 11.1 illustrates the location of the NSDD source control. Historically, the NSDD received wastewater from the C-400 Cleaning Building that housed equipment for decontamination, metal etching and plating, metals recovery, radioactive materials stabilization and recovery, uranium trioxide production, diffusion process equipment testing, and uranium tetrafluoride (UF_4) pulverization. Additional sources of runoff to the ditch include the C-600 Steam Plant, the C-335 and C-337 Process Buildings, the C-635 Cooling Tower, and the C-535 and C-537 Switchyards. As a consequence, the soil and sediment in the ditch were contaminated with radionuclides, metals, and PCBs. Over the years, fly ash and coal dust from the C-600 Steam Plant and sediment from the ditch watershed had nearly filled the NSDD, causing the ditch to overflow onto an adjacent stretch of 10th Street during heavy rains.

11.1 REMEDY SELECTION

In March 1994, DOE and EPA, with the concurrence of KDEP, signed a *Record of Decision for Interim Action Source Control at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1213&D3, as an initial step toward addressing sitewide problems (DOE 1994c).

The PHEA found that the critical exposure pathway is related to the off-site migration of on-site contaminant sources (CH2M HILL 1992). The PHEA also recommended action to eliminate migration of these contaminants off-site. The NSDD ROD also stated there was potential for exposure of site maintenance personnel to the contaminants within the ditch through routine maintenance activities. The personnel potentially were exposed to unacceptable risk via direct gamma radiation from contaminated sediment and soil; dermal contact with soil, sediment, and debris; inhalation of resuspended particulate during mowing; and incidental ingestion of contaminated surface water, soil, and sediment. The source control RA, discussed in this section, and the response actions for Sections 1 and 2 (SWMU 59), as discussed in Section 12, eliminated exposure pathways. In addition, aquatic organisms living in the NSDD were likely at risk for adverse effects that could reduce populations. Predators of aquatic organisms also may have been at equivalent levels of risk due to the bioaccumulation of PCBs.

No formal RAOs were presented in the NSDD ROD; however, the principal goals of the interim action were the following.

- Mitigate the introduction of contaminants into the NSDD.
- Decrease the migration of contaminants already present in the NSDD.
- Decrease the potential for direct contact with the contaminated material.

The IRA consisted of the following activities:

- Installing an ion exchange system in the C-400 Cleaning Building;

- Rerouting effluent from the C-400 Cleaning Building from the NSDD to KPDES Outfall 008;

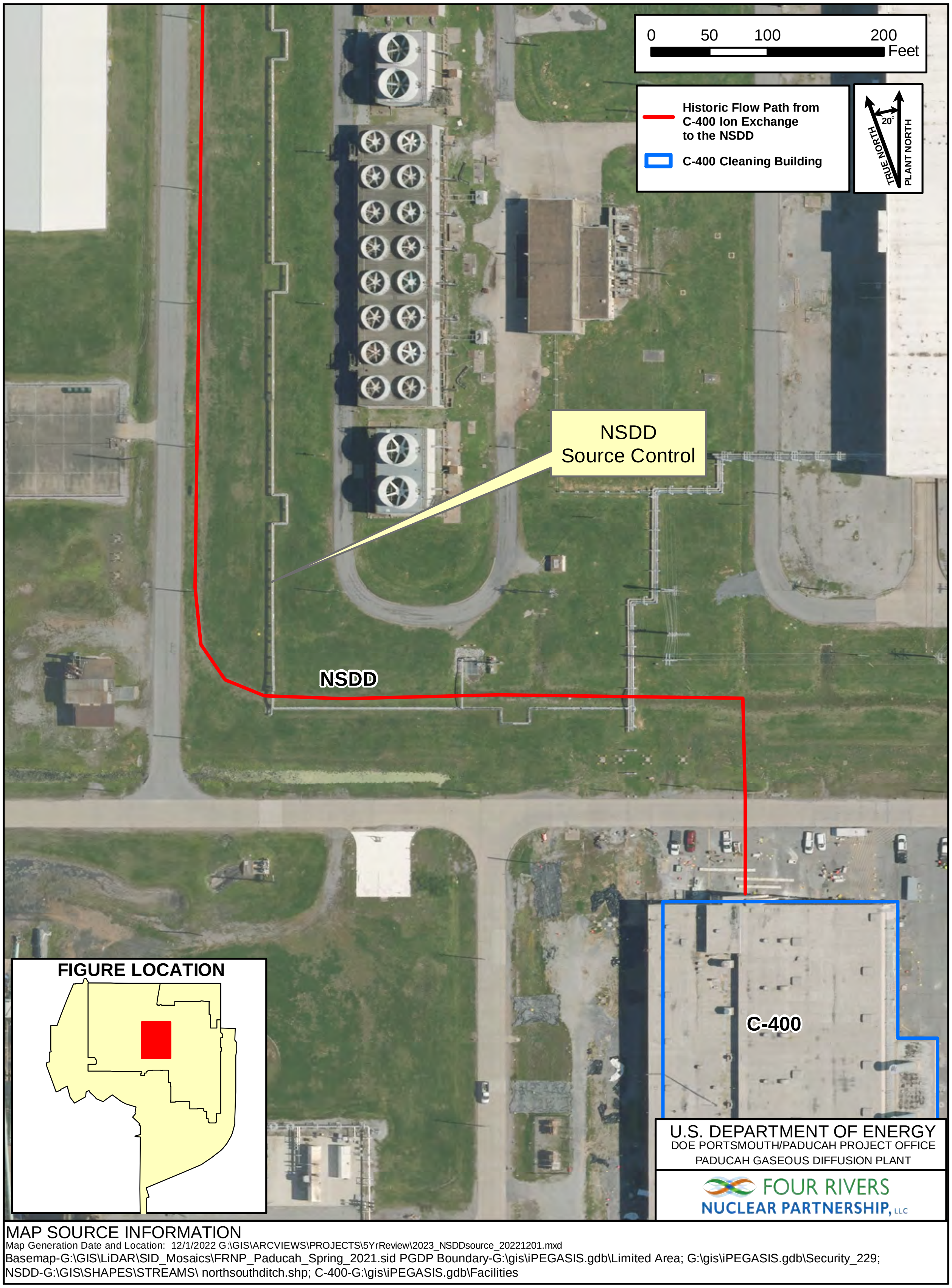


Figure 11.1. Location of NSDD Source Control

- Constructing an aboveground pipe and lift stations (C-400-L and C-616-L) and pumping NSDD flow along the aboveground pipeline to the existing C-615-K Lift Station;

- Removing fly ash from the C-600 Steam Plant ash pile runoff by constructing settling lagoons and then pumping the supernatant in the lagoons into the piping that replaced the southern part of the NSDD channel;

- Constructing a gabion to trap sediment and reducing the potential for sediment transport off-site from the NSDD; and

- Installing warning signs on both sides of the NSDD inside the security fence from Virginia Avenue to the C-616-C Lift Station to provide notice of elevated levels of radionuclides, metals, and PCBs in the area. These signs were removed upon successful completion of the response action for the NSDD Sections 1 and 2, which is discussed in Section 12.

11.2 REMEDY IMPLEMENTATION

DOE completed the IRA in August 1995 (DOE 1995c). Lagoons constructed at the C-600 Steam Plant eliminated fly ash deposition in the NSDD. Also, the discharge from the C-400 ion exchange system was routed to the KPDES Outfall 008 storm water drain, thereby eliminating discharges from the C-400 Cleaning Building to the NSDD. This change in design, routing to KPDES Outfall 008 instead of KPDES Outfall 001, was documented in the *Interim Measure Report and Operations & Maintenance Plan for the North/South Diversion Ditch Interim Corrective Measures at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1425&D1 (DOE 1995c), which was issued in December 1995. Section 3.1, Modification to the Original Design and/or the Approved Work Plan, of the referenced document states:

> A scope change was encountered during construction, which regarded the discharge pipe from the collection tank (C-400-B) located in building C-400. The discharge pipe (drain) that was to be used to discharge the collection tank water to the NSDD was to be routed through a man-hole, which during construction was identified as SWMU 203. SWMU 203 was included in the August 25, 1995 SWMU assessment report submitted to EPA and the state. Since the discharge line would be releasing clean water, the resolution was to reroute the 140 foot discharge line (pipe) out the west side of building C-400 and into a stormwater drain. The discharge water will be transferred through the storm water drainage system to Outfall 008.[14]

Since completion of the NSDD Source Control IRA, a second ROD for an IRA at the NSDD was signed on September 25, 2002, which is discussed in Section 12.

11.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

The O&M requirements are documented in *Operation and Maintenance Plan for Sections 1 and 2 of the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2057&D2 (DOE 2005c). The primary activities associated with O&M include the following:

[14] The term "clean" refers to water that has been treated by the C-400 ion exchange system. If water had been discharged into the manhole (SWMU 203) as planned, there would be the possibility of contamination being washed into the NSDD by the C-400 discharge water.

- Inspecting lift stations weekly (fully automated) to ensure the lift station screens remain clean, the lift stations are operational, and the pipeline is not leaking;

- Activating heat tracing that was installed on the aboveground piping in the fall, deactivating the heat tracing in the spring, and inspecting the installed heat tracing weekly;

- Inspecting quarterly the warning signs that were put in place when the ROD was developed; and

- Mowing the area adjacent to the pipeline and warning signs twice during the summer months.

Until 2013, USEC enriched uranium at the Paducah Site to supply nuclear fuel to electric utilities worldwide. The operations of the C-400 ion exchange system and discharges from it were conducted according to a memorandum of understanding between USEC and DOE until October 2014, at which time, USEC terminated its lease agreement with DOE and returned the leased facilities. Subsequent to delease of the property, C-400 operations had closed. The ion exchange system no longer was needed, and it was removed prior to the end of 2017. The O&M Plan reflects the current status.

The C-400-L Lift Station is located on the north side of the NSDD near its upper reach close to the intersection of 10th Street and Virginia Avenue. It is included in the radiological boundary posting along the NSDD. With the exception of a gravel walkway, access is limited to the station electrical control panels and the east side of the lift station. The lift station is in good condition and appears to be functioning normally.

The C-616-L Lift Station is located on the south side of Virginia Avenue and north of the C-600 Steam Plant. This lift station collected coal pile runoff and fly ash settling basin water from C-600. Water from the fly ash settling basins enters the station through underground piping from the basins. Coal pile runoff was routed into the west side of the lift station by a trench. This lift station was under the control and operation of USEC prior to DOE’s assuming ownership in 2014. Sections 1 and 2 of the O&M Plan have been revised to reflect DOE's responsibility for the operation of C-616-L and C-615-K Lift Stations.

The discharge piping from the C-400-L and C-616-L Lift Stations, which is mounted on abovegrade concrete and steel pipe supports, originally routed water around the more contaminated southern-most reaches of the NSDD to a point just south of the east-west ditch leading to KPDES Outfall 001. To facilitate the remediation of Sections 1 and 2 of the NSDD, this piping was extended, both aboveground and underground, to a point just north of the C-616-L Lift Station inlet. The piping appears in good condition, with no evidence of leaks, and is performing as designed. The aboveground piping insulation was in good condition and intact; the metal jacket covering was not rusted or deteriorated.

A gabion with a nonwoven, geotextile filter was installed at the existing C-615-K Lift Station located on the east side of 10th Street and north of the C-400-L and C-616-L Lift Stations. This sediment trap was installed to reduce the potential for sediment transport off-site (i.e., outside the existing security fence) from the NSDD. During inspection, the gabion appeared to be in good condition and functioning as designed.

The costs associated specifically with O&M activities are not accounted for separately, because they are performed as part of the facility-wide, long-term surveillance and maintenance and environmental monitoring programs.

11.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The 2018 Five-Year Review determined that the exposure pathways for the NSDD source control that could result in unacceptable risk were being controlled; therefore, they were protective of human health and the environment (DOE 2014a). The following is from the 2018 review.

"The remedy for the NSDD Source Control is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled. This project is not a final action and was not designed to return the areas to unrestricted use."

There were no previous issues or recommendations for the NSDD source control in the 2018 Five-Year Review. The site remains unchanged as described in the 2018 Five-Year Review, and no new actions have occurred.

11.5 SITE INSPECTION

On December 8, 2022, a site inspection of the following facilities associated with the NSDD IRA was conducted by the five-year review team, the facility manager, KDEP, and a representative from DOE's support contractor: (1) the C-400-L Lift Station and associated piping (Figure 11.2), (2) the C-616-L Lift Station and associated piping (Figure 11.3), and (3) the gabion installed at the C-615-K Lift Station (Figure 11.4). There was no excessive debris over the gabion screens. The aboveground piping was in good condition, the insulation was intact, and the metal jacket covering was not rusted or deteriorated. The lift stations appear to be functioning properly. The facility manager participated as part of the inspection team and did not have any concerns.

Figure 11.2. C-400-L Lift Station

Figure 11.3. C-616-L Lift Station and C-400-L Piping

Figure 11.4. Gabion Structure

11.6 TECHNICAL ASSESSMENT

The ion exchange system was installed in the C-400 Cleaning Building to treat elevated levels of radionuclides in effluent being released from the C-400-B Storage Tank. USEC leased the C-400 Cleaning Building and its operations from DOE in 1993. The C-400 ion exchange system effluent was routed to the USEC-operated C-400 Cleaning Building collection tank, where it was stored until the treatment levels were assessed. The wastewater was repeatedly processed through the uranium precipitation and ion exchange systems until a point of diminishing return was reached (i.e., until the percentage of reduction becomes insignificant with subsequent treatments). The final concentration in the treated water was contingent upon the initial concentration. After treatment, the water either was recycled in C-400 Cleaning Building processes or was discharged via KPDES Outfall 008. Because the effluent discharge from the C-400 Cleaning Building was treated until a point of diminishing return was reached and was rerouted to KPDES Outfall 008 during the design phase, the introduction of contaminants into the NSDD from the C-400 Cleaning Building was eliminated completely. Deactivation of the C-400 Cleaning Building was completed during this five-year review period (i.e., 2018–2022).

Two concrete settling lagoons, the C-600 Fly Ash Lagoons, were used to keep coal-pile water runoff out of the NSDD, thereby lowering the levels of sediment being deposited in the NSDD. Coal no longer is used at the site. With the installation of the two lift stations, C-400-L and C-616-L, and associated aboveground and underground pipelines to bypass the NSDD, the introduction of contaminants from the C-600 Steam Plant has been eliminated completely.

A gabion with a nonwoven, geotextile filter was installed to minimize sediment transport off-site from the NSDD. The gabion is functioning as designed.

11.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. Based upon the site inspection, the NSDD IRA is meeting the remedial objectives as stated in the ROD. Inspections of the lift stations and heat tracing (as needed) occur weekly and are reviewed by the facility manager. Mowing the area adjacent to the pipeline occurs a minimum of two times during the summer months.

11.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

DOE remains in control of the property that the NSDD source control encompasses and the land use remains industrial; therefore, the exposure assumptions used in the ROD remain valid.

Changes in risk assessment methodology subsequent to approval of the ROD have been significant; however, these changes are not pertinent because the remedy relied on two components: (1) restricting access through use of signs and (2) mitigating contaminant discharge to the ditch through treatment. Neither of these components is related to changes in risk methodology. There have been no new contaminants or new understanding of geologic conditions identified.

No cleanup levels were established in the ROD because the selected remedy did not include excavation and removal of the impacted soils.

The 1998 Five-Year Review found that jurisdictional wetlands had been identified in the NSDD after the ROD had been signed (in 1994). Because the wetlands were not identified prior to signing the ROD, ARARs for the protection of wetlands were not included in the ROD. They were added by the 2003 Five-Year Review. DOE has complied with all identified requirements during implementation of the RA.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in TBCs identified in the ROD that impact the protectiveness of the remedy.

The RAOs used at the time of remedy selection still are valid.

11.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

11.6.4 Technical Assessment Summary

Sections 1 and 2 of the O&M Plan require weekly inspections and inspections following a storm event to ensure that the screens of the lift stations remain clean; that all of the lift stations are operational; and that the pipeline is not leaking. The principal goals of the interim action were the following:

- Mitigate the introduction of contaminants into the NSDD.
- Decrease the migration of contaminants already present in the NSDD.
- Decrease the potential for direct contact with the contaminated material.

The interim action is functioning as designed; therefore, it is protective of human health and the environment.

11.7 ISSUES

None.

12. NSDD SECTIONS 1 AND 2

The NSDD originates within the north-central portion of the Paducah Site industrial area and joins with Little Bayou Creek to the north of the facility. Figure 12.1 illustrates the location of the NSDD Sections 1 and 2 (SWMU 59). Historically, the NSDD received wastewater from the C-400 Cleaning Building that houses equipment for decontamination, metal etching and plating, metals recovery, radioactive materials stabilization and recovery, uranium trioxide production, diffusion process equipment testing, and UF_4 pulverization. Additional sources of runoff to the ditch include the C-600 Steam Plant, the C-335 and C-337 Process Buildings, the C-635 Cooling Tower, and the C-535 and C-537 Switchyards. As a consequence, the soil and sediment in the ditch were contaminated with radionuclides, metals, and PCBs. Over the years, fly ash and coal dust from the C-600 Steam Plant and sediment from the ditch watershed had nearly filled the NSDD causing the ditch to overflow during heavy rains onto an adjacent stretch of 10th Street.

According to the NSDD ROD, there was potential for exposure of industrial worker to the contaminants within the ditch through routine maintenance activities (DOE 2002e). Personnel were exposed to unacceptable risk via direct gamma radiation from contaminated sediment and soil; dermal contact with soil, sediment, and debris; inhalation of resuspended particulate during mowing; and incidental ingestion of contaminated surface water, soil, and sediment. The source control RA (as discussed in Section 11) and the response actions for Sections 1 and 2 eliminated exposure pathways.

12.1 REMEDY SELECTION

Risks associated with the NSDD are presented in *Record of Decision for Interim Remedial Action at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah Kentucky*, DOE/OR/07-1948&D2. According to the NSDD ROD, there was potential for exposure of site maintenance personnel to the contaminants within the ditch through routine maintenance activities (DOE 2002e).

The RAOs for Phase II are the following.

- Prevent future discharge of process waste to the NSDD.

- Reduce the risk to industrial workers and ecological receptors from exposure to contaminated surface soil, sediment, and surface water to acceptable levels by eliminating direct exposure to contaminated media at the NSDD.

- Prevent future on-site (i.e., inside the existing security fence) run-off from being transported off-site (i.e., outside the existing security fence) via the NSDD.

The LUC objective identified to assure the protectiveness of the preferred alternative for Sections 1 and 2 of the NSDD is as follows:

- Sections 1 and 2 (Industrial areas)—Restrict unauthorized access, restrict unauthorized excavations or penetrations below prescribed contamination cleanup depth, and restrict uses of the area that are inconsistent with the assumed industrial use (i.e., to prevent recreational and/or residential use).

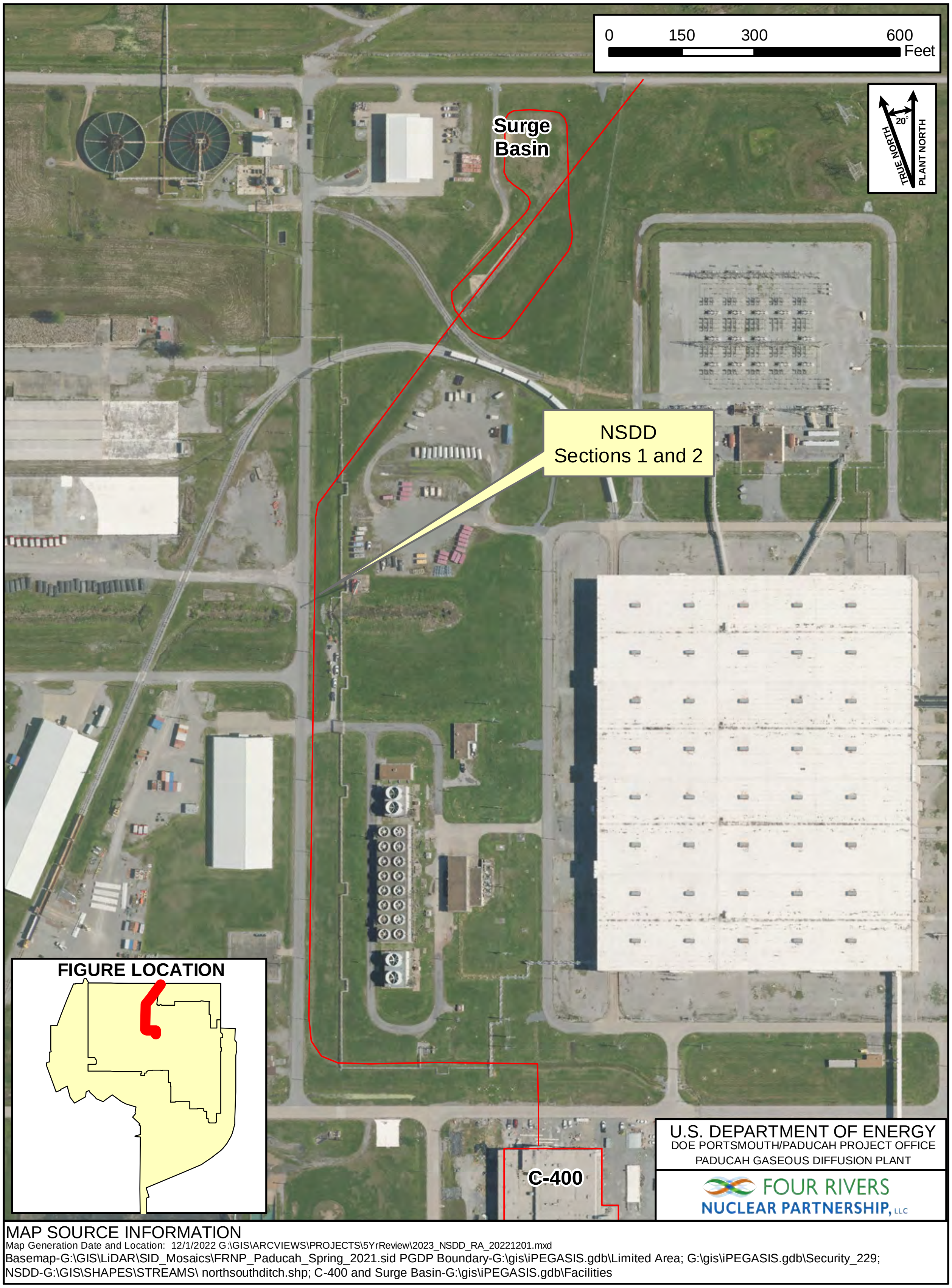


Figure 12.1. Location of NSDD Sections 1 and 2

12.2 REMEDY IMPLEMENTATION

A remedy for Sections 1 and 2 of the NSDD was implemented and completed in 2004. During the planning phases of this response action, additional waste characterization efforts were initiated at the direction of the KDWM. These extra sampling activities included field analyses for PCBs and volatile organics in soil. These analyses ensured that waste soils met the waste acceptance criteria (WAC) for the C-746-U Landfill.

As part of the implementation of the NSDD Sections 1 and 2 project, EPA required an evaluation of the C-746-U Landfill to ensure that waste from the NSDD that was disposed of there would not pose unacceptable risks to human health and the environment. This requirement was provided in a letter dated April 24, 2003, (EPA 2003) and stated the following:

> "…because the disposal in the landfill from the NSDD interim action is expected to leave levels of contamination – both within the remediated NSDD area and on-site in the C-746-U Landfill disposal area – above levels that allow for unrestricted use and unlimited exposure, the Five-Year Reviews required to ensure protectiveness of this action must examine conditions in both these areas to insure that the entire action remains protective."

The C-746-U Landfill is a contained landfill, as defined in Kentucky regulations at 401 *KAR* 47:005. The landfill meets the technical standards found in 401 *KAR* 47:080, 401 *KAR* 48:050, and 401 *KAR* 48:070 to 401 *KAR* 48:090, and DOE's D&R Contractor has procedures in place to ensure that no wastes are disposed of in the landfill that do not meet the WAC for this facility. This includes soil waste from the NSDD and other areas of the Paducah Site. One aspect of the WAC is the "authorized limits" for waste with *de minimis* levels of radiological contamination to be disposed of in the C-746-U Landfill, as described in *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah Kentucky*, DOE/OR/07-2041&D2R1 (DOE 2003c). The results of this study are summarized as follows:

These results indicate that the total volume of SWMU 59 excavation can be placed in the landfill and that this placement may adversely impact the balance between the percentage of volume taken and the percentage of contaminant inventory limit taken by Neptunium-237 but no other contaminants. It must be cautioned that these results are dependent upon the quality of the data set used to generate the average contaminant concentrations. If these data do not represent areas and volumes within SWMU 59 with higher contaminant concentrations, then the results may be biased low; however, if these data come from sampling biased towards areas of suspected higher contamination, then the results may be biased high. Sampling during waste disposition will be used to address this uncertainty.

Waste characterization activities resulted in all of the excavated soil being disposed of in the C-746-U Landfill. No contaminant levels exceeded threshold criteria that would have caused the waste to be designated as RCRA-hazardous, Toxic Substances Control Act-regulated, or above the authorized limits of the C-746-U Landfill. The amount of waste that might add to the inventory of hazardous constituents or radioisotopes in the landfill is tracked by the DOE PPPO health physicist. This is done through documentation prepared for all waste disposed of in the C-746-U Landfill, referred to as "landfill packages." These packages are reviewed to determine if the waste they describe may have minute quantities of radiological contamination. If that is the case, then the radiological data are analyzed to determine an estimated inventory of each isotope that will be associated with that landfill package. The estimates based on projected weights and volumes are compared against actual weights and volumes disposed of to ensure that the inventory does not exceed the projections. The inventory allowed for disposal in the C-746-U Landfill is that amount that can be disposed of without exceeding a 1 millirem (mrem)/year dose to any member of the general public. This tracking method has ensured that disposal of wastes from the NSDD and other CERCLA-derived wastes do not pose unacceptable risks to human health and the environment.

Figures 12.2 and 12.3 show "before and after" views of the NSDD Sections 1 and 2. The total cost of excavation of Sections 1 and 2, construction of the detention basin, and disposal of approximately 3,200 yd^3 of soil in the C-746-U Landfill was \$12.2M, according to the *Remedial Action Completion Report for the North-South Diversion Ditch Sections 1 and 2 at the Paducah Gaseous Diffusion Plant, Paducah Kentucky*, DOE/OR/07-2195&D2 (DOE 2005d).

A residual risk evaluation was prepared as a result of a recommendation in the 2008 Five-Year Review to determine if the remedy for Sections 1 and 2 of the NSDD could be optimized (e.g., risks were at a level that would support modification of institutional controls and/or cessation of five-year reviews). The evaluation showed that the cleanup goals of the ROD were met.

Figure 12.2. NSDD Sections 1 and 2 before Remedial Action

Figure 12.3. NSDD and Gabion Structure

12.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

Because the excavation exceeded the cleanup criteria set forth in the ROD, long-term maintenance of the clay cover is not required to eliminate exposure pathways. The excavated and lined ditch is maintained as part of the Paducah Site's ongoing grounds maintenance program, and the cost is not tracked separately.

12.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The 2018 Five-Year Review protectiveness statement follows:

> The remedy for the NSDD Sections 1 and 2 (SWMU 59) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk currently are being controlled. This project is not a comprehensive final action for the NSDD Sections 1 and 2. In order to establish long-term protectiveness, additional action will be evaluated and selected, as necessary, under the SWOU.

There were no issues or recommendations for the NSDD Sections 1 and 2 in the 2018 Five-Year Review. The site remains unchanged, as described in the 2018 Five-Year Review, and no new actions have occurred.

12.5 SITE INSPECTION

The NSDD site inspection was conducted on December 8, 2022, by the five-year review team, the facility manager, KDEP, and a representative from DOE's support contractor. The ditch has been well-maintained; grass was established in the channel, but was not impeding flow. The flow into the surge basin was unimpeded. There was no standing water in the surge basin. The grass cover was well established and had been mowed. There were no visible signs of erosion along the banks of the surge basin. NSDD inspections are ongoing as part of the current D&R Contractor's scope.

12.6 TECHNICAL ASSESSMENT

The goals of the remedy were to be implemented by excavating contaminated soil and sediment from the channel of the NSDD and disposing of it in the C-746-U Landfill, if nonhazardous, or at a permitted facility, if RCRA-hazardous, Toxic Substances Control Act-regulated, or greater than authorized limits for the on-site C-746-U Landfill. The WAC at the C-746-U Landfill were met; therefore, all waste soils were disposed of on-site. Upon excavation, a 2-ft clay layer was placed in the NSDD channel to add an extra layer of protection for maintenance workers. The channel was brought to grade with another 2 ft of clean soil and vegetated to prevent erosion. Plugged culverts and a detention basin prevent rainfall from inside the plant from flowing beyond the security fence and transporting potentially contaminated sediment with it.

The cleanup levels for the excavation were met or exceeded at each measurement section; therefore, maintenance of the clay layer to control exposure is not required (DOE 2005d).

The residual risk evaluation used the decisions/assumptions in the ROD; therefore, the industrial worker, under unrestricted use, was the receptor considered when calculating cleanup levels (LATA Kentucky 2012). The residual risk evaluation quantitatively compared the contamination left in place at the base of the NSDD excavation with outdoor and industrial worker risk-based concentrations as if the contamination were on the surface. The evaluation showed that the residual risk to these receptors falls within the EPA risk range (EPA 1999).

12.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy is functioning as designed. The excavation as designed met or exceeded the cleanup criteria. A certification of the LUCIP is provided each year in the SMP. The LUCs to restrict unauthorized access, restrict unauthorized excavation or penetrations below prescribed contamination cleanup depths, and restrict use of the area that is inconsistent with the assumed industrial use (i.e., to restrict recreational and/or residential use) are in place and functioning as intended.

12.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

DOE remains in control of the property that NSDD Sections 1 and 2 encompass and the land use remains industrial; therefore, the exposure assumptions used in the ROD regarding disturbance or contact with the contamination remains valid. There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected.

The residual risk evaluation shows that the goals of the ROD were met, and the cleanup levels established still are valid (Table 12.1). Table 12.1 shows the cleanup value cited in the NSDD ROD and the current similarly derived risk-based values (DOE 2002c, DOE 2022e). For thorium-230, aluminum, and uranium,

Table 12.1. Comparison of Cleanup Levels for NSDD Sections 1 and 2 and New Risk-based Values

Contaminant	Media	Cleanup Level[a] (DOE 2002c)	Risk-based Value[b] (DOE 2022c)
Aluminum	Sediment	139,200 mg/kg	100,000 mg/kg
Antimony	Sediment	11.37 mg/kg	2,800 mg/kg
Arsenic	Sediment	52.3 mg/kg	160 mg/kg
Barium	Sediment	6,870 mg/kg	100,000 mg/kg
Beryllium	Sediment	28.44 mg/kg	13,500 mg/kg
Cadmium	Sediment	639 mg/kg	1,820 mg/kg
Chromium[c]	Sediment	85.2 mg/kg	100,000 mg/kg
Copper	Sediment	14,790 mg/kg	100,000 mg/kg
Iron	Sediment	62,100 mg/kg	100,000 mg/kg
Lead	Sediment	50 mg/kg	800 mg/kg
Manganese	Sediment	2,598 mg/kg	100,000 mg/kg
Mercury	Sediment	29.46 mg/kg	2,100 mg/kg
Nickel	Sediment	7,260 mg/kg	100,000 mg/kg
Selenium	Sediment	2,847 mg/kg	35,100 mg/kg
Silver	Sediment	1,233 mg/kg	35,100 mg/kg
Thallium	Sediment	2.2 mg/kg	70.2 mg/kg
Uranium[d]	Sediment	3,030 mg/kg	1,400 mg/kg
Vanadium	Sediment	99.6 mg/kg	34,500 mg/kg
Total PCBs	Sediment	19.9 mg/kg	29.3 mg/kg
Total PAHs	Sediment	2.12 mg/kg	64.3 mg/kg
Americium-241	Sediment	467 pCi/g	1,320 pCi/g
Cesium-137	Sediment	13.3 pCi/g	40.5 pCi/g
Neptunium-237	Sediment	45.4 pCi/g	131 pCi/g
Plutonium-239	Sediment	563 pCi/g	1,650 pCi/g
Tc-99	Sediment	227,000 pCi/g	501,000 pCi/g
Thorium-230	Sediment	3,510 pCi/g	1,940 pCi/g
Uranium-234	Sediment	6,880 pCi/g	9,590 pCi/g
Uranium-235	Sediment	81.6 pCi/g	194 pCi/g
Uranium-238	Sediment	313 pCi/g	1,020 pCi/g

[a] Previous cleanup levels were derived from risk-based human health cleanup levels for restricted use of area by an industrial worker and were the lesser of the risk-based and hazard-based values set at targets of ELCR = 1E-04 and HI = 3 or the dose-based human health cleanup levels for restricted use of area by an industrial worker calculated using a target dose of 25 mrem/year, see Section 2.12 and Table 2.13 of the NSDD ROD (DOE 2002c).
[b] New risk-based values are based on the industrial worker action levels (Table A.1) and the dose-based soil/sediment screening levels for 25 mrem/year (Table A.8) presented in the 2022 Risk Methods Document (DOE 2022e).
[c] Chromium (III) (insoluble salts)
[d] Uranium (soluble salts)

the current risk-based values are lower than the cleanup level, but are within an order of magnitude of the cleanup level, so the cleanup level would fall within the same risk range as the new risk-based value [i.e., an excess lifetime cancer risk (ELCR) of 1E-04 or a hazard index (HI) of 3]. The cleanup levels still are protective. There have been no new contaminants or new understanding of geologic conditions identified.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in TBCs identified in the ROD that impact the protectiveness of the remedy.

The RAOs used at the time of remedy selection still are valid.

12.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

12.6.4 Technical Assessment Summary

The RA for Sections 1 and 2 of the NSDD is protective of human health and the environment because contaminated soils and sediments were excavated, eliminating the threat of exposure to these media. Plugging culverts and constructing a detention basin prevent rainfall from flowing off-site (i.e., outside the existing security fence) through the ditch and moving contaminated sediment with it.

The maintenance of the clay cover to prevent exposure is not required because the samples collected from the open excavation indicated that the cleanup goals in the ROD were exceeded along the entire length of the ditch. The clay cover is maintained as part of the overall grounds maintenance program at the Paducah Site.

12.7 ISSUES

None.

13. C-746-K SANITARY LANDFILL

The C-746-K Sanitary Landfill (SWMU 8) is located southwest of the PGDP security-fenced area and approximately 650 ft southeast of the C-611 Water Treatment Plant. It is situated immediately west of Bayou Creek and north of an unnamed tributary to Bayou Creek. Drainage ditches located along the western and northern edges of the landfill flow to the south into the unnamed tributary and to the east into Bayou Creek, respectively. Figure 13.1 illustrates the location of the C-746-K Sanitary Landfill.

Records indicate that facility operations used the landfill between 1951 and 1981 for disposal of fly ash from PGDP's coal combustion boilers, uncontaminated combustible waste, and potential radiologically contaminated waste. The fly ash was believed to have been disposed of in trenches excavated 5 to 10 ft bgs. During operations, trenches were cut in the fly ash and used for burning trash. This practice ceased in 1967, after which waste was buried without burning. The waste, consisting mostly of office and kitchen trash and some construction debris, was placed in trenches excavated within the fly ash and covered, when necessary, with additional fly ash or soil fill. In addition to these materials, sludge from the C-615 Sewage Treatment Plant may have been buried at the unit, as it reportedly was used as fill material. Soil boring information indicated that up to 28 ft of fly ash and trash had been placed in the landfill. The landfill was closed in 1982 and covered with a 6- to 12-inch clay cap and an 18-inch vegetative cover.

On January 30, 1992, Paducah Site personnel discovered leachate in a ditch on the southwest side of the landfill. DOE conducted sampling at five leachate seep locations around the landfill. VOCs (TCE; 1,1-DCE; 1,1-dichloroethane; and *trans*-1,2-DCE) and metals (aluminum, iron, manganese, and zinc) were detected above background levels in the leachate samples. The leachate was acidic and the particulate matter in the leachate generally was orange to yellow in color. Precipitation of dissolved metals from the leachate was thought to be causing the orange to yellow staining observed at various points along the creek banks. The condition was deemed to be in noncompliance with the water quality provisions of 401 *KAR* 5:031, which prohibit discharges that produce "objectionable color" into waters of the Commonwealth of Kentucky. On September 15, 1992, the Kentucky Division of Water issued a Notice of Violation to DOE for "unpermitted seepage areas from the C-746-K Sanitary Landfill into waters of the Commonwealth."

As a result of the Notice of Violation, DOE, with the approval of EPA and KDEP, undertook an interim corrective action to address the seeps. To prevent any further release of solids to the unnamed tributary, DOE installed a sandbag dam with a liner in the drainage ditch southwest of the landfill. During the interim action, subsidence of the landfill cap was repaired and recontoured to promote surface water runoff. The actions were completed in October 1992 and have been effective in reducing seepage into the creeks. In addition, a surface water monitoring program was initiated at the landfill to monitor contaminant levels in the leachate and adjacent creeks.

13.1 REMEDY SELECTION

The interim ROD for the C-746-K Sanitary Landfill was signed by DOE on February 20, 1998, and by EPA on August 10, 1998 (DOE 1998b). KDEP concurred with the selected remedy June 24, 1998, as documented in the *Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1470&D3 (DOE 1998b). The RAOs for this unit are as follows:

- Control the release of COCs from the unit.
- Limit direct contact by humans.
- Reduce overall risks to ecological receptors.

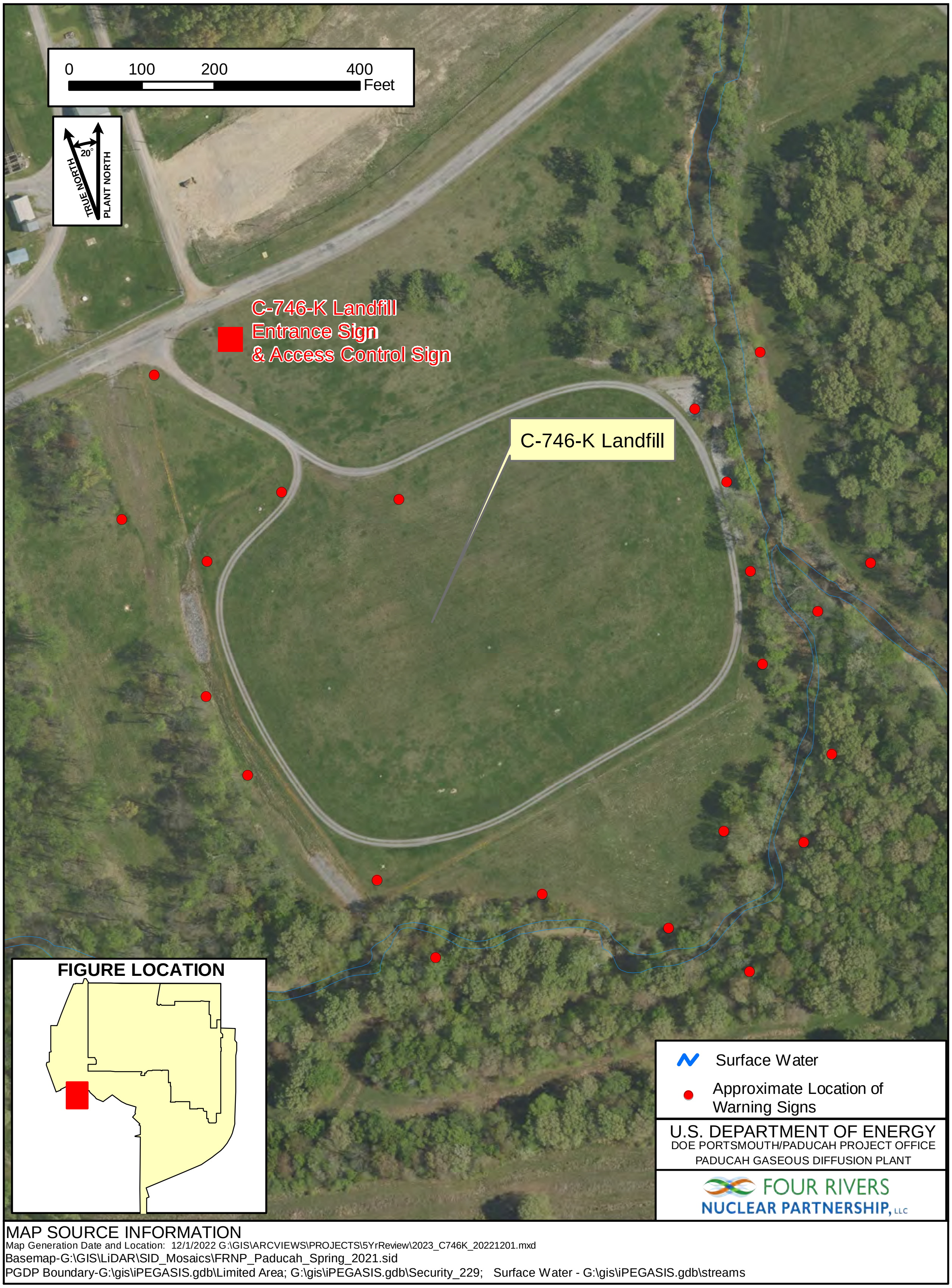


Figure 13.1. C-746-K Landfill Site Plan

13.2 REMEDY IMPLEMENTATION

The ROD defined and identified the following components of the RA for the C-746-K Sanitary Landfill (DOE 1998b).

- Install warning signs.
- Place riprap.
- Institute a deed notice and restrictions.
- Continue the existing surface water monitoring program.
- Modify the groundwater monitoring program.
- Continue the current landfill cap maintenance program.

Because the ROD for this IRA was signed prior to the effective date of the Paducah Site MOA and LUCAP (DOE 2000a), there is no LUCIP for the LUCs at the C-746-K Sanitary Landfill. It is recommended that the LUCs at the C-746-K Sanitary Landfill be added to Appendix B of the LUCAP.

The *Post-Construction Report and Operations and Maintenance Plan for Waste Area Groupings (WAGs) 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1743&D1 (DOE 1999b), documents the RAs taken at the C-746-K Sanitary Landfill (DOE 1999b). The O&M requirements then were revised in the document, *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1904&D1 (DOE 2000c). The 2005 SWOU O&M Plan was updated in 2015 [*Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky*, DOE/OR/07-1904&D1/R2 (DOE 2015e)] but did not alter the O&M requirements for this action.

The action implemented at the C-746-K Sanitary Landfill satisfies the RAOs stated by limiting human and animal exposure to contaminated sediments and acidic leachate by placing riprap over the seep locations. Further reduction of human risks was accomplished by posting warning signs and by placing a deed notice and restrictions on the C-746-K Sanitary Landfill property.

Surface water monitoring at the C-746-K Sanitary Landfill began in February 1992 following the discovery of leachate in adjacent ditches and creek banks. DOE summarized the monitoring data through October 1992 in the *Work Plan for Interim Corrective Measures at the C-746-K Sanitary Landfill*, DOE/OR/07-1211&D2, and developed the monitoring program that was used until October 1998 (DOE 1992a). Currently, two stations, 746KTB1A and C-7416-K (Figure 13.2), are monitored; they are located on the adjacent unnamed tributary of Bayou Creek and Bayou Creek, respectively. Station 746KTB1A provides upstream information and station C-746-K-5 provides downstream information. The analytical suite for the stream monitoring locations included 13 common metals, arsenic, mercury, uranium, VOCs, PCBs, and pH.

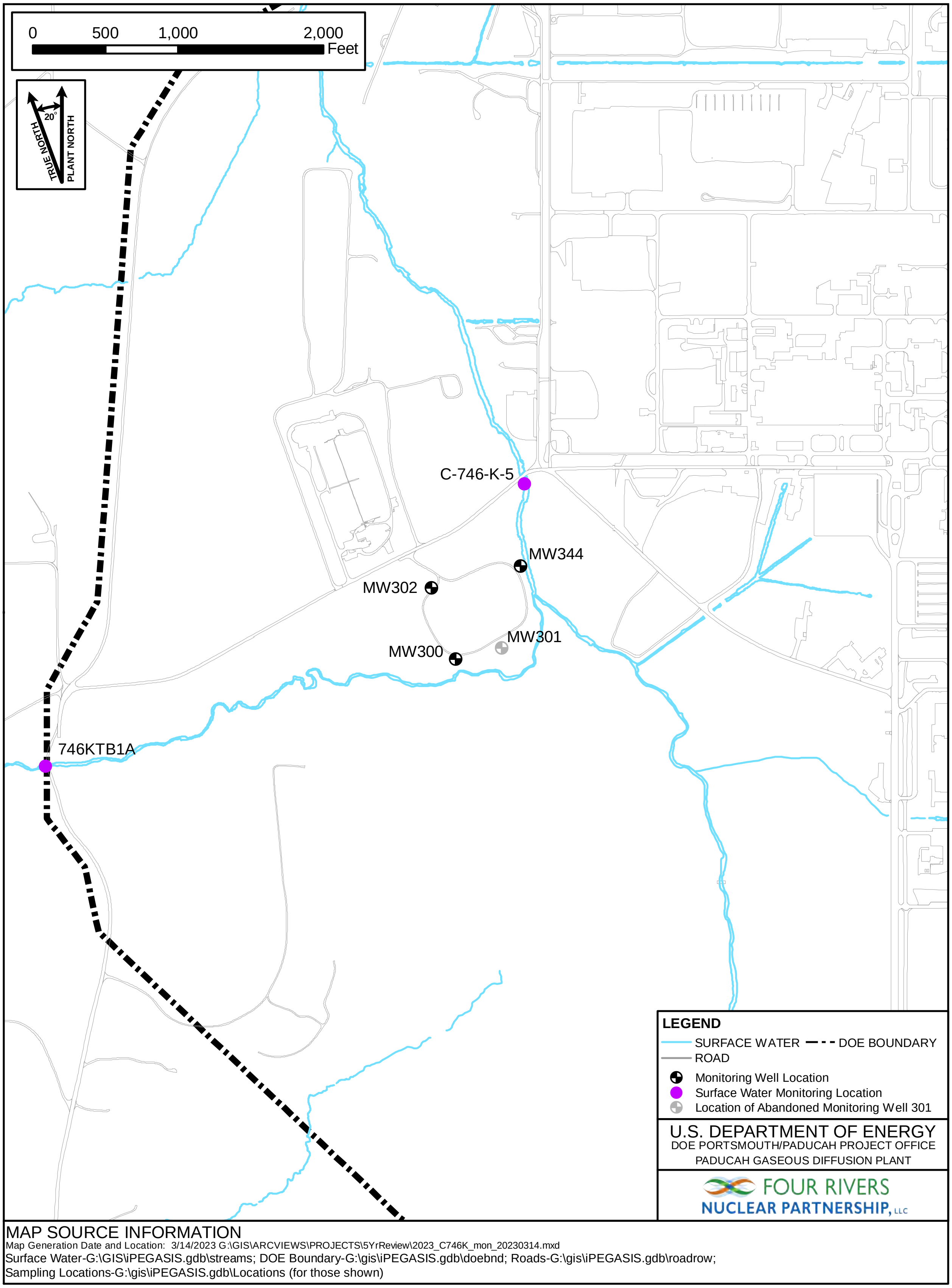


Figure 13.2. Sampling Locations at the C-746-K Landfill

As stipulated in the ROD, the surface water monitoring requirements for the C-746-K Sanitary Landfill were supplanted by a Watershed Monitoring Plan (initially approved October 14, 1998; revised on September 29, 2006; and revised again on February 1, 2010) that was required by the renewed KPDES Permit with an effective date of December 1, 2009. The 2009 KPDES Permit allowed for cessation of the aquatic organism sampling because the creeks had been sampled to the point that further sampling could result in a deleterious effect on the aquatic community. The 2009 KPDES Permit also required that surface water be sampled quarterly for PCBs and TCE only in Bayou Creek. After additional evaluations of the plan and historical data sets, the requirements for metals analysis and aquatic organism sampling were removed through a revised Watershed Monitoring Plan, which was submitted to Kentucky Division of Water on September 27, 2011. Water last was sampled for chemical analysis at the upstream monitoring station on Bayou Creek and the downstream monitoring station on the unnamed tributary to Bayou Creek in 2005 and 2003, respectively. The Watershed Monitoring Plan (1998) included three other interim surface water monitoring stations to assess the C-746-K area. Surface water last was collected for chemical analyses from these stations in 1999. The latest KPDES permit, which became effective September 1, 2017, no longer requires surface water monitoring for the C-746-K Sanitary Landfill.

The remedy identified in the C-746-K Sanitary Landfill ROD included placement of riprap on visible leachate seep locations to minimize the potential for human and animal exposure. The action included covering three leachate seep sites and stabilizing the bank of Bayou Creek on the east side of the C-746-K Sanitary Landfill. Before the leachate seeps were covered, the site was cleared of existing vegetation, and a geotextile fabric layer was placed under a layer of riprap. Construction work for this component of the action began August 5, 1997, and was completed August 12, 1997.

DOE installed warning signs in November 1997 at each of the leachate seep areas and around the landfill. The signs notify the public of the risk associated with the areas. A sign was placed at the entrance of the C-746-K Sanitary Landfill in February 1998. These signs are inspected on a routine basis and are replaced as necessary. Figure 13.1 shows the approximate location of each of these signs.

As specified in the ROD and with the approval of KDWM, two MWs (MW184 and MW303) were abandoned. One new well (MW344) was installed to replace MW303 at the C-746-K Sanitary Landfill in March 1998. The intent of the new well was to detect any contamination that could be migrating from the landfill and traveling along the top of the Porters Creek Clay and into the RGA.

A deed notice and a restriction were placed in the chain of title to the deed of the property to inform potential buyers and/or users of the potential risks to human health and the environment posed by the leachate seeps. The notice and restriction were filed August 24, 1998, with the McCracken County Clerk.

13.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

Two locations in the unnamed tributary and Bayou Creek in the vicinity of the C-746-K Sanitary Landfill are sampled quarterly. Three MWs are sampled semiannually. Figure 13.2 shows the three MW locations and the two surface water monitoring locations.

The FY 2023 Environmental Monitoring Plan analytical suite for surface water monitoring includes metals, volatiles, pH, and other field measurements (FRNP 2022b). Table 13.1 summarizes the latest analyses for the surface water monitoring stations. Groundwater Monitoring Program continues under the Paducah Site Groundwater Monitoring Program. Groundwater TCE results are included in the FFA Semiannual Reports. The reports show the maximum TCE result during this five year reporting period was 5.1 µg/L, which was a slight exceedance of the 5.0 µg/L MCL. Three other VOCs exceeded their respective MCLs during the reporting period. With the exception of vinyl chloride, these compounds were present, and exceeding their respective MCLs, when the remedy was selected. Vinyl chloride is a degradation product of the TCE and is expected to naturally attenuate similar to TCE. Other than these VOCs there were no other groundwater contaminants that exceeded their respective MCLs.

Table 13.1. Latest Surface Water Monitoring Analyses from 2018 through 2022*

Analysis	Units	746KTB1A (11/3/2022)		C-746-K-5 (11/3/2022)	
1,1-DCE	µg/L	1	U	1	U
Alkalinity	mg/L	45		48	
Aluminum	mg/L	0.05	U	0.0471	J
Arsenic	mg/L	0.005	U	0.005	U
Barium	mg/L	0.0538		0.0549	
Beryllium	mg/L	0.0005	U	0.0005	U
Cadmium	mg/L	0.001	U	0.001	U
Calcium	mg/L	17.7		29.5	
cis-1,2-DCE	µg/L	1	U	1	U
Conductivity	µmho/cm	365		342	
Dissolved Oxygen	mg/L	5.61		7.01	
Flow Rate	mgd	0.03		0.18	
Iron	mg/L	0.0777	J	0.384	
Lead	mg/L	0.002	U	0.002	U
Magnesium	mg/L	4.55		6	
Manganese	mg/L	0.0616		0.132	
Nickel	mg/L	0.000638		0.000773	J
pH	Std Unit	7.24		6.97	
Potassium	mg/L	3.64		3.24	
Sodium	mg/L	47.1		27.9	
Temperature	°F	55.6		57	
trans-1,2-DCE	µg/L	1	U	1	U
Trichloroethene	µg/L	1	U	1	U
Uranium	mg/L	0.000122	J	0.00053	
Vinyl Chloride	µg/L	1	UY1	1	UY1

Gray shading indicates no entry.
J = estimated value.
U = analyte analyzed for, but not detected.
Y1 = matrix spike/matrix spike duplicate recovery outside acceptance criteria.
*VOC, including TCE, were not detected in surface water samples collected during the review period.

13.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The summation of the 2018 Five-Year Review protectiveness statement follows: The remedy for the C-746-K Sanitary Landfill (SWMU 8) is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled. This project is not a final action and was not designed to return the areas to unrestricted use. There were no issues or recommendations for the C-746-K Sanitary Landfill in the 2018 Five-Year Review. The site remains unchanged from the description in the 2018 Five-Year Review and no new actions have occurred. Surface water is monitored in accordance with the Environmental Monitoring Plan and the KPDES Permit.

13.5 SITE INSPECTION

The C-746-K Sanitary Landfill and its immediate surroundings were inspected on December 8, 2022, by members of the Five-Year Review team, the facility manager, and representatives from KDEP, to determine if the required RAOs for the C-746-K Sanitary Landfill ROD are being met (DOE 1998b). No concerns were noted at that time.

A sign posted at the entrance to the landfill area clearly identifies the potential human health risks posed by the leachate seeps and contaminated sediments present in the creeks and drainage ditches around the landfill. Additional warning signs are posted at periodic intervals along the west bank of Bayou Creek to the east of the C-746-K Sanitary Landfill and along the north bank of the unnamed tributary to the south of the C-746-K Sanitary Landfill. The signs are in good condition and clearly legible.

Riprap that was placed along the west bank of Bayou Creek for erosion protection and to cover apparent seep sites is in place. Riprap also has been placed at one apparent seep area along the unnamed tributary on the south side of the landfill and the area drainage ditch along the west side. These areas also are in good condition.

The covered and capped area of the landfill is in good condition with a well-established grass cover that appears to drain well. There are no indications that water stands on the cap or side slopes. There are no signs of erosion on the landfill cap or side slopes. The area is well maintained and is mowed regularly. There are 7 passive gas vents on top of the landfill that are in good condition and show no signs of leakage or settlement. The service road around the landfill is maintained and in good condition.

13.6 TECHNICAL ASSESSMENT

A conclusion of the risk assessment for the C-746-K Sanitary Landfill was the unit posed unacceptable risk to industrial workers and animals via direct contact with leachate and contaminated sediments. The overall objectives of the C-746-K Landfill ROD were to control the release of COCs from the unit, reducing ecological risks, and to limit human contact.

The current remedy for the C-746-K area includes institutional controls and engineered barriers to prevent exposure, along with groundwater monitoring for potential migration of contaminants off-site. This remedy continues to be protective of human health and the environment by restricting direct exposure.

13.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy is functioning as intended. The riprap, landfill cap, and signs are in place and in good condition. No problems were noted with the landfill's O&M.

13.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

DOE remains in control of the property that the C-746-K Sanitary Landfill encompasses and the land use remains industrial. The facility's excavation/penetration permit program requires formal authorization prior to performance of all excavations and other intrusive activities; therefore, the exposure assumptions used in the ROD regarding disturbance or contact with the waste, sediments, and leachate remain valid. There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected. There have been no new contaminants or new understanding of geologic conditions identified.

No cleanup levels were established in the ROD because the selected remedy did not include excavation and removal or treatment of the waste and impacted soils.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in TBCs identified in the ROD that impact the protectiveness of the remedy.

The RAOs used at the time of remedy selection still are valid.

13.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

13.6.4 Technical Assessment Summary

The remedy is functioning as intended by the ROD. ARARs for leachate discharges and radionuclide exposures cited in the ROD have been met. During this five-year review period, the RA at the C-746-K Sanitary Landfill continued to reduce the potential for human exposure by notifying persons of the potential hazards in the area from contaminants seeping from the landfill. The potential for direct human contact also is reduced by placement of riprap along the seeps and by deed notice and restrictions recorded for the C-746-K Sanitary Landfill, which restrict use of the property.

13.7 ISSUES

None.

14. FIRE TRAINING AREA

The Fire Training Area (SWMU 100) is located in the southwest corner of the Paducah Site. At the time of the investigation of this area, it consisted of one large rectangular surface burn area, two circular burn pan areas, one circular electric pump area, an elevated and bermed fuel tank area, and two square burn area depressions. The burn areas were unlined and were not bermed. The Fire Training Area has been used since 1982 for staging fire training exercises involving waste oils, fuels, and other combustible liquids. Combustible liquids were not burned in the unlined areas after 1987. Fire training exercises continue to be conducted in the vicinity, but in order to prevent any negative impacts to the environment, no burning is conducted in unlined areas, and flammable liquids no longer are used. Figure 14.1 illustrates the location of the Fire Training Area.

14.1 REMEDY SELECTION

The selected remedy for the Fire Training Area, which depends on the area remaining industrial, was NFA (outside of maintaining institutional controls), as documented in the *Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1470&D3 (DOE 1998b). It is recommended that the LUCs at the Fire Training Area be added to Appendix B of the LUCAP.

14.2 REMEDY IMPLEMENTATION

The remedy selected was NFA, and DOE remains in control of the property that the Fire Training Area encompasses.

14.3 SYSTEMS OPERATIONS/OPERATION **AND MAINTENANCE**

The costs associated specifically with maintenance of the Fire Training Area are not tracked separately because they are part of the facility-wide, long-term surveillance and maintenance and environmental monitoring programs.

14.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The summation of the 2018 Five-Year Review protectiveness statement follows: The remedy for the Fire Training Area is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled. This project is not a final action and was not designed to return the areas to unrestricted use and unlimited exposure.

There were no previous issues or recommendations for the Fire Training Area in the 2018 Five-Year Review. The area remains unchanged from the description in the 2018 Five-Year Review, and no new actions have occurred.

In relation to SWMU 100 (Fire Training Area), per- and polyfluoroalkyl substances, “PFAS is an emergent contaminant that was not considered as part of the scope of the WAGs 1 & 7 RI/FS or ROD. The presence of PFAS will be evaluated separately; if cleanup under CERCLA is required, a new remedial action project will be identified to address the contamination.” (DOE 2022a). In March 2023, EPA proposed MCLs for

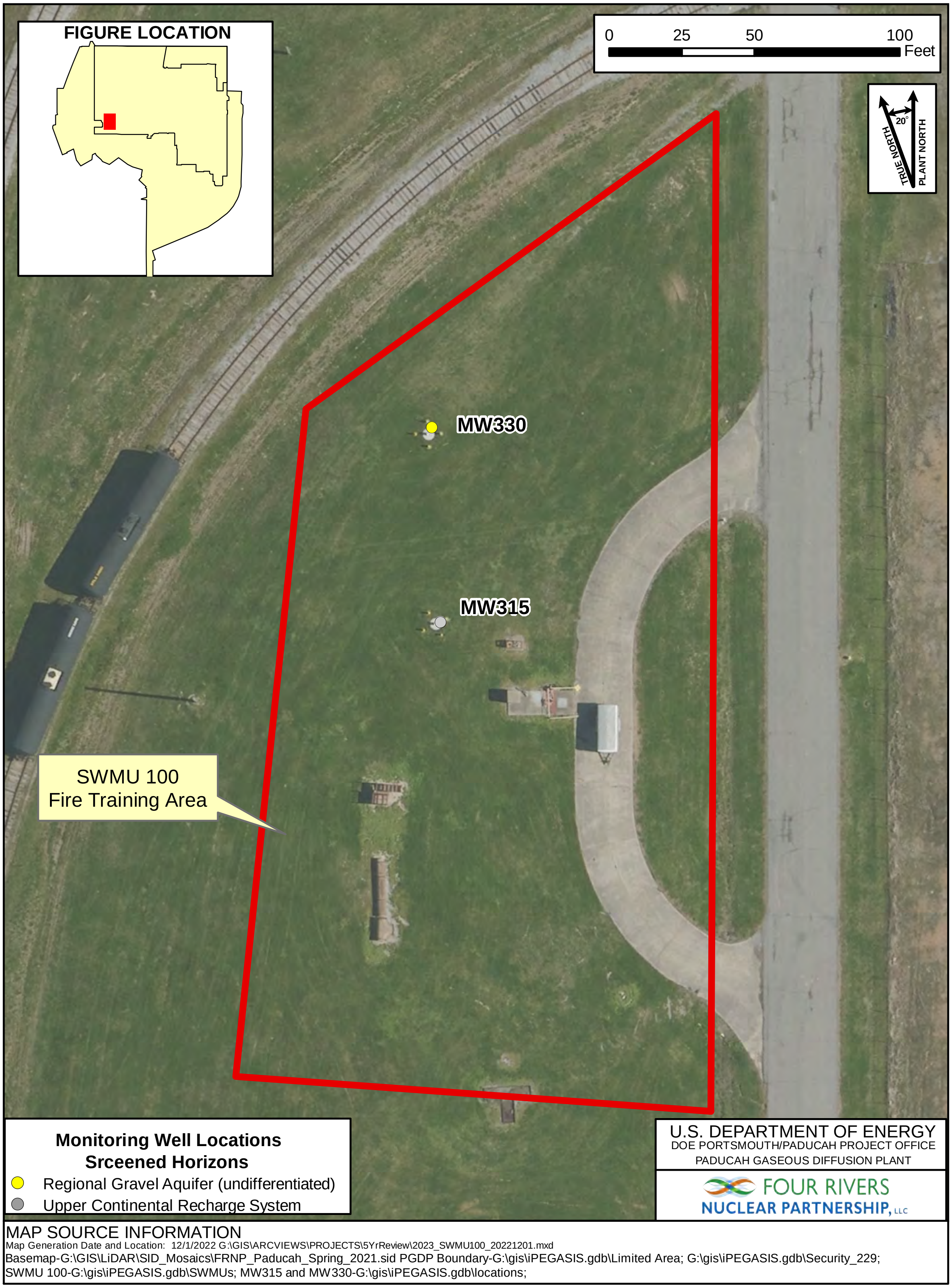


Figure 14.1. Location of the Fire Training Area

six PFAS. The presence of PFAS is being evaluated as a separate project in CY 2023. If cleanup is required, a new RA project or similar project, will be identified to address the contamination.

14.5 SITE INSPECTION

A site inspection of the Fire Training Area was conducted on December 6, 2022, by the five-year review team, the facility manager, and a representative from DOE's support contractor. Firefighting equipment was present at the facility. Grass was established in the area and appears to be maintained. There were no areas of erosion. The facility manager was consulted with regard to the facility and did not have any concerns.

14.6 TECHNICAL ASSESSMENT

There have been no detrimental changes to the Fire Training Area. The NFA decision remains protective. Its current use as a firefighters training area shows no apparent harm to the environment. No further action is necessary to protect site workers at the Fire Training Area who are not associated with the fire protection department.

14.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy, specifically the current land use, is functioning as intended.

14.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. DOE remains in control of the property that the Fire Training Area encompasses, and the land use remains industrial. The facility's excavation/penetration permit program requires formal authorization prior to performance of all excavations and other intrusive activities; therefore, the exposure assumptions used in the ROD remain valid. For the Fire Training Area, the WAGs 1 and 7 RI report states that the primary pathway contributing to both the total HI and the total ELCR is dermal contact with sediment (DOE 1996b).

Updates have been made to toxicity values since the 1996 RI, but these updates do not impact the remedy selected adversely. Although there have been changes to the risk assessment methodology, the protectiveness of the remedy has not been affected. There have been no new contaminants or new understanding of geologic conditions identified.

No cleanup levels, RAOs, or ARARs were established in the ROD because the selected remedy was NFA (outside of maintaining institutional controls).

14.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

In March 2023, EPA proposed MCLs for six PFAS. As an emergent contaminant, PFAS was not considered as part of the scope of the WAGs 1 & 7 RI/FS or ROD. As discussed in the FY 2023 SMP, the presence of PFAS will be evaluated separately; if cleanup under CERCLA is required, a new remedial action project will be identified to address the contamination. (DOE 2022a). Groundwater monitoring wells MW315 (UCRS) and MW330 (RGA) in the Fire Training Area were sampled for PFAS in August and September 2019. The samples were analyzed for 18 PFAS compounds, and results were validated by an independent third party. At that time, there was no EPA approved analytical method for PFAS in groundwater, surface water, or wastewater; therefore, the most appropriate available method was used (EPA Method 537.1). Maximum PFOA and PFOS concentrations in groundwater were 5,230 ppt and 128,000 ppt, respectively. PFBS, perfluoroheptanoic acid (PFHpA), PFHxS, and perfluorohexanoic acid (PFHxA) were also detected at maximum concentrations between 1,420 ppt and 63,200 ppt.

14.7 ISSUES

None.

15. SURFACE WATER INTERIM CORRECTIVE MEASURES

Initial SIs at the Paducah Site indicated that various units were contributing to off-site surface water contamination. The *Results of the Site Investigation, Phase I*, KY/ER-4, (CH2M HILL 1991) give a preliminary description of the nature and extent of contamination and risk associated with the off-site contamination. Phase II [*Results of the Site Investigation, Phase II*, KY/SUB/13B-97777C, P-03 1991/1 (CH2M HILL 1992)] of the investigation further assessed the nature, extent, and risk of off-site contamination and identified and characterized those SWMUs possibly contributing to off-site contamination. Phase II also included the draft PHEA. The results of the SI identified 21 SWMUs that were believed to be contributing to off-site contamination. Of these, nine were identified as contributing primarily to groundwater contamination, nine were identified as contributing primarily to soils and sediment contamination, and three were found to be contributing to both. The contaminants included PCBs, radionuclides (primarily uranium-238) and metals.

Of particular concern at the time were the surface water, sediment, and soils at KPDES outfalls located west, north, and east of the facility, which includes KPDES Outfalls 001, 002, 003, 010, 011, and 012. Surface-water patterns at the facility at the time that the action took place have changed significantly. The concerns at the time are noted below, along with information on whether that surface water drainage has changed.

15.1 REMEDY SELECTION

In July 1993, DOE implemented an interim measure to reduce potential for exposure to contamination in surface water and sediment in the vicinity of the Paducah Site. The proposed action was documented in the *Interim Corrective Measure Workplan for Institutional Control of Offsite Contamination in Surface Water Outfalls, Creeks, and Lagoons*, DOE-OR 1030 (DOE 1992b). The actions chosen were installation of fencing and posting of signs to warn people in the area of the dangers posed by direct contact with the water and/or sediments.

The objectives of the Surface Water ICMs chosen actions were the following:

- To restrict access by the general public and site personnel to contaminated areas, thus reducing direct exposure and the potential for inadvertent transport of contaminants;
- To restrict access by the general public to contaminated areas for recreational uses;
- To identify contamination areas to the public and site personnel; and
- To monitor water and sediments as part of the KPDES program.

No ARARs were identified for this action in the decision document.

A modification to the work plan, as documented in the approved *Interim Measure Report for Institutional Control of Off-Site Contamination in Surface Water*, DOE/OR/07-1206&D1, had deferred activities on Bayou Creek until additional characterization was performed (DOE 1993c).

15.2 REMEDY IMPLEMENTATION

To achieve the objectives listed, signs and fencing were required for the locations indicated on Figure 15.1. DOE installed fencing and posted warning signs in areas of contamination at eight locations to prevent direct human contact with contaminated sediments. Each location was posted with a varying number of signs, dependent upon the area of contamination. These signs are referred to as the Surface Water ICM signs. The *Operation and Maintenance Plan for Institutional Control of Off-site Contamination in Surface Water Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/ER-42, was the original documentation for the O&M activities for the Surface Water ICM (MMES 1993b).

The language originally proposed was revised in the document, *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1904&D1 (DOE 2000c). The O&M requirements were revised again in 2015 to incorporate the recommendation in the 2013 Five-Year Review in the document *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky*, (DOE/OR/07-1904&Dl/R2) (DOE 2015e). The recommendation was made to replace the Surface Water ICM signs with the more current language of the environmental indicator signs. Each sign has been assigned a unique number, thereby allowing the ICM locations to be identified separately for this and subsequent five-year reviews.

The environmental responses for the NSDD, the Scrap Metal Disposition Project, and SWOU On-site have positively impacted the Surface Water ICM. These actions also included construction projects at the Paducah Site that work to prevent the transport of contaminated sediment off-site (i.e., outside the existing security fence and off DOE property). In addition, the Surface Water On-site Sediment Removal Project (discussed in Section 16) removed areas of contaminated sediment both inside and outside the facility security fence in 2010. After September 11, 2001, the Paducah Site instituted a Property Protection Area, which prevents members of the public from accessing the locations of some signs (see Figure 15.1 for current areas closed to public access). Because of the limited access that has been imposed at some of the sign locations and the environmental response actions that have taken place, the possibility of long-term exposure of humans to contaminated sediment and surface water is much less than it was when the signs were put in place. Water and sediments were monitored as part of the KPDES program. All KPDES program requirements are specified in the Environmental Monitoring Plan, which is updated on an annual basis.

15.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

The O&M requirements are specified in the *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky* (DOE/OR/07-1904&Dl/R2 (DOE 2015e). Signs and fences are inspected semiannually and repaired or replaced, as needed.

Although sampling and assessment of surface water and sediment data are part of the site Environmental Monitoring Program, it is not part of the Surface Water ICM. The results of the Environmental Monitoring Program are reported in the Annual Site Environmental Report.

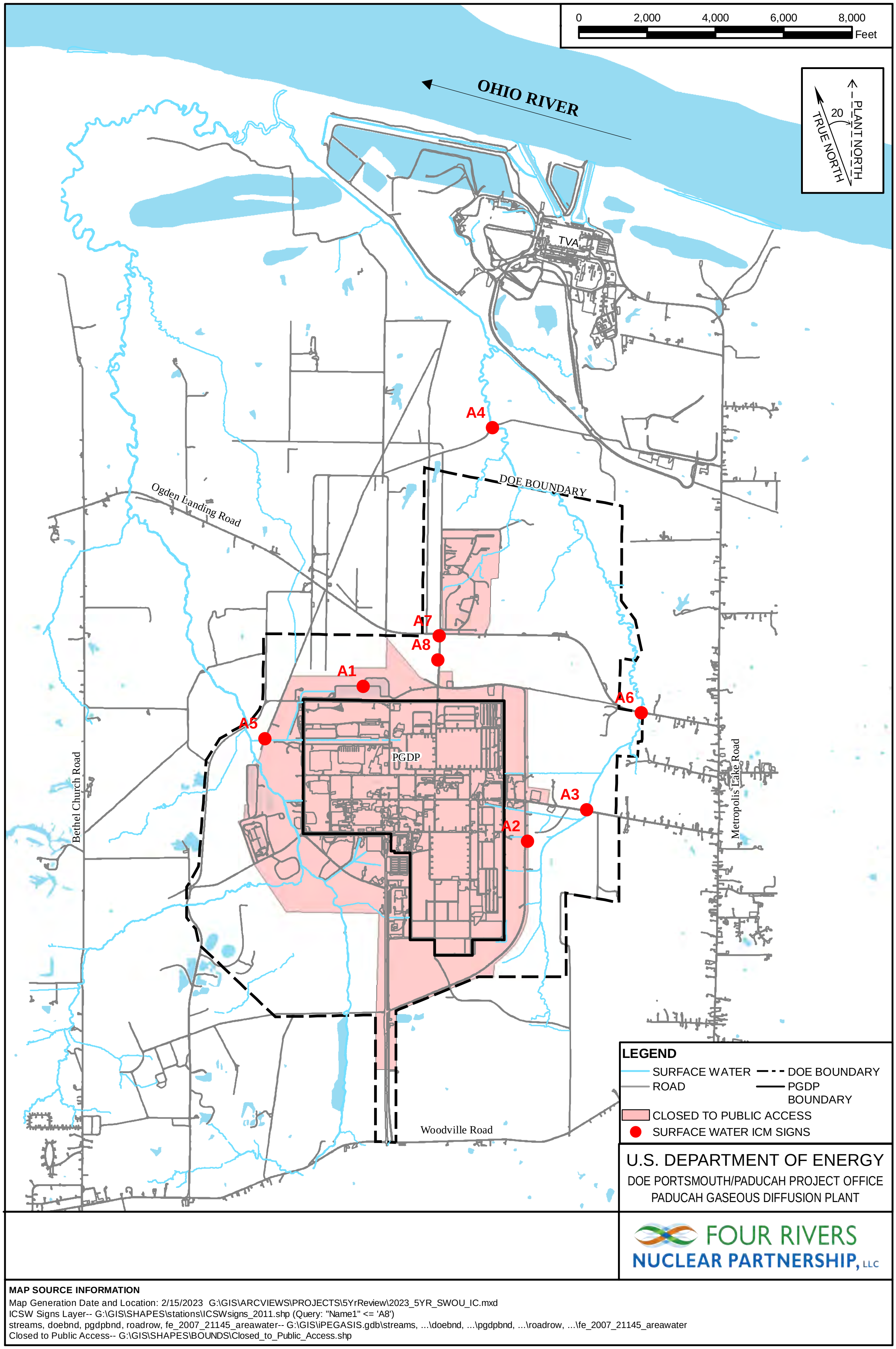


Figure 15.1. Location of Signs and Fencing Installed for the Surface Water ICM

15.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The 2018 review contained the following protectiveness statement: "The remedy for the surface water ICMs currently protects human health and the environment by institutional controls; however, additional actions under the SWOU need to be evaluated for long-term protectiveness."

There were no issues or recommendations for the Surface Water ICMs in the 2018 Five-Year Review. The area remains unchanged from the description in the 2018 Five-Year Review.

15.5 SITE INSPECTION

The locations of the signs and fences were inspected on December 6, 2022, by the five-year review team, the facility manager, and a representative from DOE's support contractor. The ICM signs all were legible (see Figures 15.2 through 15.4 for examples). Also, at all locations the Surface Water ICM signs were posted along with "KEEP OUT," "NO TRESPASSING," and radiological warning signs. The fences at all locations were in place.

15.6 TECHNICAL ASSESSMENT

KPDES Outfalls 002, 010, 011, 012, 013, 019, and 020 drain the eastern boundary of the facility and flow eastward toward Little Bayou Creek. The areas included in the drainage networks for these outfalls are comprised mostly of former plant processes areas and the on-site landfill. In 2010, the Surface Water On-site Sediment Removal (discussed in Section 16) removed areas of contaminated sediment, both inside and outside the facility security fence. Construction projects since the last five-year review do not negatively impact the selected remedy. KPDES Outfall 001 drains the units in the northwest corner of the security-fenced area. The C-613 Sedimentation Basin was constructed as part of the scrap metal disposition project to capture contaminated sediment that was transported off-site (i.e., outside the existing security fence) while moving heavy equipment inside the C-746-P, C-746-E, and C-746-C Scrap Yards during sorting, segregating, downsizing, and packaging activities and during ongoing and upcoming environmental response actions.

The surface water flowing north of the facility was drained primarily by KPDES Outfall 003, which drained some overflow during storm events from the NSDD. Actions taken by two projects that were discussed in other sections of this report, NSDD Source Control (Section 11) and NSDD Sections 1 and 2 (SWMU 59) (Section 12), have eliminated this outfall. The storm water that drained through NSDD to KPDES Outfall 003 when the Surface Water ICM was implemented was diverted to the C-616 treatment facility, and then it is discharged through KPDES Outfall 001.

15.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. Potential users of creeks, ponds, or streams outside the facility security fence are warned that contact with contaminated water and sediment may pose potential dangers, as detailed in Section 15.5, "Site Inspection." Sediments and water continue to be monitored through the Environmental Monitoring Program in accordance with the KPDES Permit, and results are made available through the Annual Site Environmental Report.

Figure 15.2. Sign and Fencing Installed for the Surface Water ICM

Figure 15.3. Sign and Fencing Installed for the Surface Water ICM

Figure 15.4. Sign and Fencing Installed for the Surface Water ICM

15.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. Land use for the area has not changed. Exposure pathways included direct radiation, ingestion of fish, dermal absorption, ingestion of sediment and water, although specific exposure parameters were not described in the decision document. These exposure pathways still are valid. This interim action did not remove the source of contamination, nor did it prevent biota that was exposed to the surface water and sediment from becoming contaminated. Changes in risk assessment methodology subsequent to the ROD have been significant. These changes, however, are not pertinent because the remedy relied on two components: (1) access restrictions through use of signs and fences, and (2) continued monitoring of water and sediments as part of the KPDES program. Neither of these components is related to changes in risk methodology.

Toxicity information or specific cleanup criteria were not discussed in the work plan because the selected remedy did not include excavation and removal of impacted soils/sediments. There have been no new contaminants or new understanding of geologic conditions identified.

There were no ARARs identified in the work plan (DOE 1992b).

The RAOs at the time of remedy selection are still valid.

15.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

The NSDD, Sections 3, 4, and 5 (SWMU 58), are part of the Surface Water ICMs. As part of the SWOU On-Site Removal Action Report, a residual risk evaluation was prepared that included these sections of the NSDD (DOE 2011a). Analytical data were compared against current industrial worker no action levels at all locations and recreational user no action levels at the NSDD for soil/sediment presented in *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1506&D2 (DOE 2001b). The RAO for the removal action to ensure direct contact risk at the NSDD for both the current industrial worker and recreational user that falls within the EPA risk range was met. The calculation of cumulative residual risk and hazard indicates that the cleanup goal of achieving a cumulative ELCR of 1E-05 and a cumulative HI of 1.0 was obtained for the targeted action areas, but did not provide for unlimited use/unrestricted exposure (see Section 16.6.2 for additional information).

No other information has come to light that would call into question the protectiveness of the remedy.

15.6.4 Technical Assessment Summary

This action is meeting the objectives as stated in the decision document by restricting access to the general public and site personnel to contaminated areas; restricting access by the general public to contaminated areas for recreational uses; identifying contamination areas to the public and site personnel; and monitoring water and sediments as part of the KPDES program. This action was not intended to restore the area in which it was implemented to unrestricted use.

15.7 ISSUES

None.

THIS PAGE INTENTIONALLY LEFT BLANK

16. SURFACE WATER ON-SITE SEDIMENT REMOVAL

NSDD Sections 3, 4, and 5 and KPDES Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and areas have been identified as SWMUs under the FFA due to the potential for actual or threatened releases of hazardous constituents. The following are the specific SWMUs.

- SWMU 58—Sections 3, 4, and 5 of the NSDD
- SWMU 63—KPDES Outfall 008
- SWMU 66—KPDES Outfall 010
- SWMU 67—KPDES Outfall 011
- SWMU 68—KPDES Outfall 015
- SWMU 69—KPDES Outfall 001
- SWMU 92—C-420 PCB Spill
- SWMU 97—C-601 Diesel Spill

The identified contamination was derived from surface water runoff and wastewater from various facility activities conducted at the Paducah Site, and it was determined to pose human health risks from direct contact with contaminated sediments greater than the EPA risk range under some scenarios. Figure 16.1 illustrates the location of the Surface Water On-site Sediment Removal action.

Sections 3, 4, and 5 of the NSDD (SWMU 58) are located outside the security-fenced area on property owned by DOE. The NSDD originates within the north-central portion of the Paducah Site and discharges into Little Bayou Creek north of the facility.

KPDES Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and areas are located both inside and outside the security-fenced area on property owned by DOE. The internal facility ditches that discharge to NSDD and the outfalls were trenched when PGDP was built and became fully operational when PGDP opened in 1951. Water discharged at each outfall is regulated by a KPDES Permit, and the water quality is tested regularly at established monitoring stations, in accordance with the conditions of the KPDES Permit.

The C-420 PCB Spill was designated as a SWMU due to the use of PCB-contaminated soils as fill from a transformer rupture in 1967. The C-601 Diesel Spill was designated as a SWMU due to a diesel oil spill that occurred on March 9, 1979.

NSDD Sections 3, 4, and 5 and KPDES Outfalls 001, 008, 010, 011, and 015, and their associated internal ditches and areas (including the C-420 PCB Spill and the C-601 Diesel Spill) have been characterized in several investigations, which include the Phase I and Phase II SIs (CH2M HILL 1991, CH2M HILL 1992); various WAG and SWMU RIs, site evaluations, and removal actions; and a 1996 PCB Study by the U.S. Army Corps of Engineers (COE 1996). In 2005, the SI for the SWOU was conducted and focused on the first sequenced response action for on-site portions of the SWOU at the Paducah Site (DOE 2008b). The investigation involved the collection of surface soil and sediment samples from various outfalls and their associated internal ditches and storm sewer discharge water to evaluate areas within the SWOU that had the greatest potential for contaminant discharge to creeks surrounding the facility.

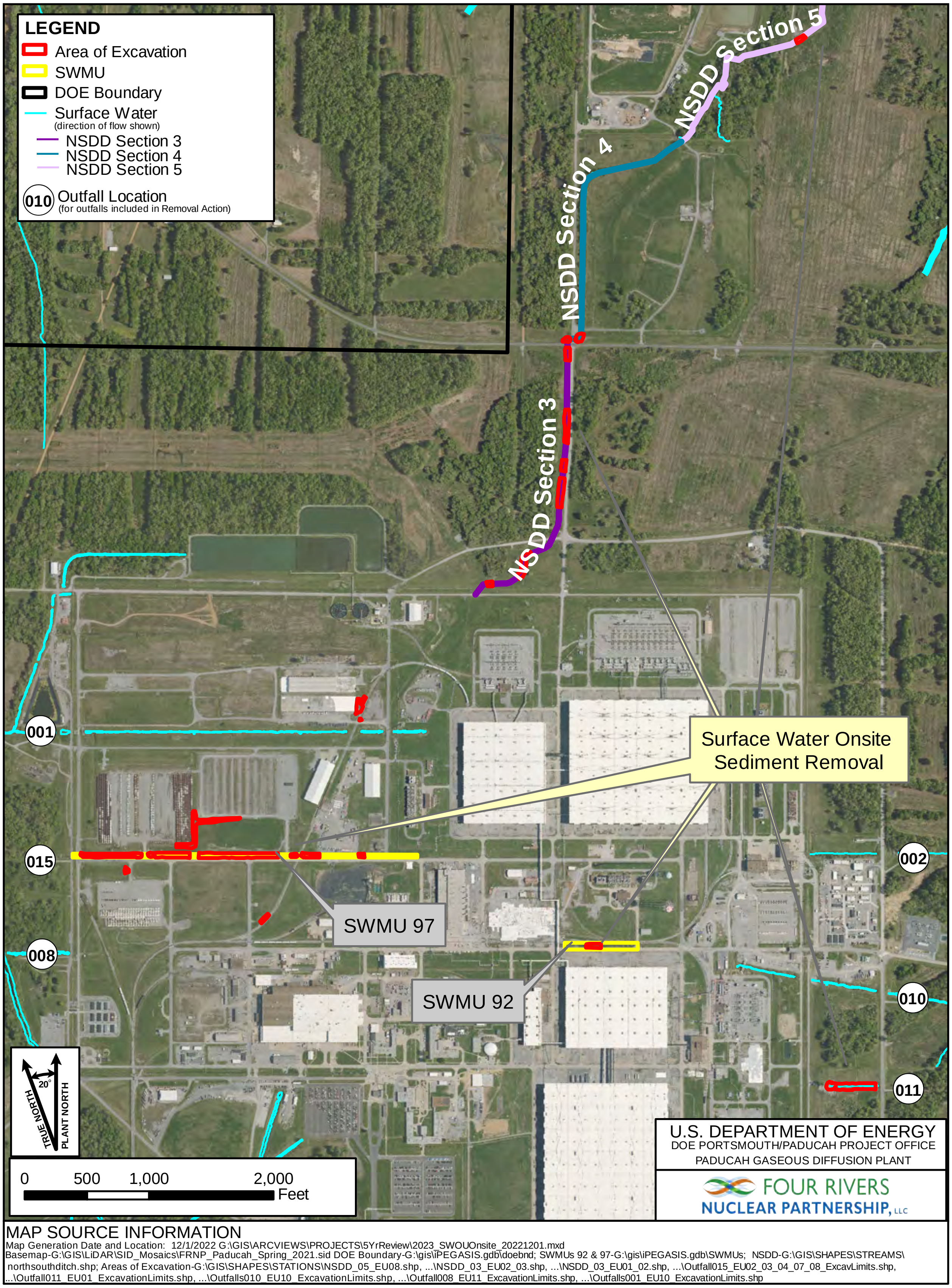


Figure 16.1. Location of Surface Water On-site Sediment Removal

16.1 REMEDY SELECTION

The surface water on-site sediment removal was performed as a NTCRA under the Paducah FFA. The *Action Memorandum for Contaminated Sediment Associated with the SWOU (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0119&D2/R1, (DOE 2009b) documents the NTCRA in specific areas or defined exposure units (EUs) located within KPDES Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and specific areas or EUs located within the NSDD Sections 3 and 5. Section 4 did not have any identified "hot spots." This action implements excavation and removal of "hot spots" associated with these areas and includes one or more engineering controls to prevent the transport of contaminated soils and sediment, as needed, during removal activities.

CERCLA documents that described the logic for this project and the basis for its implementation are as follows: *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012&D2 (DOE 2008c); *Action Memorandum for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07 0119&D2/R1 (DOE 2009b); and *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0221&D2/R1 (DOE 2009c).

The following RAOs were consistent with the overall RAOs for the SWOU.

- Ensure direct contact risk at the on-site ditches for the current industrial worker falls within the EPA risk range (EPA 1999).

- Ensure direct contact risk at the NSDD for both the current industrial worker and recreational user falls within the EPA risk range (EPA 1999).

16.2 REMEDY IMPLEMENTATION

The action implemented excavation and removal of areas of known contamination (i.e., soil/sediment) associated with the NSDD Sections 3 and 5 and KPDES Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and areas (including the C-420 PCB Spill and the C-601 Diesel Spill).

The action was implemented in November 2009 and completed in September 2010 and consisted of the following components.

- Excavated hot spots to a depth of 2 ft to eliminate the risk of human receptors contacting contaminated sediment. Hot spots under this action were identified using a cumulative ELCR of 1E-05 and a cumulative HI of 1.0.

- Collected samples from the bottom of the hot spot to confirm that the specified cleanup levels were achieved, and project RAOs were met.

- Verified, consistent with the results of the risk-based cost-benefit analysis, cleanup to the cumulative ELCR of 1E-05 and a cumulative HI of 1.0 following excavation was based upon comparisons between sampling results and chemical-specific ELCR-based and HI-based cleanup levels. The ELCR target used in deriving the cleanup levels was 5E-06. The HI target used in deriving the cleanup levels was 1.0.

- Implemented methods to validate the achievement of the chemical-specific cleanup levels similar to the NSDD Sections 1 and 2 (SWMU 59) remediation.

- Installed temporary, localized engineering controls, including a small storm water retention area, silt fencing, and rock check dams during excavation activities. The installation controlled sediment and contaminant migration.

- Restored (i.e., backfill with clean soil, reseeding) disturbed acreage to prevent erosion, migration and recontamination.

- Characterized, containerized, transported, and disposed of all equipment and contaminated soil/sediment at an appropriate disposal/storage facility.

- Assessed temporary localized engineering controls and discontinued as appropriate.

- Continued inspection and site maintenance, during and after excavation and restoration, to control erosion until the excavated/restored area was stable.

Figures 16.2 through 16.4 show current views of internal ditches and areas associated with KPDES Outfalls 001, 010, and 015. The total cost of excavation and disposing of the approximately 10,160 yd^3 of soil in the C-746-U Landfill and 12,517 yd^3 of soil at Energy*Solutions* was $18,312,363, according to the *Removal Action Report for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0357&D2 (DOE 2011a).

The RAOs were attained through removal of identified hot spots and verification of cleanup to a cumulative ELCR of 1E-05 and a cumulative HI of 1.0. The cumulative hazard and cancer risk for the EUs are listed in Table 16.1.

A residual risk evaluation was prepared as part of the Removal Action Report (DOE 2011a). Analytical data were compared against current industrial worker no action levels at all locations and recreational user no action levels at the NSDD for soil/sediment presented in *Methods for Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1506&D2 (DOE 2001b). The calculation of cumulative residual risk and hazard indicates that the removal goal of cleanup to a cumulative ELCR of 1E-05 and a cumulative HI of 1.0 was achieved.

This NTCRA was considered complete after the RAOs had been verified as achieved; verification or characterization sampling was performed; engineering and temporary access controls were evaluated and discontinued, as appropriate; the site was restored and determined stable; and treatment, storage, or disposal of contaminated media and waste was completed.

16.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

There is no O&M for this remedy.

Figure 16.2. KPDES Outfall 001 Internal Ditches, January 18, 2023 (Looking Northwest)

Figure 16.3. KPDES Outfall 010 Internal Ditch and Area, December 6, 2022 (Looking West)

Figure 16.4. KPDES Outfall 015 Internal Ditches, December 6, 2022 (Looking East)

Table 16.1. Cumulative ELCR and HI for SWOU EUs

KPDES Outfall/ NSDD Section	EU	ELCR (Cancer)	HI (Hazard)
INDUSTRIAL WORKER			
Outfall 001	15	4.90E-06	0.1
Outfall 008	11	4.50E-06	0.1
Outfall 010	10	4.30E-06	0.1
Outfall 011	1	3.80E-06	0.3
Outfall 015	2	2.50E-06	0.1
	3	2.20E-06	0.1
	4	1.00E-05	0.2
	7	2.80E-06	0.1
	8	9.20E-06	0.2
Section 3	1	3.90E-06	0.2
	2	5.10E-06	0.1
	3	7.30E-06	0.2
Section 5	8	5.80E-06	0.4
KPDES Outfall/ NSDD Section	**EU**	**ELCR (Cancer)**	**HI (Hazard)**
RECREATIONAL USER			
Section 3	1	5.40E-06	< 0.1
	2	5.30E-06	< 0.1
	3	5.80E-06	< 0.1
Section 5	8	1.20E-05	< 0.1

16.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The summation of the 2018 Five-Year Review protectiveness statement follows:

> The remedy for the Surface Water On-site Sediment Removal is protective of human health and the environment in the short-term due to excavation of contaminated sediment/soil and placement of clean soil to meet the cleanup goal. In order to establish long-term protectiveness, additional RAs will be evaluated and selected, as necessary, under the SWOU.

There were no previous issues or recommendations for the Surface Water On-site Sediment Removal in the 2018 Five-Year Review. The area remains unchanged from the description in the 2018 Five-Year Review, and no new actions have occurred.

16.5 SITE INSPECTION

A site inspection was conducted on December 6, 2022, by members of the five-year review team, the facility manager, and a representative from DOE's support contractor. All areas were grass covered or riprap covered and in good condition. Some signs of erosion were noted near Section 3 of the NSDD on the steep slopes and on portions of the C-601 Diesel Spill area. Standing water also was noted in several locations.

16.6 TECHNICAL ASSESSMENT

The RA for NSDD Sections 3 and 5 and KPDES Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and areas (including the C-420 PCB Spill and the C-602 Diesel Spill) is protective of human health and the environment because the threat of exposure from direct contact was eliminated by removing the known sources of contamination.

16.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy is functioning as designed. The excavation, as designed, met or exceeded the cleanup criteria. The RAOs for this removal action were achieved by reducing the risk to current industrial workers and recreational users from direct contact by removing known sources of contamination.

16.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The land use has not changed for any area addressed by the removal action and remains either industrial or recreational; therefore, the exposure assumptions used in the AM remain valid (DOE 2009b).

There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected as demonstrated by the results of the residual risk evaluation. There have been no new contaminants or new understanding of geologic conditions identified.

Many of the new risk-based values, compared to the cleanup level established in the AM, are lower because the exposure factors are higher for the new standards (Table 16.2) (DOE 2009b). The cleanup levels were based on a current industrial worker accessing the ditches 14 days per year. Using exposure factors in the Risk Methods Document (DOE 2022e) and an exposure frequency of 14 days per year, updated standards were derived using the Risk Assessment Information System (RAIS 2023). The updated standards are similar to or greater than the cleanup levels (i.e., an ELCR of 1E-05). The cleanup levels still are protective.

There are no changes in standards identified as ARARs in the AM that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in TBCs identified in the AM that impact the protectiveness of the remedy.

The RAOs used at the time of remedy selection still are valid.

16.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

16.7 ISSUES

None.

Table 16.2. Changes in Chemical-Specific Standards for the Surface Water On-Site Sediment Removal

Contaminant	Media	Cleanup Level[a] (DOE 2009b)	Standard[b] (RAIS 2023)
Arsenic	Sediment	27 mg/kg	143 mg/kg
Beryllium	Sediment	50,000 mg/kg	620,000 mg/kg
Total PCB	Sediment	16 mg/kg	26.2 mg/kg
Americium-241	Sediment	115 pCi/g	480 pCi/g
Cesium-137	Sediment	8 pCi/g	8.11 pCi/g
Neptunium-237	Sediment	22 pCi/g	18.2 pCi/g
Plutonium-239/240	Sediment	108 pCi/g	2,030 pCi g
Tc-99	Sediment	3,825 pCi/g	100,000 pCi/g
Thorium-230	Sediment	147 pCi/g	2,780 pCi/g
Thorium-232	Sediment	129 pCi/g	2,750 pCi/g
Uranium-234	Sediment	188 pCi/g	4,470 pCi/g
Uranium-235	Sediment	30 pCi/g	27 pCi/g
Uranium-238	Sediment	94 pCi/g	128 pCi/g
Uranium	Sediment	227 mg/kg	8,330 mg/kg

[a] Previous standards were derived from risk-based human health cleanup levels for restricted use of area by a current industrial worker and were set at the risk-based target of ELCR = 5E-06 for most COCs and a target of HI = 1.0 for uranium (metal) to achieve cleanup of a cumulative ELCR of 1E-05 and a cumulative HI of 1.0, see Section 3 and Table 1 of the AM (DOE 2009b).
[b] Updated standards are based on a similar exposure frequency of 14 days/year and other industrial worker exposure parameters from the 2022 Risk Methods Document (DOE 2022e). The updated standards were calculated for the risk-based target of ELCR = 5E-06 for most COCs and a target of HI = 1.0 for uranium (metal) (soluble salts) using http://rais.ornl.gov/cgi-bin/prg/PRG_search (accessed February 2023).

17. C-749 URANIUM BURIAL GROUND

The C-749 Uranium Burial Ground (SWMU 2) is located in the west-central portion of the facility north of Virginia Avenue and on the western edge of the C-404 Low-Level Radioactive/Hazardous Waste Burial Ground (SWMU 3) (Figures 17.1 and 17.2). The C-749 Uranium Burial Ground was used from approximately 1951 to 1977 for the disposal of uranium and uranium-containing wastes.

17.1 REMEDY SELECTION

The *Record of Decision for Interim Remedial Action at Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1351&D1, was signed in 1995 (DOE 1995d). Because the C-404 Contaminated Burial Ground (SWMU 3) is closed with a RCRA cap and is being addressed by RCRA postclosure permit requirements, the 1995 ROD required NFA for it. For the C-749 Uranium Burial Ground, the interim ROD selected an impermeable cap to reduce leachate migration from surface infiltration, groundwater monitoring, and institutional controls.

DOE conducted an investigation at the C-749 Uranium Burial Ground to provide information needed before the selected interim action was fully implemented and to provide additional data to evaluate a final RA for the C-749 Uranium Burial Ground (DOE 1997b). One of the goals of this investigation was to determine if the waste within the C-749 Uranium Burial Ground was saturated with groundwater. The results of the investigation indicated that the waste within was saturated; therefore, placement of a cap on the C-749 Uranium Burial Ground and the design and construction activities outlined within the ROD were canceled (Hodges 1996). The following are the conclusions of the investigation.

- Uranium and uranium precipitate dissolver sludge, contaminated with TCE from the C-400 Cleaning Building, is the primary component of the buried waste (with minimal, associated PCB oil).

- Migration of contaminants from the waste cell and underlying contaminated soil may have contributed to TCE at the Paducah Site boundary in concentrations that exceed both human health risk-based and regulatory (i.e., MCL) preliminary remediation goals; however, modeling indicates that migration of radionuclides is not a concern.

- Lateral movement of groundwater in the UCRS does occur, but not to a significant extent. Vertical transport of TCE is significant, but vertical transport of uranium is not significant.

The RAOs for the interim action were to mitigate migration of uranium and TCE from the C-749 Uranium Burial Ground to groundwater and to prevent disturbance or contact with the buried waste materials. To accomplish this, the selected IRA, Alternative 5, consisted of installation of the following components.

- Once a determination has been made regarding possible groundwater interaction with the buried wastes, a low permeability, multilayered cap may be placed on the C-749 Uranium Burial Ground to reduce infiltration of surface water from precipitation events into and through buried wastes. This also will reduce potential leaching of contaminants to groundwater. The cap also will decrease the gamma exposure rate to background levels and further decrease the likelihood of on-site workers and terrestrial animals coming into direct contact with the buried wastes.

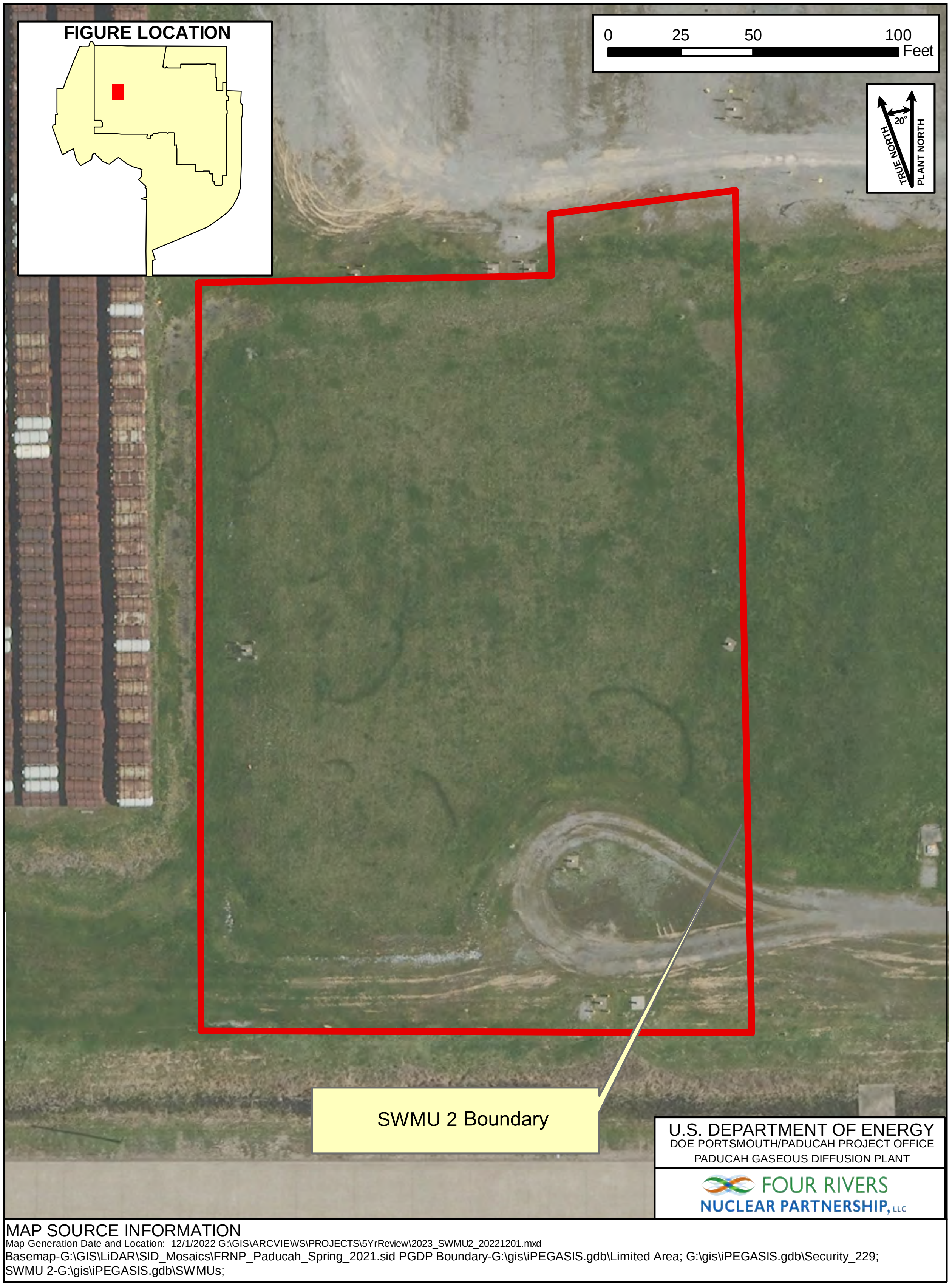


Figure 17.1. Location of C-749 Uranium Burial Ground

Figure 17.2. C-749 Uranium Burial Ground (Looking South)

- A groundwater monitoring program will be implemented in the uppermost aquifer, the RGA, to detect any release of contaminants from the C-749 Uranium Burial Ground.

- Institutional controls will be implemented to prevent transferal of the C-749 Uranium Burial Ground property and prevent future intrusive activities at the unit (DOE 1995d).

In addition to the five-year review, the ROD states that the groundwater data will be evaluated annually. These evaluations are documented in the FFA semiannual reports; the report for the second half of FY 2022 contains a map depicting the C-749 Uranium Burial Ground groundwater MWs and a summary of the trends for TCE and Tc-99 (DOE 2022f).

17.2 REMEDY IMPLEMENTATION

Following the post-ROD investigation, it was determined that the multilayer low-permeability cap, which was meant to minimize vertical infiltration of rain water through unsaturated waste, would be ineffective because of the shallow groundwater found at the C-749 Uranium Burial Ground. This investigation fulfilled the IRA requirement to evaluate the cap's effect(s) on the shallow groundwater level in the UCRS and fill data gaps. As a result, the multilayer low-permeability cap installation was cancelled (Hodges 1996).

In 1996, three RGA MWs were constructed to detect potential releases from the C-749 Uranium Burial Ground. MW337 and MW338 were installed downgradient of the C-749 Uranium Burial Ground, and MW333 was installed upgradient of the burial ground. The wells currently are sampled as part of the Paducah Site Groundwater Monitoring Program, as specified in the FY 2023 Environmental Monitoring Plan (FRNP 2022b).

Because the ROD for this IRA was signed prior to the effective date of the Paducah Site MOA and LUCAP, a LUCIP does not exist for the institutional controls at the C-749 Uranium Burial Ground.

DOE remains in control of the property that the C-749 Uranium Burial Ground encompasses. No deed restriction has been filed as part of this IRA. Exposure pathways that could result in unacceptable risk are being controlled through DOE ownership and use of the property.

17.3 SYSTEMS OPERATIONS/OPERATION AND MAINTENANCE

There is no required O&M for this remedy.

17.4 PROGRESS SINCE LAST FIVE-YEAR REVIEW

The summation of the 2018 Five-Year Review protectiveness statement follows:

> The remedy for the C-749 Uranium Burial Ground (SWMU 2) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled through DOE access controls. This earlier remedy is not a final RA and was not designed to fully address the risks to human health and the environment from the buried wastes nor return the areas to unrestricted use and/or unlimited exposure. The selected remedy for the C-749 Uranium Burial Ground was an interim action, and a final CERCLA action will be evaluated under the BGOU to ensure long-term protectiveness.

There were no previous issues or recommendations for the C-749 Uranium Burial Ground in the 2018 Five-Year Review. The site remains unchanged from the description in the 2018 Five-Year Review, and no new actions have occurred.

17.5 SITE INSPECTION

On December 6, 2022, a site inspection of the C-749 Uranium Burial Ground was performed by members of the five-year review team, the facility manager, and a representative from DOE's support contractor. This area is located north and west of the C-600 Utility Plant and within the boundaries of the security-fenced area of the Paducah Site. There were no indications of erosion or standing water in the area. An access road is located on the south side of the burial ground. The road is well maintained and is in good condition. Access to the north side of the area is through the C-745-C Cylinder Storage yard. The area is covered with grass, and it is mowed and well maintained. MWs in the area appear to be in good condition and are well maintained. The wells are secured with protective caps and casings with locks and are surrounded with guard posts.

17.6 TECHNICAL ASSESSMENT

The RAOs for the interim action were to mitigate migration of uranium and TCE from the C-749 Uranium Burial Ground to groundwater and to prevent disturbance or contact with the buried waste materials.

The C-749 Uranium Burial Ground low-permeability, multilayer cap was intended to mitigate migration of uranium and TCE from the area to groundwater; however, this component of the action was cancelled after it was determined that it would be ineffective because of the shallow groundwater found at the burial ground.

Five RGA MWs adjacent to the C-749 Uranium Burial Ground are sampled and analyzed for VOCs and Tc-99. The maximum detected levels of contaminants from these MWs during this five-year review period are listed in (Table 17.1).

The RAO to prevent disturbance or contact with buried waste material is being met, and the current action is protective of human health by preventing human exposure to buried wastes and groundwater through rigorous operational controls (i.e., radiological postings, radiological work permits, excavation permits).

Tables 17.2 and 17.3 present downgradient and upgradient data, respectively. Both tables compare the initial (i.e., pre-1996) and current maximum concentrations of the principal contaminants detected in RGA wells at the C-749 Uranium Burial Ground, based on groundwater sampling conducted between 1996 and 2022. The table also list contaminant background and MCL, where applicable.

Concentrations of uranium currently are at nondetectable levels and have been previously, with the exception of two sampling events in downgradient well MW338. In one event, uranium was detected at a high level (350 µg/L on September 24, 2001), but subsequent sampling at the well and isotopic uranium analysis of the same sample showed nondetectable levels;[15] therefore, the credibility of the high result is questionable. The second event showed that another detection (1.6 µg/L on December 3, 2002) was below the level established for RGA background (2 µg/L) and was followed by analyses that reported nondetectable concentrations.

Figure 17.3 illustrates TCE trends in upgradient MW333 and downgradient wells MW337 and MW338. RGA flow direction is also shown on the map. These data show that TCE concentrations are higher in upgradient MW333 than in the downgradient wells. These data indicate that TCE contamination in the RGA at the C-749 Uranium Burial Ground is coming from an upgradient source and that the net groundwater flow direction is northward.

[15] The laboratory reporting limit for uranium typically is 1 µg/L or less.

Table 17.1. Summary of C-749 Groundwater Monitoring Results (2018–2022)

Volatile Organic Compounds	MCL (µg/L)	Maximum Level Detected (µg/L)				
		MW333	MW548	MW67	MW337	MW338
1,1,1-Trichloroethane	200					
1,1,2-Trichloroethane	5		2.11	1.41	3.77	1.16
1,1-Dichloroethane	N/A		1.39	0.43 J	0.35 J	
1,1-DCE	7			1.14		
1,2-Dichloroethane	5					
Benzene	5					
Bromodichloromethane	N/A					
Carbon Tetrachloride	5	117	94 J	26.4	0.78 J	1.1
Chloroform	80[a]	229	258	31.8	1.56	1.22
cis-1,2-DCE	70	381	504	86.2	39.2	27.2
Dimethylbenzene	10,000					
Ethylbenzene	700					
Tetrachloroethene	5		0.94 J			
Toluene	1,000					
trans-1,2-DCE	100		0.91 J	1.29	3.95	1.82
TCE	5	5,130	6,170	1,520	1,780	1,680
Vinyl Chloride	2		4.01	0.78 J		
Radionuclide	**MCL (pCi/L)**	**Maximum Level Detected (pCi/L)**				
		MW333	**MW548**	**MW67**	**MW337**	**MW338**
Tc-99	900	101	57.1	140	316	161

J = estimated value
N/A = not applicable
[a] MCL is for the sum of the concentrations for trihalomethanes.
Note: Shading indicates analysis available but was not detected.

Table 17.2. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Downgradient of the C-749 Uranium Burial Ground

Analyte	Conditions before ROD signed (9/11/1995)			Conditions after ROD signed (9/11/1995)			Screening Levels		Units
	Maximum Detected Results	Associated Well	Sampling Date	Maximum Detected Results	Associated Well	Sampling Date	RGA Background Values[a]	Maximum Contaminant Level	
TCE	3	MW50	11/10/1988 10/15/1991 1/29/1992 7/28/1992 10/7/1992	2,990	MW67	1/27/2015	No Value	5	µg/L
Uranium	0.001	MW51	5/1/1991	0.35[b]	MW338	9/24/2001	0.002	0.03	mg/L
cis-1,2-DCE	Not Analyzed	N/A	ALL	150	MW337	3/6/2008	No Value	70	µg/L
Beryllium	0.0023	MW50	4/5/1990	0.0014	MW337	10/4/1996	0.004	0.004	mg/L
Calcium	16.8	MW50	10/20/1989	16	MW337	10/4/1996	40	No Value	mg/L
Chloride	13	MW67	2/18/1988	24.3	MW338	3/10/1998	89.2	250[c]	mg/L
Fluoride	0.89	MW51	5/1/1991	0.41	MW338 MW67	10/4/1996 10/8/1996	0.245	4	mg/L
Iron	82.8	MW50	10/20/1989	56	MW337	10/4/1996	3.72	0.3[c]	mg/L
Magnesium	6.43	MW67	2/24/1993	7.3	MW337	10/4/1996	15.7	No Value	mg/L
Manganese	1.8	MW51	1/13/1988	2.1	MW337	10/4/1996	0.082	0.05[c]	mg/L
Nitrate/Nitrite	0.07	MW50	4/5/1990	0.21	MW337	10/4/1996	13.5[d]	10[d]/1[e]	mg/L
Potassium	2.38	MW50	10/20/1989	3.9	MW337	10/4/1996	4.47	No Value	mg/L
Sodium	333	MW50	10/20/1989	14	MW338	10/4/1996	63.5	No Value	mg/L
Sulfate	12	MW67	2/24/1993	8.7	MW67	10/8/1996	19.1	No Value	mg/L

Table 17.2. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Downgradient of the C-749 Uranium Burial Ground (Continued)

Analyte	Conditions before ROD signed (9/11/1995)			Conditions after ROD signed (9/11/1995)			Screening Levels		Units
	Maximum Detected Results	Associated Well	Sampling Date	Maximum Detected Results	Associated Well	Sampling Date	RGA Background Values[a]	MCL	
Vanadium	0.0568	MW50	10/20/1989	0.052	MW337	10/4/1996	0.139	No Value	mg/L
Gross Alpha	33.3[f]	MW67	11/17/1988	10.8	MW337	12/4/2003	2.36	15	pCi/L
Gross Beta	38 38[f]	MW50 MW51	10/20/1989 3/28/1991	196	MW337	9/25/2009	7.3	50[g]	pCi/L
Americium-241	1.6	MW51	1/13/1988	0.35	MW67	10/8/1996	No Value	No Value	pCi/L
Plutonium-239	0.28	MW67	3/11/1991	0.13	MW338	10/4/1996	0.03	No Value	pCi/L
Tc-99	53.2	MW51	7/23/1992	347	MW337	8/10/2011	10.8	900	pCi/L
Thorium-230	ND	N/A	ALL	0.74	MW67	10/8/1996	0.54	No Value	pCi/L
Uranium-234	2.5	MW67	3/11/1991	0.56	MW338	10/4/1996	0.7	10.24[h]	pCi/L
Uranium-235/ Uranium-236	ND	N/A	ALL	0.11	MW337	10/4/1996	0.3[i]	0.466[g]	pCi/L
Uranium-238	3.3	MW67	3/11/1991	0.67	MW338	10/4/1996	0.7	9.99[g]	pCi/L

ND = not detected
N/A = not applicable
[a] Background values of RGA wells from Volume 5 of the GWOU FS, *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* (Volume 5 of the GWOU FS) (DOE 2001a).
[b] Isolated detection, isotopic analysis shows nondetects.
[c] Secondary MCL for reference only.
[d] Value is nitrate as nitrogen.
[e] Value is nitrite as nitrogen.
[f] Dissolved activity.
[g] 401 *KAR* 47:030 value.
[h] 2022 Update of the Human Health Risk Methods Document (DOE 2022e).
[i] Background value for Uranium-235.

Table 17.3. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Upgradient of the C-749 Uranium Burial Ground

Analyte	Conditions before ROD signed (9/11/1995)			Conditions after ROD signed (9/11/1995)			Screening Levels		Units
	Maximum Detected Results	Associated Well	Sampling Date	Maximum Detected Results	Associated Well	Sampling Date	RGA Background Values[a]	Maximum Contaminant Level	
TCE	ND	N/A	ALL	10,700	MW333	6/3/2015	No Value	0.005	μg/L
Uranium	0.019	MW48	8/1/1989	ND	N/A	ALL	0.002	0.03	mg/L
cis-1,2-DCE	Not Analyzed	N/A	ALL	808	MW333	6/3/2015	No Value	0.07	μg/L
Beryllium	0.01	MW48	8/1/1989	ND	N/A	ALL	0.004	0.004	mg/L
Calcium	17.2	MW48	4/3/1991	24.0	MW333	10/14/1996	40	No Value	mg/L
Chloride	12	MW48	3/9/1993	12.1	MW333	3/10/1998	89.2	250[b]	mg/L
Fluoride	0.18	MW48	5/24/1989	0.32	MW333	10/14/1996	0.245	4	mg/L
Iron	706	MW48	8/1/1989	8.19	MW333	7/13/2020	3.72	0.3[b]	mg/L
Magnesium	6.99	MW48	4/3/1991	9.2	MW333	10/14/1996	15.7	No Value	mg/L
Manganese	5.87	MW48	8/1/1989	2.6	MW333	10/14/1996	0.082	0.05[b]	mg/L
Nitrate/Nitrite	1.9[c]	MW48	12/11/1991	0.05	MW333	10/14/1996	13.5[c]	10[c]/1[d]	mg/L
Potassium	2.07	MW48	10/13/1989	1.2	MW333	10/14/1996	4.47	No Value	mg/L
Sodium	13.7	MW48	4/3/1991	16	MW333	10/14/1996	63.5	No Value	mg/L
Sulfate	12	MW48	3/9/1993 12/11/1992	16	MW333	10/14/1996	19.1	No Value	mg/L
Vanadium	0.0085	MW48	10/13/1989	0.0097	MW333	10/14/1996	0.139	No Value	mg/L
Gross Alpha	20.4[e]	MW48	1/13/1988	4.34	MW333	3/19/2007	2.36	15	pCi/L

Table 17.3. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Upgradient of the C-749 Uranium Burial Ground (Continued)

Analyte	Conditions before ROD signed (9/11/1995)			Conditions after ROD signed (9/11/1995)			Screening Levels		Units
	Maximum Detected Results	Associated Well	Sampling Date	Maximum Detected Results	Associated Well	Sampling Date	RGA Background Values[a]	MCL	
Gross Beta	23[e]	MW48	1/13/1988	24.7	MW333	3/8/2010	7.3	50[f]	pCi/L
Americium-241	3.7	MW48	3/27/1991	0.19	MW333	10/14/1996	No Value	No Value	pCi/L
Plutonium-239	ND	N/A	ALL	ND[g]	N/A	ALL	0.03	No Value	pCi/L
Tc-99	33	MW48	8/1/1989	122	MW333	7/17/2017	10.8	900	pCi/L
Thorium-230	ND	N/A	ALL	0.25	MW333	10/14/1996	0.54	No Value	pCi/L
Uranium-234	ND	N/A	ALL	9.66	MW333	10/14/1996	0.7	10.24[h]	pCi/L
Uranium-235/ Uranium-236	ND	N/A	ALL	0.35	MW333	10/14/1996	0.3[i]	0.466[h]	pCi/L
Uranium-238	1.3	MW48	4/3/1991	0.14	MW333	10/14/1996	0.7	9.99[h]	pCi/L

ND = not detected.
N/A = not applicable
[a] Background values of RGA wells from Volume 5 of the GWOU FS, *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* (Volume 5 of GWOU FS) (DOE 2001a).
[b] Secondary MCL for reference only.
[c] Value is nitrate as nitrogen.
[d] Value is nitrite as nitrogen.
[e] Dissolved activity.
[f] 401 *KAR* 47:030 value.
[g] Value reported below laboratory detection limit but was not laboratory qualified as a nondetect.
[h] 2022 Update of the Human Health Risk Methods Document (DOE 2022e)
[i] Background value for Uranium-235.

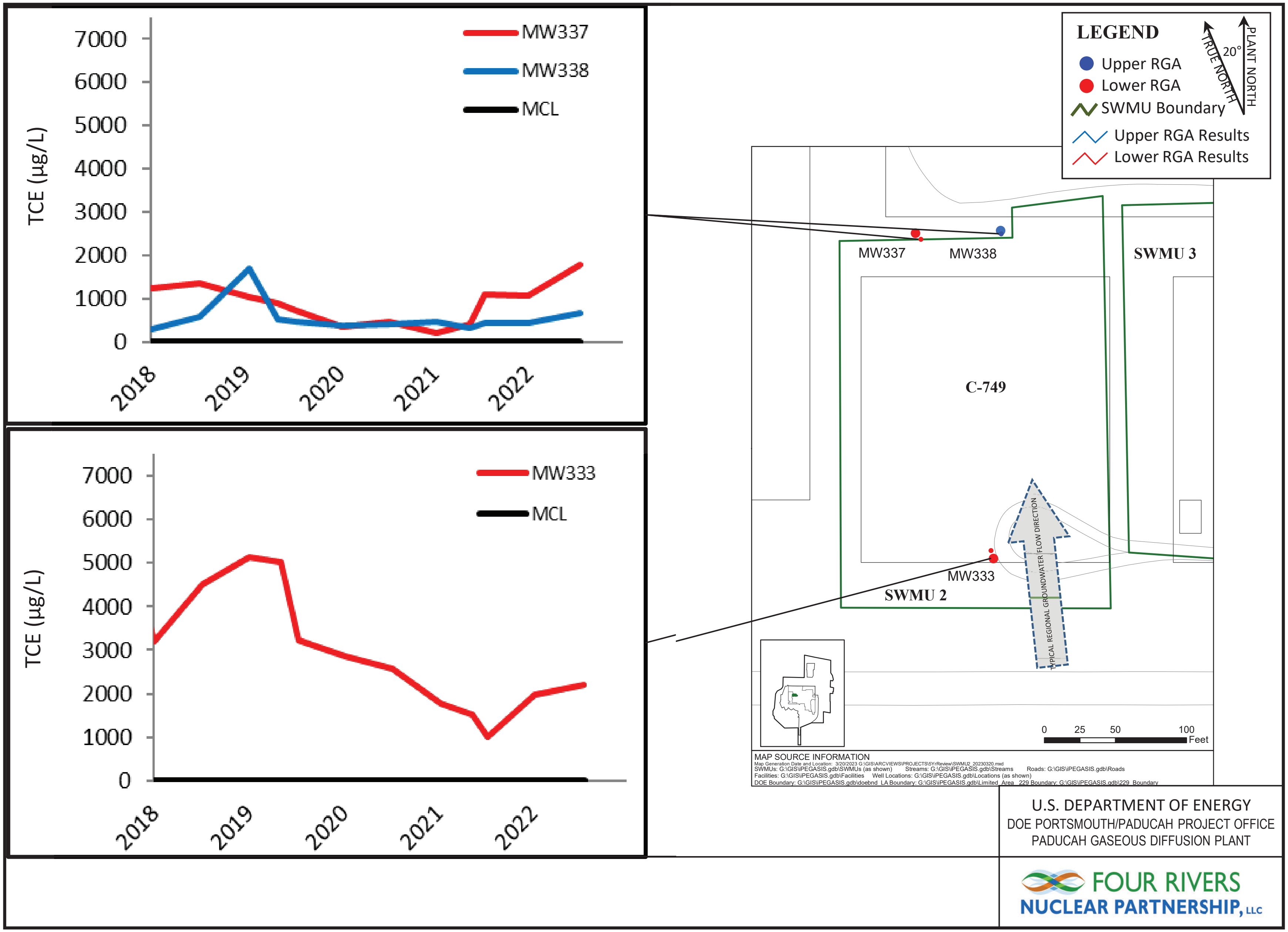


Figure 17.3. TCE Trends in MWs and RGA Flow Direction for the C-749 Uranium Burial Ground

Because the C-749 Uranium Burial Ground is located inside the facility security-fenced area and under DOE ownership and control, deed restrictions have not been necessary. The burial ground is roped and posted along the perimeter of the unit to identify it as a radiological contamination zone requiring personal protective equipment, special training, and permits to gain access or to work within the area.

17.6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The components of the remedy that were implemented are functioning as intended. Groundwater MWs constructed for the C-749 Uranium Burial Ground, consisting of two downgradient wells (MW337 and MW338) and one upgradient well (MW333), are located to monitor the facility. Furthermore, MW67 and MW548 provide additional RGA monitoring points, upgradient and downgradient respectively.

17.6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. DOE remains in control of the property that the C-749 Uranium Burial Ground encompasses, and the land use remains industrial; therefore, the exposure assumptions used in the ROD regarding disturbance or contact with the buried waste materials remains valid. There have been changes to the risk assessment methodology, but the protectiveness of the remedy was not affected. There have been no new contaminants identified.

The current groundwater data indicate that assumptions underlying the remedy selection in the ROD still are valid. The post-ROD monitoring program evaluated the proposed cap's effect on the shallow groundwater level and identified that the waste predominately was saturated, and the installation of the cap would not reduce potential groundwater contamination. Based on this conclusion by the parties, implementation of the cap's design and construction activities, as outlined in the current ROD, was canceled (Hodges 1996).

The exposure assumptions used to develop the human health risk assessment included both current exposures (industrial worker) and potential future exposures (future resident using groundwater and future industrial worker). The MCL for TCE remains 5 μg/L as it was during the original remedy selection; however, the parameters for risk evaluation of TCE have been revised. The original remedy was based on the assumption that institutional controls prevent access to the groundwater at the unit and eliminate any exposure pathway. Because the exposure assumption (no exposure) still is valid, the remedy remains protective. Also, the groundwater monitoring data for the C-749 Uranium Burial Ground indicate that the burial ground does not contribute significantly to the area-wide groundwater contamination that is being addressed through other actions.

No cleanup levels were established in the ROD because the selected remedy did not include excavation and removal of the waste and impacted soils.

There are no changes in standards identified as ARARs in the ROD that impact the protectiveness of the remedy. Additionally, there are no newly promulgated standards that might apply or be relevant and appropriate to the site that affect the protectiveness of the remedy. Finally, there are no changes in TBCs identified in the ROD that impact the protectiveness of the remedy.

The RAOs used at the time of remedy selection still are valid.

17.6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

For those remedy components that were implemented, no additional information has come to light since implementation of the remedy that could call into question their protectiveness.

17.7 ISSUES

None.

THIS PAGE INTENTIONALLY LEFT BLANK

18. ISSUES, RECOMMENDATIONS, AND FOLLOW-UP ACTIONS

Operable Unit	Issue	Party Responsible	Oversight Agency	Recommendations and Follow-up Actions	Completion Date	Affects Protectiveness (Y/N)	
						Current	Future
Groundwater, Northwest Plume (SWMU 201)	The Northwest Plume (SWMU 201) IRA, designed to initiate hydraulic control of the high TCE concentration of the Northwest Plume, has achieved the IRA goals in the area of the original north EW wellfield (EW 228 and EW 229). TCE detections in the North Wellfield now are consistently low (~ 5 ppb or less) and the contaminant trends indicate the Northwest Plume has migrated east of the North Wellfield. The risk posed by the unused wells exceeds any potential benefit of future reuse of the wells.	DOE	EPA and the Commonwealth of Kentucky	Perform an evaluation of the north EW wellfield (EW 228 and EW 229) for deactivation and abandonment and gain concurrence of the FFA parties.	12/31/2027 (End of next five-year review period)	N[a]	Y[a]
Groundwater, Northwest Plume (SWMU 201)	The C-612 groundwater treatment facility was constructed in 1995 pursuant to the Northwest Plume (SWMU 201) IRA. The facility was designed for a five-year life span and the treatment of contaminant concentrations much higher than are currently present. Though some major components of the facility have been replaced since 1995, many components are nearly 30 years old.	DOE	EPA and the Commonwealth of Kentucky	Perform a comprehensive evaluation of the C-612 groundwater treatment facility to determine the extent of modifications needed to optimize reliability and performance.	12/31/2027 (end of next five-year review period)	N[b]	N[b]
Groundwater, Northeast Plume (SWMU 202)	NW and NE Plume systems are working as designed to increase TCE mass removal and enhance hydraulic capture of the plumes; however, the containment systems could be further optimized by installing additional EW(s) near the C-400 Complex.	DOE	EPA and the Commonwealth of Kentucky	Perform an evaluation for the installation of additional EW(s) near the C-400 Complex, which is consistent with the groundwater flow modeling assessment completed as part of the RAWP (DOE 2018a).	12/31/2027 (end of next five-year review period)	N[b]	N[b]

Operable Unit	Issue	Party Responsible	Oversight Agency	Recommendations and Follow-up Actions	Completion Date	Affects Protectiveness (Y/N)	
						Current	Future
Water Policy	Information obtained during the last five years demonstrates that the Tc-99 plume no longer exists at concentrations exceeding the Tc-99 MCL in areas off of DOE property and that the TCE plumes have reduced concentrations and areal extent in areas off of DOE property. Sources of relevant TCE and Tc-99 plume information that support these reductions are as follows: (1) results of monitoring plume concentrations and changes in those concentrations; (2) changes in plume extent as shown in biennial plume map reports; (3) information and findings on groundwater flow and concentration trends evaluated as part of the sitewide groundwater strategy; (4) insights developed from updates to the sitewide groundwater flow and fate and transport models; and (5) results of plume stability analyses.	DOE	EPA and the Commonwealth of Kentucky	Develop a technical paper using relevant TCE and Tc-99 plume information to better understand the status of the Water Policy action and whether an optimization of the Water Policy action is warranted.	12/31/2027 (end of next five-year review period)	N[b]	N[b]

[a] The EWs and MWs are maintained to ensure current protectiveness. Unless maintained in perpetuity, proper abandonment is needed to prevent the EWs and MWs from becoming future avenues of migration of surface contaminants to the RGA.

[b] Although the issue does not affect the current or future protectiveness, the issue and recommended actions are an optimization to the current remedy established and are included as recommended by guidance.

19. PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

2018 Issue	2018 Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Results	Date of Action
Northwest Plume (SWMU 201) (GWOU)					
The Northwest Plume (SWMU 201) IRA, which was designed to initiate hydraulic control of the high TCE concentration of the Northwest Plume, saw increases in TCE levels in a downgradient MW. The increasing TCE levels in downgradient MW460 may be an indication of capture of downgradient groundwater that is impacted by site contaminants in response to the drawdown of the aquifer or increasing TCE levels may indicate limited plume bypass of the optimization EW wellfield.	EW pump placement and pumping rates should be evaluated to optimize capture of the Northwest Plume.	DOE	12/30/2022	DOE completed a review of contaminant trends upgradient, downgradient, and within the optimized EW wellfield to assess the capture of contamination in the Northwest Plume. The review determined that the NWPGS is performing as intended and that no adjustment of pump placement or pumping rate is required.	The white paper that presents the review of contaminant trends is attached to this Five-Year Review as Appendix D.
Northwest Plume (SWMU 201), Northeast Plume, and Water Policy (GWOU) Additional Action					
Detailed lithologic plots are needed to manage the uncertainty regarding the potential for faulting and the influences on the subsurface lithologic units potentially impacting Paducah Site contaminant plume migration on-site and beyond the Paducah Site boundaries, including the Water Policy Box affected area.	DOE will develop a technical paper that addresses the correlations among lithologic units across the entire Paducah Site, including the Water Policy Box affected area, using existing data that currently is available, along with the data that will be generated as part of the C-400 Complex OU RI/FS Work Plan implementation. The technical paper will be developed in accordance with Attachment 2 to this dispute resolution agreement. DOE will issue the technical paper within one month of submittal of the D1 C-400 Complex OU RI/FS Report to support the review of data presented in the C-400 Complex OU RI/FS Report.	DOE	12/30/2022	The report will be used in the 2023 Five-Year Review protectiveness determinations for the Northeast Plume, Northwest Plume, and Water Policy response actions.	Concurrence of acknowledgment of closure of action received from EPA and KDEP on 1/18/2023.

2018 Issue	2018 Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Results	Date of Action
Water Policy (GWOU)					
Water Policy Additional Action (EPA): DOE written commitment to expansion of the Water Policy Education Fact Sheet distribution list for the next (FY 2020) annual mailing, and in subsequent years, beyond the residents and businesses in the Water Policy Box affected area to include trusted individuals and information sources in the broader community.	DOE to establish a revised distribution list for the Water Policy Education Fact Sheet mailer that will be utilized for future updates of the fact sheet. Additionally, a direct link to the most current Water Policy Education Fact Sheet mailer has been provided on the Environmental Information Center website (https://eic.pad.pppo.gov/) to enhance public accessibility.	DOE	N/A	The revised distribution list (effective FY 2020) includes the following: All residences and businesses within the Water Policy Box affected area; • Owners of property within the Water Policy Box affected area who do not reside at the property; • CAB members; • Local elected officials and city contacts; • PGDP Reading File to be maintained by the McCracken County Library Special Collections.	Second quarter, FY 2020
Water Policy Additional Action (EPA): DOE provision (as Official Use Only) of the annual Water Policy Due Diligence Report by December 30, 2019, to EPA and KDEP for review and subsequent DOE provision of a briefing on the report to the regulatory agencies no later than January 30, 2020.	DOE added a Water Policy section within the FFA Semiannual Progress Report for communication and documentation of activities related to the Water Policy.	DOE	April 2020	The FFA Semiannual Progress Report is updated and submitted every six months (April and October) and includes Water Policy activities starting in April 2020.	Action closed by MOA.
Water Policy Additional Action (EPA): DOE preparation and submittal of a Water Policy D1 Removal Action Work Plan proposing a revised residential well and MW sampling proposal for EPA and KDEP review.	DOE will incorporate elements of Water Policy boundary monitoring currently conducted under the Paducah Site Environmental Monitoring Plan (shown in Attachment 1) into the Northeast and Northwest Plumes O&M plans and submit the revised documents to EPA and KDEP in FY 2020 in lieu of developing a D1 Removal Action Work Plan for the Water Policy. Water Policy information will be included in FFA Semiannual Progress Reports for use in evaluating continued protectiveness in support of future five-year reviews.	DOE	N/A	Data generated in support of Water Policy monitoring will be made available in PEGASIS and a summary reported in FFA Semiannual progress reports.	Action closed by MOA.

2018 Issue	2018 Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Results	Date of Action
Water Policy Additional Action (KDEP): Consider cost offsets.	During dispute resolution discussions, KDEP and EPA were advised that the DOE Portsmouth-Paducah Project Office is actively pursuing license agreements for payment of monthly water bills to all residential and business addresses in the Water Policy Box affected area. It was also discussed that some residents refuse to allow DOE to pay their water bills and/or refuse to sign license agreements.	DOE	N/A	These discussions satisfied the condition.	Action closed by MOA.
Water Policy Additional Action (KDEP): Implement a public awareness campaign that employs multiple communication efforts (such as well lock contact tags), especially for residents that have not signed license agreements, to verify that existing MWs are not being used for primary or secondary uses.	DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE's implementation, and regulatory agency understanding, of the Water Policy and in support of future five-year reviews. See also recommendations to EPA Additional Actions 1 and 2.	DOE	N/A	This documentation and discussion satisfied the condition.	Action closed by MOA.
Water Policy Additional Action (KDEP): Compile a consolidated Water Policy occupant list that includes the property owner(s), license status, municipal water cost offset status, and shortest distance to the TCE plume by December 31, 2019.	DOE compiled and shared lists of addresses and license status to enhance regulatory agency understanding of DOE's implementation of the Water Policy and in support of future five-year reviews.	DOE	N/A	This documentation and discussion satisfied the condition.	Action closed by MOA.
Water Policy Additional Action (KDEP): Develop a consolidated, management-approved, standard set of procedures that will be followed to ensure that exposure to contaminated groundwater is not occurring.	DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE's implementation, and regulatory agency understanding, of the Water Policy and in support of future five-year reviews.	DOE	N/A	This documentation and discussion satisfied the condition.	Action closed by MOA.

2018 Issue	2018 Recommendations/ Follow-up Actions	Party Responsible	Milestone Date	Results	Date of Action
Water Policy Additional Action (KDEP): Provide appropriate documentation to demonstrate that efforts have been made to contact households in the Water Policy Box and to document well usage status. This documentation should be updated on a regular basis.	DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE's implementation, and regulatory agency understanding, of the Water Policy, in support of future five-year reviews. The documentation and discussion satisfied the condition.	DOE	N/A	D&R Contractor procedure CP4-ES-1013, *Water Policy Management*, became effective on 12/10/2019, and was posted to the public documents website.	Action closed by MOA. A briefing was held for EPA and KY on 12/18/2019.
Southwest Plume (GWOU)					
The Southwest Plume project is starting the long-term monitoring phase at SWMU 211-A and has just completed construction of the remedy. The RA is designed to address VOC releases in UCRS soils to groundwater. Currently, sufficient data is not available to determine how effective the RA is performing. Follow-up five-year review evaluations are needed to ensure long-term protection and that the remedy is performing as designed.	Continue with the implementation of the performance and long-term monitoring of the SWMU 211-A system as planned. The collection of data will provide the information needed to determine if the remedy is performing as planned and contaminant levels are decreasing leading to long-term effectiveness at the SWMU. Further evaluation is needed to ensure that the potential VOC sources not addressed by the remedy that could be underlying the C-720 building and SWMU 211-B are addressed as part of any subsequent follow-up GWOU actions (e.g., Dissolved-Phase Plumes OU or C-720 Building).	DOE	2017	Collection of the needed data is already planned and being performed. In the interim, interim LUCs are in place and providing the needed protection along with additional previous groundwater actions implemented.	2/8/2023
Fire Training Area (SWMU 100) (SWOU)					
Fire Training Area (SWMU 100) Additional Action (EPA): PFAS sampling in selected groundwater wells in FY 2019 and the results reported in the FFA Semiannual Progress Report for the first half of FY 2020 for EPA and KDEP evaluation.	DOE conducted groundwater sampling for PFAS at the Fire Training Area in 2019. The PFAS data associated with MW315 and MW330 were placed into PEGASIS on March 26, 2020, and provided to EPA and KDEP on April 13, 2020. As an emergent contaminant, PFAS was not considered as part of the scope of the WAGs 1 & 7 RI/FS or ROD. As discussed in the FY 2023 SMP, the presence of PFAS will be evaluated separately; if cleanup under CERCLA is required, a new remedial action project will be identified to address the contamination (DOE 2022a).	DOE	N/A	The submittal of the data via letter satisfied the condition.	Action closed by MOA.

N/A = not applicable

Note: These schedules are estimates for planning. They are included only for informational purposes and are not intended to establish enforceable schedules or milestones. Enforceable milestones are contained in Appendix C of the FFA and Appendix 5 of the SMP.

20. 2023 PROTECTIVENESS STATEMENTS

Overall, the selected remedies implemented thus far are protective, but the Paducah Site cleanup activities still are ongoing with additional future actions planned. The groundwater exposure pathways for the Paducah Site are being controlled by providing potentially affected residents access to municipal water under the Water Policy, combined with a series of source and plume control actions to reduce off-site contaminant migration. Other exposure pathways for other media (e.g., soil and sediment) are being controlled through individual OU actions, along with DOE ownership and use of the property.

20.1 GROUNDWATER OPERABLE UNIT

20.1.1 Northwest Plume

The IRA for the Northwest Plume (SWMU 201) is protective of human health and the environment in the short-term. Reduction in contaminant concentrations and reduction in the plume footprint have contributed to control or reduction in unacceptable risks. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plume OU [see Appendix 3 of the FY 2023 SMP for a discussion of the scope of the Dissolved-Phase Plumes OU (DOE 2022a)], need to be evaluated for long-term protection. A recommendation was made for an evaluation to be performed of the north EW wellfield (EW 228 and EW 229) for deactivation and abandonment and gain concurrence of the FFA parties.

The objective of this IRA is to initiate control of the source and mitigate the spread of contamination in the Northwest Plume. The optimization of the Northwest Plume IRA is intended to increase VOC mass removal and enhance the contaminant capture in the vicinity of the existing south wellfield located immediately north of the facility. In addition, successful control of the plume, in combination with existing controls (alternate water supply, monitoring, etc.), ensures protection during the period of the interim response.

20.1.2 Northeast Plume

The IRA for the Northeast Plume (SWMU 202) is protective of human health and the environment in the short-term. The Northeast Plume groundwater extraction system has been optimized to increase TCE mass removal, to enhance control of plume migration at the eastern edge of the PGDP industrial area. Reduction in contaminant concentrations and reduction in the plume footprint have contributed to control or reduction in unacceptable risks. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plume OU [see Appendix 3 of the FY 2023 SMP for a discussion of the scope of the Dissolved-Phase Plumes OU (DOE 2022a)], need to be evaluated for long-term protection.

The objective of this IRA is to initiate hydraulic control of the high concentration area within the Northeast Plume that extends outside the facility security fence. Optimization of the Northeast Plume is ongoing to increase TCE and 1,1-DCE mass removal and to enhance the contaminant capture in the Northeast Plume in the vicinity of the eastern edge of the Paducah Site. In addition, successful control of the plume, in combination with existing controls (alternate water supply, monitoring, etc.), ensures protection during the period of the interim response.

20.1.3 Cylinder Drop Test Area

The IRA for the Cylinder Drop Test Area (SWMU 91) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled through DOE access controls. This project is not a final action and was not designed to return the areas to unrestricted use and unlimited exposure. A final TCE cleanup level providing long-term protection of groundwater has not yet been established. In order to establish long-term protectiveness, per Section III of the FFA, "…any necessary RA shall be selected and implemented…." as part of the CSOU (EPA 1998).

The RAO for this interim remedial action is intended to prevent rural residents from exposure to the only COC, TCE. This RAO has been met through treatment of soils to a concentration below cleanup goals, thereby reducing the amount of TCE available to leach to groundwater.

20.1.4 Water Policy

The removal action for the Water Policy currently protects human health and the environment by implementing institutional controls, including administrative controls, in the short-term. Exposure pathways that could result in unacceptable risk are being controlled; however, additional actions, as part of the Dissolved-Phase Plume OU, need to be evaluated for long-term protection.

The objective of this RA is to prohibit the use of contaminated groundwater and provide a safe, alternate water supply to the residents in the Water Policy Box affected area. This objective has been met by providing potentially affected residents access to municipal water in accordance with the Water Policy Program and corresponding Water Policy license agreements, thereby reducing opportunities for exposure to contaminated groundwater.

Information obtained during the last five years demonstrates that the Tc-99 plume no longer exists at concentrations exceeding the Tc-99 MCL in areas off DOE property and that the TCE plumes have reduced concentrations and areal extent in areas off DOE property. Sources of relevant TCE and Tc-99 plume information supporting these reductions are as follows: (1) results of monitoring plume concentrations and changes in those concentrations; (2) changes in plume extent as shown in biennial plume map reports; (3) information and findings on groundwater flow and concentration trends evaluated as part of the sitewide groundwater strategy; (4) insights developed from updates to the sitewide groundwater flow and fate and transport models; and (5) results of plume stability analyses. A recommendation is included in Section 18 for DOE to develop a technical paper using relevant TCE and Tc-99 plume information to better understand the status of the Water Policy action and whether an optimization of the Water Policy action is warranted.

20.1.5 C-400 Electrical Resistance Heating

The IRA for the VOC contamination at C-400 Cleaning Building is protective of human health and the environment in the short-term. LUCs for this action include property record notices and deed restrictions, administrative controls, and access controls. This action, in combination with other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), has adequately addressed known exposure pathways that could result in unacceptable risks originating from C-400. In order to establish long-term protectiveness, an additional RA will be selected, under the C-400 Complex OU ROD.

20.1.6 Southwest Plume

Oil Landfarm

The final RA for VOC sources at the Oil Landfarm is protective of human health and the environment. Collected data indicates that TCE contaminant levels in general have continued to decline following the completion of the action. As indicated in the ROD, a period of time is expected before attainment of RAO 3 is confirmed. RAO 3 states, "Reduce VOC migration from contaminated subsurface soils in the treatment areas at the Oil Landfarm and the C-720 Northeast and Southeast Sites so that contaminants migrating from the treatment areas do not result in the exceedance of MCLs in the underlying RGA groundwater." Interim LUCs consisting of placement of warning signs and DOE's excavation/penetration permit program are in place to prevent exposure to site contaminants until RAO 3 is attained. This action, in combination with other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), has addressed adequately known exposure pathways that could result in unacceptable risks originating from the Southwest Plume (SWMU 210).

C-720 Building TCE Northeast Spill Site (SWMU 211-A)

Implementation of the selected final RA at the C-720 Building TCE Northeast Spill Site was completed at the end of this reporting period. The bioremediation RA construction is complete. The RA has now entered the long-term and performance monitoring phase of the remedy during which groundwater contamination levels attributable to SWMU 211-A will decrease until attaining RAO 3 when groundwater contaminant levels are below their MCL concentrations. The collection of performance and long-term monitoring data will support determining the impact of the RA as planned during the required Five-Year Reviews. The data collected indicates that bioremediation is occurring as expected. Therefore, the SWMU 211-A action is considered to be protective (EPA 2019) The interim LUCs, associated with the remedy, have been implemented since 2012. This action, in combination of other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), has addressed known exposure pathways that could result in unacceptable risks originating from the Southwest Plume C-720 Building TCE Northeast Spill Site. Interim LUCs consisting of placement of warning signs and DOE's excavation/penetration permit program are in place to prevent exposure to site contaminants.

20.2 SURFACE WATER OPERABLE UNIT

20.2.1 NSDD Source Control

The IRA for the NSDD Source Control is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled. The remedy is functioning as intended per the definition of "protective." This project was not designed to return the areas to unrestricted use and unlimited exposure.

The objective of this IRA is to initiate control of the source of continued contaminant releases into the NSDD and mitigate the spread of contamination from the NSDD. This objective was achieved by mitigating the discharge of contaminants into NSDD, institutional controls to limit the potential for direct exposure, and engineering controls to mitigate the infiltration and migration of contaminants from the NSDD to the subsurface environment and off-site (i.e., outside the existing security fence).

20.2.2 NSDD Sections 1 and 2

The IRA for the NSDD Sections 1 and 2 (SWMU 59) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk currently are being controlled. In order to establish long-term protectiveness, additional remedial action will be evaluated and selected, as necessary, under the SWOU.

The ROD established the following RAOs: prevention of future discharge of process water to the NSDD; reduction of the risk to industrial workers and ecological receptors from exposure to contaminated surface soil, sediment, and surface water; and prevention of future on-site runoff from being transported off-site (i.e., outside the existing security fence) via the NSDD. The RAOs have been achieved effectively through excavation of contaminated sediment and placement of clean soil to meet the cleanup goal and implementation of LUCs assuring protectiveness.

20.2.3 C-746-K Sanitary Landfill

The RA for the C-746-K Landfill (SWMU 8) is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled and the remedy is functioning as expected. This project was not designed to return the areas to unrestricted use and unlimited exposure.

The RAOs for this unit are to control the release of COCs from the unit, limit direct contact by humans, and reduce overall risks to ecological receptors. The RAOs have been met through reduction of human risks by posting warning signs and other institutional controls, through reduction of ecological risks by installing riprap over exposed acidic leachate seeps, and by mitigating current direct contact with the buried waste through DOE ownership and use of the property.

20.2.4 Fire Training Area

The RA for the Fire Training Area (SWMU 100) is protective of human health and the environment in the short -term. Exposure pathways that could result in unacceptable risk are being controlled and the remedy is functioning as expected. This project was not designed to return the areas to unrestricted use and unlimited exposure. In order to establish long-term protectiveness, per Section III of the FFA, "…any necessary RA shall be selected and implemented…." as part of the CSOU (EPA 1998).

The selected remedy for the Fire Training Area, which rested upon the surrounding area remaining industrialized, is NFA (outside of maintaining institutional controls). The same land use that was in place and relied upon to support NFA still is in place and remains effective. This also is consistent with the expected future use of the area, as described in the SMP.

In March 2023, EPA proposed maximum MCLs for six PFAS. As an emergent contaminant, PFAS was not considered as part of the scope of the WAGs 1 & 7 RI/FS or ROD. As discussed in the FY 2023 SMP, the presence of PFAS will be evaluated separately; if cleanup under CERCLA is required, a new remedial action project will be identified to address the contamination (DOE 2022a).

20.2.5 Surface Water Interim Corrective Measures

The interim/institutional corrective/control measures for the surface water currently protects human health and the environment by institutional controls; however, additional actions under the SWOU need to be evaluated for long-term protectiveness.

The objective of the surface water ICMs work plan is to design a system of institutional controls that will identify the areas of contamination through posting warning signs and restrict casual public access to the creeks. This objective has been met through posting warning signs and constructing fences near bridges crossing affected streams. These institutional controls serve to inform the public about the areas of contamination, resulting in a reduction of casual public access to the streams.

20.2.6 Surface Water On-site Sediment Removal

The Surface Water On-site Sediment Removal Action is protective of human health and the environment in the short-term due to excavation of contaminated sediment/soil and placement of clean soil to meet the cleanup goal. In order to establish long-term protectiveness, RAs will be evaluated and selected, as necessary, under the SWOU.

The RAOs for this unit were to ensure that direct contact risk at the on-site ditches for the current industrial worker falls within the EPA risk range and to ensure that direct contact risk at the NSDD for both the current industrial worker and recreational user falls within the EPA risk range. These RAOs were met by excavation of contaminated sediment/soil and placement clean soil to meet the cleanup goal.

20.3 BURIAL GROUNDS OPERABLE UNIT

20.3.1 C-749 Uranium Burial Ground

The IRA for the C-749 Uranium Burial Ground (SWMU 2) is protective of human health and the environment in the short-term. Exposure pathways that could result in unacceptable risk are being controlled through DOE access controls. This remedy was not designed to address fully the risks to human health and the environment from the buried wastes nor return the areas to unrestricted use and/or unlimited exposure. A final RA will be selected under the BGOU to ensure long-term protectiveness.

The RAOs for the interim action were to mitigate migration of uranium and TCE from the C-749 Uranium Burial Ground to groundwater and to prevent disturbance or contact with the buried waste materials. The interim ROD selected an impermeable cap, groundwater monitoring, and institutional controls. Based on a conclusion by the parties that the waste within the burial ground was saturated, implementation of the cap's design and construction activities as outlined in the current ROD was canceled (Hodges 1996). The interim action, as implemented, provides protection by mitigating direct contact with the buried waste through DOE ownership and use of the property. This action, in combination with other CERCLA response actions and existing controls (alternate water supply, monitoring, etc.), has addressed adequately current known exposure pathways that could result in unacceptable risks originating from the C-749 Uranium Burial Ground.

THIS PAGE INTENTIONALLY LEFT BLANK

21. NEXT REVIEW

DOE expects that the next five-year review for the Paducah Site will be issued by the end of July 2028. Note: These schedules are estimates for planning and are included for informational purposes only; they are not intended to establish enforceable schedules or milestones. Enforceable milestones are contained in Appendix C of the FFA and Appendix 5 of the SMP. All RAs discussed within this text, in addition to any new actions initiated or completed within the next five years, will be included in that review.

THIS PAGE INTENTIONALLY LEFT BLANK

22. FIVE-YEAR REVIEW PROCESS

22.1 ADMINISTRATIVE COMPONENTS

DOE's D&R Contractor performed this fifth synchronized Five-Year Review. The reviews were conducted from December 2022 through February 2023. The following are the components of this review.

- Document review
- Data review
- Site inspection
- Interviews of personnel responsible for specific aspects of some of the response actions
- Five-year review report development and review

22.2 COMMUNITY NOTIFICATION AND INVOLVEMENT

Community involvement at the Paducah Site is handled primarily in conjunction with the CAB. The CAB meets monthly to discuss many aspects of environmental restoration efforts at the Paducah Site. Copies of Administrative Record decision documents are kept at the Environmental Information Center. The Environmental Information Center is open to the public during regular business hours. DOE published a public notice in the local newspaper on December 10, 2022, announcing the five-year review had been initiated and requesting that any suggestions, issues, questions, or concerns regarding this review be provided from December 16 through December 31, 2022. No comments were received.

22.3 DOCUMENT REVIEW

This activity consisted of a review of relevant documents to the RA of each of the units and the previous five-year reviews. This was conducted from December 2022 through February 2023. These documents are included as references in Section 23.

22.4 DATA REVIEW

Groundwater, surface water, and sediment samples are collected routinely at the Paducah Site to assess environmental conditions. These data are stored in Paducah's Oak Ridge Environmental Information System. Data were downloaded for review from Paducah's Oak Ridge Environmental Information System throughout the review process.

22.5 SITE INSPECTIONS

Inspections were conducted at each of the response action sites during December 2022. The DOE D&R Contractor conducted the inspections. Results of the inspections are discussed in each respective response action section. The scope of the inspections was to verify that the selected remedy in the decision document remained protective. Copies of the inspection checklists are included in Appendix A. These include participants in the site inspections which involved representatives from DOE support contractor, Enterprise Technical Assistance Services, Inc.; DOE D&R Contractor, FRNP; and KDEP.

22.6 INTERVIEWS

Interviews were conducted in January 2023 and February 2023 with various personnel that had connections to some of the response actions. Specifically, the frontline supervisor of the Northwest and Northeast Plumes treatment systems provided information on operation and maintenance of those systems, and the facility managers for various areas provided information on site conditions. Other interview specifics can be found in each selected remedy section. Also, interviews that are located in Appendix B were conducted with DOE, KDEP, Kentucky Department of Fish and Wildlife Resources, CAB, DOE's D&R Contractor, and local residents concerning the overall DOE project.

23. REFERENCES

Almayahi, A. and E. Woolery 2018. "Fault-controlled contaminant plume migration: Inferences from SH-wave reflection and electrical resistivity experiments," *Journal of Applied Geophysics*, 158, 57–64.

Blits, C., E. Woolery, K. Macpherson, and S. Hampson 2008. "Integrated Geophysical Imaging Techniques for Detecting Neotectonic Deformation in the Fluorspar Area Fault Complex of Western Kentucky," 42nd Annual Meeting of the North Central Section of the Geological Society of America, Evansville, IN, Abstract 137954, 16 pps.

CH2M HILL 1991. *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/ER-4, CH2M HILL, Paducah, KY.

CH2M HILL 1992. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-031991/1, CH2M HILL Paducah, KY.

COE (U.S. Army Corps of Engineers) 1996. *Paducah Gaseous Diffusion Plant PCB Sediment Survey Big Bayou Creek and Little Bayou Creek Paducah Kentucky*, U.S. Army Corps of Engineers, Nashville, TN, December.

DOC (U.S. Department of Commerce) 2020. McCracken County Quick Facts from the US Census Bureau, www.census.gov/quickfacts/fact/table/mccrackencountykentucky,paducahcitykentucky/POP010220 (accessed March 23, 2023).

DOE (U.S. Department of Energy) 1992a. *Work Plan for Interim Corrective Measures at the C-746-K Landfill*, DOE/OR/07-1211&D2, U.S. Department of Energy, Paducah, KY, November.

DOE 1992b. *Interim Corrective Measure Workplan for Institutional Control of Offsite Contamination in Surface Water Outfalls, Creeks, and Lagoons*, DOE-OR 1030, U.S. Department of Energy, Paducah, KY, May.

DOE 1993a. *Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1143&D4, U.S. Department of Energy, Paducah, KY, July.

DOE 1993b. *Engineering Evaluation/Cost Analysis for the Water Policy at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1142&D3, U.S. Department of Energy, Paducah, KY, July.

DOE 1993c. *Interim Measure Report for Institutional Control of Off-Site Contamination in Surface Water*, DOE/OR/07-1206&D1, U.S. Department of Energy, Paducah, KY, October.

DOE 1994a. *Remedial Action Work Plan for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/08-1212&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 1994b. *Action Memorandum for the Water Policy at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/06-1201&D2, U.S. Department of Energy, Paducah, KY, June.

DOE 1994c. *Record of Decision for Interim Action Source Control at the North-South Diversion Ditch, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1213&D3, U.S. Department of Energy, Paducah, KY, March.

DOE 1995a. *Northeast Plume Preliminary Characterization Summary Report*, DOE/OR/07-1339/V1&D2, U.S. Department of Energy, Paducah, KY, July.

DOE 1995b. *Record of Decision for Interim Remedial Action at the Northeast Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1356&D2, U.S. Department of Energy, Paducah, KY, June.

DOE 1995c. *Interim Measures Report and Operation & Maintenance Plan for the North/South Diversion Ditch Interim Corrective Measures at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1425&D1, U.S. Department of Energy, Paducah, KY, November.

DOE 1995d. *Record of Decision for Interim Remedial Action at Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/06-1351&D1, U.S. Department of Energy, Paducah, KY, July.

DOE 1996a. *Explanation of Significant Differences for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1481&D2, U.S. Department of Energy, Paducah, KY, November.

DOE 1996b. *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1404&D2, U.S. Department of Energy, Paducah, KY, April.

DOE 1997a. *Postconstruction Report for the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1555&D1, U.S. Department of Energy, Paducah, KY, February.

DOE 1997b. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1549&D1, U.S. Department of Energy, Paducah, KY, February.

DOE 1998a. *Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1527&D2, U.S. Department of Energy, Paducah, KY, July.

DOE 1998b. *Record of Decision for Waste Area Groups 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1470&D3, U.S. Department of Energy, Paducah, KY, February.

DOE 1999a. *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1727/V1&D2, U.S. Department of Energy, Paducah, KY, January.

DOE 1999b. *Post-Construction Report and Operations and Maintenance Plan for Waste Area Groupings (WAGs) 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1743&D1, U.S. Department of Energy, Paducah, KY, February.

DOE 2000a. *Memorandum of Agreement for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Paducah Gaseous Diffusion Plant and Land Use Control Assurance Plan for Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1799&D2, U.S. Department of Energy, Paducah, KY, January.

DOE 2000b. *Post-Construction Report for the Lasagna™ Phase IIb In-situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1856&D1, U.S. Department of Energy, Paducah, KY, January.

DOE 2000c. *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1904&D1, U.S. Department of Energy, Paducah, KY, September.

DOE 2001a. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1857&D2, U.S. Department of Energy, Paducah, KY, August.

DOE 2001b. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1506&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2002a. "Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Five-Year Review Guide," unnumbered, Office of Environmental Management, U.S. Department of Energy, Washington, DC, March.

DOE 2002b. *Final Remedial Action Report for Lasagna™ Phase IIb In-Situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2037&D1, U.S. Department of Energy, Paducah, KY, September.

DOE 2002c. *Record of Decision for Interim Remedial Action at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1948&D2, U.S. Department of Energy, Paducah, KY, August.

DOE 2003a. *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2067&D2, U.S. Department of Energy, Paducah, KY, October.

DOE 2003b. *Addendum to the Final Remedial Action Report for Lasagna™, Phase IIb In-Situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2037&D1/R1, U.S. Department of Energy, Paducah, KY, June.

DOE 2003c. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2041&D2/R1, U.S. Department of Energy, Paducah, KY, November.

DOE 2004. *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-2038&D2, U.S. Department of Energy, Paducah, KY, March.

DOE 2005a. *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*, DOE/OR/07-2150&D2/R2, U.S. Department of Energy, Paducah, KY, July.

DOE 2005b. *Remedial Design Support Investigation Characterization 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/OR/07-2211&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2005c. *Operation and Maintenance Plan for Sections 1 and 2 of the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2057&D2, U.S. Department of Energy, Paducah, KY, February.

DOE 2005d. *Remedial Action Completion Report for the North-South Diversion Ditch Sections 1&2 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2195&D2, U.S. Department of Energy, Paducah, KY, September.

DOE 2006. *Paducah 2006 Sitewide Remedy Review*, Office of Environmental Management, Office of Engineering Technical Expertise Project 610, U.S. Department of Energy, April.

DOE 2007a. *Review Report: Groundwater Remedial System Performance Optimization at PGDP, Paducah, Kentucky*, prepared for Office of Groundwater and Soil Remediation, Office of Engineering and Technology, U.S. Department of Energy, May.

DOE 2007b. *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1, U.S. Department of Energy, Paducah, KY, June.

DOE 2008a. *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, 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*, DOE/LX/07-0005&D2/R1, U.S. Department of Energy, Paducah, KY, July.

DOE 2008b. *Surface Water Operable Unit (On-Site) Site Investigation and Baseline Risk Assessment Report at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0001&D2/R1, U.S. Department of Energy, Paducah, KY, February.

DOE 2008c. *Engineering Evaluation/Cost Analysis for Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012&D2, U.S. Department of Energy, Paducah, KY, September.

DOE 2009a. *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0117&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2009b. *Action Memorandum for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0119&D2/R1, U.S. Department of Energy, Paducah, KY, April.

DOE 2009c. *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0221&D2/R1, U.S. Department of Energy, Paducah, KY, December.

DOE 2010. *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0343&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2011a. *Removal Action Report for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0357&D2, U.S. Department of Energy, Paducah, KY, April.

DOE 2011b. *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/R1/V1, U.S. Department of Energy, Paducah, KY, February.

DOE 2011c. *Revised Focused Feasibility Study for Solid Waste Management Units 1, 211A, and 211B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0362&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2012a. S*ite Management Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky Annual Revision—FY 2012*, DOE/LX/07-1264&D2, U.S. Department of Energy, Paducah, KY, February.

DOE 2012b. *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Phase IIa Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1272&D2/R1, U.S. Department of Energy, Paducah, KY, August.

DOE 2012c. *Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0365&D2/R1, U.S. Department of Energy, Paducah, KY, March.

DOE 2012d. *Remedial Design Support Investigation Characterization Plan for the C-747-C Oil Landfarm and C-720 Northeast and Southeast Sites at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0350&D1, U.S. Department of Energy, Paducah, KY, February.

DOE 2013a. *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-1291&D2, U.S. Department of Energy, Paducah, KY, August.

DOE 2013b. Letter from J. Woodard, U.S. Department of Energy, to T. Mullins, Kentucky Division of Waste Management, and J. Tufts, U.S. Environmental Protection Agency, "Paducah Federal Facility Agreement—Resolution of U.S. Department of Energy Notification of Invocation of Informal Dispute on the Groundwater Operable Unit Revised Proposed Plan for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1263&D2)," PPPO-02-2069014-14, dated October 31, 2013.

DOE 2013c. *Remedial Action Work Plan for Phase IIa of 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/07-1271&D2/R3, U.S. Department of Energy, Paducah, KY, October.

DOE 2013d. *Remedial Design Report In Situ Source Treatment Using Deep Soil Mixing for the Southwest Groundwater Plume Volatile Organic Compound Source at the C-747-C Oil Landfarm (Solid*

Waste Management Unit 1) at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, DOE/LX/07-1276&D2/R1, U.S. Department of Energy, Paducah, KY, September.

DOE 2013e. *Final Characterization Report for the Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D1, U.S. Department of Energy, Paducah, KY, June.

DOE 2013f. *Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2013g. Letter from R. Blumenfeld, U.S. Department of Energy, to T. Mullins, Kentucky Department for Environmental Protection, and J. Tufts, U.S. Environmental Protection Agency, "Final Characterization Notification for Solid Waste Management Unit 211-A and Solid Waste Management Unit 211-B at the Paducah Gaseous Diffusion Plant, Paducah Kentucky," PPPO-02-1979222-13B, dated July 10.

DOE 2014a. *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1289&D2, U.S. Department of Energy, Paducah, KY, April.

DOE 2014b. *Remedial Action Work Plan for In Situ Source Treatment by Deep Soil Mixing of the Southwest Groundwater Plume Volatile Organic Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1287&D2/A1/R1, U.S. Department of Energy, Paducah, KY, July.

DOE 2015a. *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-1291&D2/R2, U.S. Department of Energy, Paducah, KY, November.

DOE 2015b. *Memorandum of Agreement for Resolution of Formal Dispute of the Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, *DOE/LX/07-1291&D2, and Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-1280&D2*, U.S. Department of Energy, Paducah, KY, July.

DOE 2015c. *Addendum to the Remedial Design Work Plan for Solid Waste Management Units 1, 211-A, and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Sampling and Analysis Plan*, DOE/LX/07-1268&D2/R2/A1, U.S. Department of Energy, Paducah, KY, February.

DOE 2015d. *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2/A1, U.S. Department of Energy, Paducah, KY, December.

DOE 2015e. *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1904&D1/R2, U.S. Department of Energy, Paducah, KY, October.

DOE 2016a. *Water Policy Area Vapor Intrusion Screening Study Report for the Five-Year Review of Remedial Actions Paducah, Kentucky*, DOE/LX/07-1289&D2/R1/A1/R1, U.S. Department of Energy, Paducah, KY, February.

DOE 2016b. *Treatability Study Report for the C-400 Interim Remedial Action Phase IIb Steam Injection Treatability Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2202&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2016c. *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2/A1/R1, U.S. Department of Energy, Paducah, KY, April.

DOE 2017a. *Memorandum of Agreement on the C-400 Complex under the Federal Facility Agreement for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, U.S. Department of Energy, Paducah, KY, August.

DOE 2017b. *Memorandum of Agreement for Resolution of Formal Dispute Regarding the Non-concurrence by EPA and KDEP on the DOE Milestone Modification Request for Submittal of the Revised Proposed Plan for the Volatile Organic Compound Contamination at the C-400 Cleaning building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2407&D1*, U.S. Department of Energy, Paducah, KY, September 28.

DOE 2017c. *Remedial Action Completion Report for In Situ Source Treatment by Deep Soil Mixing of the Southwest Groundwater Plume Volatile Organic Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1), at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2405&D2. U.S. Department of Energy, Paducah, KY, January.

DOE 2017d. *U.S. Department of Energy Paducah Gaseous Diffusion Plant Federal Facility Agreement Semiannual Progress Report for the Second Half of Fiscal Year 2017, Paducah, Kentucky*, DOE/LX/07-2416/V2, U.S. Department of Energy, Paducah, KY, October.

DOE 2018a. *Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1280&D2/R3/A1, U.S. Department of Energy, Paducah, KY, July.

DOE 2018b. *Postconstruction Report for the Northeast Plume Optimization at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2419&D2/R1, U.S. Department of Energy, Paducah, KY, June.

DOE 2018c. *Remedial Action Completion Report for the 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*, DOE/LX/07-2417&D2, U.S. Department of Energy, Paducah, KY, June.

DOE 2018d. "SWMU 211-A and SWMU 211-B Options," WebEx Meeting, Paducah Environmental Information Center, Accession Number ENV 1.A-05126, U.S. Department of Energy, Paducah, KY, May.

DOE 2019a. *CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (Fourth Synchronized Five-Year Review)*, DOE/LX/07-2426&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2019b. *Certified for Construction Remedial Design Report for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2435&D2, December.

DOE 2020. *Memorandum of Agreement for Resolution of the Informal Dispute Concerning US. Environmental Protection Agency and Kentucky Department for Environmental Protection Requirements for Additional Actions or Modifications Regarding the CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2426&D2*, U.S. Department of Energy, Paducah, KY, July.

DOE 2021a. *Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2469&D2, U.S. Department of Energy, Paducah, KY, October.

DOE 2021b. *Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky*, DOE/LX/07-2470&D1, U.S. Department of Energy, Paducah, KY, November.

DOE 2021c. *Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2443&D2/R2, U.S. Department of Energy, December.

DOE 2022a. *Site Management Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky Annual Revision-FY 2023*, DOE/LX/07-2482&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2022b. *Community Relations Plan under the Federal Facility Agreement at the U.S. Department of Energy Paducah Gaseous Diffusion Plant*, DOE/LX/07-2481&D1, U.S. Department of Energy, Paducah, KY, May.

DOE 2022c. *Remedial Investigation/Feasibility Study Report for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2474&D1, U.S. Department of Energy, Paducah, KY, December.

DOE 2022d. *Explanation of Significant Differences to the Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2480&D2, U.S. Department of Energy, Paducah, KY, November.

DOE 2022e. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0107&D2/R13/V1, U.S. Department of Energy, Paducah, KY, June.

DOE 2022f. *U.S. Department of Energy Paducah Gaseous Diffusion Plant Federal Facility Agreement Semiannual Progress Report for the Second Half of Fiscal Year 2022 Paducah, Kentucky*, DOE/LX/07-2478/V2, U.S. Department of Energy, Paducah, KY, October.

DOE 2023. *Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2483&D1, U.S. Department of Energy, Paducah, KY, January.

EPA (U.S. Environmental Protection Agency) 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, U.S. Environmental Protection Agency, Atlanta, GA, February.

EPA 1999. *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, EPA-540-R-98-031, U.S. Environmental Protection Agency, Washington, DC, July.

EPA 2001. *Comprehensive Five-Year Review Guidance*, EPA 540-R-01-007, U.S. Environmental Protection Agency, Washington, DC, June.

EPA 2003. Jay V. Bassett, Chief, DOE Remedial Section Federal Facilities Branch, Atlanta, GA, letter to W. Don Seaborg, Site Manager U.S. Department of Energy, Paducah, KY, and Gordon Dover, Paducah Manager of Projects, Bechtel Jacobs Company LLC, Kevil, KY, April 24.

EPA 2011. *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance," OSWER Directive 9355.7-18*, U.S. Environmental Protection Agency, Washington, DC, September.

EPA 2013. Letter from J. Tufts, U.S. Environmental Protection Agency, to R. Blumenfeld, U.S. Department of Energy, "Response to the Final Characterization Notification for SWMU 211-A and SWMU 211-B at the Paducah Gaseous Diffusion Plant, Paducah, KY," dated January 13.

EPA 2014. Letter from J. Tufts, U.S. Environmental Protection Agency, to R. Blumenfeld, U.S. Department of Energy, "EPA Modification Request to the Remedial Design Work Plan for SWMUs 1, 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, KY (DOE/LX/07-1268&D2/R2)," dated February 25.

EPA 2016. Letter from J. Corkran, U.S. Environmental Protection Agency, to T. Duncan, U.S. Department of Energy, "EPA Comments: Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1288&D2/A1/R1), Secondary Document, transmittal dated April 25, 2016 (PPPO-02-3444761-16)," dated May 25.

FRNP (Four Rivers Nuclear Partnership, LLC) 2018. *Environmental Monitoring Plan Fiscal Year 2018 Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, CP2-ES-0006/FR1, Four Rivers Nuclear Partnership, LLC, Paducah, KY, January.

FRNP 2021. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2020 at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky*, FRNP-RPT-0175, Four Rivers Nuclear Partnership, LLC, Kevil, KY, July.

FRNP 2022a. *Paducah Plume Operations Maintenance, Sampling and Analysis, and Calibration and Testing Plan*, CP2-ER-0046/FR2A, Four Rivers Nuclear Partnership, LLC, Paducah, KY, July.

FRNP 2022b. *Environmental Monitoring Plan Fiscal Year 2023 Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, CP2-ES-0006/FR8, Four Rivers Nuclear Partnership, LLC, Paducah, KY, October.

Hodges, Jimmie C. 1996. Letter from J. Hodges, U.S. Department of Energy, to T. Able, U.S. Environmental Protection Agency, and R. H. Daniell, Kentucky Department for Environmental Protection, "Waste Area Grouping (WAG) 22 Post-Record of Decision (ROD) Change," dated October 23.

ITR (Independent Technical Review) 2007. *Review Report: Building C-400 Thermal Treatment 90% Remedial Design Report and Site Investigation, PGDP, Paducah Kentucky*, WSRC-STI-2007-00427, U.S. Department of Energy Office of Environmental Management, Savannah River National Laboratory, Aiken, SC, August.

Johnston 1998. Johnston, Jon D., Chief, Federal Facilities Branch, U.S. Environmental Protection Agency, Region 4, Policy Memorandum to the Federal Facilities Branch, "Assuring Land Use Controls at Federal Facilities," Atlanta, GA, April 21.

KRCEE (Kentucky Research Consortium for Energy and Environment) 2006. *Investigation of Holocene Faulting, Proposed C-746-U Landfill Expansion, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, William Lettis and Associates, Inc. (author) UK/KRCEE Doc #: 17.6 2006, Kentucky Research Consortium for Energy and Environment, Lexington, KY July. (Available electronically at http://www.uky.edu/krcee/Reports.html).

LATA Kentucky (LATA Environmental Services of Kentucky, LLC) 2012. *Residual Risk Evaluation Report for North-South Diversion Ditch Sections 1 and 2 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-REG-1010, LATA Environmental Services of Kentucky, Kevil, KY, December.

LMES (Lockheed Martin Energy Systems, Inc.) 1996a. *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128, Lockheed Martin Energy Systems, Inc. Paducah, KY, May.

LMES 1996b. *Lasagna™ Soil Remediation: Innovative Technology Summary Report*, Lockheed Martin Energy Systems, Paducah, KY, August.

MMES (Martin Marietta Energy Systems, Inc.) 1989. *Paducah Gaseous Diffusion Plant Site Environmental Report for 1988*, Martin Marietta Energy Systems, Inc., ES/ESH-8/V3, May.

MMES 1992. *Resource Conservation and Recovery Act Part B Permit Modification for Inclusion of C-404 Low-Level Radioactive/Hazardous Waste Landfill*, KY/E-129, Martin Marietta Energy Systems, Inc., Paducah, KY, November.

MMES 1993a. *Remedial Design Work Plan for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/08-1148&D1 and KY/ER 3 & D1, Martin Marietta Energy Systems, Inc., Paducah, KY, May.

MMES 1993b. *Operation and Maintenance Plan for Institutional Control of Off-site Contamination in Surface Water Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/ER-42, Martin Marietta Energy Systems, Inc., Paducah, KY, September.

RAIS (Risk Assessment Information System) 2023. *Risk Assessment Information System* Website, developed by Oak Ridge National Laboratory and the University of Tennessee, available at https://rais.ornl.gov/ (accessed January 2023).

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

SITE INSPECTIONS

This appendix contains the site inspection checklists used by the lead inspectors. These checklists document the observations made by the lead inspectors at the time of the inspection. The observations were subsequently combined with other information to develop the main text of the document (Sections 1–22). Because the lead inspectors were not aware of some project information at the time of the inspection, some statements found in the checklists vary from those in the main text. The main text presents the concluding information that is appropriate and pertinent for this fifth synchronized Five-Year Review.

THIS PAGE INTENTIONALLY LEFT BLANK

Five-Year Review Site Inspection Checklist
C-400 Electrical Resistance Heating

<table>
<tr><th colspan="2">I. SITE INFORMATION</th></tr>
<tr><td>Site name: C-400 IRA</td><td>Date of inspection: 12/7/2022</td></tr>
<tr><td>Location and Region: Paducah, KY/Region 4</td><td>EPA ID: KY8890008982</td></tr>
<tr><td>Agency, office, or company leading the five-year review: U.S. Department of Energy (DOE)</td><td>Weather/temperature: Overcast/54ºF</td></tr>
<tr><td colspan="2">Remedy Includes: (Check all that apply)
☐ Landfill cover/containment ☐ Monitored natural attenuation
☐ Access controls ☐ Groundwater containment
X Institutional controls ☐ Vertical barrier walls
☐ Groundwater pump and treatment
☐ Surface water collection and treatment
X Other <u>Soil Vapor Groundwater Treatment System (SVGTS)</u>______________________________</td></tr>
<tr><td colspan="2">Attachments: X Inspection team roster attached X Site map attached</td></tr>
<tr><th colspan="2">II. INTERVIEWS (Check all that apply)</th></tr>
<tr><td colspan="2">1. O&M site manager <u>Brian Lowrance</u> <u>Facility Manager</u> <u>12/7/2022</u>
Name Title Date
Interviewed X at site ☐ at office ☐ by phone no. <u>(270) 559-6371</u>
Problems, suggestions; ☐ Report attached ____
<u>_Electrical resistance heating actions and decontamination and decommissioning (D&D) of facilities completed. Land use controls (LUCs) continuing.</u></td></tr>
<tr><td colspan="2">2. O&M staff _<u>N/A</u>___________________________ _______________________ ____________
Name Title Date
Interviewed ☐ at site ☐ at office ☐ by phone no. _______________
Problems, suggestions; ☐ Report attached ____</td></tr>
</table>

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply. Agency _Kentucky Division for Environmental Protection Contact _Christopher Travis______ Environmental Scientist 12/7/2022_ 502-782-5897 _ Name Title Date Phone no. Problems; suggestions; ☐ Report attached _None.________________ Agency ____________ Contact ____________ ________ ____ ______ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____________ Agency ____________ Contact ____________ ________ ____ ______ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____________ Agency ____________ Contact ____________ ________ ____ ______ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____________
4.	**Other interviews** (optional) ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1. **O&M Documents**				
☐ O&M manual	☐ Readily available	☐ Up to date	X N/A	
X As-built drawings	X Readily available	X Up to date	☐ N/A	
☐ Maintenance logs	☐ Readily available	☐ Up to date	X N/A	
Remarks: LUC only remaining field activity under remedial action.				
2. **Site-Specific Health and Safety Plan**	☐ Readily available	☐ Up to date	X N/A	
☐ Contingency plan/emergency response plan	☐ Readily available	☐ Up to date	X N/A	
Remarks: LUC only remaining field activity under remedial action.				
3. **O&M and OSHA Training Records**	☐ Readily available	☐ Up to date	X N/A	
Remarks: LUC only remaining field activity under remedial action.				
4. **Permits and Service Agreements**				
☐ Air discharge permit	☐ Readily available	☐ Up to date	X N/A	
☐ Effluent discharge	☐ Readily available	☐ Up to date	X N/A	
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	X N/A	
☐ Other permits____________	☐ Readily available	☐ Up to date	X N/A	
Remarks: LUC only remaining field activity under remedial action.				

5.	**Gas Generation Records** ☐ Readily available ☐ Up to date X N/A Remarks:______	
6.	**Settlement Monument Records** ☐ Readily available ☐ Up to date X N/A Remarks:______	
7.	**Groundwater Monitoring Records** X Readily available X Up to date ☐ N/A Remarks: Available to public through PEGASIS data retrieval system. Reported in semiannual Federal Facility Agreement reports.	
8.	**Leachate Extraction Records** ☐ Readily available ☐ Up to date X N/A Remarks:______	
9.	**Discharge Compliance Records** ☐ Air ☐ Readily available ☐ Up to date X N/A ☐ Water (effluent) ☐ Readily available ☐ Up to date X N/A Remarks:______	
10.	Daily Access/Security Logs ☐ Readily available ☐ Up to date X N/A Remarks:______	

IV. O&M COSTS	
1.	**O&M Organization** ☐ State in-house ☐ Contractor for State ☐ PRP in-house ☐ Contractor for PRP ☐ Federal Facility in-house X Contractor for Federal Facility ☐ Other______
	O&M Cost Records Field actions for IRA completed in 2014, D&D completed in 2015. ☐ Readily available ☐ Up to date ☐ Funding mechanism/agreement in place Original O&M cost estimate $2.25M ☐ Breakdown attached Total annual cost by fiscal year (Oct. 1–Sept. 30) FY 2018 $0 ☐ Breakdown attached FY 2019 $0 ☐ Breakdown attached FY 2020 $0 ☐ Breakdown attached FY 2021 $0 ☐ Breakdown attached FY 2022 $0 ☐ Breakdown attached * Source – C-400 Phase IIa O&M Plan (DOE/LX/07-1285&D2).
3.	**Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: N/A

V. ACCESS AND INSTITUTIONAL CONTROLS X Applicable ☐ N/A	
A. Fencing	
1.	**Fencing damaged** ☐ Location shown on site map ☐ Gates secured X N/A Remarks:
B. Other Access Restrictions	
1.	**Signs and other security measures** ☐ Location shown on site map ☐ N/A Remarks: A LUC boundary map for the C-400 area is attached. Monitoring wells are secured by locks.
C. Institutional Controls (ICs)	
1.	**Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes X No ☐ N/A Site conditions imply ICs not being fully enforced ☐ Yes X No ☐ N/A Type of monitoring (e.g., self-reporting, drive by) self-reporting Frequency annual Responsible party/agency DOE Contact Dave Dollins (Name) PPPO Site Project Manager (Title) (Date) (270) 441-6819 (Phone no.) Reporting is up-to-date X Yes ☐ No ☐ N/A Reports are verified by the lead agency X Yes ☐ No ☐ N/A Specific requirements in deed or decision documents have been met X Yes ☐ No ☐ N/A Violations have been reported ☐ Yes ☐ No X N/A Other problems or suggestions: ☐ Report attached None
2.	**Adequacy** X ICs are adequate ☐ ICs are inadequate ☐ N/A Remarks: LUC implementation plan for C-400 is in place and controls land use.
D. General	
1.	**Vandalism/trespassing** ☐ Location shown on site map X No vandalism evident Remarks:
2.	**Land use changes on site** ☐ N/A Remarks: All remedial action equipment and facilities have undergone D&D. Building has been decommissioned.
3.	**Land use changes off site** X N/A Remarks:

VI. GENERAL SITE CONDITIONS
A. Roads X Applicable ☐ N/A
1. **Roads damaged** ☐ Location shown on site map X Roads adequate ☐ N/A Remarks: A location map showing surrounding roads is attached.
B. Other Site Conditions
Remarks: Field activities for remedial action and D&D have been completed.
VII. LANDFILL COVERS ☐ Applicable X N/A
VIII. VERTICAL BARRIER WALLS ☐ Applicable X N/A
IX. GROUNDWATER/SURFACE WATER REMEDIES X Applicable ☐ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable X N/A
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable X N/A
C. Treatment System X Applicable ☐ N/A
1. **Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation X Air stripping ☐ Carbon adsorbers ☐ Filters__________ ☐ Additive (*e.g.*, chelation agent, flocculent)__________ X Others ion exchange, carbon regeneration (D&D completed) ☐ Good condition ☐ Needs Maintenance ☐ Sampling ports properly marked and functional ☐ Sampling/maintenance log displayed and up to date ☐ Equipment properly identified ☐ Quantity of groundwater treated annually Action completed in 2014 ☐ Quantity of surface water treated annually__________ Remarks: Electrical resistance heating actions completed in 2014 and D&D of facilities completed in 2015.
2. **Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A X Good condition ☐ Needs Maintenance Remarks: A few electrical stick ups remain.
3. **Tanks, Vaults, Storage Vessels** X N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks:__________
4. **Discharge Structure and Appurtenances** X N/A ☐ Good condition ☐ Needs Maintenance Remarks:__________
5. **Treatment Building(s)** X N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks: Building D&D completed prior to 2017 (start of period of this Five-Year Review).

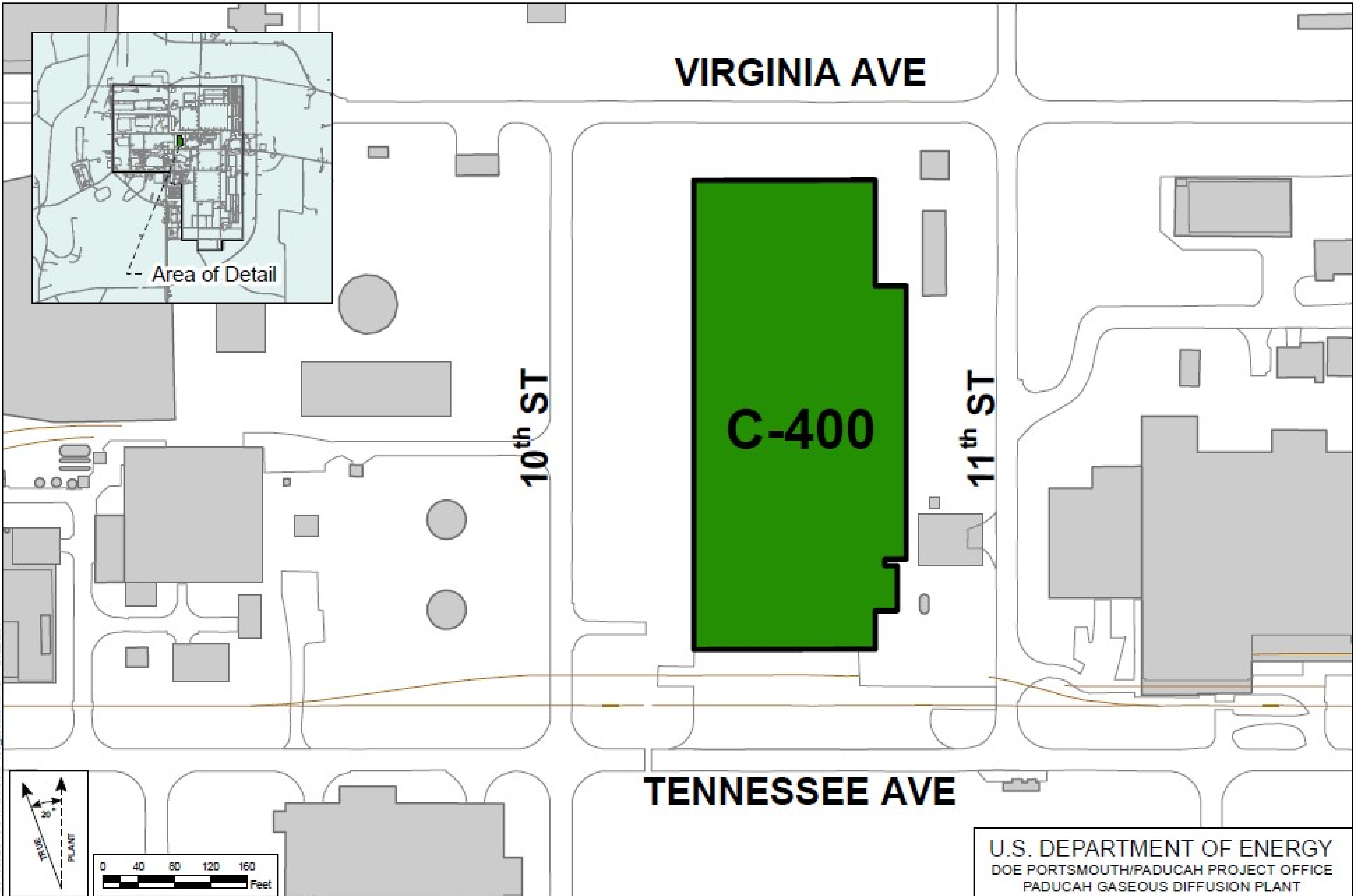
6.	**Monitoring Wells** (Long-term monitoring) X Properly secured/locked X Functioning X Routinely sampled X Good condition X All required wells located ☐ Needs Maintenance ☐ N/A Remarks:________________
D. Monitoring Data	
1.	Monitoring Data X Is routinely submitted on time X Is of acceptable quality
2.	Monitoring data suggests: ☐ Groundwater plume is effectively contained X Contaminant concentrations are declining* *Groundwater TCE concentrations related to the south C-400 source zones, addressed by the C-400 Phase I and IIa remedial actions, are declining. Tc-99 groundwater concentrations, related to another C-400 source zone have recently increased. A C-400 Complex remedial action is scheduled to address all remaining C-400 area contamination.
D. Monitored Natural Attenuation	
1.	**Monitoring Wells** (natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance X N/A Remarks:________________
X. OTHER REMEDIES	
	If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction. <u>N/A</u>
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). <u>Field activities for remedy and D&D of the remediation facilities have been completed. Please reference the remedial action completion report (RACR) for details on the effectiveness of the remedy.</u>
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. <u>Field activities for the remedy and D&D of the remediation facilities have been completed. Please see the RACR for issues that are remaining for long-term protectiveness of the remedy.</u>
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. <u>Remedy problems are detailed in the C-400 RACR.</u>

D.	Opportunities for Optimization
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Follow-up on remedial actions were scoped in the draft C-400 Complex RI/FS report that was issued in January 2023. A C-400 Complex remedial action is scheduled to address all remaining C-400 area contamination.

Name

Teresa Overby
(FRNP)
Brian Lowrance
(FRNP)
Megan Mulry
(FRNP)

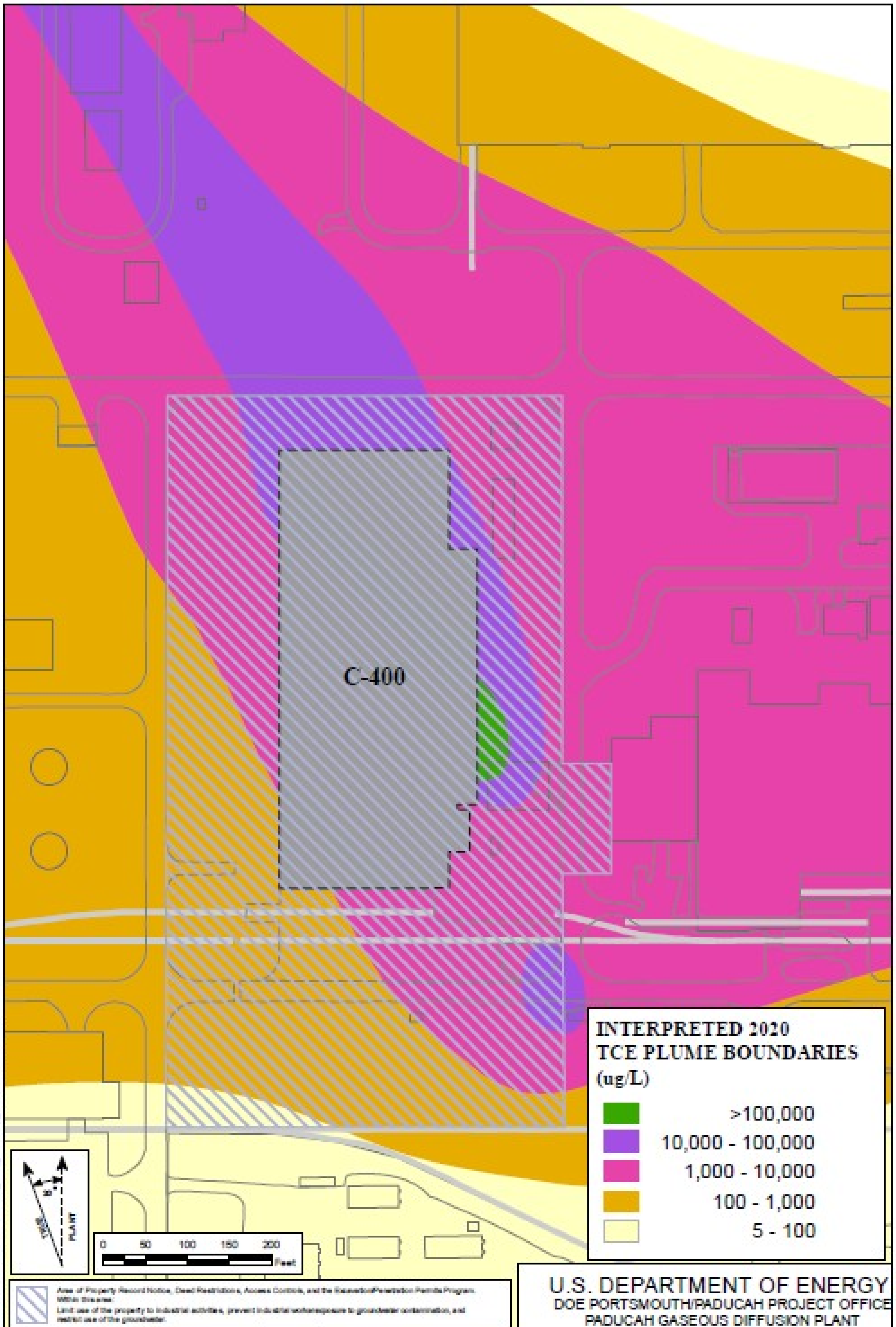
Chris Travis
(KDEP)
Jennifer Johnson
(ETAS)



Location of C-400

FOUR RIVERS
NUCLEAR PARTNERSHIP, LLC

G:\GIS\ARCVIEWS\PROJECTS\5YrReview\C-400_Location.mxd 20221201



LUC Boundary for the C-400 Area

THIS PAGE INTENTIONALLY LEFT BLANK

Five-Year Review Site Inspection Checklist
C-746-K Landfill

I. SITE INFORMATION	
Site name: C-746-K Landfill	**Date of inspection:** 12/8/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:** 54°F, 4 mph, light rain

Remedy Includes: (Check all that apply)

☒ Landfill cover/containment
□ Access controls
□ Institutional controls
□ Groundwater pump and treatment
□ Surface water collection and treatment
□ Other________________________________

□ Monitored natural attenuation
□ Groundwater containment
□ Vertical barrier walls

Attachments: ☒ Inspection team roster attached ☒ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Barry Kinsall (Name) Facility Manager (Title) 12/8/2022 (Date)
   Interviewed ☒ at site □ at office □ by phone no. (270) 816-4383
   Problems, suggestions; □ Report attached None________________________________

2. **O&M staff** N/A (Name) ____________ (Title) ________ (Date)
   Interviewed □ at site □ at office □ by phone Phone no. ____________
   Problems, suggestions; □ *Report attached* ________________________________

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county office) Fill in all that apply. Agency _Kentucky Department for Environmental Protection___________________________ Contact _Christopher Travis_________ Environmental Scientist _12/8/2022 (502) 782-5897 Name Title Date Phone no. Problems; suggestions; □ Report attached None ____ Agency Kentucky Department for Environmental Protection____________________________ Contact Brian Lainhart__________ Field Operations Lead_ 12/08/2022 (270) 559-3454 Name Title Date Phone no. Problems; suggestions; □ Report attached None.____ Agency ____________________________ Contact ____________________________ __________________ ________ ____________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ Agency ____________________________ Contact ____________________________ __________________ ________ ____________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____
4.	**Other interviews** (optional) □ *Report attached.*

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	☒ O&M manual	☒ Readily available	☒ Up to date	□ N/A
	☒ As-built drawings	☒ Readily available	□ Up to date	□ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	☒ Other permits_KPDES_______________	☒ Readily available	☒ Up to date	□ N/A
	Remarks:			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
7.	**Groundwater Monitoring Records**	☒ Readily available	☒ Up to date	□ N/A
	Remarks:			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks:			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks:			

IV. O&M COSTS

1. **O&M Organization**
☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ☒ Contractor for Federal Facility
☐ Other____

2. **O&M Cost Records** *Refer to Section 13.3 of the report.*
☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate____________________ ☐ Breakdown attached

Total annual cost by year for review period if available

From__________ (Date)	To__________ (Date)	__________ (Total cost)	☐ Breakdown attached
From__________ (Date)	To__________ (Date)	__________ (Total cost)	☐ Breakdown attached
From__________ (Date)	To__________ (Date)	__________ (Total cost)	☐ Breakdown attached
From__________ (Date)	To__________ (Date)	__________ (Total cost)	☐ Breakdown attached
From__________ (Date)	To__________ (Date)	__________ (Total cost)	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons: Costs are discussed in Section 13.3 of the report.

V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured ☒ N/A
Remarks:____

B. Other Access Restrictions

1. **Signs and other security measures** ☒ Location shown on site map ☐ N/A
Remarks:____

C. Institutional Controls (ICs)	
1.	**Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A Type of monitoring (e.g., self-reporting, drive by) ______ Frequency ______ Responsible party/agency ______ Contact ______ Name ______ Title ______ Date ______ Phone no. Reporting is up-to-date ☐ Yes ☐ No ☒ N/A Reports are verified by the lead agency ☐ Yes ☐ No ☒N/A Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A Violations have been reported ☐ Yes ☐ No ☒ N/A Other problems or suggestions: ☐ Report attached
2.	**Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A Remarks: ______
D. General	
1.	**Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident Remarks: ______
2.	**Land use changes on site** ☐ N/A Remarks: None.
3.	**Land use changes off site** ☐ N/A Remarks: None.

VI. GENERAL SITE CONDITIONS
A. Roads ☒Applicable ☐ N/A
1. **Roads damaged** ☒ Location shown on site map ☒ Roads adequate ☐ N/A Remarks:____
B. Other Site Conditions
Remarks:____
VII. LANDFILL COVERS ☒ Applicable ☐ N/A
A. Landfill Surface
1. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident Areal extent____________ Depth____________ Remarks: ____
2. **Cracks** ☐ Location shown on site map ☒ Cracking not evident Lengths____________ Widths____________ Depths____________ Remarks: ____
3. **Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent____________ Depth____________ Remarks: ____
4. **Holes** ☐ Location shown on site map ☒ Holes not evident Areal extent____________ Depth____________ Remarks: ____
5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☒ No signs of stress ☐ Trees/Shrubs (indicate size and locations on a diagram) Remarks: ____
6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A Remarks:____
7. **Bulges** ☐ Location shown on site map ☒ Bulges not evident Areal extent____________ Height____________ Remarks: ____
8. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident ☐ Wet areas ☐ Location shown on site map Areal extent____________ ☐ Ponding ☐ Location shown on site map Areal extent____________ ☐ Seeps ☐ Location shown on site map Areal extent____________ ☐ Soft subgrade ☐ Location shown on site map Areal extent____________ Remarks: ____

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ☒ No evidence of slope instability
Areal extent______________
Remarks: ____
____

B. Benches ☐ Applicable ☒ N/A
(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

C. Letdown Channels ☐ Applicable ☒ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

D. Cover Penetrations ☒ Applicable ☐ N/A

1. **Gas Vents** ☐ Active ☒ Passive
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☒ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks: ____
____

2. **Gas Monitoring Probes**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☒ N/A
Remarks: ____
____

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☒ N/A
Remarks: ____
____

4. **Leachate Extraction Wells**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☒ N/A
Remarks: ____
____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ☒ N/A
Remarks: ____
____

E. Gas Collection and Treatment ☐ Applicable ☒ N/A	
F. Cover Drainage Layer ☐ Applicable ☒ N/A	
G. Detention/Sedimentation Ponds ☐ Applicable ☒ N/A	
H. Retaining Walls ☐ Applicable ☒ N/A	
I. Perimeter Ditches/Off-Site Discharge ☒ Applicable ☐ N/A	
1.	**Siltation** ☐ Location shown on site map ☒ Siltation not evident Areal extent______________ Depth____________ Remarks: ____________________
2.	**Vegetative Growth** ☐ Location shown on site map ☒ N/A ☐ Vegetation does not impede flow Areal extent______________ Type____________ Remarks: ____________________
3.	**Erosion** ☐ Location shown on site map ☒ Erosion not evident Areal extent______________ Depth____________ Remarks: ____________________
4.	**Discharge Structure** ☒Functioning ☐ N/A Remarks: ____________________
VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A	
IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A	
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☒ N/A	
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☒ N/A	
C. Treatment System ☐ Applicable ☒ N/A	
D. Monitoring Data	
1.	Monitoring Data ☒ Is routinely submitted on time ☒ Is of acceptable quality
2.	Monitoring data suggests: ☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining
D. Monitored Natural Attenuation	
1.	**Monitoring Wells** (natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☒ N/A Remarks:____________________
X. OTHER REMEDIES	
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.	

XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). No problems were noted with the systems operation or maintenance. The signs, riprap, and landfill cap, are in place and in good condition.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. See Section 13.3 in main text.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. None.

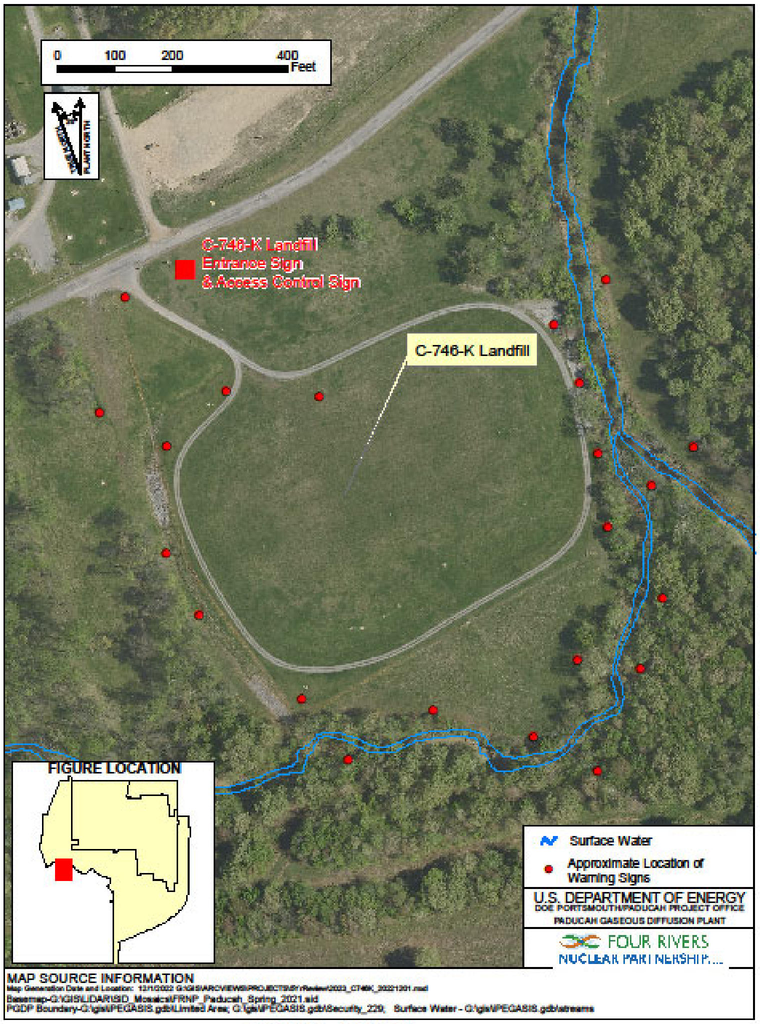
ATTACHMENT

Inspection team roster (12/8/2022):

Teresa Overby (FRNP)
Barry Kinsall (FRNP)
Megan Mulry (FRNP)

Brian Lainhart (KDEP)
Chris Travis (KDEP)

Site map:



C-746-K Landfill Site Plan

Five-Year Review Site Inspection Checklist
C-749 Uranium Burial Ground

I. SITE INFORMATION	
Site name: C-749 Uranium Burial Ground	**Date of inspection:** 12/6/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:** 39°F and clear

Remedy Includes: (Check all that apply)

☒ Landfill cover/containment
□ Access controls
□ Institutional controls
□ Groundwater pump and treatment
□ Surface water collection and treatment
□ Other___
□ Monitored natural attenuation
□ Groundwater containment
□ Vertical barrier walls

Attachments: ☒ Inspection team roster attached ☒ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Brian Lowrance (Name) Facility Manager (Title) 12/6/2022 (Date)
   Interviewed ☒ at site □ at office □ by phone no. ___
   Problems, suggestions; □ Report attached None

2. **O&M staff** N/A
   Interviewed □ at site □ at office □ by phone Phone no. ___
   Problems, suggestions; □ Report attached ___

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency _________________________ Contact _________________________ ________________ _______ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ Agency _________________________ Contact _________________________ ________________ _______ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ Agency _________________________ Contact _________________________ ________________ _______ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ Agency _________________________ Contact _________________________ ________________ _______ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____
4.	**Other interviews** (optional) □ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	O&M Documents			
	□ O&M manual	□ Readily available	□ Up to date	☒ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remark: ______			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits__________	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
7.	**Groundwater Monitoring Records**	☒ Readily available	☒ Up to date	□ N/A
	Remarks: ______			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			

IV. O&M COSTS

1. **O&M Organization**
☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ☒ Contractor for Federal Facility
☐ Other____

2. **O&M Cost Records** Refer to Section 17.3 of the report.
☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate____________________ ☐ Breakdown attached

Total annual cost by year for review period if available

From__________ To__________ __________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ __________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ __________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ __________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ __________________ ☐ Breakdown attached
Date Date Total cost

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons: Costs are discussed in Section 17.3 of the report.

V. ACCESS AND INSTITUTIONAL CONTROLS ☐ Applicable ☒ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured ☒ N/A
Remarks: ____

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks: ____

C. Institutional Controls (ICs)			
1. **Implementation and enforcement**			
Site conditions imply ICs not properly implemented	□ Yes	☒ No	□ N/A
Site conditions imply ICs not being fully enforced	□ Yes	☒ No	□ N/A

Type of monitoring (e.g., self-reporting, drive by) ______
Frequency ______
Responsible party/agency ______
Contact ______ Name ______ Title ______ Date ______ Phone no.

Reporting is up-to-date	□ Yes	□ No	☒ N/A
Reports are verified by the lead agency	□ Yes	□ No	☒ N/A
Specific requirements in deed or decision documents have been met	□ Yes	□ No	☒ N/A
Violations have been reported	□ Yes	□ No	☒ N/A

Other problems or suggestions: □ Report attached
______
______

2. **Adequacy** ☒ ICs are adequate □ ICs are inadequate □ N/A
Remark: ______
______

D. General

1. **Vandalism/trespassing** □ Location shown on site map ☒ No vandalism evident
Remarks: ______:
______

2. **Land use changes on site** ☒ N/A
Remarks: ______
______

3. **Land use changes off site** ☒ N/A
Remarks: ______
______

VI. GENERAL SITE CONDITIONS

A. Roads ☒Applicable □ N/A

1. **Roads damaged** ☒ Location shown on site map ☒ Roads adequate □ N/A
Remarks: ______

B. Other Site Conditions

Remarks: No issues were noted on the site inspection.

VII. LANDFILL COVERS ☒ Applicable ☐ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☒ Settlement not evident
Areal extent______________ Depth____________
Remarks: ____

2. **Cracks** ☐ Location shown on site map ☒ Cracking not evident
Lengths____________ Widths___________ Depths__________
Remarks: ____

3. **Erosion** ☐ Location shown on site map ☒ Erosion not evident
Areal extent______________ Depth____________
Remarks: ____

4. **Holes** ☐ Location shown on site map ☒ Holes not evident
Areal extent______________ Depth____________
Remarks: ____

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☒ No signs of stress
☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks: ____

6. **Alternative Cover (armored rock, concrete, etc.)** ☒ N/A
Remarks: ____

7. **Bulges** ☐ Location shown on site map ☒ Bulges not evident
Areal extent______________ Height____________
Remarks: ____

8. **Wet Areas/Water Damage** ☒ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent______________
☐ Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks: ____

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ☒ No evidence of slope instability
Areal extent______________
Remarks: ____

B. Benches ☐ Applicable ☒ N/A

(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

C. Letdown Channels □ Applicable ☒ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

D. Cover Penetrations □ Applicable ☒ N/A

E. Gas Collection and Treatment □ Applicable ☒ N/A

F. Cover Drainage Layer □ Applicable ☒ N/A

G. Detention/Sedimentation Ponds □ Applicable ☒ N/A

H. Retaining Walls □ Applicable ☒ N/A

I. Perimeter Ditches/Off-Site Discharge ☒ Applicable □ N/A

1. **Siltation** □ Location shown on site map ☒ Siltation not evident
Areal extent______________ Depth____________
Remarks:____
____

2. **Vegetative Growth** □ Location shown on site map ☒ N/A
□ Vegetation does not impede flow
Areal extent______________ Type____________
Remarks:____
____

3. **Erosion** □ Location shown on site map ☒ Erosion not evident
Areal extent______________ Depth____________
Remarks:____
____

4. **Discharge Structure** ☒Functioning □ N/A
Remarks:____
____

VIII. VERTICAL BARRIER WALLS □ Applicable ☒ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES □ Applicable ☒ N/A

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

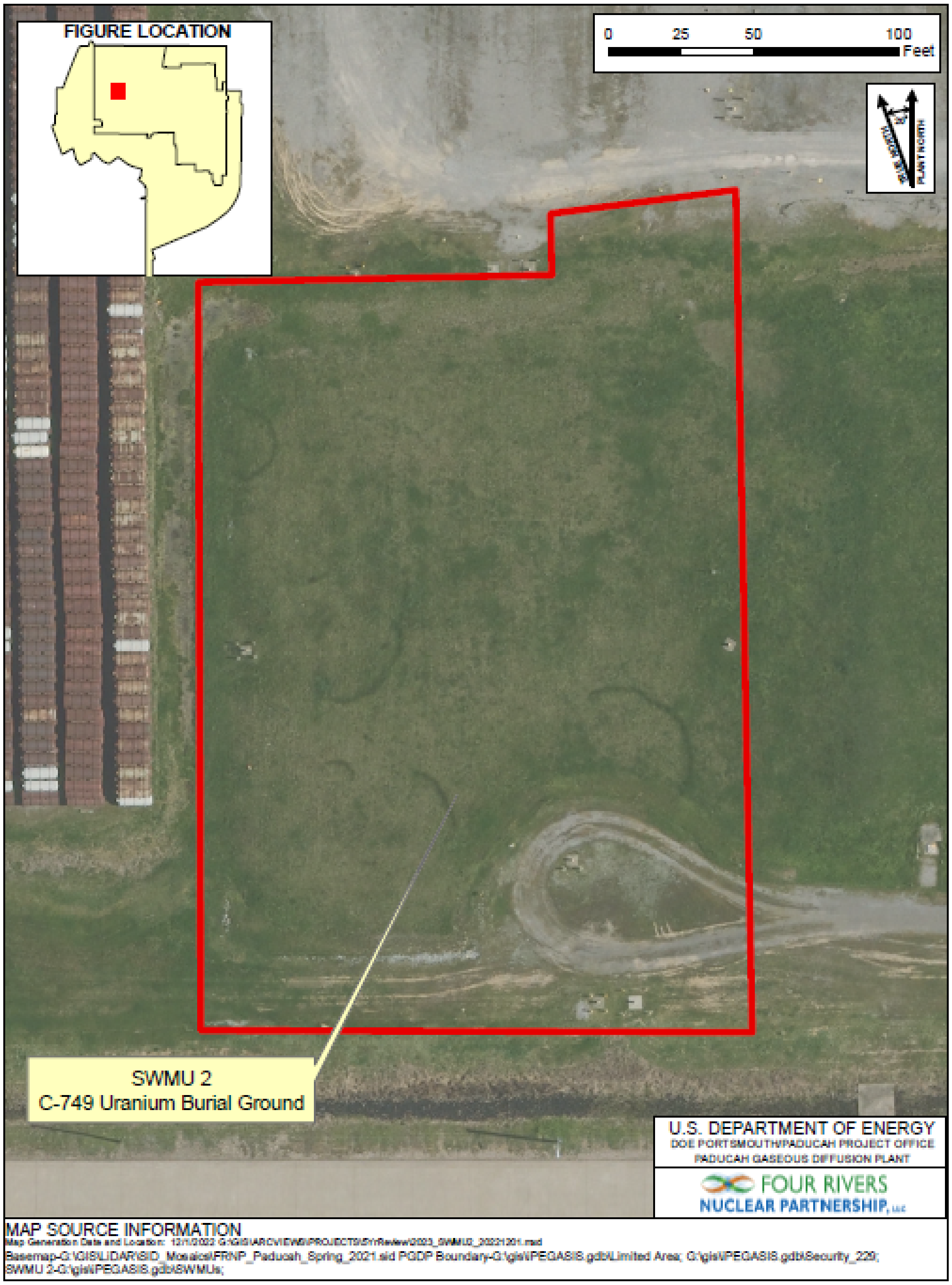
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). The landfill and signs are in place and in good condition. No problems were noted with the maintenance. Monitoring wells are in place and are inspected yearly.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. See Section 17.3 of the report.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. None.

ATTACHMENT

Inspection team roster (12/6/2022):

Jennifer Johnson (ETAS)	Brian Lowrance (FRNP)	Justin Riley (FRNP)
Teresa Overby (FRNP)	Megan Mulry (FRNP)	

Site map:



THIS PAGE INTENTIONALLY LEFT BLANK

Five-Year Review Site Inspection Checklist
Fire Training Area

<table>
<tr><th colspan="2">I. SITE INFORMATION</th></tr>
<tr><td>Site name: Fire Training Area, SWMU 100</td><td>Date of inspection: 12/6/2022</td></tr>
<tr><td>Location and Region: Paducah, KY/Region 4</td><td>EPA ID: KY8890008982</td></tr>
<tr><td>Agency, office, or company leading the five-year review: U.S. Department of Energy</td><td>Weather/temperature: Light Fog with breaking sun, 48°</td></tr>
<tr><td colspan="2">Remedy Includes: (Check all that apply)
□ Landfill cover/containment   □ Monitored natural attenuation
☒ Access controls   □ Groundwater containment
□ Institutional controls   □ Vertical barrier walls
□ Groundwater pump and treatment
□ Surface water collection and treatment
□ Other</td></tr>
<tr><td colspan="2">Attachments: ☒ Inspection team roster attached   ☒ Site map attached</td></tr>
<tr><th colspan="2">II. INTERVIEWS (Check all that apply)</th></tr>
<tr><td colspan="2">1. O&M site manager Brian Lowrance   Facility Manager   12/6/2022
Name   Title   Date
Interviewed ☒ at site □ at office □ by phone   Phone no. 270-441-5896
Problems, suggestions; □ Report attached</td></tr>
<tr><td colspan="2">2. O&M staff N/A
Name   Title   Date
Interviewed □ at site □ at office □ by phone   Phone no.
Problems, suggestions; □ Report attached</td></tr>
</table>

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency ______________________________ Contact ______________________________ ___________________ ________ ____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ___________________ ________ ____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ___________________ ________ ____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ___________________ ________ ____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____
4.	**Other interviews** (optional) ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	□ O&M manual	□ Readily available	□ Up to date	☒ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits__________	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks:__________			

IV. O&M COSTS	
1.	**O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility □ Other______________________________
2.	**O&M Cost Records** *Refer to Section 14.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate____________ □ Breakdown attached Total annual cost by year for review period if available From_______ To_______ ___________ □ Breakdown attached Date Date Total cost From_______ To_______ ___________ □ Breakdown attached Date Date Total cost From_______ To_______ ___________ □ Breakdown attached Date Date Total cost From_______ To_______ ___________ □ Breakdown attached Date Date Total cost From_______ To_______ ___________ □ Breakdown attached Date Date Total cost
3.	**Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: Costs are discussed in Section 14.3 of the report.
V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable □ N/A	
A. Fencing	
1.	**Fencing damaged** □ Location shown on site map □ Gates secured □ N/A Remarks: Plant fence._
B. Other Access Restrictions	
1.	**Signs and other security measures** □ Location shown on site map ☒ N/A Remarks:______________________________

C. Institutional Controls (ICs)		
1.	**Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A Type of monitoring (e.g., self-reporting, drive by) None. SWMU 100 is NFA. Frequency ______ Responsible party/agency ______ Contact ______ ______ ______ ______ Name Title Date Phone no. Reporting is up-to-date ☐ Yes ☐ No ☒ N/A Reports are verified by the lead agency ☐ Yes ☐ No ☒ N/A Specific requirements in deed or decision documents have been met ☐ Yes ☐ No ☒ N/A Violations have been reported ☐ Yes ☐ No ☒ N/A Other problems or suggestions: ☐ Report attached	
2.	**Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A Remarks:	
D. General		
1.	**Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident Remarks:	
2.	**Land use changes on site** ☒ N/A Remarks:	
3.	**Land use changes off site** ☒ N/A Remarks:	
VI. GENERAL SITE CONDITIONS		
A. Roads ☐ Applicable ☒ N/A		
1.	**Roads damaged** ☐ Location shown on site map ☐ Roads adequate ☐ N/A Remarks:	

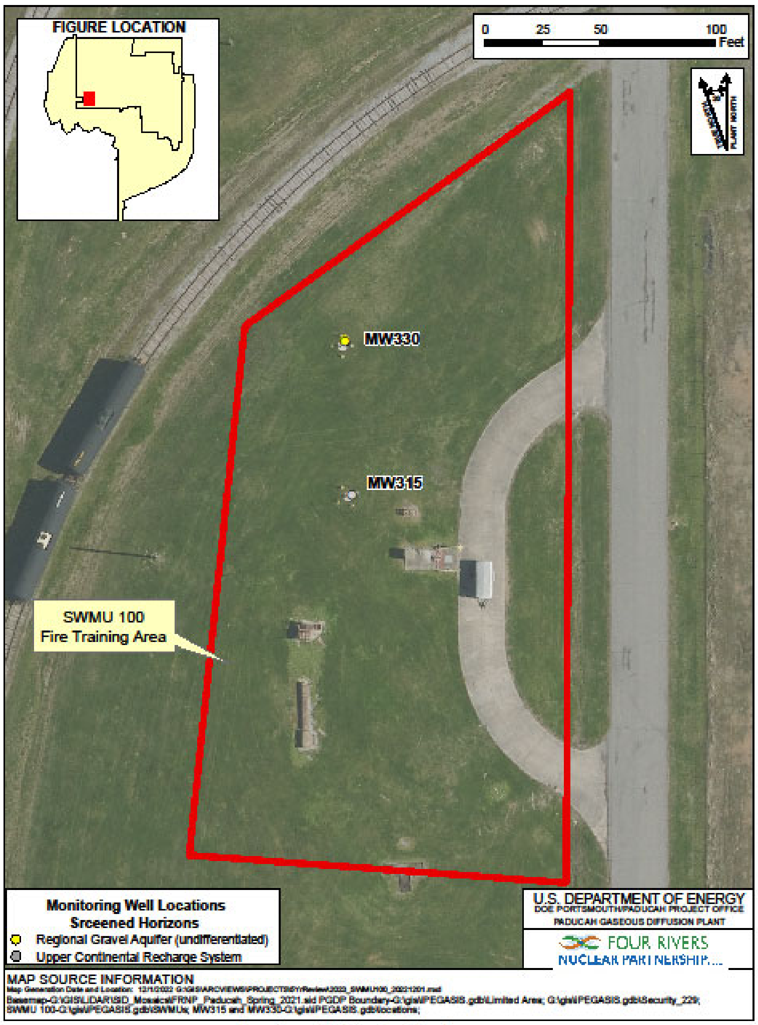
B. Other Site Conditions
Remarks: Fire training facility area. MW 315 and MW330 are on-site. Both wells are locked. Some equipment present include ladder/stand, pipes, and a sewer.
VII. LANDFILL COVERS □ Applicable ☒ N/A
VIII. ERTICAL BARRIER WALLS □ Applicable ☒ N/A
IX. GROUNDWATER/SURFACE WATER REMEDIES □ Applicable ☒ N/A
X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.
XI. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission).
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.
C. Early Indicators of Potential Remedy Problems
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.

ATTACHMENT

Inspection team roster (12/6/2022):

Megan Mulry (FRNP)
Jennifer Johnson (ETAS)
Brian Lowrance (FRNP)
Teresa Overby (FRNP)
Justin Riley (FRNP)

Site map:



Location of the Fire Training Area

THIS PAGE INTENTIONALLY LEFT BLANK

Five-Year Review Site Inspection Checklist
Cylinder Drop Test Area or LASAGNA™ Technology Demonstration

I. SITE INFORMATION	
Site name: Lasagna Treatment Area/Cylinder Drop Test Area, SWMU 91	**Date of inspection:** 12/6/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:** Light Fog, 49°F, 1 mph winds

Remedy Includes: (Check all that apply)
- □ Landfill cover/containment
- □ Access controls
- □ Institutional controls
- □ Groundwater pump and treatment
- □ Surface water collection and treatment
- x Other Lasagna Technology Demonstration
- □ Monitored natural attenuation
- □ Groundwater containment
- □ Vertical barrier walls

Attachments: ☒ Inspection team roster attached ☒ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Brian Lowrance (Name) Facility Manager (Title) 12/6/2022 (Date)
   Interviewed ☒ at site □ at office □ by phone no. (270) 559-6371___
   Problems, suggestions; □ Report attached. No problems or suggestions identified.
   ____

2. **O&M staff** N/A (Name) ______________ (Title) ______________ (Date)
   Interviewed □ at site □ at office □ by phone Phone no. ______________
   Problems, suggestions; □ Report attached ______________________________________
   ____

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency ______________________ Contact ______________________ ______________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________ ______________________ Agency ______________________ Contact ______________________ ______________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________ ______________________ Agency ______________________ Contact ______________________ ______________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________ ______________________ Agency ______________________ Contact ______________________ ______________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________ ______________________
4.	**Other interviews** (optional) □ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	□ O&M manual	□ Readily available	□ Up to date	☒ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits______________	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______________________________			

IV. O&M COSTS
1. **O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility x Other No operation and maintenance specifically required for SWMU 91.
2. **O&M Cost Records** *Refer to Section 14.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate____________________ □ Breakdown attached Total annual cost by year for review period if available From__________ To__________ __________________ □ Breakdown attached Date Date Total cost From__________ To__________ __________________ □ Breakdown attached Date Date Total cost From__________ To__________ __________________ □ Breakdown attached Date Date Total cost From__________ To__________ __________________ □ Breakdown attached Date Date Total cost From__________ To__________ __________________ □ Breakdown attached Date Date Total cost
3. **Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: ____
V. ACCESS AND INSTITUTIONAL CONTROLS □ Applicable x N/A
VI. GENERAL SITE CONDITIONS
A. Roads □ Applicable ☒ N/A
B. Other Site Conditions
Remarks: Treatment area is not distinguishable from surrounding area by observation. The northern portion of the surface is gravel covered, similar to the C-745-B Cylinder yard, while the southern portion of the treatment area is bare soil with limited grass and some gravel present.
VII. LANDFILL COVERS □ Applicable ☒ N/A
VIII. VERTICAL BARRIER WALLS □ Applicable ☒ N/A
IX. GROUNDWATER/SURFACE WATER REMEDIES □ Applicable ☒ N/A

X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction. See Attachment

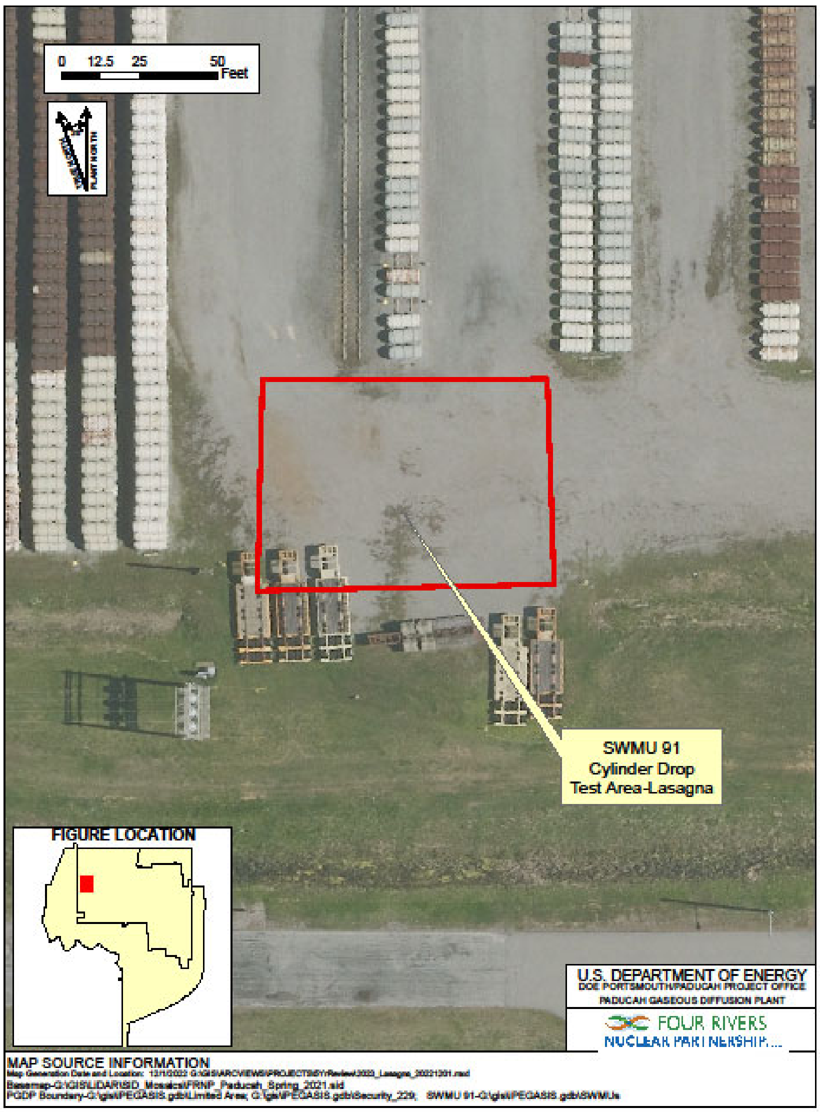
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). The Lasagna™ remedy implementation at the Cylinder Drop Test Area was completed in December 2001. The SWMU 91 treatment area at the time of inspection (12/6/2022) was gravel covered, with a bare soil, grass, and gravel mix covering the southern portion of the area. The area appeared well kept with no tall grass, water holes, or erosion visible. The treatment area lies within several radiologically controlled areas which are not associated with the treatment area. The treatment area also shares an area with the C-745-B Cylinder Yard. All treatment was performed on subsurface soils and visual inspection from the surface is not feasible. No issues identified.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The Lasagna™ remedy does not have ongoing operation and maintenance activities.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. Review. No indicators of potential remedy problems were identified during this five-year_review period.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Review. No optimization opportunities were identified during this five-year review period.

ATTACHMENT

Inspection team roster (12/6/2022):

Brian Lowrance (FRNP)
Teresa Overby (FRNP)
Jennifer Johnson (ETAS)
Megan Mulry (FRNP)
Justin Riley (FRNP)

Site map:



Location of Cylinder Drop Test Area

Five-Year Review Site Inspection Checklist
Northeast Plume Containment System

I. SITE INFORMATION	
Site name: Northeast Plume Containment System	**Date of inspection:** 12/5/2022
Location and Region: Paducah, Kentucky	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:** Overcast with some fog/mist/45–47°F

Remedy Includes: (Check all that apply)

☐ Landfill cover/containment
X Access controls
☐ Institutional controls
X Groundwater pump and treatment
☐ Surface water collection and treatment
☐ Other____

☐ Monitored natural attenuation
☐ Groundwater containment
☐ Vertical barrier walls

Attachments: X Inspection team roster attached X Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** David Veach (Name) NEPCS Manager (Title) 12/5/2022 (Date)
   Interviewed X at site ☐ at office ☐ by Phone no. _______________
   Problems, suggestions; ☐ Report attached ______________________
   Northeast Plume Containment System operating as planed with no anticipated problems forthcoming.

2. **O&M staff** N/A (Name) ____________ (Title) ____________ (Date)
   Interviewed ☐ at site ☐ at office ☐ by phone no. _______________
   Problems, suggestions; ☐ Report attached ______________________

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency _Kentucky Division for Environmental Protection____________________________ Contact _Christopher Travis_________ Environmental Scientist _12/5/2022 502-782-5897 Name Title Date Phone no. Problems; suggestions; ☐ Report attached None____ Agency ______________________________ Contact ______________________________ ______________ ________ __________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ Agency ______________________________ Contact ______________________________ ______________ ________ __________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ Agency ______________________________ Contact ______________________________ ______________ ________ __________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____
4.	**Other interviews** (optional) ☐ Report attached.
	III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)
1.	**O&M Documents** X O&M manual (November 2021) X Readily available X Up to date ☐ N/A X As-built drawings X Readily available X Up to date ☐ N/A X Maintenance logs X Readily available X Up to date ☐ N/A Remarks: Required and preventative maintenance activities are scheduled and reported in SOMAX. O&M manual is available electronically on the facility S: Drive.
2.	**Site-Specific Health and Safety Plan** X Readily available X Up to date ☐ N/A X Contingency plan/emergency response plan X Readily available X Up to date ☐ N/A Remarks: JHA-10844 R10/Health and Safety (H&S) Plan: CP2-ER-0067/FR2B emergency response is addressed in the H&S Plan.
3.	**O&M and OSHA Training Records** X Readily available ☐ Up to date ☐ N/A Remarks: Site training records are maintained electronically.

4.	**Permits and Service Agreements**			
	☐ Air discharge permit	☐ Readily available	☐ Up to date	☐ N/A
	☐ Effluent discharge	☐ Readily available	☐ Up to date	☐ N/A
	☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☐ N/A
	☐ Other permits______	☐ Readily available	☐ Up to date	☐ N/A
	Remarks: Effluent monitored as a Record of Decision requirement (Outfall C001). Site waste management program addresses waste.			
5.	**Gas Generation Records**	☐ Readily available	☐ Up to date	X N/A
	Remarks: ______			
6.	**Settlement Monument Records**	☐ Readily available	☐ Up to date	X N/A
	Remarks: ______			
7.	**Groundwater Monitoring Records**	X Readily available	X Up to date	☐ N/A
	Remarks: Available to public through PEGASIS data retrieval system. Reported in semi-annual Federal Facility Agreement reports.			
8.	**Leachate Extraction Records**	☐ Readily available	☐ Up to date	X N/A
	Remarks: ______			
9.	**Discharge Compliance Records**			
	☐ Air	☐ Readily available	☐ Up to date	☐ N/A
	X Water (effluent)	X Readily available	X Up to date	☐ N/A
	Remarks: Available to public through PEGASIS data retrieval system. Included in semi-annual Federal Facility Agreement reports.			
10.	**Daily Access/Security Logs**	☐ Readily available	☐ Up to date	X N/A
	Remarks: ______			

IV. O&M COSTS

1.	**O&M Organization**	
	☐ State in-house	☐ Contractor for State
	☐ PRP in-house	☐ Contractor for PRP
	☐ Federal Facility in-house	X Contractor for Federal Facility
	☐ Other______	

2. **O&M Cost Records**
X Readily available X Up to date: Revisited semi-annually (FFA semi-annual reports)
X Funding mechanism/agreement in place
Original O&M cost estimate_$240K/year for Northeast Plume P&T_ ☐ Breakdown attached

Total annual cost by year for review period if available

From 10/1/17 To 9/30/18 $799,000 for NE and NW P&T Systems ☐ Breakdown attached
Date Date Total cost
From 10/1/18 To 9/30/19 $1,187,000 for NE and NW P&T Systems ☐ Breakdown attached
Date Date Total cost
From 10/1/19 To 9/30/20 $810,000 for NE and NW P&T Systems ☐ Breakdown attached
Date Date Total cost
From 10/1/20 To 9/30/21 $830,000 for NE and NW P&T Systems ☐ Breakdown attached
Date Date Total cost
From 10/1/21 To 9/30/22 $1,451,000 for NE and NW P&T Systems ☐ Breakdown attached
Date Date Total cost

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons: Higher O&M costs during 2019 and 2022 (see above) resulted from maintenance and repair actions related to a greater number of days of extraction well pump down time during those years (94 days of pump down time in 2019 and 128 days of pump down time in 2022.

V. ACCESS AND INSTITUTIONAL CONTROLS ☐ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map X Gates secured ☐ N/A
Remarks: Both treatment systems are enclosed by security fencing. The fences are in good condition.

B. ther Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks: Standby extraction wells are secured by fencing. Monitoring wells are locked.

C. Institutional Controls (ICs) N/A				
1.	**Implementation and enforcement** Site conditions imply ICs not properly implemented Site conditions imply ICs not being fully enforced Type of monitoring (*e.g.*, self-reporting, drive by) ______ Frequency ______ Responsible party/agency ______ Contact ______ ______ ______ ______ Name Title Date Phone no. Reporting is up-to-date Reports are verified by the lead agency Specific requirements in deed or decision documents have been met Violations have been reported Other problems or suggestions: ☐ Report attached ______	☐ Yes ☐ Yes ☐ Yes ☐ Yes ☐ Yes ☐ Yes	☐ No ☐ No ☐ No ☐ No ☐ No ☐ No	X N/A X N/A X N/A X N/A X N/A X N/A
2.	**Adequacy** ☐ ICs are adequate ☐ ICs are inadequate X N/A Remarks: ______			
D. General				
1.	**Vandalism/trespassing** ☐ Location shown on site map X No vandalism evident Remarks: ______			
2.	**Land use changes on site** X N/A Remarks: ______			
3.	**Land use changes off site** X N/A Remarks: ______			
VI. GENERAL SITE CONDITIONS				
A. Roads X Applicable ☐ N/A				
1.	**Roads damaged** ☐ Location shown on site map X Roads adequate ☐ N/A Remarks: Roads are in good condition.			
B. Other Site Conditions				
	Remarks: Treatment facility and extraction well vaults are well ordered and labeled. The grounds are well maintained.			
VII. LANDFILL COVERS ☐ Applicable X N/A				
VIII. VERTICAL BARRIER WALLS ☐ Applicable X N/A				

IX. GROUNDWATER/SURFACE WATER REMEDIES X Applicable ☐ N/A	
A. Groundwater Extraction Wells, Pumps, and Pipelines X Applicable ☐ N/A	
1.	**Pumps, Wellhead Plumbing, and Electrical** X Good condition X All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks: Operation of the optimized Northeast Plume Containment System began in October 2017.
2.	**Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** X Good condition ☐ Needs Maintenance Remarks: Two operating extraction wells. Two extraction wells on standby.
3.	**Spare Parts and Equipment** X Readily available X Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks: There have been supply-chain issues for some critical parts, which affected the reporting period.
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable X N/A	
C. Treatment System X Applicable ☐ N/A	
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation X Air stripping ☐ Carbon adsorbers X Filters (4) bag filters at beginning of treatment train ☐ Additive (*e.g.*, chelation agent, flocculent) ☐ Others X Good condition ☐ Needs Maintenance X Sampling ports properly marked and functional X Sampling/maintenance log displayed and up to date (available through SOMAX) X Equipment properly identified X Quantity of groundwater treated annually Treated 58, 985, 89 gal 10/1/21–9/30/22 ☐ Quantity of surface water treated annually Remarks:
2.	**Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A X Good condition ☐ Needs Maintenance Remarks:
3.	**Tanks, Vaults, Storage Vessels** ☐ N/A X Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks: Extraction wells are housed in vaults.
4.	**Discharge Structure and Appurtenances** ☐ N/A X Good condition ☐ Needs Maintenance Remarks: Discharges through C001 outfall.
5.	**Treatment Building(s)** ☐ N/A X Good condition (esp. roof and doorways) ☐ Needs repair X Chemicals and equipment properly stored Remarks: Treatment systems for both extraction wells are housed in trailers.

6.	**Monitoring Wells** (pump and treatment remedy) X Properly secured/locked X Functioning X Routinely sampled X Good condition X All required wells located ☐ Needs Maintenance ☐ N/A Remarks: ______
D. Monitoring Data	
1.	Monitoring Data X Is routinely submitted on time X Is of acceptable quality
2.	Monitoring data suggests: ☐ Groundwater plume is effectively contained X Contaminant concentrations are declining (distal extent)
D. Monitored Natural Attenuation N/A	
1.	**Monitoring Wells** (natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance X N/A Remarks: ______

X. OTHER REMEDIES N/A

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission).

The Northeast Plume IRA is intended to control the TCE high-concentration area of the Northeast Plume that extends outside of the plant security area and to also track contaminant migration. The 2020 biannual update of the TCE plume map for the site documents reduced off-site extent of the Northeast Plume and separation of the upgradient plume into smaller east and west plume centroids since start of operations for the Northeast Plume Optimization Project.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

O&M of the Northeast Plume Containment System is addressed by both plans and procedures, which are regularly reviewed and updated as needed. The site's commitment to periodic and timely attention to O&M ensures that the action is, and will remain, protective.

C.	Early Indicators of Potential Remedy Problems
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. The total days of extraction well pump failure were significantly greater in both 2019 and 2022. The extended period of downtime during 2022 was, in part, due to supply chain issues related to the COVID-19 epidemic. Steps to improve on-site storage of backup equipment have been instigated to address supply-chain issues. Other steps have been taken to improve the quality of the electrical power to the extraction well pumps. The optimized Northeast Plume Containment System began operation immediately before the period of this review. The extraction well failures are not thought to be an indication that protectiveness may be compromised in the future.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. An optimization of the IRA was completed in October 2017. Opportunities for additional optimization are not yet evident.

MAP SOURCE INFORMATION
Map Generation Date and Location: G:\GIS\ARCVIEWS\PROJECTS\5YrReview\2022_5YR_NEPlumeEWField_inspection.mxd 3/15/2023
Locations-- G:\GIS\iPEGASIS.gdb\Locations (Query: STA_NAME IN ('EW234','EW235','C001'))
Facilities (Facilities Shown), DOE Boundary, Roadrow, Streams-- G:\GIS\iPEGASIS.gdb\Facilities, ...\doebnd, ...\roadrow, ...\streams
Aerial Image-- G:\GIS\LiDAR\SID_Mosaics\FRNP_Paducah_Spring_2021.sid

THIS PAGE INTENTIONALLY LEFT BLANK

Five-Year Review Site Inspection Checklist
NSDD Sections 1 and 2

I. SITE INFORMATION	
Site name: NSDD Sections 1 and 2	**Date of inspection:** 12/8/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy (DOE)	**Weather/temperature:** 48°F, rainy
Remedy Includes: (Check all that apply) □ Landfill cover/containment □ Access controls ☒ Institutional controls □ Groundwater pump and treatment ☒ Surface water collection and treatment □ Other____________________	□ Monitored natural attenuation □ Groundwater containment □ Vertical barrier walls
Attachments: ☒ Inspection team roster attached	☒ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Barry Kinsall (Name) Alt Facility Manager (Title) 12/8/2022 (Date)
   Interviewed ☒ at site □ at office □ by phone Phone no. (270) 816-4383
   Problems, suggestions; □ Report attached None____________________

2. **O&M staff** __N/A____________ (Name) ____________ (Title) ________ (Date)
   Interviewed □ at site □ at office □ by phone Phone no. ____________
   Problems, suggestions; □ *Report attached* ____________________

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency _Kentucky Department for Environmental Protection____________________ Contact _Christopher Travis_____ Environmental Scientist 12/8/2022 (502) 782-5897___ Name Title Date Phone no. Problems; suggestions; □ Report attached _None.____ ____ Agency _Kentucky Department for Environmental Protection_____________________ Contact _Brian Lainhart________ Field Operations Lead 12/8/2022 (270) 559-3454_____ Name Title Date Phone no. Problems; suggestions; □ Report attached None.____ ____ Agency ____________________________ Contact ____________________________ __________________ ________ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____ Agency ____________________________ Contact ____________________________ __________________ ________ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____	
4.	**Other interviews** (optional) □ *Report attached.*	

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	☒ O&M manual	☒ Readily available	☒ Up to date	□ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits______	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ______			

IV. O&M COSTS	
1.	**O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility □ Other________________
2.	**O&M Cost Records** *Refer to Section 12.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate__________ □ Breakdown attached Total annual cost by year for review period if available From______ To______ ________ □ Breakdown attached Date Date Total cost From______ To______ ________ □ Breakdown attached Date Date Total cost From______ To______ ________ □ Breakdown attached Date Date Total cost From______ To______ ________ □ Breakdown attached Date Date Total cost From______ To______ ________ □ Breakdown attached Date Date Total cost
3.	**Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: Costs are discussed in Section 12.3 of the report.
V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable □ N/A	
A. Fencing	
1.	**Fencing damaged** □ Location shown on site map ☒ Gates secured □ N/A Remarks: ________________
B. Other Access Restrictions	
1.	**Signs and other security measures** □ Location shown on site map ☒ N/A Remarks: ________________

C. Institutional Controls (ICs)
1. **Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A Type of monitoring (e.g., self-reporting, drive by) self-reporting Frequency Semi-Annual inspections Responsible party/agency Contractor to DOE Contact ______ Name ______ Title ______ Date ______ Phone no. Reporting is up-to-date ☐ Yes ☐ No ☒ N/A Reports are verified by the lead agency ☐ Yes ☐ No ☒ N/A Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A Violations have been reported ☐ Yes ☐ No ☒ N/A Other problems or suggestions: ☐ Report attached Deed restrictions are in place and are verified annually.
2. **Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A Remarks:
D. General
1. **Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident Remarks:
2. **Land use changes on site** ☐ N/A Remarks: No changes.
3. **Land use changes off site** ☐ N/A Remarks: No changes.
VI. GENERAL SITE CONDITIONS
A. Roads ☐ Applicable ☒ N/A
B. Other Site Conditions
Remarks:

VII. LANDFILL COVERS ☐ Applicable ☒ N/A
VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A
IX. ROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☒ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☒ N/A
B. Surface Water Collection Structures, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Collection Structures, Pumps, and Electrical** ☒ Good condition ☐ Needs Maintenance Remarks: ___
2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks: ___
3. **Spare Parts and Equipment** ☐ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks: ___
C. Treatment System ☐ Applicable ☒ N/A
D. Monitoring Data
1. Monitoring Data ☐ Is routinely submitted on time ☐ Is of acceptable quality
2. Monitoring data suggests: ☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining
D. onitored Natural Attenuation
1. **Monitoring Wells** (natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☒ N/A Remarks: ___
X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

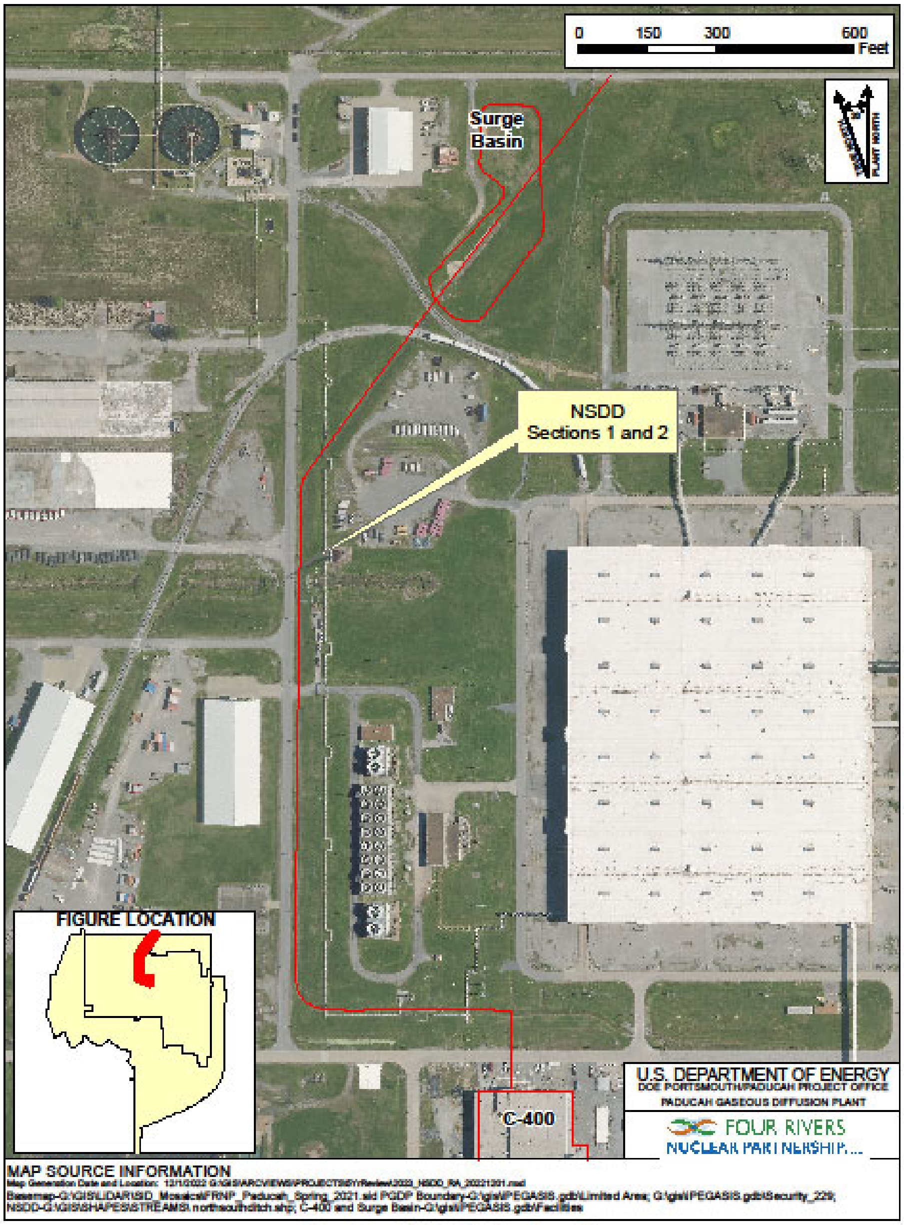
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). The goals of the remedy were implemented by excavating contaminated soil and sediment from the channel of the NSDD. Upon excavation, a 2-ft clay layer was placed in the NSDD channel to add an extra layer of protection for maintenance workers.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. The ditch has been well-maintained; grass was established in the channel, but was not impeding flow. The flow into the surge basin was unimpeded. The grass cover is well established and was mowed. There were no visible signs of erosion along the banks of the surge basin. See Section 12.3.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. None.

ATTACHMENT

Inspection team roster (12/8/2022):

Jennifer Johnson (ETAS)	Megan Mulry (FRNP)
Teresa Overby (FRNP)	Chris Travis (KDEP)
Barry Kinsall (FRNP)	Brian Lainhart (KDEP)

Site map:



Location of NSDD Sections 1 and 2

Five-Year Review Site Inspection Checklist
NSDD Source Control

I. SITE INFORMATION	
Site name: NSDD Source Control	**Date of inspection:** 12/8/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy (DOE)	**Weather/temperature:** 48°F, rainy
Remedy Includes: (Check all that apply) □ Landfill cover/containment □ Access controls □ Institutional controls □ Groundwater pump and treatment ☒ Surface water collection and treatment □ Other________________	□ Monitored natural attenuation □ Groundwater containment □ Vertical barrier walls
Attachments: ☒ Inspection team roster attached	☒ Site map attached
II. INTERVIEWS (Check all that apply)	
1. **O&M site manager** Barry Kinsall (Name) Alt Facility Manager (Title) 12/8/2022 (Date) Interviewed ☒ at site □ at office □ by phone Phone no. (270) 816-4383 Problems, suggestions; □ Report attached None________________	
2. **O&M staff** N/A ________ (Name) ________ (Title) ________ (Date) Interviewed □ at site □ at office □ by phone Phone no. ________ Problems, suggestions; □ *Report attached* ________________	

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency _Kentucky Department for Environmental Protection Contact _Christopher Travis_________ Environmental Scientist_ 12/8/2022 _(502) 782-5897_ Name Title Date Phone no. Problems; suggestions; □ Report attached _ None ____ ____ Agency _Kentucky Department for Environmental Protection__________________ Contact _Brian Lainhart__________ Field Operations Lead _ 12/8/2022 _(270) 559-3454 Name Title Date Phone no. Problems; suggestions; □ Report attached None____ ____ Agency ____________________________ Contact ____________________________ __________________ ________ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____ Agency ____________________________ Contact ____________________________ __________________ ________ __________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____	
4.	**Other interviews** (optional) □ Report attached.	

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	☒ O&M manual	☒ Readily available	☒ Up to date	□ N/A
	☒ As-built drawings	☒ Readily available	☒ Up to date	□ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits___	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks:___			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks: ___			

IV. O&M COSTS	
1.	**O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility □ Other____________________
2.	**O&M Cost Records** *Refer to Section 11.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate__________ □ Breakdown attached Total annual cost by year for review period if available From______ To______ __________ □ Breakdown attached Date Date Total cost From______ To______ __________ □ Breakdown attached Date Date Total cost From______ To______ __________ □ Breakdown attached Date Date Total cost From______ To______ __________ □ Breakdown attached Date Date Total cost From______ To______ __________ □ Breakdown attached Date Date Total cost
3.	**Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: Costs are discussed in Section 11.3 of the report.

V. ACCESS AND INSTITUTIONAL CONTROLS □ Applicable ☒ N/A	
A. Fencing	
1.	**Fencing damaged** □ Location shown on site map □ Gates secured □ N/A Remarks:____________________
B. Other Access Restrictions	
1.	**Signs and other security measures** □ Location shown on site map □ N/A Remarks:____________________

C. Institutional Controls (ICs)
1. **Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes ☒ No ☐ N/A Site conditions imply ICs not being fully enforced ☐ Yes ☒ No ☐ N/A Type of monitoring (e.g., self-reporting, drive by) self-reporting Frequency Semi-Annual inspections Responsible party/agency Contractor to DOE Contact ____ Name ____ Title ____ Date ____ Phone no. Reporting is up-to-date ☐ Yes ☐ No ☒ N/A Reports are verified by the lead agency ☐ Yes ☐ No ☒ N/A Specific requirements in deed or decision documents have been met ☒ Yes ☐ No ☐ N/A Violations have been reported ☐ Yes ☐ No ☒ N/A Other problems or suggestions: ☐ Report attached Deed restrictions are in place and are verified annually.
2. **Adequacy** ☒ ICs are adequate ☐ ICs are inadequate ☐ N/A Remarks:
D. General
1. **Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident Remarks:
2. **Land use changes on site** ☐ N/A Remarks: No changes.
3. **Land use changes off site** ☐ N/A Remarks: No changes.
VI. GENERAL SITE CONDITIONS
A. Roads ☐ Applicable ☒ N/A
VII. LANDFILL COVERS ☐ Applicable ☒ N/A
VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES ☒ Applicable ☐ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☒ N/A
B. Surface Water Collection Structures, Pumps, and Pipelines ☒ Applicable ☐ N/A
1. **Collection Structures, Pumps, and Electrical** ☒ Good condition ☐ Needs Maintenance Remarks:____
2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☒ Good condition ☐ Needs Maintenance Remarks:____
3. **Spare Parts and Equipment** ☐ Readily available ☒ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks:____
C. Treatment System ☐ Applicable ☒ N/A
D. Monitoring Data
1. Monitoring Data N/A ☐ Is routinely submitted on time ☐ Is of acceptable quality
2. Monitoring data suggests: ☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining
D. Monitored Natural Attenuation
1. **Monitoring Wells** (natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☒ N/A Remarks:____
X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

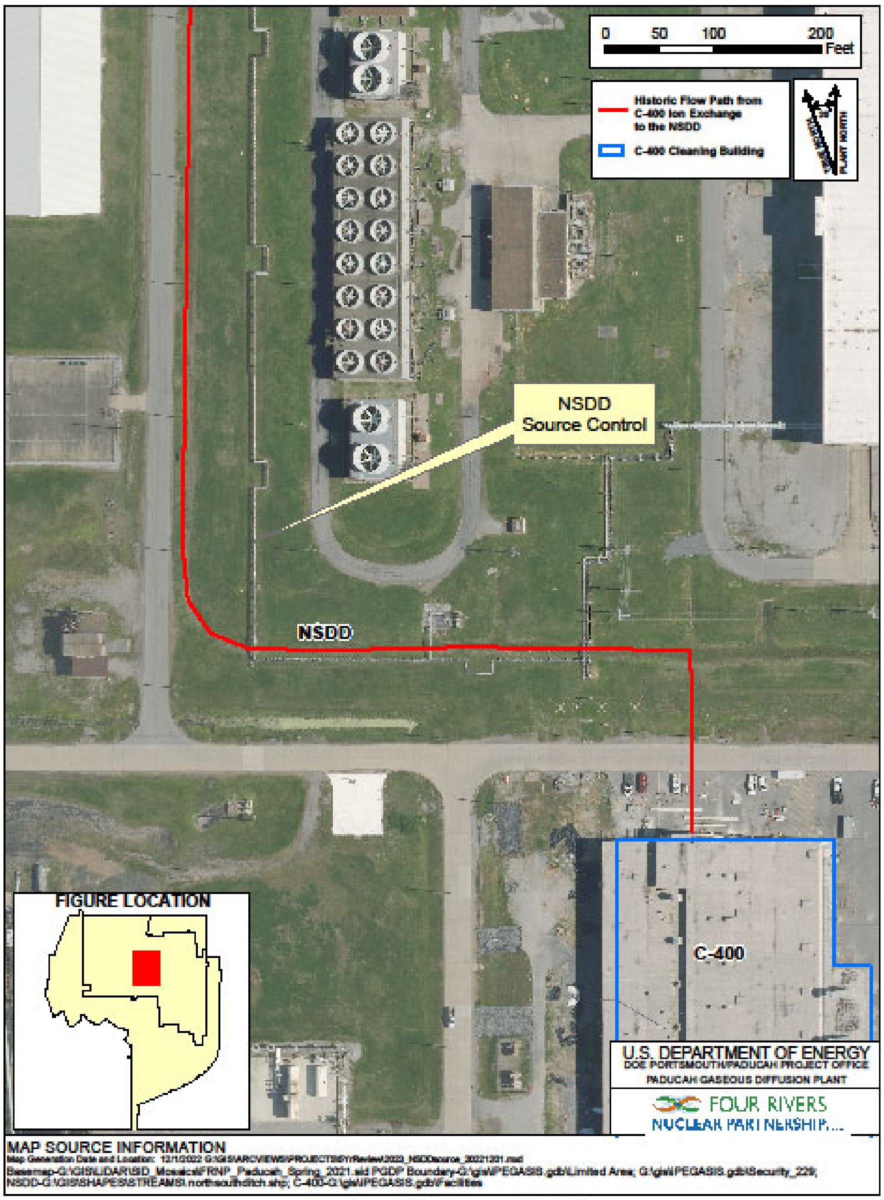
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). The principal goals of the interim action were to: mitigate the introductive of contaminants into the NSDD; decrease the migration of contaminants already present in the NSDD; and decrease the potential for direct contact with the contaminated material. These goals were accomplished by installing an ion exchange system in the C-400 Cleaning Building, rerouting effluent from C-400 to Outfall 008, constructing aboveground piping and lift stations to an existing lift station, installing settling lagoons for the fly ash, installing a gabion sediment trap, and installing warning signs.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. There was no excessive debris over the gabion screens. The aboveground piping was in good condition, the insulation was intact, and the metal jacket covering was not rusted or deteriorated. The lift stations appear to be functioning properly. See Section 11.3.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. None.

ATTACHMENT

Inspection team roster (12/8/2022):

Jennifer Johnson (ETAS)
Teresa Overby (FRNP)
Barry Kinsall (FRNP)
Megan Mulry (FRNP)
Chris Travis (KDEP)
Brian Lainhart (KDEP)

Site map:



Location of NSDD Source Control

ATTACHMENT

Five-Year Review Site Inspection Checklist
Northwest Plume Groundwater System

<table>
<tr><th colspan="2">I. SITE INFORMATION</th></tr>
<tr><td>Site name: Northwest Plume Groundwater System</td><td>Date of inspection: 12/5/2022</td></tr>
<tr><td>Location and Region: Paducah, Kentucky</td><td>EPA ID:KY8890008982</td></tr>
<tr><td>Agency, office, or company leading the five-year review: U.S. Department of Energy</td><td>Weather/temperature: Overcast/42–45ºF</td></tr>
<tr><td colspan="2">Remedy Includes: (Check all that apply)
☐ Landfill cover/containment
X Access controls
☐ Institutional controls
X Groundwater pump and treatment
☐ Surface water collection and treatment
☐ Other____________
☐ Monitored natural attenuation
☐ Groundwater containment
☐ Vertical barrier walls</td></tr>
<tr><td colspan="2">Attachments: X Inspection team roster attached X Site map attached</td></tr>
<tr><th colspan="2">II. INTERVIEWS (Check all that apply)</th></tr>
<tr><td colspan="2">1. O&M site manager <u>David Veach</u> (Name) <u>WPGS Manager</u> (Title) <u>12/5/2022</u> (Date)
Interviewed X at site ☐ at office ☐ by phone Phone no. ______
Problems, suggestions; ☐ Report attached ______
<u>Northwest Plume Groundwater System is operating (as planned), with no anticipated problems forthcoming.</u></td></tr>
<tr><td colspan="2">2. O&M staff <u>N/A</u> (Name) ______ (Title) ______ (Date)
Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ______
Problems, suggestions; ☐ Report attached ______
______</td></tr>
</table>

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency Kentucky Department for Environmental Protection____________________________ Contact Christopher Travis____________ _Environmental Scientist _12/5/2022 (502) 782-5897 Name Title Date Phone no. Problems; suggestions; ☐ Report attached None.___________________________________ Agency ____________________________ Contact ____________________________ ________________ ________ ___________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ Agency ____________________________ Contact ____________________________ ________________ ________ ___________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ Agency ____________________________ Contact ____________________________ ________________ ________ ___________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____
4.	**Other interviews** (optional) ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1. **O&M Documents**				
X O&M manual (November 2020)	X Readily available	X Up to date	☐ N/A	
X As-built drawings	X Readily available	X Up to date	☐ N/A	
X Maintenance logs	X Readily available	X Up to date	☐ N/A	
Remarks: _Required and preventive maintenance activities are scheduled and reported in SOMAX. O&M manual is available electronically in the facility S: Drive.				
2. **Site-Specific Health and Safety Plan**	X Readily available	X Up to date	☐ N/A	
X Contingency plan/emergency response plan	X Readily available	X Up to date	☐ N/A	
Remarks: JHA-10844 R10/ Health and Safety (H&S) Plan: CP2-ER-0067/FR2B emergency response is addressed in the H&S Plan.				
3. **O&M and OSHA Training Records**	X Readily available	☐ Up to date	☐ N/A	
Remarks: Site training records are maintained electronically.				

ATTACHMENT

4.	**Permits and Service Agreements**				
	☐ Air discharge permit	☐ Readily available	☐ Up to date	☐ N/A	
	☐ Effluent discharge	☐ Readily available	☐ Up to date	☐ N/A	
	☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	☐ N/A	
	☐ Other permits______________________	☐ Readily available	☐ Up to date	☐ N/A	
	Remarks: Effluent monitored by KPDES permit (Outfall 001). Site waste management program addresses waste. Carbon vessel change out occurs every 6 months.				
5.	**Gas Generation Records**	☐ Readily available	☐ Up to date	X N/A	
	Remarks: ______________________				
6.	**Settlement Monument Records**	☐ Readily available	☐ Up to date	X N/A	
	Remarks: ______________________				
7.	**Groundwater Monitoring Records**	X Readily available	X Up to date	☐ N/A	
	Remarks: Available to public through PEGASIS data retrieval system. Reported in semi-annual Federal Facility Agreement reports.				
8.	**Leachate Extraction Records**	☐ Readily available	☐ Up to date	X N/A	
	Remarks: ______________________				
9.	**Discharge Compliance Records**				
	☐ Air	☐ Readily available	☐ Up to date	☐ N/A	
	X Water (effluent)	X Readily available	X Up to date	☐ N/A	
	Remarks: Available to public through PEGASIS data retrieval system. Included in semi-annual Federal Facility Agreement reports.				
10.	**Daily Access/Security Logs**	☐ Readily available	☐ Up to date	X N/A	
	Remarks: ______________________				

IV. O&M COSTS
1. **O&M Organization** ☐ State in-house ☐ Contractor for State ☐ PRP in-house ☐ Contractor for PRP ☐ Federal Facility in-house X Contractor for Federal Facility ☐ Other
2. **O&M Cost Records** X Readily available X Up to date: Revisited semi-annually (FFA semi-annual reports) X Funding mechanism/agreement in place Original O&M cost estimate $240K/year for NE Plume P&T ☐ Breakdown attached Total annual cost by year for review period if available From 10/1/17 (Date) To 9/30/18 (Date) $799,000 for NE and NW P&T Systems (Total cost) ☐ Breakdown attached From 10/1/18 (Date) To 9/30/19 (Date) $1,187,000 for NE and NW P&T Systems (Total cost) ☐ Breakdown attached From 10/1/19 (Date) To 9/30/20 (Date) $810,000 for NE and NW P&T Systems (Total cost) ☐ Breakdown attached From 10/1/20 (Date) To 9/30/21 (Date) $830,000 for NE and NW P&T Systems (Total cost) ☐ Breakdown attached From 10/1/21 (Date) To 9/30/22 (Date) $1,451,000 for NE and NW P&T Systems (Total cost) ☐ Breakdown attached
3. **Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: Higher O&M costs during 2019 and 2022 (see above) primarily resulted from maintenance and repair actions related to a greater number of days of extraction well pump down time for the Northeast Plume Containment System during those years (94 days of pump down time in 2019 and 128 days of pump down time in 2022). The Northwest Plume Groundwater System also experienced a significant period of extraction well pump down time in 2022 (61 days).
V. ACCESS AND INSTITUTIONAL CONTROLS ☐ Applicable ☐ N/A
A. Fencing
1. **Fencing damaged** ☐ Location shown on site map X Gates secured ☐ N/A Remarks: Treatment system is enclosed by security fence. The fence is in good condition.
B. Other Access Restrictions
1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A Remarks: Monitoring wells and standby extraction wells are secured by locks.

ATTACHMENT

C. Institutional Controls (ICs) N/A
1. **Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes ☐ No X N/A Site conditions imply ICs not being fully enforced ☐ Yes ☐ No X N/A Type of monitoring (e.g., self-reporting, drive by) ______ Frequency ______ Responsible party/agency ______ Contact ______ ______ ______ ______ Name Title Date Phone no. Reporting is up-to-date ☐ Yes ☐ No X N/A Reports are verified by the lead agency ☐ Yes ☐ No X N/A Specific requirements in deed or decision documents have been met ☐ Yes ☐ No X N/A Violations have been reported ☐ Yes ☐ No X N/A Other problems or suggestions: ☐ Report attached ______
2. **Adequacy** ☐ ICs are adequate ☐ ICs are inadequate X N/A Remarks: ______
D. General
1. **Vandalism/trespassing** ☐ Location shown on site map X No vandalism evident Remarks: ______
2. **Land use changes on site** X N/A Remarks: ______
3. **Land use changes off site** X N/A Remarks: ______
VI. GENERAL SITE CONDITIONS
A. Roads X Applicable ☐ N/A
1. **Roads damaged** ☐ Location shown on site map ☐ Roads adequate☐ N/A Remarks: Roads are in good condition.
B. Other Site Conditions
Remarks: Treatment facility and extraction well vaults are well ordered and labeled. The grounds are well maintained.
VII. LANDFILL COVERS ☐ Applicable X N/A
VIII. VERTICAL BARRIER WALLS ☐ Applicable X N/A
IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps, and Pipelines X Applicable ☐ N/A	
1.	**Pumps, Wellhead Plumbing, and Electrical** X Good condition X All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks:
2.	**Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** X Good condition☐ Needs Maintenance Remarks: Two operating extraction wells. Two extraction wells on standby.
3.	**Spare Parts and Equipment** X Readily available X Good condition☐ Requires upgrade ☐ Needs to be provided Remarks: There have been supply-chain issues for some critical parts, which affected the reporting period.
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable X N/A	
C. Treatment System X Applicable ☐ N/A	
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation X Air stripping X Carbon adsorbers X Filters (2) sand filters at beginning of treatment train. ☐ Additive (e.g., chelation agent, flocculent) X Others ion exchange – (4) tanks. X Good condition ☐ Needs Maintenance X Sampling ports properly marked and functional X Sampling/maintenance log displayed and up to date (available through SOMAX) X Equipment properly identified X Quantity of groundwater treated annually Treated 97,552,716 gal 10/1/21–9/30/22 ☐ Quantity of surface water treated annually Remarks:
2.	**Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A X Good condition ☐ Needs Maintenance Remarks:
3.	**Tanks, Vaults, Storage Vessels** ☐ N/A X Good condition X Proper secondary containment ☐ Needs Maintenance Remarks: Treatment system contains tanks. Extraction wells are housed in vaults.
4.	**Discharge Structure and Appurtenances** ☐ N/A X Good condition☐ Needs Maintenance Remarks: Beaver dams downstream of discharge are removed as necessary.
5.	**Treatment Building(s)** ☐ N/A X Good condition (esp. roof and doorways) ☐ Needs repair X Chemicals and equipment properly stored. Remarks:

ATTACHMENT

6. **Monitoring Wells** (pump and treatment remedy)
X Properly secured/locked X Functioning X Routinely sampled X Good condition
X All required wells located ☐ Needs Maintenance ☐ N/A
Remarks: ____________________

D. Monitoring Data

1. Monitoring Data
X Is routinely submitted on time X Is of acceptable quality

2. Monitoring data suggests:
☐ Groundwater plume is effectively contained X Contaminant concentrations are declining (distal extent)

D. Monitored Natural Attenuation NA

1. **Monitoring Wells** (natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance X N/A
Remarks: ____________________

X. OTHER REMEDIES N/A

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).
The Northwest Plume IRA is intended to initiate control of the high-concentration zones of TCE and Tc-99 in the Northwest Plume. Monitoring data indicate off-site contaminant levels; the extent of the main plume is declining.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

O&M of the Northwest Plume Containment System is addressed by both plans and procedures, which are regularly reviewed and updated as needed. The site's commitment to periodic and timely attention to O&M ensures that the action is, and will remain, protective.

C.	Early Indicators of Potential Remedy Problems
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. With the exception of one significant pump failure for the Northwest Plume IRA during the review period (in EW232 8/4/2022 through 10/4/2022), the operation has required only minimal, unscheduled maintenance. The one significant pump failure was due to a lightning strike and doesn't portend a future compromise of the protectiveness of the remedy. Supply-chain issues related to the COVID-19 pandemic significantly extended the down time. Steps to improve on-site storage of backup equipment have been instigated to address supply-chain issues.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. The location of extraction and monitoring wells were optimized in 2010. A recent review of contaminant trends in the area of the extraction wells (*Assessment of Northwest Plume Capture at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0274) indicates the Northwest Plume IRA is meeting its design goals and no adjustments are required. The site reassesses the extent and concentrations of groundwater plumes on a 2-year basis to identify any emerging issues. Groundwater monitoring frequencies are re-evaluated each year and adjusted, as needed, to assess contaminant trends.

ATTACHMENT

Inspection team roster (12/5/2022)

Kenneth Davis (FRNP)	David Veach (FRNP)
Megan Mulry(FRNP)	Jennifer Johnson (ETAS)
Justin Riley (FRNP)	Chris Travis (KDEP)

Site Map:

MAP SOURCE INFORMATION
Map Generation Date and Location: G:\GIS\ARCVIEWS\PROJECTS\5YrReview\2022_5YR_NWPlumeEWField_inspectionR1.mxd 5/17/2023
Locations-- G:\GIS\iPEGASIS.gdb\Locations (Query: STA_NAME IN ('EW232','EW233','EW230','EW231'))
Facilities (Facilities Shown), DOE Boundary, Roadrow, Streams-- G:\GIS\iPEGASIS.gdb\Facilities, ...\doebnd, ...\roadrow, ...\streams
Aerial Image-- G:\GIS\LiDAR\SID_Mosaics\FRNP_Paducah_Spring_2021.sid

Five-Year Review Site Inspection Checklist
Southwest Plume—Oil Landfarm

I. SITE INFORMATION	
Site name: Southwest Plume, SWMU 1—Oil Landfarm, Soil Mixing	**Date of inspection:** 12/07/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy (DOE)	**Weather/temperature:** Overcast, 54°F, 4 mph winds, Intermittent Drizzle
Remedy Includes: (Check all that apply) □ Landfill cover/containment □ Monitored natural attenuation □ Access controls □ Groundwater containment □ Institutional controls □ Vertical barrier walls □ Groundwater pump and treatment □ Surface water collection and treatment ☒ Other Soil Mixing with Zero-Valent Iron Remedial Action Area and Interim Landuse Controls—Remedial Action completed in 2016.	
Attachments: ☒ Inspection team roster attached ☒ Site map attached	
II. INTERVIEWS (Check all that apply)	
1. **O&M site manager** Clint Dietsch/Bryan Clayton (Name) Facility Manager/Project Manager (Title) 12/7/2022 (Date) Interviewed ☒ at site □ at office □ by phone no. 270-441-5254/270-441-5412 Problems, suggestions; □ Report attached No problems or suggestions identified.	
2. **O&M staff** N/A ______ (Name) (Title) (Date) Interviewed □ at site □ at office □ by phone Phone no. ______ Problems, suggestions; □ Report attached ______	

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency Kentucky Department for Environmental Protection Contact Christopher Travis ________ Environmental Scientist 12/7/2022 (502) 782-5897 Name Title Date Phone no. Problems; suggestions; □ Report attached No problems or suggestions identified during 12-7-2022 inspection ____________________ Agency ____________ Contact ____________ ________ ____ ______ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________ ____________________ Agency ____________ Contact ____________ ________ ____ ______ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________ ____________________ Agency ____________ Contact ____________ ________ ____ ______ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________ ____________________
4.	**Other interviews** (optional) □ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	□ O&M manual	□ Readily available	□ Up to date	☒ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits__________	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
7.	**Groundwater Monitoring Records**	☒ Readily available	□ Up to date	□ N/A
	Remarks: Groundwater monitoring results available electronically in PGDP Environmental Information System__________			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			

IV. O&M COSTS
1. **O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility ☒ Other No active operation and maintenance specifically required for SWMU 1 since remediation is passive once the soil mixing was completed in 2016. ____________________
2. **O&M Cost Records** *Refer to Sect. 14.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate____________________ □ Breakdown attached Total annual cost by year for review period if available From__________ To__________ ____________________ □ Breakdown attached Date Date Total cost From__________ To__________ ____________________ □ Breakdown attached Date Date Total cost From__________ To__________ ____________________ □ Breakdown attached Date Date Total cost From__________ To__________ ____________________ □ Breakdown attached Date Date Total cost From__________ To__________ ____________________ □ Breakdown attached Date Date Total cost
3. **Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: ____________________ ____________________
V. ACCESS AND INSTITUTIONAL CONTROLS □ Applicable ☒ N/A
A. Fencing
1. **Fencing damaged** □ Location shown on site map □ Gates secured ☒ N/A ____________________ ____________________
B. Other Access Restrictions
1. **Signs and other security measures** ☒ Location shown on site map □ N/A Remarks: Warning signs were present at the entrance to the SWMU 1.

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented	□ Yes	☒ No	□ N/A
Site conditions imply ICs not being fully enforced	□ Yes	☒ No	□ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) ______________________
Frequency ______________________
Responsible party/agency ______________________
Contact ______________ ______________ ________ ________
Name Title Date Phone no.

Reporting is up-to-date	□ Yes	□ No	☒ N/A
Reports are verified by the lead agency	□ Yes	□ No	☒ N/A
Specific requirements in deed or decision documents have been met	□ Yes	□ No	☒ N/A
Violations have been reported	□ Yes	□ No	☒ N/A

Other problems or suggestions: □ Report attached

2. **Adequacy** ☒ ICs are adequate □ ICs are inadequate □ N/A
Remarks: Land use controls required by the ROD include warning signs and implementation of DOE's Excavation/Penetration Permit Program

D. General

1. **Vandalism/trespassing** □ Location shown on site map ☒ No vandalism evident
Remarks:

2. **Land use changes on site** □ N/A
Remarks: SWMU 1 is located adjacent to the C-745-A Cylinder Storage Yard on the north. SWMU 1 is bound on the south and west by active railroad tracks. No land use changes identified.

3. **Land use changes off site** ☒ N/A
Remarks:

VI. GENERAL SITE CONDITIONS

A. Roads ☒ Applicable □ N/A

1. **Roads damaged** ☒ Location shown on site map ☒ Roads adequate □ N/A
Remarks: Roads are present and adequate to allow sampling vehicles to approach monitoring wells as needed.

B. Other Site Conditions

Remarks: Soil Mixing treatment area is not distinguishable from remaining area of SWMU 1 by observation. The SWMU is grass covered with a gravel road passing through it. To the north is the C-745-A Cylinder yard. To the south and west are active railroads and grass covered areas.

VII. LANDFILL COVERS □ Applicable ☒ N/A

VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A	
IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☒ N/A	
X. OTHER REMEDIES	
	If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction. See Attachment
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). SWMU 1 remedial action was the implementation of soil mixing technology followed by placement of zero-valent iron in the mixed soil to depths of approximately 60' below ground surface. All remedial activities were performed in the subsurface. Therefore, no visible observations are possible. Monitoring wells drilled following the remedial action are present and show no maintenance issues.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. SWMU 1 Soil Mixing and Zero-Valent Iron does not have ongoing active operation and maintenance activities. Only longterm monitoring through monitoring wells is occurring.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. No indicators of potential remedy problems were identified during this 2023 Five-Year Review inspection.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. No optimization opportunities were identified during this Five Year Review inspection.

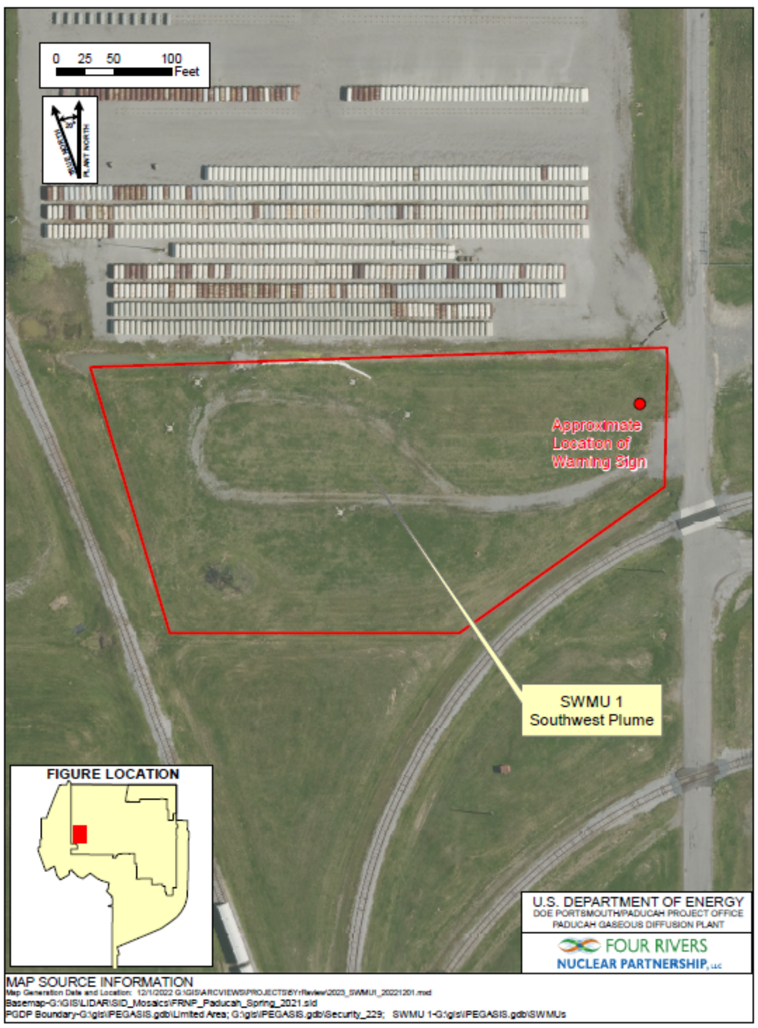
ATTACHMENT

<u>Section X - Other Remedies</u>:
SWMU 1—Oil Landfarm Remedy—Soil Mixing with Zero-Valent Iron Placement with Interim LUCs: The SWMU 1 treatment area at the time of inspection (12/7/2022) was grass covered with a gravel road passing through the SWMU 1. The actual area that was soil mixed was not visibly present at the time of the inspection and could not be differentiated from unmixed areas of the SWMU. Field implementation was completed in 2016. The SWMU 1 area appeared well kept with no tall grass, water holes, or untreated erosion visible. All treatment was performed on subsurface soils and visual inspection from the surface is not feasible. The interim LUCs for SWMU 1 consist of the PGDP site's excavation-penetration permit program and placement of warning signs. Interim LUCs were active during the five-year inspection which included the presence of warning signs.

<u>Inspection team roster (12/7/2022)</u>:

Clinton Dietsch (FRNP)
Teresa Overby (FRNP)
Jennifer Johnson (ETAS)
Megan Mulry (FRNP)
Bryan Clayton (FRNP)
Chris Travis (KDEP)
Barry Kinsall (FRNP)

Site map:



THIS PAGE INTENTIONALLY LEFT BLANK

Five-Year Review Site Inspection Checklist
Southwest Plume—C-720 Building TCE
211-A (Northeast) and 211-B (Southeast) Spill Sites

I. SITE INFORMATION	
Site name: SW Plume SWMUs 211A and 211B	**Date of inspection:** 12/7/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:**
Remedy Includes: (Check all that apply) ☐ Landfill cover/containment ☐ Monitored natural attenuation ☐ Access controls ☐ Groundwater containment ☐ Institutional controls ☐ Vertical barrier walls ☐ Groundwater pump and treatment ☐ Surface water collection and treatment X Other – SWMU 211-A during 2022 underwent the implementation of an enhanced in-situ bioremediation remedial action with interim landuse controls. SWMU 211-B remedial action was not selected or implemented as determined by the FFA parties in 2020, but was rescheduled to be further evaluated as part of the overall evaluation of the C-720 Building in the future.	
Attachments: X Inspection team roster attached X Site map attached	
II. INTERVIEWS (Check all that apply)	
1. **O&M site manager** Bryan Clayton (Name) Project Manager (Title) 12/7/2022 (Date) Interviewed X☐ at site ☐ at office ☐ by phone no. ______________ Problems, suggestions; ☐ Report attached __No problems or suggestions identified during the inspection.__	
2. **O&M staff** N/A ______________________ Name Title Date Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ______________ Problems, suggestions; ☐ Report attached ______________________	

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency Kentucky Department for Environmental Protection________ Contact Christopher Travis____________ Environmental Scientist 12/7/2022 __(502) 782-5897 Name Title Date Phone no. Problems; suggestions; ☐ Report attached __No problems or suggestions identified during 12/7/2023 inspection________________________________ Agency ______________________________ Contact ______________________________ ___________________ ________ _____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ___________________ ________ _____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ___________________ ________ _____________ Name Title Date Phone no. Problems; suggestions; ☐ Report attached ____ ____
4.	**Other interviews** (optional) ☐ Report attached.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1. **O&M Documents**				
☐ O&M manual	☐ Readily available	☐ Up to date	X N/A	
☐ As-built drawings	☐ Readily available	☐ Up to date	X N/A	
☐ Maintenance logs	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
2. **Site-Specific Health and Safety Plan**	☐ Readily available	☐ Up to date	X N/A	
☐ Contingency plan/emergency response plan	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
3. **O&M and OSHA Training Records**	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
4. **Permits and Service Agreements**				
☐ Air discharge permit	☐ Readily available	☐ Up to date	X N/A	
☐ Effluent discharge	☐ Readily available	☐ Up to date	X N/A	
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	X N/A	
☐ Other permits____________________	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
5. **Gas Generation Records**	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
6. **Settlement Monument Records**	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
7. **Groundwater Monitoring Records**	**X** Readily available	☐ Up to date	☐ N/A	
Remarks: Groundwater monitoring results available electronically in PGDP Environmental Information system				
8. **Leachate Extraction Records**	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
9. **Discharge Compliance Records**				
☐ Air	☐ Readily available	☐ Up to date	X N/A	
☐ Water (effluent)	☐ Readily available	☐ Up to date	X N/A	
Remarks:				
10. **Daily Access/Security Logs**	☐ Readily available	☐ Up to date	X N/A	
Remarks:				

IV. O&M COSTS

1. **O&M Organization**
☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house X Contractor for Federal Facility
☐ Other__No active operation and maintenance specifically required for SWMU 211-A since remediation is passive once the enhanced *in situ* bioremediation system has been installed in the subsurface and which was completed in 2022. Long-term and performance well monitoring are the only activities that are scheduled in the project's specific remedial action work plan to support the remedial action. SWMU 211-B has no remedial action performed on it. Further SWMU 211-B evaluation will be performed along with evaluation of the C-720 Building in the future.

2. **O&M Cost Records** *Refer to Section 14.3 of the Report.*
☐ Readily available ☐ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate____________________ ☐ Breakdown attached

Total annual cost by year for review period if available

From__________ To__________ ____________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ ____________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ ____________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ ____________________ ☐ Breakdown attached
Date Date Total cost
From__________ To__________ ____________________ ☐ Breakdown attached
Date Date Total cost

3. **Unanticipated or Unusually High O&M Costs During Review Period**
Describe costs and reasons: ____

V. ACCESS AND INSTITUTIONAL CONTROLS ☐ Applicable X N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured X N/A
Remarks:____

B. Other Access Restrictions

1. **Signs and other security measures** X Location shown on site map ☐ N/A
Remarks: Warning signs were present at the entrances to SWMU 211-A and SWMU 211-B.

C. Institutional Controls (ICs)	
1.	**Implementation and enforcement** Site conditions imply ICs not properly implemented ☐ Yes X No ☐ N/A Site conditions imply ICs not being fully enforced ☐ Yes X No ☐ N/A Type of monitoring (*e.g.*, self-reporting, drive by) ____ Frequency ____ Responsible party/agency ____ Contact ____ ____ ____ ____ Name Title Date Phone no. Reporting is up-to-date ☐ Yes ☐ No X N/A Reports are verified by the lead agency ☐ Yes ☐ No X N/A Specific requirements in deed or decision documents have been met ☐ Yes ☐ No X N/A Violations have been reported ☐ Yes ☐ No X N/A Other problems or suggestions: ☐ Report attached
2.	**Adequacy** X ICs are adequate ☐ ICs are inadequate ☐ N/A Remarks: ____
D. General	
1.	**Vandalism/trespassing** ☐ Location shown on site map X No vandalism evident Remarks: ____
2.	**Land use changes on site** ☐ N/A Remarks: SWMU 211-A is located northeast of the northeast corner of the C-720 Building; while SWMU 211-B is located at the southeast corner of the C-720 Building.
3.	**Land use changes off site X** N/A Remarks: ____
VI. GENERAL SITE CONDITIONS	
A. Roads X Applicable ☐ N/A	
1.	**Roads damaged** ☐ Location shown on site map X Roads adequate ☐ N/A Remarks: Both SWMU 211-A and SWMU 211-B are partially covered by concrete pavement with sufficient space to allow access for sampling crews.

B. Other Site Conditions

Remarks: SWMU 211-A is bound on the north by a grassy area and the C-724 Motor Cleaning Facility, on the east by 8th street and the west by a paved area associated with C-720- Building. C-720 is located to the south of SWMU 211-A.
SWMU 211-B is bound on the east by 8th street, the south by a grassy area and on the west by the paved area south of the C-720 building. The C-720 Building lies north and adjacent to the SWMU 211-B area.

VII. LANDFILL COVERS ☐ Applicable X N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident
Areal extent______________ Depth____________
Remarks:____

2. **Cracks** ☐ Location shown on site map ☐ Cracking not evident
Lengths____________ Widths___________ Depths__________
Remarks:____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
Areal extent______________ Depth____________
Remarks:____

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
Areal extent______________ Depth____________
Remarks:____

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress
☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks:____

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
Remarks:____

7. **Bulges** ☐ Location shown on site map ☐ Bulges not evident
Areal extent______________ Height____________
Remarks:____

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent______________
☐ Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks:____

9.	**Slope Instability** ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability Areal extent______________ Remarks:____ ____			
B. Benches	☐ Applicable ☐ N/A (Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)			
1.	**Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay Remarks:____ ____			
2.	**Bench Breached** ☐ Location shown on site map ☐ N/A or okay Remarks:____ ____			
3.	**Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay Remarks:____ ____			
C. Letdown Channels	☐ Applicable ☐ N/A (Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)			
1.	**Settlement** ☐ Location shown on site map ☐ No evidence of settlement Areal extent______________ Depth____________ Remarks:____ ____			
2.	**Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation Material type_______________ Areal extent_____________ Remarks:____ ____			
3.	**Erosion** ☐ Location shown on site map ☐ No evidence of erosion Areal extent______________ Depth____________ Remarks:____ ____			

4. **Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting
Areal extent______________ Depth____________
Remarks:____
____

5. **Obstructions** Type_____________________ ☐ No obstructions
☐ Location shown on site map Areal extent______________
Size____________
Remarks:____
____

6. **Excessive Vegetative Growth** Type____________________
☐ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on site map Areal extent______________
Remarks:____
____

D. Cover Penetrations ☐ Applicable ☐ N/A

1. **Gas Vents** ☐ Active ☐ Passive
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks:____
____

2. **Gas Monitoring Probes**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks:____
____

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks:____
____

4. **Leachate Extraction Wells**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks:____
____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A
Remarks:____
____

E. **Gas Collection and Treatment** ☐ Applicable ☐ N/A
1. **Gas Treatment Facilities** ☐ Flaring ☐ Thermal destruction ☐ Collection for reuse ☐ Good condition ☐ Needs Maintenance Remarks:______________________________
2. **Gas Collection Wells, Manifolds and Piping** ☐ Good condition ☐ Needs Maintenance Remarks:______________________________
3. **Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings) ☐ Good condition ☐ Needs Maintenance ☐ N/A Remarks:______________________________
F. Cover Drainage Layer ☐ Applicable ☐ N/A
1. **Outlet Pipes Inspected** ☐ Functioning ☐ N/A Remarks:______________________________
2. **Outlet Rock Inspected** ☐ Functioning ☐ N/A Remarks:______________________________
G. Detention/Sedimentation Ponds ☐ Applicable ☐ N/A
1. **Siltation** Areal extent______________ Depth____________ ☐ N/A ☐ Siltation not evident Remarks:______________________________
2. **Erosion** Areal extent______________ Depth____________ ☐ Erosion not evident Remarks:______________________________
3. **Outlet Works** ☐ Functioning ☐ N/A Remarks:______________________________
4. **Dam** ☐ Functioning ☐ N/A Remarks:______________________________

H. Retaining Walls ☐ Applicable ☐ N/A	
1.	**Deformations** ☐ Location shown on site map ☐ Deformation not evident Horizontal displacement____________ Vertical displacement_______________ Rotational displacement____________ Remarks:____
2.	**Degradation** ☐ Location shown on site map ☐ Degradation not evident Remarks:____
I. Perimeter Ditches/Off-Site Discharge ☐ Applicable ☐ N/A	
1.	**Siltation** ☐ Location shown on site map ☐ Siltation not evident Areal extent______________ Depth____________ Remarks:____
2.	**Vegetative Growth** ☐ Location shown on site map ☐ N/A ☐ Vegetation does not impede flow Areal extent______________ Type____________ Remarks:____
3.	**Erosion** ☐ Location shown on site map ☐ Erosion not evident Areal extent______________ Depth____________ Remarks:____
4.	**Discharge Structure** ☐ Functioning ☐ N/A Remarks:____
VIII. VERTICAL BARRIER WALLS ☐ Applicable X☐ N/A	
1.	**Settlement** ☐ Location shown on site map ☐ Settlement not evident Areal extent______________ Depth____________ Remarks:____
2.	**Performance Monitoring** Type of monitoring__________________________ ☐ Performance not monitored Frequency_______________________________ ☐ Evidence of breaching Head differential__________________________ Remarks:____

IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable X N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☐ Good condition☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A Remarks:______
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☐ Good condition☐ Needs Maintenance Remarks:______
3. **Spare Parts and Equipment** ☐ Readily available ☐ Good condition☐ Requires upgrade ☐ Needs to be provided Remarks:______
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ☐ N/A
1. **Collection Structures, Pumps, and Electrical** ☐ Good condition☐ Needs Maintenance Remarks:______
2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☐ Good condition☐ Needs Maintenance Remarks:______
3. **Spare Parts and Equipment** ☐ Readily available ☐ Good condition☐ Requires upgrade ☐ Needs to be provided Remarks:______

C. Treatment System	☐ Applicable ☐ N/A
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☐ Carbon adsorbers ☐ Filters__________ ☐ Additive (*e.g.*, chelation agent, flocculent)__________ ☐ Others__________ ☐ Good condition ☐ Needs Maintenance ☐ Sampling ports properly marked and functional ☐ Sampling/maintenance log displayed and up to date ☐ Equipment properly identified ☐ Quantity of groundwater treated annually__________ ☐ Quantity of surface water treated annually__________ Remarks:__________
2.	**Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☐ Good condition☐ Needs Maintenance Remarks:__________
3.	**Tanks, Vaults, Storage Vessels** ☐ N/A ☐ Good condition☐ Proper secondary containment ☐ Needs Maintenance Remarks:__________
4.	**Discharge Structure and Appurtenances** ☐ N/A ☐ Good condition☐ Needs Maintenance Remarks:__________
5.	**Treatment Building(s)** ☐ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks:__________
6.	**Monitoring Wells** (pump and treatment remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☐ N/A Remarks:__________
D. Monitoring Data	
1.	Monitoring Data ☐ Is routinely submitted on time ☐ Is of acceptable quality
2.	Monitoring data suggests: ☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining

D. Monitored Natural Attenuation	
1.	**Monitoring Wells** (natural attenuation remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☐ N/A Remarks:____ ____

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction. *See Attachment.*

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission).
SWMU 211-A Enhanced *In Situ* Bioremediation remedial action was implemented during the latter part of 2022. The bioremediation was supplemented with in-situ fracturing using zero-valent iron as a fracture proppant and to further treat the TCE contamination. The entire remedy system is passive and occurs in the subsurface and therefore visual observations of the remediation occurring are not feasible. Performance monitoring wells and long-term monitoring wells were installed to provide periodic groundwater samples to temporally evaluate the presence of bioremediation characteristics. Only the 1st quarter's monitoring wells samples were completed prior to the end of the five-year period (December 2022). Currently the monitoring systems are showing no issues.

SWMU 211-B remedial action was not selected or implemented as determined by the FFA parties. In 2020, SWMU 211-B was rescheduled to be further evaluated as part of the overall evaluation of the C-720 Building in the future.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

SWMU 211-A Enhanced *In Situ* Bioremediation is passive and therefore does not require ongoing operation and maintenance activities. Any additional bioremedial maintenance activities will be identified utilizing the performance and long-term monitoring data trends. Since the implementation of the remedial action was completed in late 2022, the collection of monitoring data is just beginning and trends have not been developed.

C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. No indicators of potential remedy problems were identified during this 2023 five year review inspection.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. No indicators of potential remedy optimizations were identified during this 2023 five year review inspection.

Attachment

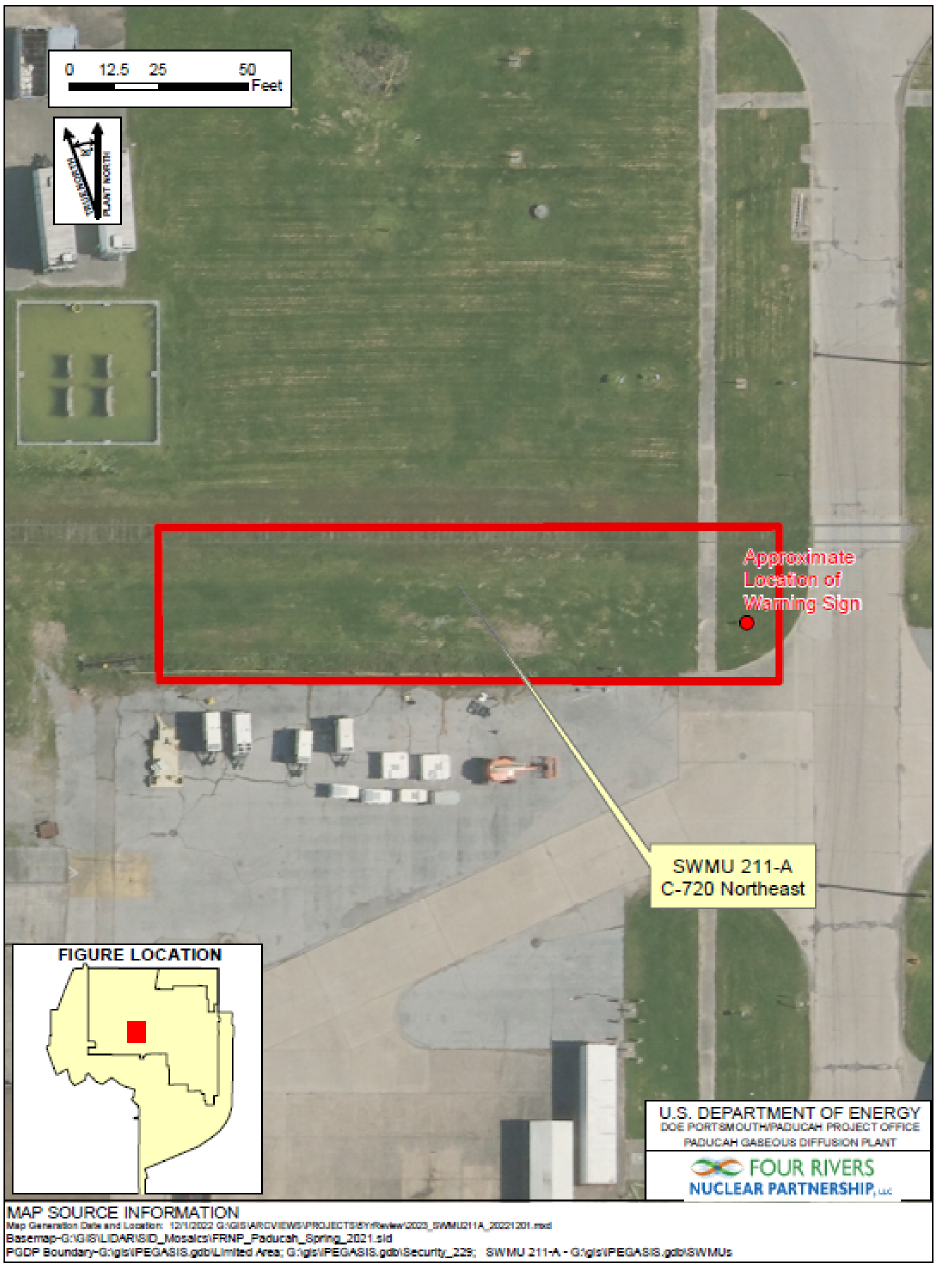
SWMU 211-A Enhanced *In Situ* Biormediation remedial action was implemented during the latter part of 2022. The bioremediation was supplemented with in-situ fracturing using zero-valent iron as a fracture proppant and to further treat the TCE contamination. The entire remedy system is passive and occurs in the subsurface and therefore visual observations of the remediation occurring are not feasible. Performance monitoring wells and long-term monitoring wells were installed to provide periodic groundwater samples to temporally evaluate the presence of bioremediation characteristics. Only the 1st quarter's monitoring wells samples were completed prior to the end of the five-year period (December 2022). Currently the monitoring systems are showing no maintenance issues.

SWMU 211-B remedial action was not selected or implemented as determined by the FFA parties. In 2020, SWMU 211-B was rescheduled to be further evaluated as part of the overall evaluation of the C-720 Building in the future.

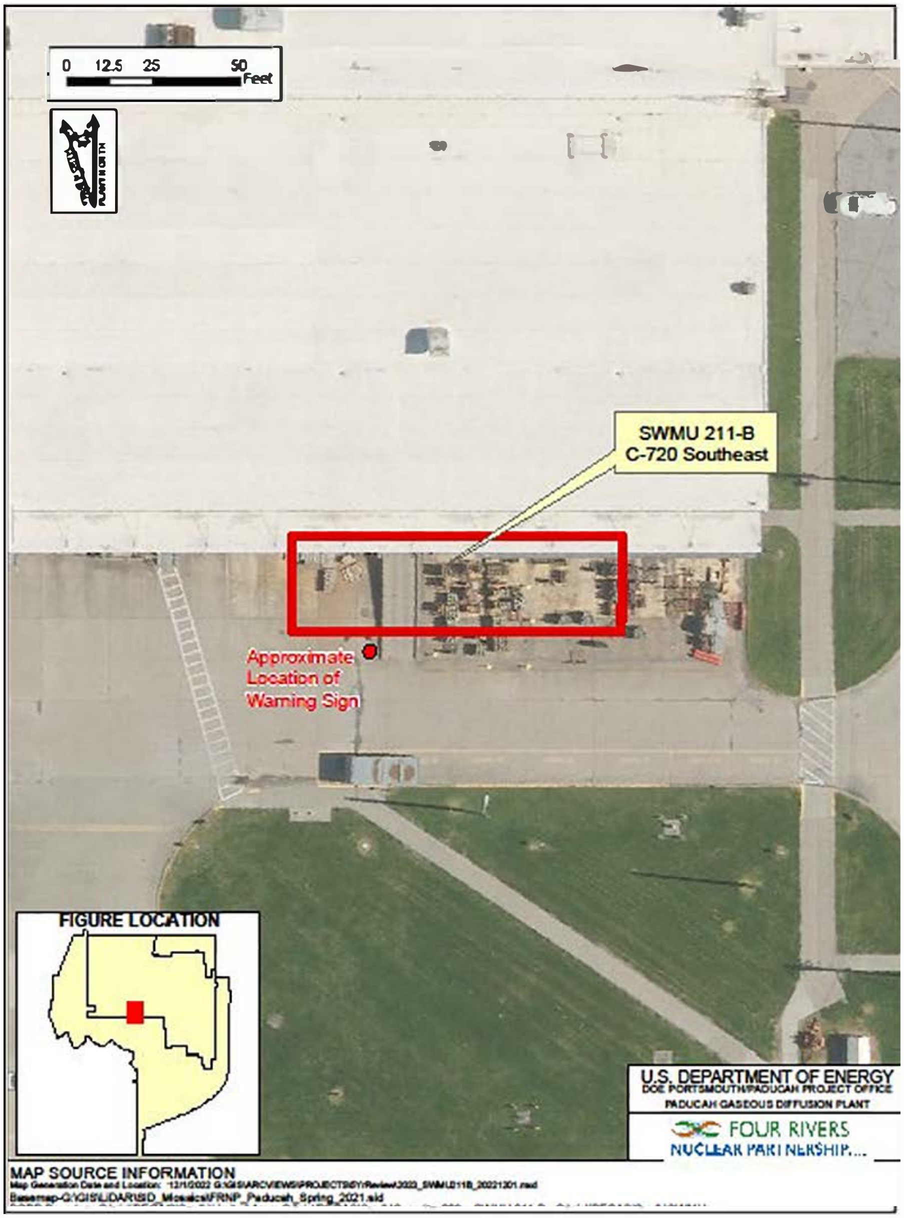
Inspection team roster (12/7/2022):

Clinton Dietsch (FRNP)
Teresa Overby (FRNP)
Jennifer Johnson (ETAS)
Megan Mulry (FRNP)
Bryan Clayton (FRNP)
Chris Travis (KDEP)
Barry Kinsall (FRNP)

Site map:



Location of the C-720 Building Northeast Spill Site



Location of the C-720 Building Southeast Spill Site

Five-Year Review Site Inspection Checklist
Surface Water On-Site Sediment Removal

I. SITE INFORMATION	
Site name: Surface Water On-Site Sediment Removal	**Date of inspection:** 12/6/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:** 49° Cloudy, Wind 1 mph from NW

Remedy Includes: (Check all that apply)

- □ Landfill cover/containment
- □ Access controls
- □ Institutional controls
- □ Groundwater pump and treatment
- □ Surface water collection and treatment
- ☒ Other_ non-time-critical removal action
- □ Monitored natural attenuation
- □ Groundwater containment
- □ Vertical barrier walls

Attachments: ☒ Inspection team roster attached ☒ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Justin Riley (Name) Facility Manager (Title) 12/6/2022 (Date)
   Interviewed ☒ at site □ at office □ by phone no. 270-816-7849
   Problems, suggestions; □ Report attached

2. **O&M staff** N/A (Name) (Title) (Date)
   Interviewed ☒ at site □ at office □ by phone no.
   Problems, suggestions; □ Report attached

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency ____________________ Contact ____________________ ____________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________ Agency ____________________ Contact ____________________ ____________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________ Agency ____________________ Contact ____________________ ____________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________ Agency ____________________ Contact ____________________ ____________ ______ ________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____________________
4.	**Other interviews** (optional) □ Report attached.

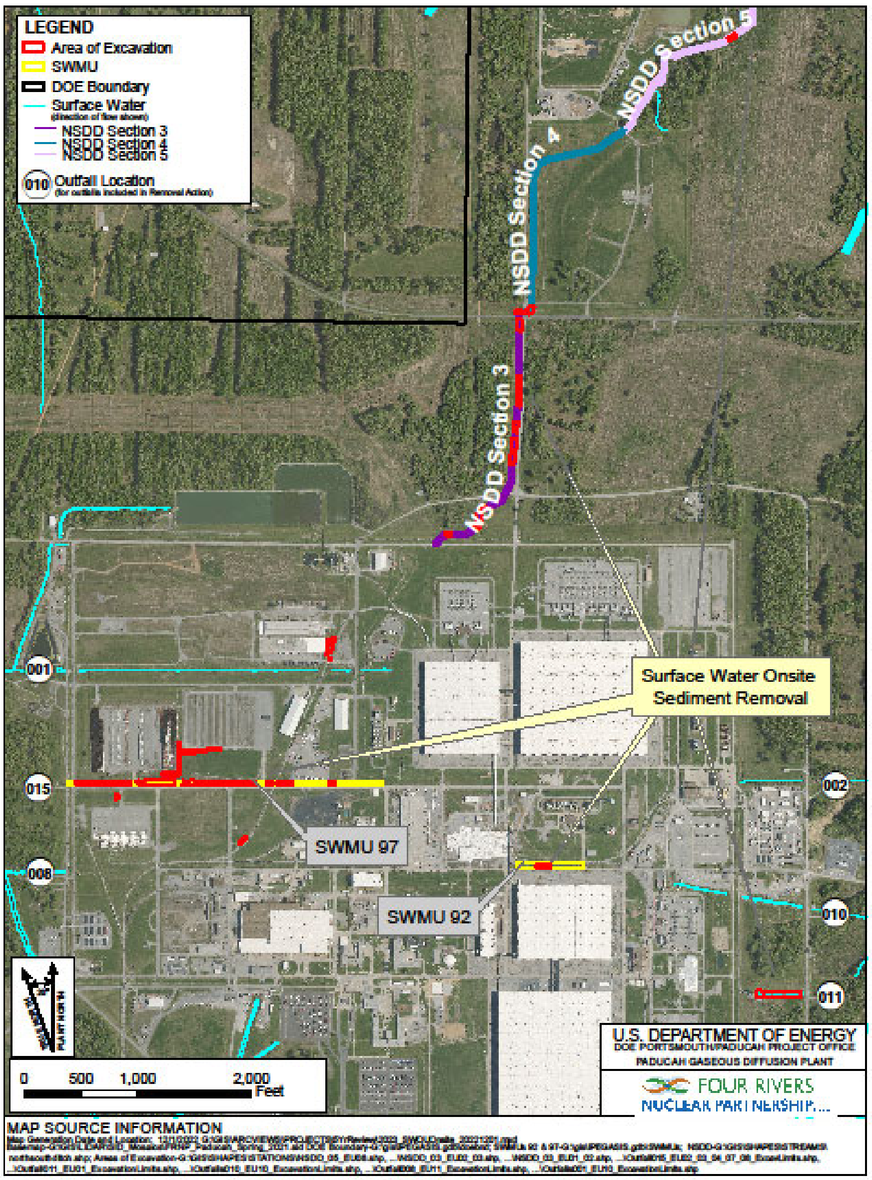
III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	□ O&M manual	□ Readily available	□ Up to date	☒ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks::______			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits______	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks:______			

IV. O&M COSTS
1. **O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility □ Other______________________
2. **O&M Cost Records** *Refer to Sect. 16.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate____________ □ Breakdown attached Total annual cost by year for review period if available From_______ To_______ ____________ □ Breakdown attached Date Date Total cost From_______ To_______ ____________ □ Breakdown attached Date Date Total cost From_______ To_______ ____________ □ Breakdown attached Date Date Total cost From_______ To_______ ____________ □ Breakdown attached Date Date Total cost From_______ To_______ ____________ □ Breakdown attached Date Date Total cost
3. **Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: Costs are discussed in Sect. 16.3 of the report.____________
V. ACCESS AND INSTITUTIONAL CONTROLS □ Applicable ☒ N/A
VI. GENERAL SITE CONDITIONS
A. Roads □ Applicable ☒ N/A
B. Other Site Conditions
Remarks: See map in attachment for general site conditions.____________
VII. LANDFILL COVERS □ Applicable ☒ N/A
VIII. VERTICAL BARRIER WALLS □ Applicable ☒ N/A
IX. GROUNDWATER/SURFACE WATER REMEDIES □ Applicable ☒ N/A
X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). Areas determined to be "hot spots" during the SWOU On-site Site Investigation were determined to require removal. This removal was previously performed as a non-time-critical removal action. Objectives of this action were to (1) ensure direct contact risk at the on-site ditches for the current industrial worker fall within the EPA risk range and (2) ensure direct contact risk at the NSDD for both the current industrial worker and recreational user fall within the EPA risk range.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. There is no O&M for this remedy.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. ____ ____

ATTACHMENT

Inspection team roster (12/6/2022):
Teresa Overby (FRNP)
Megan Mulry (FRNP)
Jennifer Johnson (ETAS)
Barry Kinsall (FRNP)
Site map:



Location of Surface Water Onsite Sediment Removal

Five-Year Review Site Inspection Checklist
Water Policy

I. SITE INFORMATION	
Site name: PGDP Water Policy	**Date of inspection:** 12/07/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: U.S. Department of Energy	**Weather/temperature:** 43°F and overcast
Remedy Includes: (Check all that apply) □ Landfill cover/containment □ Monitored natural attenuation □ Access controls □ Groundwater containment □ Institutional controls □ Vertical barrier walls □ Groundwater pump and treatment □ Surface water collection and treatment ☒ Other_removal action	
Attachments: ☒ Inspection team roster attached ☒ Site map attached	
II. INTERVIEWS (Check all that apply)	
1. **O&M site manager** David Curry (Name) Program Manager (Title) 12/7/2022 (Date) Interviewed ☒ at site □ at office □ by Phone no. 270-816-0112 Problems, suggestions; □ Report attached None	
2. **O&M staff** N/A ____ (Title) ____ (Date) Interviewed □ at site □ at office □ by phone Phone no. ______ Problems, suggestions; □ *Report attached* ______	

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices) Fill in all that apply. Agency _ Kentucky Department for Environmental Protection____________________ Contact _ Christopher Travis _______ Environmental Scientist 12/7/2023_ (502) 782-5897_ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________________ ______________________________ Agency ______________ Contact ______________ __________ _____ ______ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________________ ______________________________ Agency ______________ Contact ______________ __________ _____ ______ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________________ ______________________________ Agency ______________ Contact ______________ __________ _____ ______ Name Title Date Phone no. Problems; suggestions; □ Report attached ______________________________ ______________________________
4.	**Other interviews** (optional) □ *Report attached.*

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	□ O&M manual	□ Readily available	□ Up to date	☒ N/A
	□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
	□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
2.	**Site-Specific Health and Safety Plan**	□ Readily available	□ Up to date	☒ N/A
	□ Contingency plan/emergency response plan	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
3.	**O&M and OSHA Training Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
4.	**Permits and Service Agreements**			
	□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
	□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
	□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
	□ Other permits____________	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
5.	**Gas Generation Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
6.	**Settlement Monument Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
7.	**Groundwater Monitoring Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
8.	**Leachate Extraction Records**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
9.	**Discharge Compliance Records**			
	□ Air	□ Readily available	□ Up to date	☒ N/A
	□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			
10.	**Daily Access/Security Logs**	□ Readily available	□ Up to date	☒ N/A
	Remarks:____________________			

IV. O&M COSTS
1. **O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility □ Other______________________________
2. **O&M Cost Records** Refer to Sect. 8.3 of the report. □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate____________________ □ Breakdown attached Total annual cost by year for review period if available From__________ To__________ ________________ □ Breakdown attached Date Date Total cost From__________ To__________ ________________ □ Breakdown attached Date Date Total cost From__________ To__________ ________________ □ Breakdown attached Date Date Total cost From__________ To__________ ________________ □ Breakdown attached Date Date Total cost From__________ To__________ ________________ □ Breakdown attached Date Date Total cost
3. **Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: *Costs are discussed in Sect. 8.3 of the report.*
V. ACCESS AND INSTITUTIONAL CONTROLS □ Applicable ☒ N/A
VI. GENERAL SITE CONDITIONS
A. Roads □ Applicable ☒ N/A
B. Other Site Conditions
Remarks: ______________________________
VII. LANDFILL COVERS □ Applicable ☒ N/A
VIII. VERTICAL BARRIER WALLS □ Applicable ☒ N/A
IX. GROUNDWATER/SURFACE WATER REMEDIES □ Applicable ☒ N/A
X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

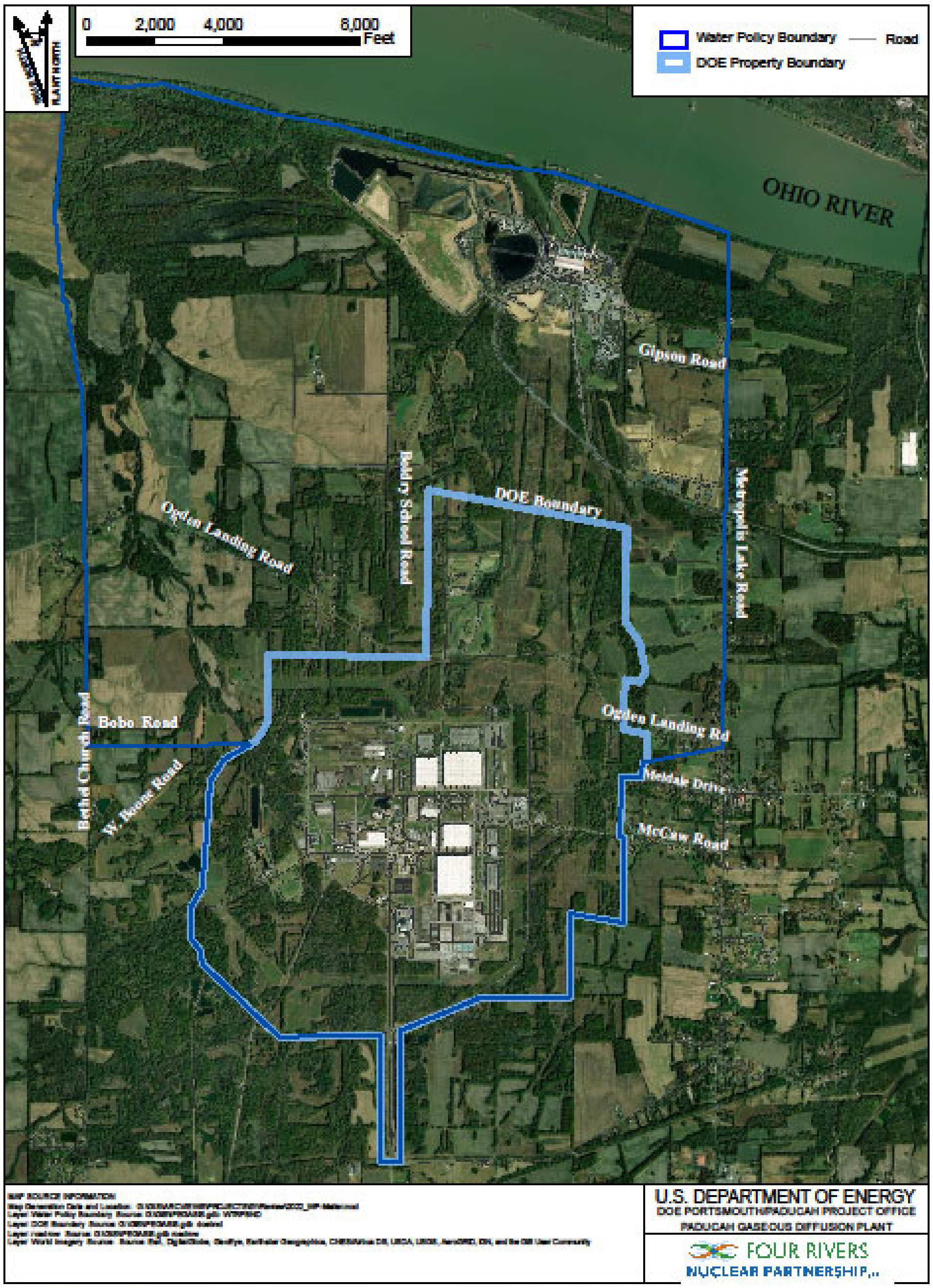
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission). The primary objective of the proposed removal action is to minimize the potential threat to human health and welfare resulting from exposure to the chemical and radioactive contaminants in the ground water. The action is supported by municipal water service being offered to all existing private residences and businesses within the water policy affected area and provisions included in the water policy license agreements that specify that the resident or businesses may not drill new water supply wells or use existing water wells. This provision in the water policy license agreements is supported by the residential well cap and lock program which monitors for unauthorized use of the existing water wells.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. See Section 8.3 in main text.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. None.

ATTACHMENT

Inspection team roster (12/7/2022):

Jennifer Johnson (ETAS) Megan Mulry (FRNP)
David Curry (FRNP) Chris Travis (KDEP)

Site map:



Location of Water Policy Boundary Relative to DOE Site

Surface Water Interim Corrective Measures

I. SITE INFORMATION	
Site name: Surface Water ICM	**Date of inspection:** 12/6/2022
Location and Region: Paducah, KY/Region 4	**EPA ID:** KY8890008982
Agency, office, or company leading the five-year review: DOE	**Weather/temperature:** 48F and partly cloudy

Remedy Includes: (Check all that apply)

- ☐ Landfill cover/containment
- ☒ Access controls
- ☐ Institutional controls
- ☐ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☐ Other______________________________
- ☐ Monitored natural attenuation
- ☐ Groundwater containment
- ☐ Vertical barrier walls

Attachments: ☒ Inspection team roster attached ☒ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Justin Riley (Name) Facility Manager (Title) 12/6/2022 (Date)
   Interviewed ☒ at site ☐ at office ☐ by phone Phone no. 270-816-7849
   Problems, suggestions; ☐ Report attached None

2. **O&M staff** n/a (Name) ______ (Title) ______ (Date)
   Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ______
   Problems, suggestions; ☐ *Report attached* ______

3.	**Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply. Agency ______________________________ Contact ______________________________ ____________________ _________ _____________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ____________________ _________ _____________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ____________________ _________ _____________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____ Agency ______________________________ Contact ______________________________ ____________________ _________ _____________ Name Title Date Phone no. Problems; suggestions; □ Report attached ____ ____
4.	**Other interviews** (optional) □ *Report attached.*

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**

☒ O&M manual	☒ Readily available	☒ Up to date	□ N/A
□ As-built drawings	□ Readily available	□ Up to date	☒ N/A
□ Maintenance logs	□ Readily available	□ Up to date	☒ N/A

Remarks____

2. **Site-Specific Health and Safety Plan** □ Readily available □ Up to date ☒ N/A

□ Contingency plan/emergency response plan □ Readily available □ Up to date ☒ N/A

Remarks____

3. **O&M and OSHA Training Records** □ Readily available □ Up to date ☒ N/A

Remarks____

4. **Permits and Service Agreements**

□ Air discharge permit	□ Readily available	□ Up to date	☒ N/A
□ Effluent discharge	□ Readily available	□ Up to date	☒ N/A
□ Waste disposal, POTW	□ Readily available	□ Up to date	☒ N/A
□ Other permits_____________	□ Readily available	□ Up to date	☒ N/A

Remarks____

5. **Gas Generation Records** □ Readily available □ Up to date ☒ N/A

Remarks____

6. **Settlement Monument Records** □ Readily available □ Up to date ☒ N/A

Remarks____

7. **Groundwater Monitoring Records** □ Readily available □ Up to date ☒ N/A

Remarks____

8. **Leachate Extraction Records** □ Readily available □ Up to date ☒ N/A

Remarks____

9. **Discharge Compliance Records**

□ Air	□ Readily available	□ Up to date	☒ N/A
□ Water (effluent)	□ Readily available	□ Up to date	☒ N/A

Remarks____

10. **Daily Access/Security Logs** □ Readily available □ Up to date ☒ N/A

Remarks____

IV. O&M COSTS
1. **O&M Organization** □ State in-house □ Contractor for State □ PRP in-house □ Contractor for PRP □ Federal Facility in-house ☒ Contractor for Federal Facility □ Other
2. **O&M Cost Records** *Refer to Sect. 15.3 of the report.* □ Readily available □ Up to date □ Funding mechanism/agreement in place Original O&M cost estimate____________ □ Breakdown attached Total annual cost by year for review period if available From______ To______ ____________ □ Breakdown attached Date Date Total cost From______ To______ ____________ □ Breakdown attached Date Date Total cost From______ To______ ____________ □ Breakdown attached Date Date Total cost From______ To______ ____________ □ Breakdown attached Date Date Total cost From______ To______ ____________ □ Breakdown attached Date Date Total cost
3. **Unanticipated or Unusually High O&M Costs During Review Period** Describe costs and reasons: *Costs are discussed in Sect. 15.3 of the report.*
V. ACCESS AND INSTITUTIONAL CONTROLS ☒ Applicable □ N/A
A. Fencing
1. **Fencing damaged** ☒ Location shown on site map □ Gates secured □ N/A Remarks Fences were in good shape.
B. Other Access Restrictions
1. **Signs and other security measures** ☒ Location shown on site map □ N/A Remarks Signs were present and were legible.

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ☐ No ☒ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ☐ No ☐ N/A

Type of monitoring (e.g., self-reporting, drive by) ______
Frequency ______
Responsible party/agency ______
Contact ______ ______ ______ ______
Name Title Date Phone no.

Reporting is up-to-date ☐ Yes ☐ No ☒ N/A
Reports are verified by the lead agency ☐ Yes ☐ No ☒ N/A

Specific requirements in deed or decision documents have been met ☐ Yes ☐ No ☒ N/A
Violations have been reported ☐ Yes ☐ No ☒ N/A
Other problems or suggestions: ☐ Report attached

2. **Adequacy** ☐ ICs are adequate ☐ ICs are inadequate ☒ N/A
Remarks______

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ☒ No vandalism evident
Remarks______

2. **Land use changes on site** ☐ N/A
Remarks No changes.

3. **Land use changes off site** ☐ N/A
Remarks No changes.

VI. GENERAL SITE CONDITIONS

A. Roads ☐ Applicable ☒ N/A

B. Other Site Conditions

Remarks ______

VII. LANDFILL COVERS ☐ Applicable ☒ N/A

VIII. VERTICAL BARRIER WALLS ☐ Applicable ☒ N/A

IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ☒ N/A

X. OTHER REMEDIES
If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

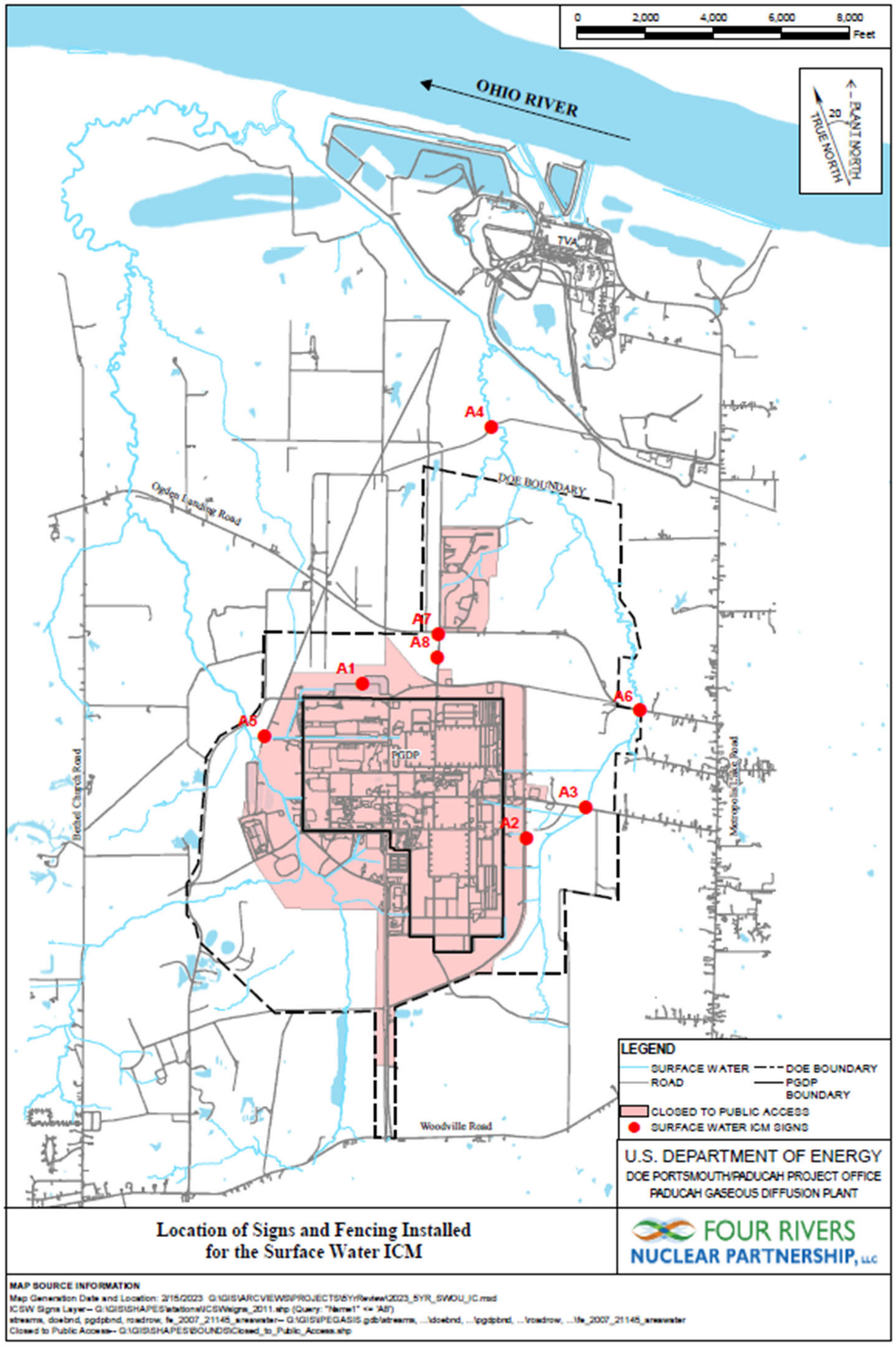
XI. OVERALL OBSERVATIONS	
A.	**Implementation of the Remedy**
	Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). The actions chosen were to install fencing and posting signs to warn people in the area of the dangers posed by direct contact with the water and/or sediments. The remedy is functioning as designed.
B.	**Adequacy of O&M**
	Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. See Section 15.3.Regular inspections and sign replace is ongoing and continue to keep the remedy functioning as designed.
C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. None.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. None.

ATTACHMENT

Inspection team roster (12/6/2022):

Jennifer Johnson (Pro2Serve) Barry Kinsall (FRNP) Megan Mulry (FRNP)
Teresa Overby (FRNP) Justin Riley (FRNP)

Site map:



THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B

INTERVIEWS

THIS PAGE INTENTIONALLY LEFT BLANK

Interviews Conducted for the 2023 Five-Year Review

Groups From Guidance	Recommended for 2023	Rationale	Interviewed in 2018
Background Information			
Lead agency staff/management*	Yes	Information sought also is available from the Administrative Record.	Yes
Nearest neighbors	Yes	Information sought cannot be obtained elsewhere.	Yes
Community representatives	Yes	Information sought cannot be obtained elsewhere.	Yes
State and Local Considerations			
State contacts	Yes	Information sought cannot be obtained elsewhere.	Yes
Local authorities	Yes	Information sought cannot be obtained elsewhere.	Yes
Construction Considerations**			
Construction Contractor	N/A	Information sought is available from the Administrative Record.	N/A
Construction Manager	N/A	Information sought is available from Operations and Maintenance (O&M) and facility managers.	N/A
Local Emergency Response Officials	N/A	These officials participate in regular drills at the site and their insight is addressed as part of those actions.	N/A
Performance, Operation and Maintenance Problems			
O&M manager (facility manager)	Yes	Information sought cannot be obtained elsewhere.	Yes
O&M staff	Yes	Information sought cannot be obtained elsewhere.	Yes
Remedial design/remedial action consultant***	N/A	Information sought is also available from the Administrative Record.	N/A

*Lead agency staff/management is listed instead of the previously listed U.S. Environmental Protection Agency (EPA) staff/management from EPA guidance because it is written for EPA project managers on EPA-lead sites.

**This group is inherent to this review process.

***This category is inherent to this review process.

NOTE: All comments received from the interviews have been forwarded to the appropriate Paducah Site manager to be addressed.

INTERVIEW RECORD			
Site Name: Paducah			
Subject: Background Information Group		**Time: 9:00 CST**	**Date: 1/19/2023**
Type: ☐☐Telephone X☐Visit ☐☐Other **Location of Visit: C-210**			
Contact Made by:			
Name: Megan Mulry	**Title: Project Manager**	**Organization: Four Rivers Nuclear Partnership, LLC (FRNP)**	
Individual Contacted:			
Name: Water Policy Resident	**Title: not applicable (N/A)**	**Organization: N/A**	
Telephone No: N/A	**E-mail Address:**		
Summary of Conversation			

1. What is your overall impression of the project? (general sentiment)

I have a good impression of the project. There is a lot of community support/goodwill. This is a positive move in the right direction.

2. What effects have site operations had on the surrounding community?

Water policy has had a positive impact on the community. Residents got good water. This is a tremendous benefit for the farmers in the area, as it removed the worry of a well going dry.

3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

Not aware. I do not know of anything.

4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

Not aware of any.

5. Do you feel well-informed about the site's activities and progress?

I do from two perspectives. From a residential perspective, I think they do a good job with the mailers of providing information. From a plant employee perspective, as a Derivative Classifier, the reports support that there is good work being done out here.

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

The project should keep doing what it is doing. They should continue with this worthwhile program.

INTERVIEW RECORD		
Site Name: Paducah Site		
Subject: Background Information Group	**Time: 13:30 CST**	**Date: 1/24/2023**
Type: X☐Telephone ☐Visit ☐Other **Location of Visit: Microsoft Teams call**		
Contact Made by:		
Name: Megan Mulry	**Title: Project Lead**	**Organization: FRNP**
Individual Contacted:		
Name: Tracey Duncan	**Title: Federal Facility Agreement Manager**	**Organization: U.S. Department of Energy (DOE)**
Telephone No: (270) 816-4684	**E-mail Address: tracey.duncan@pppo.gov**	
Summary of Conversation		

1. What is your overall impression of the project? (general sentiment)

The Paducah Project continues to achieve the Federal Facility Agreement goals with respect to the Environmental Cleanup Program. Stakeholders, Regulatory Agencies, and the Public are informed and have input into the process for ongoing actions and future cleanup plans. In general, the project is completing the cleanup mission alongside other mission-essential activities, including the depleted uranium hexafluoride procession operations and the deactivation activities. DOE and its contractors work together to keep all these activities moving forward. There is a good plan for long-term activities in place, and it is being implemented in a good manner with stakeholder involvement.

2. What effects have site operations had on the surrounding community?

Of course there have been both positive and negative effects. Positive impacts include regional employment for over 70 years with DOE willingness to share ideas, as well as considerations of community impacts as a result of DOE activities. This, along with working with agencies such as the Paducah Area Chamber of Commerce and Paducah Area Community Reuse Organization (PACRO), for reuse and other benefits the local communities. Negative effects are tied to the contaminants in the environmental media, which have affected off-site residents near the facility. Measures have been put in place to reduce and mitigate these impacts, with the ultimate goal to return the media for the beneficial use of its residents.

3. Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

I am not aware of any specific concerns at this time. DOE participates with the Citizens Advisory Board (CAB) on a monthly basis to gather input on the cleanup decisions for the Paducah Site. This avenue allows for an exchange of information and ideas. There have been concerns shared though this forum and brought to DOE. It is a means for the community to be involved and get concerns addressed in a non-confrontational forum.

4. Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

We have had over time minor vandalism instances in the large acreage area licensed to the WKWMA. This area is open and accessible to the public. These events have been minor and did not require significant repair or cost.

Mutual aid agreements are in place with local emergency, police, and fire services agencies to respond when additional support is needed for any type of emergency at the facility. For example, a fire within the facility might require additional support to control the fire. Local authorities have assisted with employee issues, but these are issues that are anticipated for a site of this size. The site performs annual emergency drills to exercise the interface with external agencies and ensure communications and protocols work efficiently in various scenarios. These Mutual aid agreements are in place to ensure we have additional support if needed.

5. Do you feel well-informed about the site's activities and progress?

Yes. DOE and contractor management have multiple avenues for communicating ongoing work to employees and stakeholders. DOE holds regular meetings with the regulatory parties through project meetings, Federal Facility Agreement (FFA) communications and documents, and the CAB. These are mechanism to provide status what is going on and the progress made towards the cleanup goals.

6. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

Site management should continue to work with the community through the community involvement processes that are in place and the regulatory agencies to reach agreement and find achievable solutions that everyone can live with.

INTERVIEW RECORD		
Site Name: Paducah		
Subject: State and Local Considerations	**Time: 09:00 CST**	**Date: 1/26/2023**
Type: X □ Telephone □Visit □Other **Location of Visit: Microsoft Teams**		
Contact Made by:		
Name: Megan Mulry	**Title: Project Lead**	**Organization: FRNP**
Individual Contacted:		
Name: Christopher Travis	**Title:** Environmental Scientist	**Organization: Kentucky Department for Environmental Protection (KDEP)**
Telephone No: (502) 782-5897 **E-mail Address: christopher.travis@ky.gov**		
Summary of Conversation		

1. What is your overall impression of the project? (general sentiment)

Overall impression is some of the general maintenance activities take longer than they should to be addressed. For example, thermal insulation around the steam pipes was damaged and needed to be secured to some degree. This work was done, but response time was slower than expected. Additionally, it wasn't noticed by personnel prior to identification. Additional example is in regards to the fixing of sanitary water leaks. There is too long of a lag between observations to correction. In addition, there is inconsistent use of barriers, which can be confusing. It should be clear if the barrier (Jersey barrier use and barricades) is for work zone or a caution area.

2. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by your office regarding the site? If so, please give purpose and results.

There are routine communications especially with the CERCLA projects that allow us to perform surveillances of field work. For example, walkdowns for this CERCLA Five-Year Review, the C-400 remediation investigation work, and the 211-A bioremediation. There was clear communication from field start to finish. Overall, there has been good communication regarding project activities and communication has been positive.

General site communication emails are not shared with KY employees. AIP state of KY employees should be added to email distribution for notification of General Site Road Closures or Activities. Road closures can impact KY sampling activities, and it would be helpful to have that knowledge.

3. Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the events and results of the responses.

There was a violation related to water which was not directly related to my office. As far as complaints, from employee or citizens, I can't recall any resulting in response.

4. Do you feel well-informed about the site's activities and progress?

Yes. As stated in question 2, above, communication is very good regarding CERCLA projects.

5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

I do not have any additional comments outside of stated in response to previous questions.

INTERVIEW RECORD			
Site Name: Paducah Site			
Subject: State and Local Considerations		**Time: 13:00 CST**	**Date: 2/1/2023**
Type: X☐Telephone ☐Visit ☐Other **Location of Visit: Microsoft Teams call**			
Contact Made B			
Name: Megan Mulry	**Title: Project Lead**	**Organization: FRNP**	
Individual Contacted:			
Name: Tim Kreher	**Title: Wildlife Biologist**	**Organization: West Kentucky Wildlife Management Area (WKWMA)**	
Telephone No: (270) 488-3233	**E-mail Address: timothy.kreher@ky.gov**		
Summary Of Conversation			

1. What is your overall impression of the project? (general sentiment)

Things are slow moving. When I came to the WKWMA/PGDP site in 1998, most, if not all, of the cleanup was scheduled to be done by now. There seems to be a lack of momentum toward completion of projects. Sometimes it appears there are projects that use flashy new (unproven) technology in lieu of using known effective methods. Developing new techniques seems to be as important as getting the projects completed using existing methods. Also, a lot of time and contractor effort is used to perform activities ahead of their need. An example of this was the "rad survey walkover" performed on much of the DOE property in preparation for a "property transfer" that I'm now being told by my DOE liaison is "dead in the water." There needs to be comprehensive foresight to get to end goal. Appears projects get half way through and then they are started over due to new or additional information that should have been considered in advance of work start.

2. Have there been routine communications or activities (site visits, inspections, reporting activities, etc.) conducted by your office regarding the site? If so, please give purpose and results.

There is routine communication; the quarterly info exchange meetings being the biggest information sharing example. These quarter meetings seem to function well, as it brings multiple agencies/people together to discuss topics and emerging topics. Opportunity to see the groundwater testing people and maintenance people, and we receive the reports annual/quarterly. There have been routine communications, and I would hope that priority is given to replace the former facilitator of these meetings timely.

3. Have there been any complaints, violations, or other incidents related to the site requiring a response by your office? If so, please give details of the events and results of the responses.

The trash and loitering at sirens was an issue where a gate was installed on Kelly Road. The same issue is now present at the SW sirens off South Acid Road, where we are seeing camp fires, vandalism, and trash dumping. These concerns have been discussed at several quarterly meetings discussed above without resolution. There can be extended lag time in issue identification and action. Due to stated “austerity” measures, the contractors have decreased the amount of time they spend taking care of the roads, mowing, etc. We receive complaints from WMA visitors about road maintenance. Example of this is condition of Water Works Road. Approval process necessary for this maintenance is lengthy and that results in the work is not being addressed in timely/efficient fashion.

4. Do you feel well-informed about the site’s activities and progress?

I think so. Of the things I know about I feel well-informed.

5. Do you have any comments, suggestions, or recommendations regarding the site’s management or operation?

To reiterate from above, activities for one reason or another, things go above and beyond common industry standards and that adds to the cost or time involved to get the work done. Examples of this are grating roads, and other maintenance. Some identifiable streamlining that could be done is not implemented, and it continues to go the way it is. There appears to be additional staff on many projects that are there for only observing, as they are not participating in the activity.

INTERVIEW RECORD		
Site Name: Paducah		
Subject: Performance, Operation, and Maintenance Problems Group	**Time: 15:30 CST**	**Date: 1/19/2023**
Type: ☐Telephone X Visit ☐Other **Location of Visit: C-764 T-9**		
Contact Made by:		
Name: Megan Mulry	**Title: Project Manager**	**Organization: FRNP**
Individual Contacted:		
Name: Clint Dietsch	**Title: Project Engineer**	**Organization: FRNP**
Telephone No: (270) 441-5254	**E-mail Address:** clinton.dietsch@pad.pppo.gov	
Summary of Conversation		

1. What is your overall impression of the project? (general sentiment)

Projects are going well. Not aware of any issue or concern.

2. Is the remedy functioning as expected? How well is the remedy performing?

The remedies are performing well and functioning as expected. Concentrations are going down which is expected.

3. What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?

Overall data shows as decrease.

4. Is there a continuous on-site O&M presence? If so, please describe staff and activities. If there is not a continuous on-site presence, describe staff and frequency of site inspections and activities.

Yes there is an on-site O&M presence. Field crew performs inspections. There is a PM, system engineering, field manager overseeing the system. Daily reporting is performed and repairs and maintenance on systems during work week.

5. Have there been any significant changes in the O&M requirements, maintenance schedules, or sampling routines since start-up or in the last five years? If so, do they affect the protectiveness or effectiveness of the remedy? Please describe changes and impacts.

In the last 5 years, there have not been significant O&M changes, although there have been updates to the O&M procedures. These updated to not affect the protectiveness or effectives of the remedy.

6. Have there been unexpected O&M difficulties or costs at the site since start-up or in the last five years? If so, please give details.

As the system ages, there are equipment repairs and replacements due to age.

7. Have there been opportunities to optimize O&M, or sampling efforts? Please describe changes and resultant or desired cost savings or improved efficiency.

No significant changes in the last 5 years. Previously optimized performed for sampling and included extraction well movement.

8. Do you have any comments, suggestions, or recommendations regarding the project?

Continue to monitor and respond accordingly.

INTERVIEW RECORD			
Site Name: Paducah Site			
Subject: Performance, Operation, and Maintenance Problems Group		**Time: 0900 CST**	**Date: 1/23/2023**
Type: X☐Telephone ☐Visit ☐Other **Location of Visit: Microsoft Teams call**			
Contact Made by:			
Name: Megan Mulry	**Title: Project Lead**	**Organization: FRNP**	
Individual Contacted:			
Name: David Veach	**Title: Pump-and-Treat Staff**	**Organization: FRNP**	
Telephone No: (270) 441-5245		**E-mail Address: David.Veach@pad.pppo.gov**	
Summary of Conversation			

1. What is your overall impression of the project? (general sentiment)

Overall impression is good.

2. Is the remedy functioning as expected? How well is the remedy performing?

The remedy is functioning well and as expected.

3. What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?

Generally speaking, there is a downward trend in contamination levels and plume size.

4. Is there a continuous on-site O&M presence? If so, please describe staff and activities. If there is not a continuous on-site presence, describe staff and frequency of site inspections and activities.

Yes, there is a continuous presence during work hours including system operators, mechanics and facility management. Operational checks are performed daily; preventive maintenance is scheduled and performed as required by O&M programs and plans. Corrective maintenance is performed as needed. Each system has an automated call out system in place that notifies personnel if response if required, during both on-shift and off-shift hours.

5. Have there been any significant changes in the O&M requirements, maintenance schedules, or sampling routines since start-up or in the last five years? If so, do they affect the protectiveness or effectiveness of the remedy? Please describe changes and impacts.

There have not been any significant changes.

6. Have there been unexpected O&M difficulties or costs at the site since start-up or in the last five years? If so, please give details.

There has been some unexpected corrective maintenance and associated cost, including replacing of extraction well motors and other electrical components. This unexpected maintenance did not negatively affect protectiveness measures, as the P&T systems were able to continue limited operation during the corrective maintenance period.

7. Have there been opportunities to optimize O&M, or sampling efforts? Please describe changes and resultant or desired cost savings or improved efficiency.

No.

8. Do you have any comments, suggestions, or recommendations regarding the project?

It would be nice to have the ability to monitor system health and operation remotely, for both Northeast and Northwest Plume systems. This ability would allow personnel to troubleshoot and diagnose issues that may occur during off-shift hours, potentially allowing the system(s) to be corrected and restarted quicker and without the need for personnel to travel to the site.

INTERVIEW RECORD			
Site Name: Brian Lowrance			
Subject: Performance, Operation, and Maintenance Problems Group		**Time: 14:00 CST**	**Date: 1/25/2023**
Type: □Telephone X□Visit □Other **Location of Visit:**			
Contact Made by:			
Name: Megan Mulry	**Title: Project Lead**	**Organization: FRNP**	
Individual Contacted:			
Name: Brian Lowrance	**Title: Program Integration Manager**	**Organization: FRNP**	
Telephone No: (270) 441-5896	**E-mail Address: brian.lowrance@pad.pppo.gov**		
Summary of Conversation			

1. What is your overall impression of the project? (general sentiment)

It is effective on ensuring protectiveness is maintained.

2. Is the remedy functioning as expected? How well is the remedy performing?

Yes. The remedy is functioning as is expected.

3. What does the monitoring data show? Are there any trends that show contaminant levels are decreasing?

Data continues to indicate decreases associated with the plumes. Environmental sampling data is not indicating any negative trends associated with these remedies.

4. Is there a continuous on-site O&M presence? If so, please describe staff and activities. If there is not a continuous on-site presence, describe staff and frequency of site inspections and activities.

O&M personnel are present during normally scheduled business hours. Personnel will be called out during off-hours as required.

5. Have there been any significant changes in the O&M requirements, maintenance schedules, or sampling routines since start-up or in the last five years? If so, do they affect the protectiveness or effectiveness of the remedy? Please describe changes and impacts.

No significant changes.

6. Have there been unexpected O&M difficulties or costs at the site since start-up or in the last five years? If so, please give details.

No.

7. Have there been opportunities to optimize O&M, or sampling efforts? Please describe changes and resultant or desired cost savings or improved efficiency.

I don’t know of any optimization opportunities.

8. Do you have any comments, suggestions, or recommendations regarding the project?

Not at this time.

APPENDIX C

MEMORANDUM OF AGREEMENT ADDITIONAL ACTIONS REGARDING CY 2018 FIVE-YEAR REVIEW OF REMEDIAL ACTIONS AT THE PADUCAH GASEOUS DIFFUSION PLANT

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CY	calendar year
DOE	U.S. Department of Energy
EMP	environmental monitoring plan
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FS	feasibility study
FY	fiscal year
FYR	five-year review
KDEP	Kentucky Department for Environmental Protection
MOA	memorandum of agreement
MW	monitoring well
OU	operable unit
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PFAS	per- and polyfluoroalkyl substances
RAWP	remedial action work plan
RI	remedial investigation
SOP	standard operating procedure
SWMU	solid waste management unit

THIS PAGE INTENTIONALLY LEFT BLANK

1. BACKGROUND

1.1 HISTORY OF ACTIONS

On September 30, 2019, and October 7, 2019, respectively, the U.S. Environmental Protection Agency (EPA) and the Kentucky Department for Environmental Protection (KDEP) identified additional actions regarding the U.S. Department of Energy (DOE) *CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2426&D2 (CY 2018 FYR), May 2019, pursuant to Section XXX, “Five Year Reviews,” of the Paducah Federal Facility Agreement (FFA). Specifically, EPA issued independent protectiveness determinations of “protectiveness deferred” for four Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) response actions:

(1) Northwest Plume Interim Remedial Action, (2) Northeast Plume Interim Remedial Action, (3) Water Policy Removal Action, and (4) Fire Training Area Interim Remedial Action. EPA also recommended multiple additional actions for those four response actions. KDEP issued one independent protectiveness determination of “protectiveness deferred” for the Water Policy Removal Action and requested multiple additional actions for the Water Policy Removal Action.

Pursuant to Section XXV.A, “Informal Dispute,” of the Paducah FFA, DOE invoked an informal dispute resolution on December 2, 2019, regarding the assessment by EPA and the reassessment by KDEP. DOE disputed three of EPA's independent protectiveness determinations (Northwest Plume Interim Remedial Action, Northeast Plume Interim Remedial Action, and Water Policy Removal Action), five of EPA’s additional actions, KDEP's independent protectiveness determination for the Water Policy Removal Action, and five of KDEP's additional actions.

The FFA parties, in good faith, conducted a period of informal dispute under Section XXV.A, “Informal Dispute,” and reached a mutually acceptable resolution on the disputed conditions associated with the CY 2018 FYR. The FFA parties consider the CY 2018 FYR complete, and all of the additional actions that EPA and KDEP brought forth in letters dated September 30, 2019, and October 7, 2019, respectively, have been resolved or will be resolved upon completion of the actions set forth in this agreement.

1.2 RESOLUTION

The FFA parties have agreed that the deferred protectiveness determinations for the CY 2018 FYR will be reevaluated as part of the fiscal year (FY) 2023 five-year review (FYR) process.

(1) Northwest Plume Interim Remedial Action,
(2) Northeast Plume Interim Remedial Action,
(3) Water Policy Removal Action, and
(4) Fire Training Area Interim Remedial Action

Table C.1 below documents the actions and information shared during the dispute process and completion of the actions. This additional data needed for protectiveness determinations as related to the additional actions identified by EPA and KDEP have been incorporated into the FY 2023 FYR document.

Table C.1. Deferred Protectiveness Action Items from 2018 CERCLA Five-Year Review Memorandum of Agreement

MOA Item	EPA/KDEP	Action Addressed by DOE	Resolution	Completion Status
1	EPA	Water Policy additional action (EPA): DOE written commitment to expansion of the *Water Policy Education Fact Sheet* distribution list for the next annual mailing (2Q FY 2020), and in subsequent years (FY 2020+) beyond the residents and businesses in the Water Policy affected area to include trusted individuals and information sources in the broader community.	DOE established a revised distribution list for the *Water Policy Education Fact Sheet* that will be utilized for future updates of the fact sheet that included the following information. Additionally, a direct link to the most current *Water Policy Education Fact Sheet* has been added to the welcome page of the Online Environmental Information Center (eic.pad.pppo.gov) to enhance accessibility to the public. The revised distribution list (effective 2Q FY 2020) now includes: • All residences and businesses within the Water Policy affected area; • Owners of property within the Water Policy affected area who do not reside at the property; • Paducah Citizens Advisory Board (CAB) members contact list (provided by the CAB office); • Local elected officials and city contacts (see 2018 Community Relations Plan, Appendix C); and • PGDP Reading File maintained by the McCracken County Public Library Special Collections desk.	COMPLETE. Action closed by Memorandum of Agreement (MOA).
2	EPA	Water Policy additional action (EPA): DOE provision (as Official Use Only) of the annual *Water Policy Due Diligence Report* by December 30, 2019, to EPA and KDEP for review and subsequent DOE provision of a briefing on the report to the regulatory agencies no later than January 30, 2020.	DOE developed a Water Policy section template within the FFA Semiannual Progress Report for communication and documentation of activities related to the Water Policy. The FFA Semiannual Progress Report is updated and submitted every 6 months (April and October) and will include Water Policy reporting starting in April 2020.	COMPLETE. Action closed by MOA.
3	EPA	Water Policy additional action (EPA): DOE preparation and submittal of a Water Policy D1 remedial action work plan (RAWP) proposing a revised residential well and monitoring well (MW) sampling proposal for EPA and KDEP review and comment.	DOE will incorporate elements of Water Policy boundary monitoring currently conducted under the DOE Environmental Monitoring Plan (EMP) (shown in Attachment 1) into the Northeast and Northwest Plume operation and maintenance plans and submit the revised documents to EPA and KDEP in FY 2020 in lieu of developing a D1 RAWP for the Water Policy. Data generated in support of Water Policy monitoring will be made available in PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS) and a summary reported in FFA Semiannual Progress Reports for use in evaluating continued protectiveness in support of future FYRs.	COMPLETE. Action closed by MOA.

Table C.1. Deferred Protectiveness Action Items from 2018 CERCLA Five-Year Review Memorandum of Agreement (Continued)

MOA Item	EPA/KDEP	Action Addressed by DOE	Resolution	Completion Status
4	EPA	Fire training area [Solid Waste Management Unit (SWMU) 100] additional action (EPA): Per- and polyfluoroalkyl substances (PFAS) sampling in selected groundwater wells in FY 2019 and the results reported in the FFA Semiannual Progress Report for the first half of FY 2020 for EPA and KDEP evaluation.	DOE will perform additional action (EPA): PFAS sampling at the fire training area (SWMU 100) in selected groundwater wells in FY 2019 and the results reported for EPA and KDEP evaluation.	COMPLETE. Groundwater from MW315 and MW330 was sampled for PFAS under the Paducah Site EMP on August 22, 2019, and August 29, 2019. The sampling results were reported in PEGASIS on March 26, 2020. The sampling results were reported to EPA and KDEP formally in a letter dated April 13, 2020 (PPPO-02-10004367-20C). The sampling results were reported in the 2019 Annual Site Environmental Report (FRNP-RPT-0137), which was released to the public on December 29, 2020.

Table C.1. Deferred Protectiveness Action Items from 2018 CERCLA Five-Year Review Memorandum of Agreement (Continued)

MOA Item	EPA/KDEP	Action Addressed by DOE	Resolution	Completion Status
5	EPA	Northwest Plume, Northeast Plume, and Water Policy additional action (EPA): Detailed lithologic plots are needed to manage the uncertainty regarding the potential for faulting and influences on the subsurface lithologic units potentially impacting Paducah Site contaminant plume migration on-site and beyond the Paducah Site boundaries, including the Water Policy area.	DOE collected McNairy Formation samples within the C-400 Complex Operable Unit (OU) in accordance with the approved C-400 Complex OU Remedial Investigation/Feasibility Study (RI/FS) Work Plan. The data and the correlation of the lithological areas within the C-400 Complex will be reported in the C-400 Complex OU RI/FS D1 Report. DOE developed a technical paper that addressed correlations between lithologic units across the entire Paducah Site, including the Water Policy area, using existing data that currently is available, along with the data that will be generated as part of the C-400 Complex OU RI/FS Work Plan implementation. The technical paper will be developed in accordance with Attachment 2 to the Dispute Resolution Agreement. DOE will issue the technical paper within one month of submittal of the D1 C-400 Complex OU RI/FS Report to support the review and comment of the C-400 specific data interpretation as part of the C-400 Complex OU RI/FS Report review process and the performance of the FY 2023 FYR revised protectiveness determinations for the Northeast, Northwest, and Water Policy response actions.	COMPLETE. A technical paper, *Detailed Correlations between Lithologic Units in the McNairy Formation across the Paducah Gaseous Diffusion Plant*, FRNP-RPT-0249, has been developed. EPA and KDEP concurrence on closure of MOA action received January 18, 2023.
6	KDEP	Water Policy additional action (KDEP): Provide appropriate documentation to demonstrate that efforts have been made to contact households in the Water Policy area and to document well usage status. This documentation should be updated on a regular basis.	DOE provided, and the FFA parties discussed, standard operating procedures to enhance DOE's implementation and regulatory agency understanding of the Water Policy in support of future FYRs. The documentation and discussion satisfied the condition.	COMPLETE. Action closed by MOA. FRNP procedure CP4-ES-1013, *Water Policy Management*, became effective on December 10, 2019, and was posted to the Public Documents website. A briefing was held for EPA and KDEP on December 18, 2019.
7	KDEP	Water Policy additional action (KDEP): Consider cost offsets.	During dispute resolution discussions, KDEP and EPA were advised that the DOE Portsmouth/Paducah Project Office is actively pursuing license agreements for payment of monthly water bills to all residential and business addresses in the Water Policy affected area. It was also discussed that some residents refuse to allow DOE to pay their water bills and/or	COMPLETE. Action closed by MOA.

Table C.1. Deferred Protectiveness Action Items from 2018 CERCLA Five-Year Review Memorandum of Agreement (Continued)

MOA Item	EPA/KDEP	Action Addressed by DOE	Resolution	Completion Status
			refuse to sign license agreements. These discussions satisfied the condition.	
8	KDEP	Water Policy additional action (KDEP): Implement a public awareness campaign that employs multiple communication efforts (e.g., well lock contact tags), especially for residents who have not signed license agreements, to verify that existing wells are not being used for primary or secondary uses.	DOE provided, and the FFA parties discussed, standard operating procedures (SOPs) to enhance DOE's implementation and regulatory agency understanding of the Water Policy and in support of future FYRs (see also resolutions to EPA additional actions 1 and 2 above). This documentation and discussion satisfied the condition.	COMPLETE. Action closed by MOA.
9	KDEP	Water Policy additional action (KDEP): Compile a consolidated Water Policy occupant list that includes the property owner(s), license status, municipal water cost offset status, and shortest distance to the trichloroethene plume by December 31, 2019.	DOE compiled and shared lists of addresses and license status to enhance regulatory agency understanding of DOE's implementation of the Water Policy and in support of future FYRs. This documentation and discussion satisfied the condition.	COMPLETE. Action closed by MOA.
10	KDEP	Water Policy additional action (KDEP): Develop a consolidated, management-approved standard set of procedures that will be followed to ensure that exposure to contaminated groundwater is not occurring.	DOE provided, and the FFA parties discussed, SOPs to enhance DOE's implementation and regulatory agency understanding of the Water Policy and in support of future FYRs. This documentation and discussion satisfied the condition.	COMPLETE. Action closed by MOA.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX D

ASSESSMENT OF NORTHWEST PLUME CAPTURE AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, FRNP-RPT-0274

THIS PAGE INTENTIONALLY LEFT BLANK

FRNP-RPT-0274

Assessment of Northwest Plume Capture at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

This document is approved for public release per review by:

JACKIE THOMPSON (Affiliate)

Digitally signed by JACKIE THOMPSON (Affiliate)
Date: 2023.02.08 11:47:29 -06'00'

FRNP Classification Support | Date

FRNP-RPT-0274

Assessment of Northwest Plume Capture at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—February 2023

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

1. INTRODUCTION

The 2019 white paper, *Evaluation of TCE Trends in MW460*, was a review of trichloroethene (TCE) levels in the downgradient monitoring wells (MWs) of the optimized Northwest Plume Groundwater System (NWPGS) (DOE 2019a). Of note, the paper suggested that a TCE plume centroid had migrated eastward in the downgradient MW transect [shifting in the lower Regional Gravel Aquifer (RGA) from MW458 to MW460] (Area of Interest A of Figure 1), and groundwater with high TCE concentrations had been observed in a lower RGA MW further downgradient in the Northwest Plume (Area of Interest B of Figure 1). The white paper concluded that the Northwest Plume centroid may be bypassing, in part, the optimized NWPGS extraction well (EW) field of EW232 and EW233. The white paper suggested the following three example approaches to optimize the capture of the TCE plume centroid.

- Adjust the pumping rates between the two EWs;
- Lower the pump intake in one or both EWs; and
- Assess the need for rehabilitation of the EWs.

The *CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2426&D2 (hereafter referred to as the "CY 2018 Five-Year Review"), includes the following recommendation/follow-up action: "EW pump placement and pumping rates should be evaluated to optimize capture of the Northwest Plume" (DOE 2019b).

This white paper has been developed to provide an additional review of the contaminant trends in the area of the optimized NWPGS EW field in order to better assess the capture of the Northwest Plume and to assess the need for further evaluation of pump placement and pumping rates and the rehabilitation of the EWs.

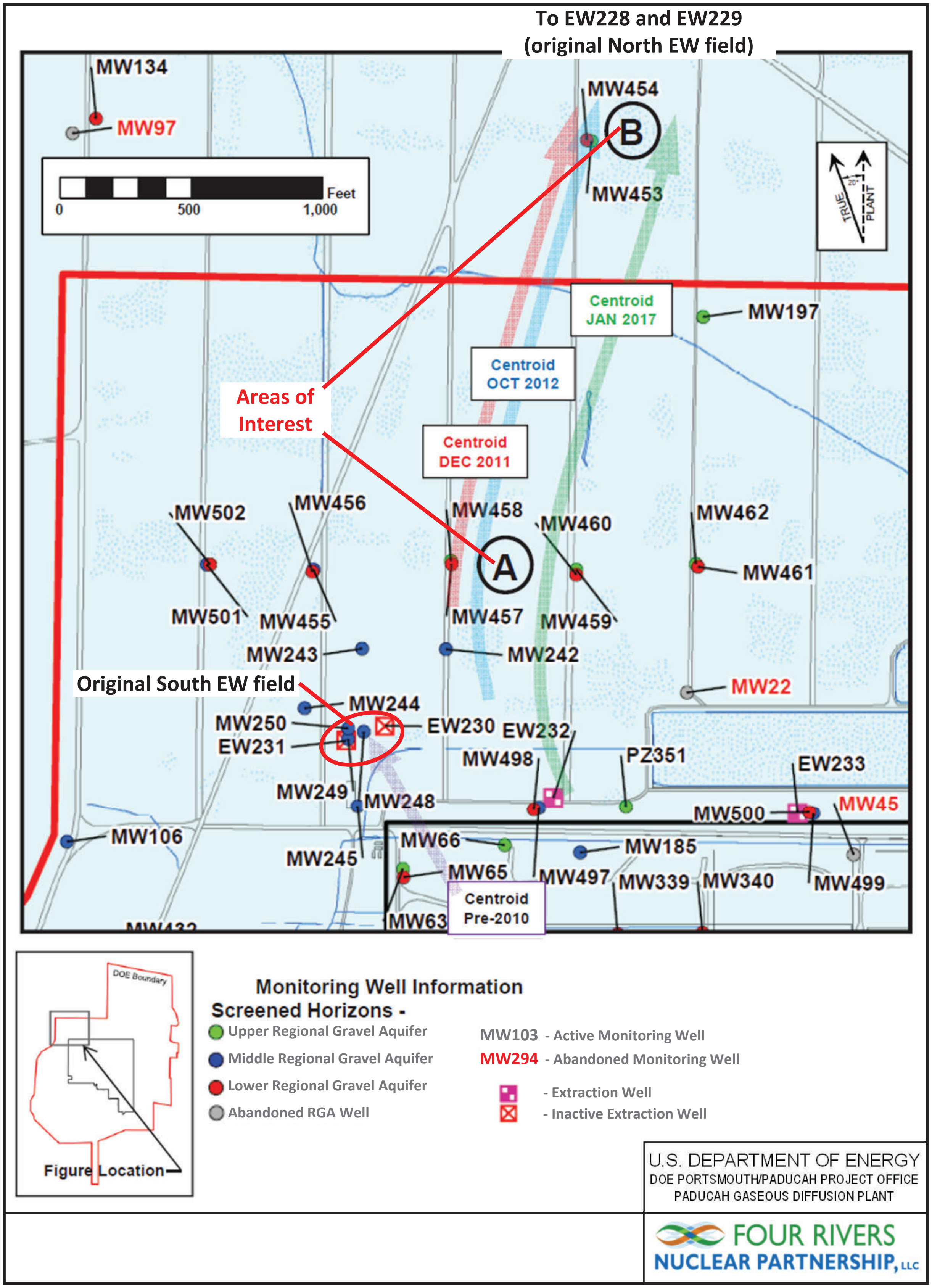
This review of TCE and technetium-99 (Tc-99) trends in the EWs and upgradient and downgradient MWs of the optimized NWPGS, beginning in 2010, has been prepared as an appendix to the CY 2023 Five-Year Review to close out the recommendation/follow-up action for the Northwest Plume in the CY 2018 Five-Year Review (DOE 2019b). This review finds that the NWPGS is meeting its objectives and that further optimization of pumping rates, pump depth, and EW development are not needed.

1.1. SITE DESCRIPTION

After the initial discovery of off-site contamination at the Paducah Site in August 1988, the U.S. Department of Energy (DOE) conducted a site investigation to identify the nature and extent of the contamination. The investigation determined that groundwater contamination was spreading generally northward toward the Ohio River in multiple plumes (CH2M HILL 1991, CH2M HILL 1992). The highest levels of both TCE and Tc-99 occur in the Northwest Plume, which is sourced within the industrial complex of the Paducah Gaseous Diffusion Plant.

A recent remedial investigation of the C-400 Complex Operable Unit (OU) from 2020 to 2022 identified discrete sources of TCE and Tc-99 to the RGA beneath and adjacent to the C-400 Building. The plumes from these contaminant sources migrate along co-mingled flow paths in the Northwest Plume.

Outside of the immediate vicinity of the source areas at the Paducah Site, the Northwest Plume is restricted to the RGA, which occurs in a thick gravel unit and thin sands above and below the gravel unit at depths of approximately 60 to 100 ft along most of the length of the plume. The extent of the Northwest Plume (and



Source: Adapted from DOE 2019a

Figure 1. Plan View in the Area of the Northwest Plume Extraction Wells

the Northeast and Southwest Plumes) is well-known through several DOE investigations. The Northwest Plume underlies land owned by DOE, some of which is licensed to the West Kentucky Wildlife Management Agency, land owned by the Tennessee Valley Authority (TVA), and privately owned land that is sparsely populated. While some contaminated groundwater from the Northwest Plume discharges in seeps in Little Bayou Creek on TVA property, the Ohio River is the regional discharge point for groundwater flow in the RGA.

Figure 2 illustrates the extent of the off-site Northwest Plume; the two original EW fields of the NWPGS, which began operation in 1995; and an optimized EW field consisting of two wells for the NWPGS, which began operation in 2010. The current downgradient limit of the Northwest Plume is near Little Bayou Creek, which is located approximately one mile south of the Ohio River.

1.2. CURRENT EXTRACTION WELL FIELD

Beginning in August 2010, as part of the optimization of the NWPGS, withdrawal switched from the original four EWs (with a combined withdrawal of approximately 220 gal/minute) to withdrawal from two new EWs (operating at a pumping rate of approximately 100 gal/minute each for a total of 200 gal/minute). The new EWs are EW232, which is located on the west side of the Northwest Plume, and EW233, which is located on the east side of the Northwest Plume. Table 1 summarizes the EW and MW screen depths.

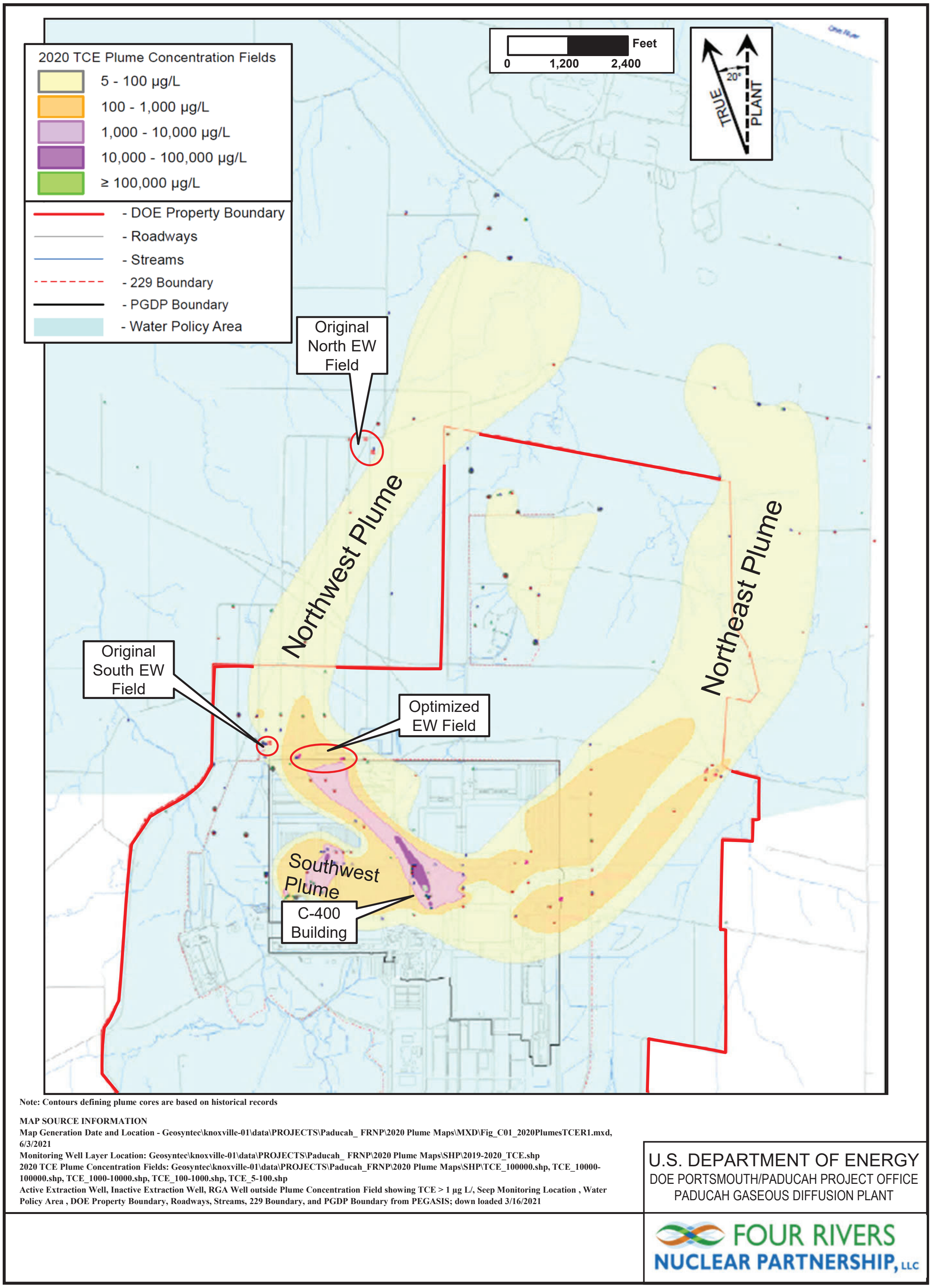
The optimized EWs are installed in the vicinity of the previous south well field. A piping system transfers the extracted groundwater to the NWPGS C-612 Pump & Treat Facility. Three lower RGA MWs, located 400 to 600 ft south of the EWs (MW261, MW339, and MW340), provide upgradient monitoring of the NWPGS. Five pairs of upper and lower RGA MWs were constructed in a transect across the Northwest Plume, located approximately 800 to 1,000 ft north of the EWs (MW455 through MW462, MW501, and MW502), to support downgradient monitoring. See Figure 3 for EW and MW locations.

2. CONTAMINANT TRENDS ASSESSMENT—REFINEMENT OF A CONCEPTUAL SITE MODEL

The refinement of the conceptual site model benefits from a long-term perspective. Operation of the optimized NWPGS (using EW232 and EW233) began in August 2010. Contaminant trends in the following three areas are the basis for the conceptual site model used for the assessment of the Northwest Plume partial bypass: (1) upgradient of the EW field, (2) within the EW field, and (3) downgradient of the EW field.

2.1. UPGRADIENT OF THE EXTRACTION WELL FIELD

Before the start of the operations of EW232 and EW233, the greatest TCE and Tc-99 levels of the upgradient MWs occurred in MW261, which is screened across the bottom 5 ft of the RGA. This is consistent with screening results of a previous drive-point sampling project that determined the centroids of the TCE and Tc-99 plumes in this area were located at the base of the RGA (DOE 1995). In September 2010, the TCE analysis for MW261 was 25,000 µg/L and the Tc-99 analysis was 2,460 pCi/L.

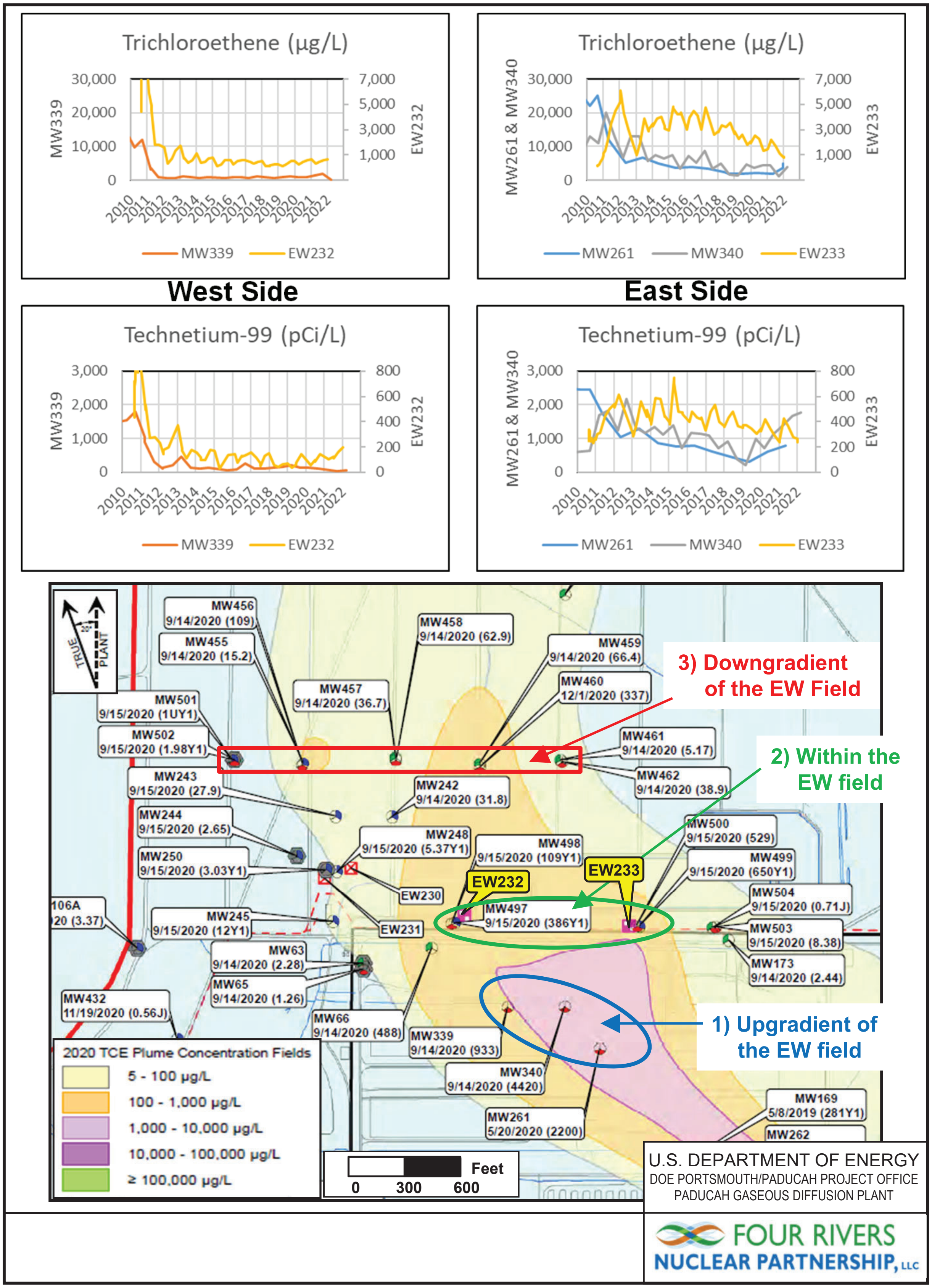


Source: Adapted from DOE 2021

Figure 2. Northwest Plume and Extraction Wells

Table 1. Well Screen Depths for NWPGS EWs and MWs

LOCATION	STATION	DEPTH (ft)			
		Top of Hydrogeological Unit 5	Top of Screen	Base of Screen	Base of RGA
Well Field	EW232	59	66.5	86.5	89
	EW233	63	74.2	94.2	96
Upgradient	MW261	66	90.0	94.7	97
	MW339	60	85.3	95.0	95
	MW340	60	85.6	95.3	95
Downgradient	MW455	58	58.3	68.3	88
	MW456		79.8	89.8	
	MW457	53	52.8	62.8	86
	MW458		76.8	86.8	
	MW459	49	51.0	61.0	88
	MW460		77.8	87.8	
	MW461	51	51.0	61.0	80
	MW462		70.9	80.9	
	MW501	60	59.4	69.4	90
	MW502		76.1	86.1	



Source: Adapted from DOE 2021

Figure 3. Upgradient and Extraction Well Contaminant Trends

The other two upgradient MWs—MW339, which is located on the west side of the Northwest Plume, and MW340, which is located in the center of the Northwest Plume, are screened across the bottom 10 ft of the RGA. September 2010 TCE levels were similar in MW339 (12,000 µg/L) and in MW340 (11,000 µg/L).[1] A broad plume of +10,000 µg/L TCE occurred in the area.

In September 2010, Tc-99 levels were significantly higher in MW339 (1,790 pCi/L) than those in MW340 (632 pCi/L). The Tc-99 plume had a narrower centroid that was located on the west side of the Northwest Plume.[2]

Within one year of the start of the operations of EW232 and EW233, higher TCE and Tc-99 levels occurred in MW340 when compared to MW339. TCE and Tc-99 trends indicate that the plume centroids migrated eastward in response to the new pumping centers of the optimized NWPGS and that the centroid locations have remained relatively constant after 2010.

Beginning in 2019, Tc-99 levels began increasing in MW261 and MW340, while TCE levels for the period of 2019 through early 2022 remained near-constant in all three upgradient MWs (MW261, MW339, and MW340). The Tc-99 increase relates to a rising trend in the C-400 source zone area, as evidenced in MW343 (Figure 4) and in the shallow sample ports of nearby wells MW422, MW423, and MW424.

2.2. WITHIN THE EXTRACTION WELL FIELD

TCE and Tc-99 trends are similar within each EW but shift between the EWs (Figure 5).

- In EW232 (located on the west side of the Northwest Plume), both TCE and Tc-99 levels were high (4,400 µg/L TCE and 433 pCi/L Tc-99) at the start of pumping in August 2010, with a subsequent sharp decline.

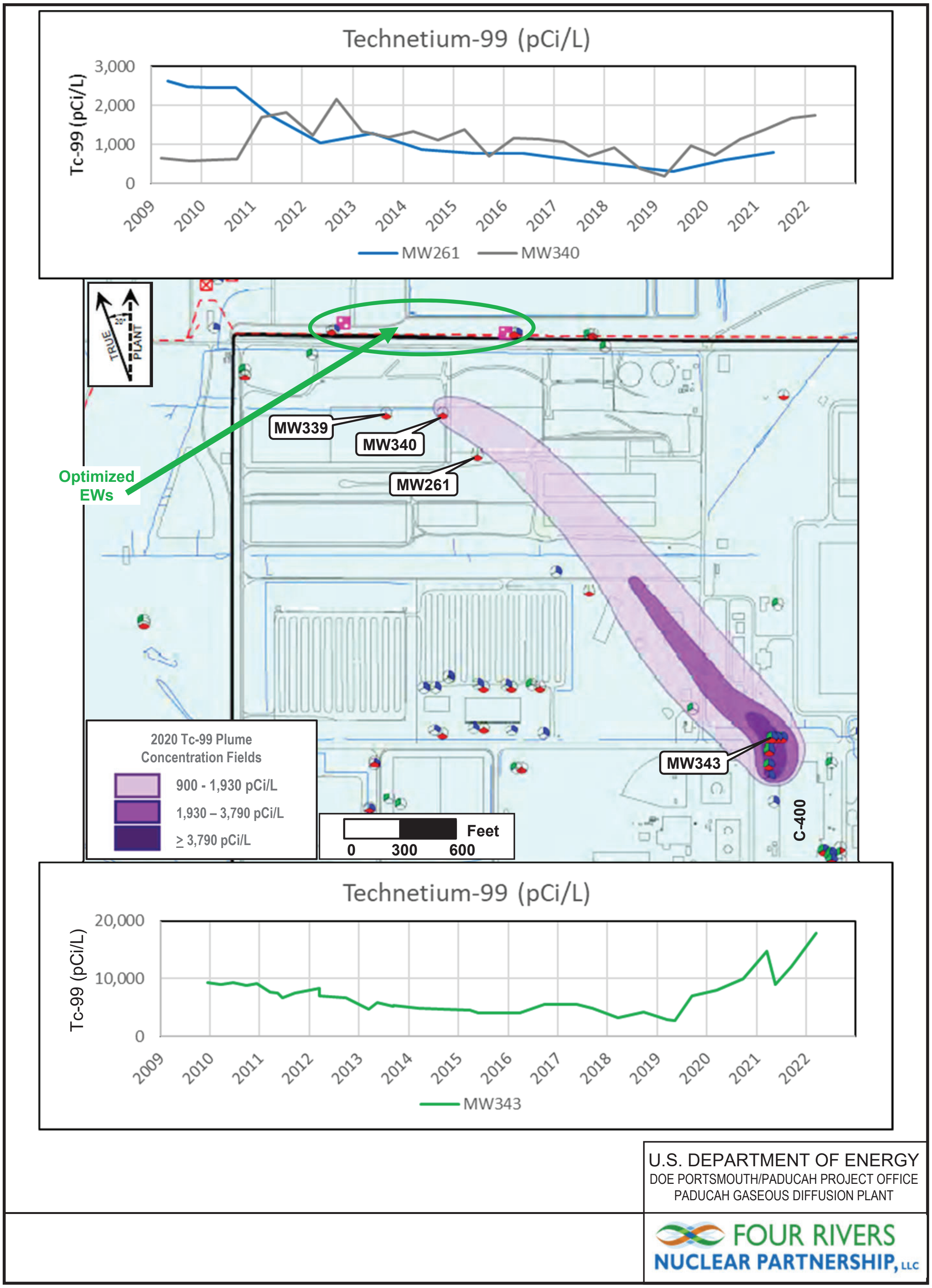
- In EW233 (located on the east side of the Northwest Plume), both TCE and Tc-99 levels were low (130 µg/L TCE and 254 pCi/L Tc-99) at the start of pumping, with a subsequent sharp rise.

These trends are consistent with the conclusion derived from upgradient MWs, which is that the plume centroids migrated eastward with the start of the optimized NWPGS.

The seasonal oscillation of contaminant peaks and lows between EW232 and EW233 is indicative that the plume centroids occur between the EWs. Subsequent to startup of the current EWs, the significantly higher contaminant levels in EW233 signify that the hydraulic capture by EW233 dominates in the EW field. EW232 and EW233 pump at a similar rate (approximately 100 gal/minute); however, the RGA in the area of EW233 has a lower hydraulic conductivity,[3] resulting in greater drawdown and plume capture extent.

---

[1] The greater length of well screen in MW339 and MW340 (10 ft) contrasted to that of MW261 (5 ft) should be considered in the comparison of results. Contaminant levels in MW339 and MW340 may be diluted by well construction compared to contaminant levels in MW261.
[2] The south EW field of the original NWPGS was located west of MW339 and EW232, which controlled the locations of the plume centroids prior to start of the optimized NWPGS.
[3] As determined by hydraulic tests of the optimized Northwest Plume EWs conducted in October 2010.



Source: Adapted from DOE 2021

Figure 4. Upgradient Tc-99 Trends (East Side of Northwest Plume)

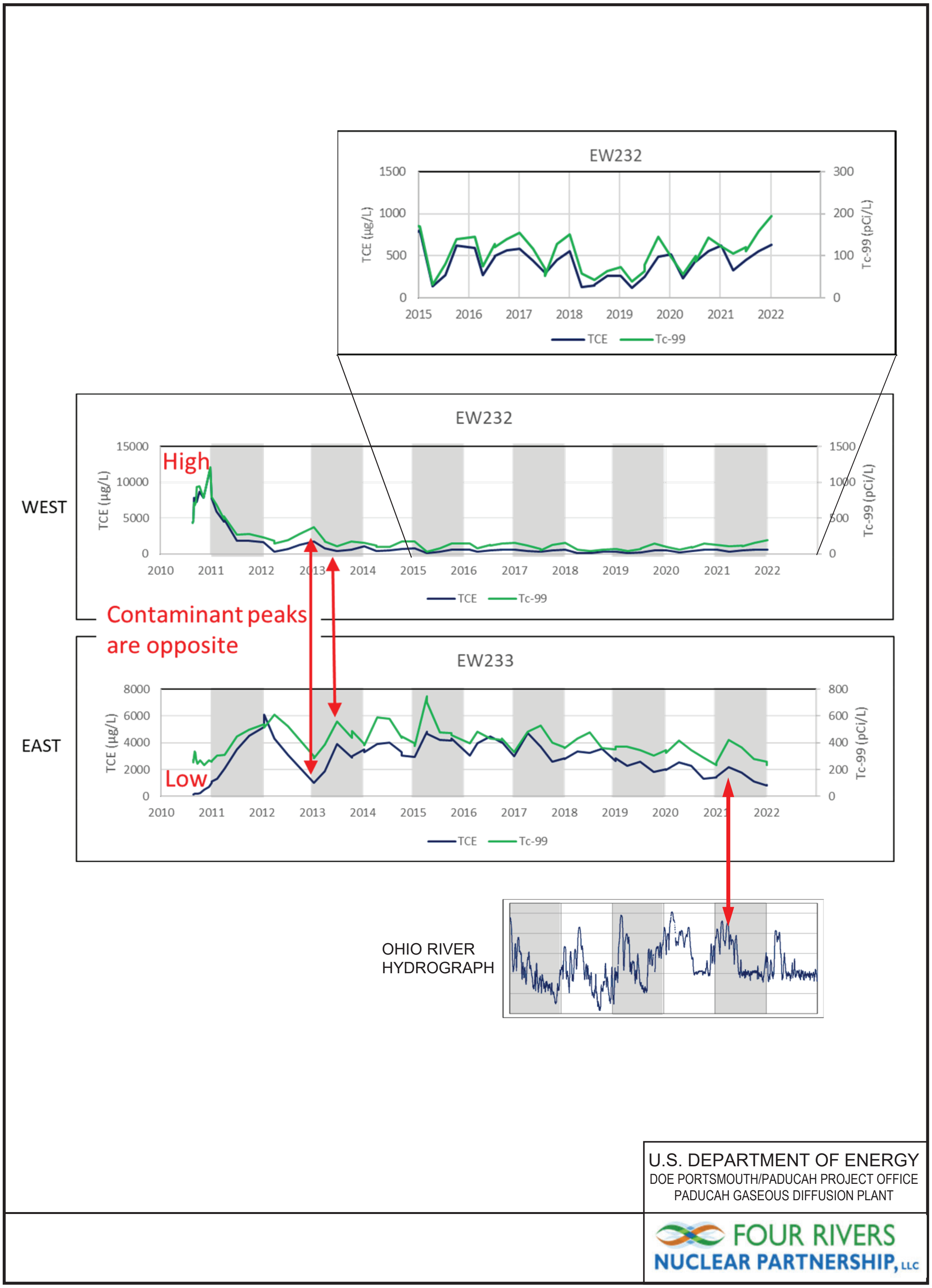


Figure 5. Contaminant Trends in Extraction Wells

The RGA hydraulic gradient, related to the Ohio River stage,[4] governs the seasonal oscillation of contaminant trends. When the RGA hydraulic gradient is low (period of high river stage), the plume's centroids shift eastward. The influence of EW233 on the RGA hydraulic potential is greater than the influence of EW232 on the RGA hydraulic potential. When the RGA hydraulic gradient is high (period of low river stage), the centroids of the plumes shift westward. The influence of EW233 on the RGA hydraulic potential is diminished when the RGA hydraulic gradient is high.

2.3. DOWNGRADIENT OF THE EXTRACTION WELL FIELD

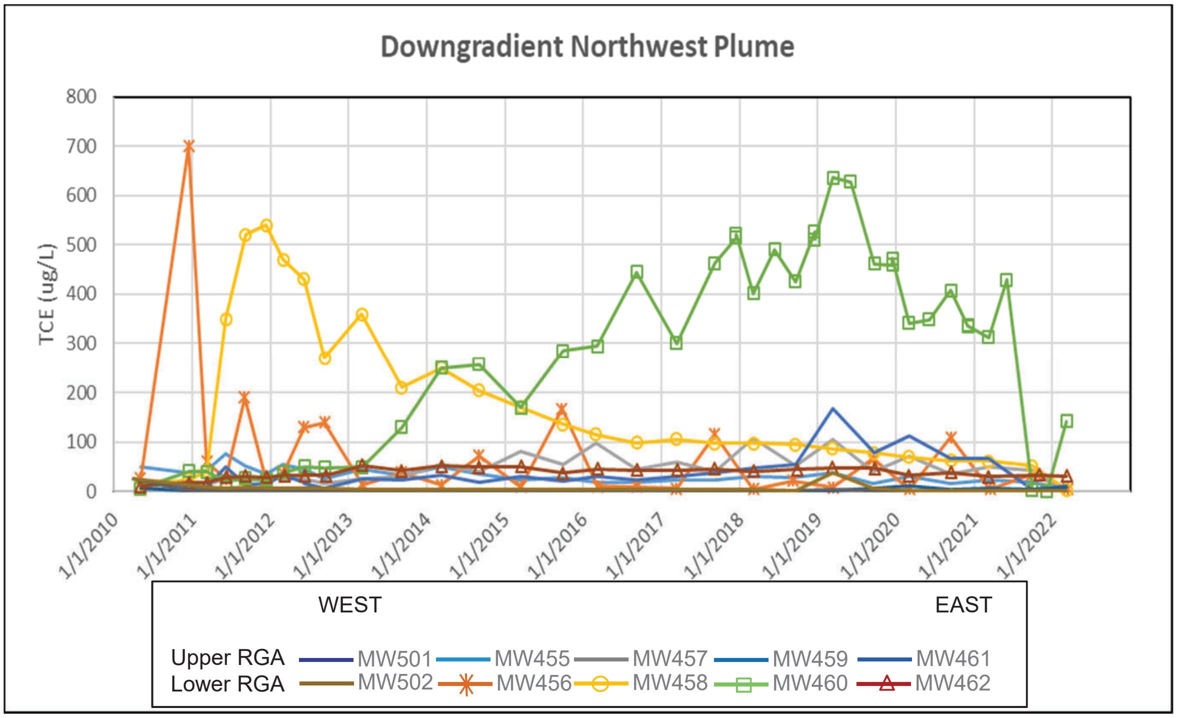
In the transect of MWs located downgradient of the EWs, TCE and Tc-99 levels consistently have been highest in the lower RGA. Beginning with the August 2010 start of operations in the optimized NWPGS, the higher TCE levels shifted eastward—beginning in MW456 during late 2010, then higher in MW458 from mid-2011 to early 2014, and then higher in MW460 from early 2014 through mid-2021. TCE levels in MW460 are typically one-fourth or less than the TCE levels in EW233. Tc-99 trends on the west side of the Northwest Plume followed a similar pattern (higher Tc-99 in MW456 in 2010, followed by higher Tc-99 in MW458 in 2011). Figure 6 illustrates the TCE and Tc-99 trends over time. The plume shifts brought the centroids of both the TCE and Tc-99 plumes between the two EWs. The downgradient transect of MWs has sufficient extent to monitor the bypass of the NWPGS.

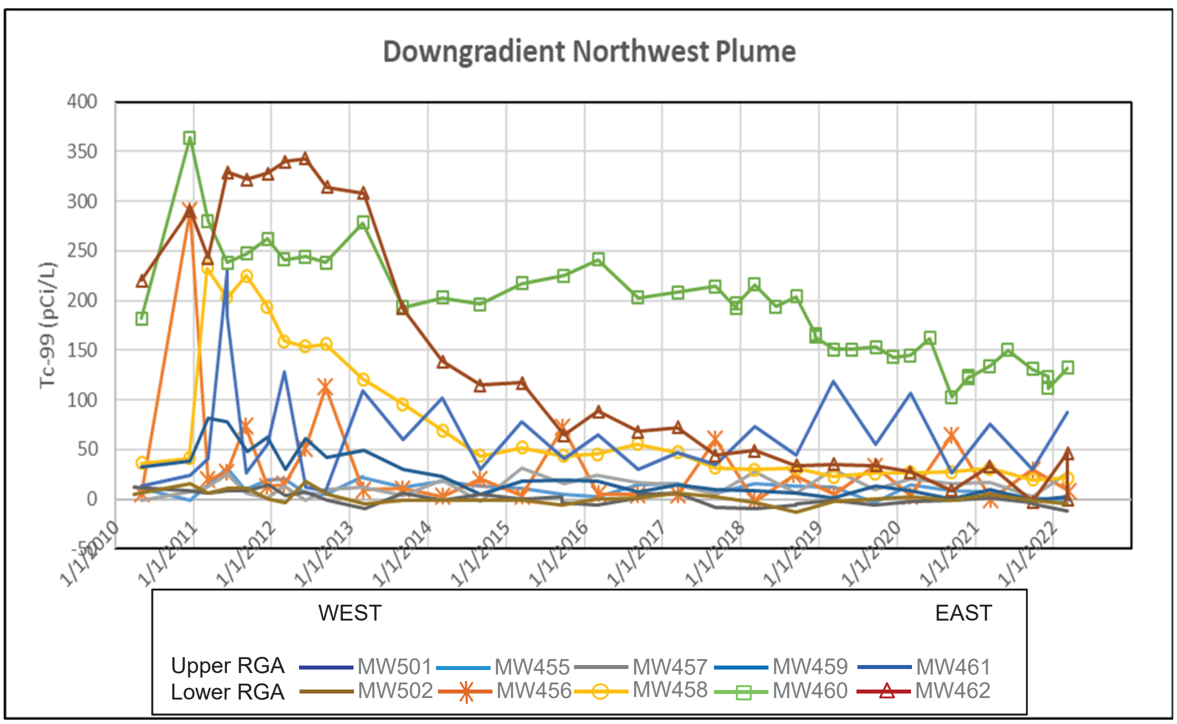
This eastward shift of the TCE and Tc-99 plume centroids over time is consistent with the interpretation of the migration of the plumes found in the 2019 TCE trends white paper (DOE 2019a). TCE levels have been the highest in MW460 for the period of September 2015 through June 2021, while the TCE trend between June 2021 and March 2022 remains uncertain. The highest TCE levels in the downgradient MWs are typically one-fourth or less than the TCE levels in EW233. Tc-99 levels in MW460 became higher than in MW462 in September 2013 and remained higher through March 2022. The highest Tc-99 levels in the downgradient MWs are typically one-half or less than Tc-99 levels in EW233.[5]

A second Tc-99 plume centroid on the east side of the Northwest Plume—first identified in the *Northwest Plume Preliminary Characterization Summary Report* (DOE 1995) and mapped in the 2007 plumes report (DOE 2009) (Figure 7)—shifted westward with the start of the optimized NWPGS, with higher Tc-99 in MW462 mid-2011 through mid-2013, followed by higher Tc-99 levels in MW460 through March 2022. Some bypass of the second Tc-99 plume centroid is occurring in the lower RGA around EW233 (the east side EW).

The seasonal oscillation of the peak TCE and Tc-99 levels in the EWs is evidence that the bypass is occurring between the EWs. Inspection of the TCE and Tc-99 trends in EW233 (i.e., the dominant EW) and MW460 (i.e., the MW with highest TCE and Tc-99 trends beginning in 2015 and 2014, respectively) revealed an approximate 440-day offset of contaminant peaks in EW233 and lower RGA MW460[6] (Figure 8). Contaminant level peaks and lows that appear in EW233 occur in MW460, approximately 440 days later. The offset is the travel time between the EW field and MW460, located approximately 1,000 ft to the north (downgradient). The defined offset is evidence that detectable bypass of the EW field

[4] Other seasonal influences on the variation observed in the RGA hydraulic gradient include flood events on the Ohio River and, to a lesser extent, the balance of area-wide infiltration and evapo-transpiration.
[5] An alternative interpretation of the TCE trend in MW460 beginning in late 2021 is that site actions, such as the deactivation and remedial actions at C-400, have reduced upgradient TCE levels in the core of the Northwest Plume.
[6] Factors that obscure the comparison of contaminant trends include differences in sample dates for EW233 and MW460 and the eastward migration of the TCE and Tc-99 plume centroids through the MW460 location.

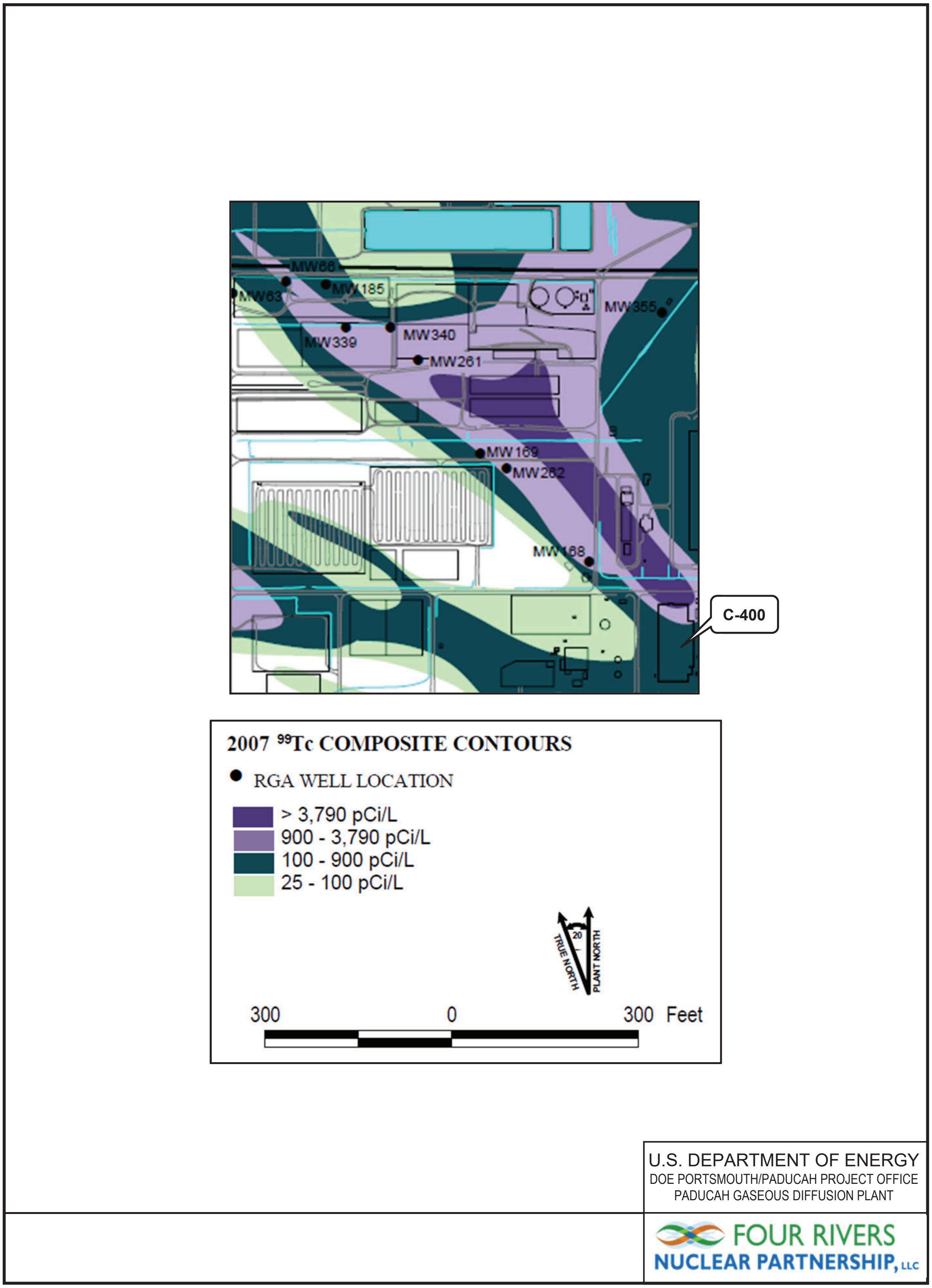




U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

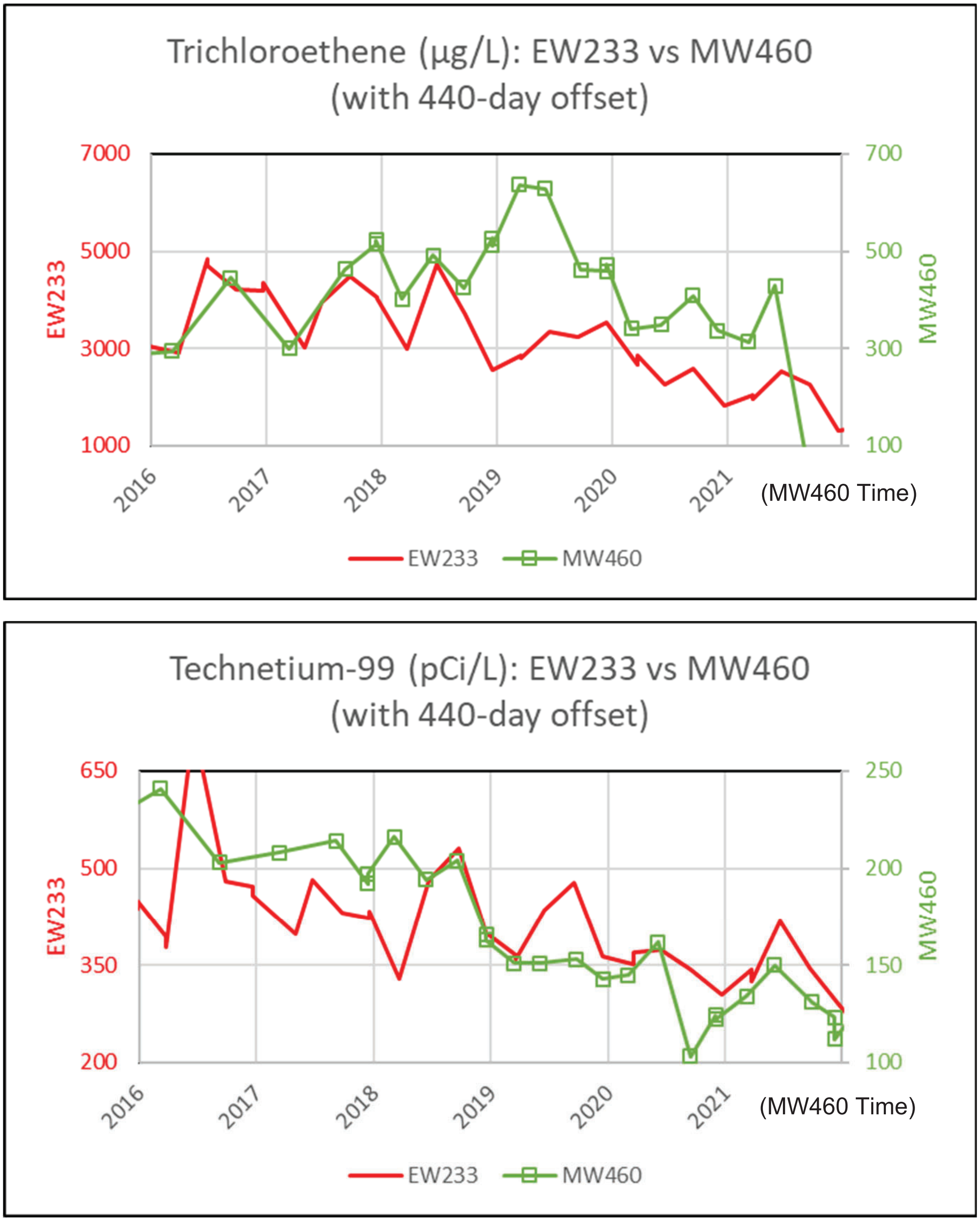
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 6. Downgradient Contaminant Trends



Source: Adapted from DOE 2009

Figure 7. Tc-99 Plumes in 2007



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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 8. Inspection of 440-Day Offset

may be occurring between the EWs in the lower RGA.[7] The extent of the downgradient MW transect, with MWs screened in the upper and lower RGA, is sufficient to assess the bypass of the primary Northwest Plume centroids of TCE and Tc-99 contamination near and between the EWs. The derived groundwater flow velocity between the EW field and MW460 is 2.3 ft per day or 1,000 ft per 440 days.

3. ASSESSMENT OF NORTHWEST PLUME CAPTURE

The conceptual site model indicates that the NWPGS is effective for the capture of the Northwest Plume. Further analysis of contaminant trends provides additional evidence.

3.1. CONTAMINANT LEVELS IN EW233 AND MW460

A comparison of contaminant levels in EW233, which is the EW with the highest contaminant levels, and MW460, which is the downgradient MW with the recent highest contaminant levels, demonstrates the effectiveness of the NWPGS. TCE levels are reduced by one order of magnitude. Among the most recent analyses, the TCE analysis was 837 µg/L in a sample collected from EW233 on January 4, 2022. This is compared to a TCE analysis of 1.05 µg/L in a sample collected from MW460 on December 7, 2021. Tc-99 levels, which are all below drinking water standards, are reduced by > 50%. Tc-99 analyses in the January 4, 2022, sample of EW233 was 261 pCi/L, compared to 123 pCi/L in the December 7, 2021, sample from MW460.

Comparing sampling data to account for the 440-day travel time offset demonstrates even greater efficiency. Among the available analyses, the 1.05 µg/L TCE analysis for the MW460 sample of December 7, 2021, relates to a 1,320 µg/L TCE analysis for the EW233 sample of October 6, 2020. These samples were collected 427 days apart. The 123 pCi/L Tc-99 analysis for the MW460 sample of December 7, 2021, relates to a 291 pCi/L Tc-99 analysis for the EW233 sample of October 6, 2020.

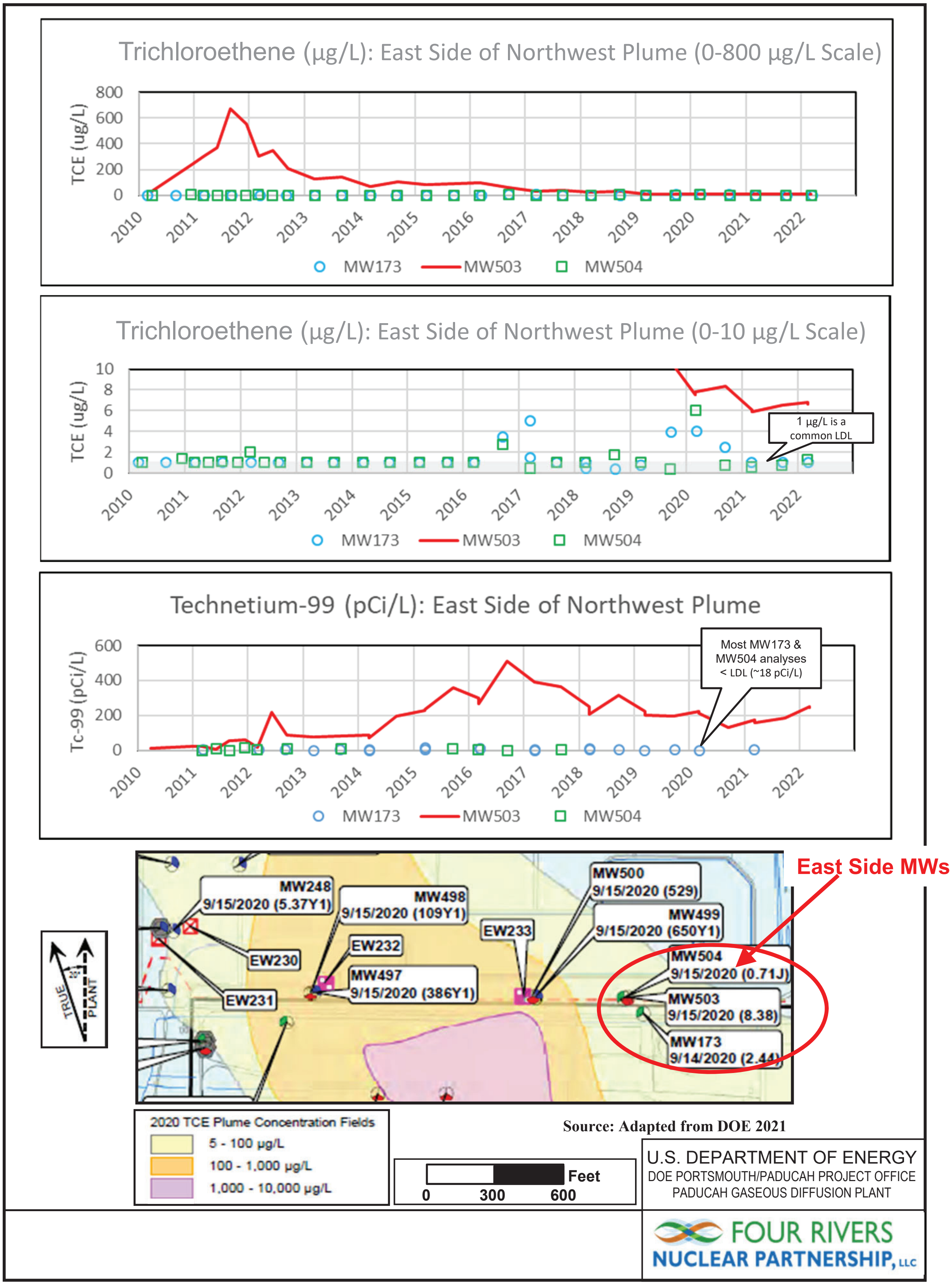
3.2. CONTAMINANT TRENDS ON THE EAST SIDE OF THE NORTHWEST PLUME GROUNDWATER SYSTEM

Analyses of samples from nested wells MW503 (lower RGA) and MW504 (upper RGA), located 464 ft and 448 ft east of EW233, respectively; and MW173 (upper RGA), located 540 ft east of EW233, are the basis for assessing the partial bypass of the NWPGS on the east side. Figure 9 summarizes the available data.

Detectable levels of both TCE and Tc-99 are mostly limited to MW503 (lower RGA). TCE levels in MW503, which were as high as 670 µg/L on September 1, 2011, have declined to 7 µg/L and less (i.e., near the maximum contaminant level of 5 µg/L). Tc-99 levels in MW503 peaked in 2016 (509 pCi/L on September 14, 2016) and have declined to approximately 200 pCi/L (252 pCi/L on March 8, 2022).

These trends indicate that the NWPGS is capturing TCE contamination on the east side of the Northwest Plume, but Tc-99 contamination that is related to a second Tc-99 centroid on the east side of the Northwest Plume persists at a level of approximately 200 pCi/L, which is less than drinking water standards.

[7] A previous alternative explanation for the contaminant trends in MW460 (no longer supported) is that the trends resulted from "pullback" (southward flow) of downgradient contamination toward the EW field.



Source: Adapted from DOE 2021

Figure 9. East Side Contaminant Analyses

4. STATUS OF OPTIMIZED NORTHWEST PLUME GROUNDWATER SYSTEM

The optimized NWPGS is performing its intended function—downgradient contaminant levels are significantly reduced by the pump-and-treat system. Moreover, the NWPGS is achieving its desired outcome—the downgradient extent of the Northwest Plume is contracting, and contaminant levels in Little Bayou Creek seeps have declined below levels of risk concern. The Record of Decision goal to decrease risk by mitigating the spread of the high concentration portion of the Northwest Plume and retarding the migration of the contaminants emanating from the source area is being realized (DOE 1993).

Figure 10 illustrates the contraction of the Northwest Plume between calendar years 2014 and 2020 and documents the decline of TCE levels in Little Bayou Creek Seep 5—the seep with highest contaminant levels (DOE 2015, DOE 2021). Note: Tc-99 levels in Little Bayou Creek Seep 5 had declined to 25 pCi/L and less beginning in 2013.

The two EWs of the optimized NWPGS, EW232 and EW233, continue to operate with good efficiency. Figure 11 presents weekly measurements of drawdown in the site's EWs, including the original and optimized Northeast Plume Containment System (for reference) for the period of August 2015 through October 2022 (the period of readily available data). Drawdown in the EWs remains undiminished. Neither biofouling nor mineral encrustation have significantly impacted the ability of the EWs to transmit water from the RGA in the producing intervals of the well screens.

5. CONCLUSION

The 2019 white paper, *Evaluation of TCE Trends in MW460*, suggested the following three approaches to optimize the capture of the TCE plume centroid (DOE 2019a).

- Adjust the pumping rates between the two EWs;
- Lower the pump intake in one or both EWs; and
- Assess the need for rehabilitation of the EWs.

These suggestions were included as a recommendation/follow-up action in the CY 2018 Five-Year Review (DOE 2019b).

This assessment finds that there is no need to reassess the pump placement and pumping rates or the rehabilitation of the EWs at this time. The NWPGS is achieving its design goals. The system's operational path forward is to continue with the current EW pumping rates, with no adjustment in the depth of the pumps. Well efficiency of the EWs remains high; therefore, rehabilitation is not needed. The sustained monitoring of contaminant levels will provide data for future assessments and also will document the impact of the remedial action(s) at the C-400 Complex OU, which should significantly reduce or contain these upgradient contaminant sources.

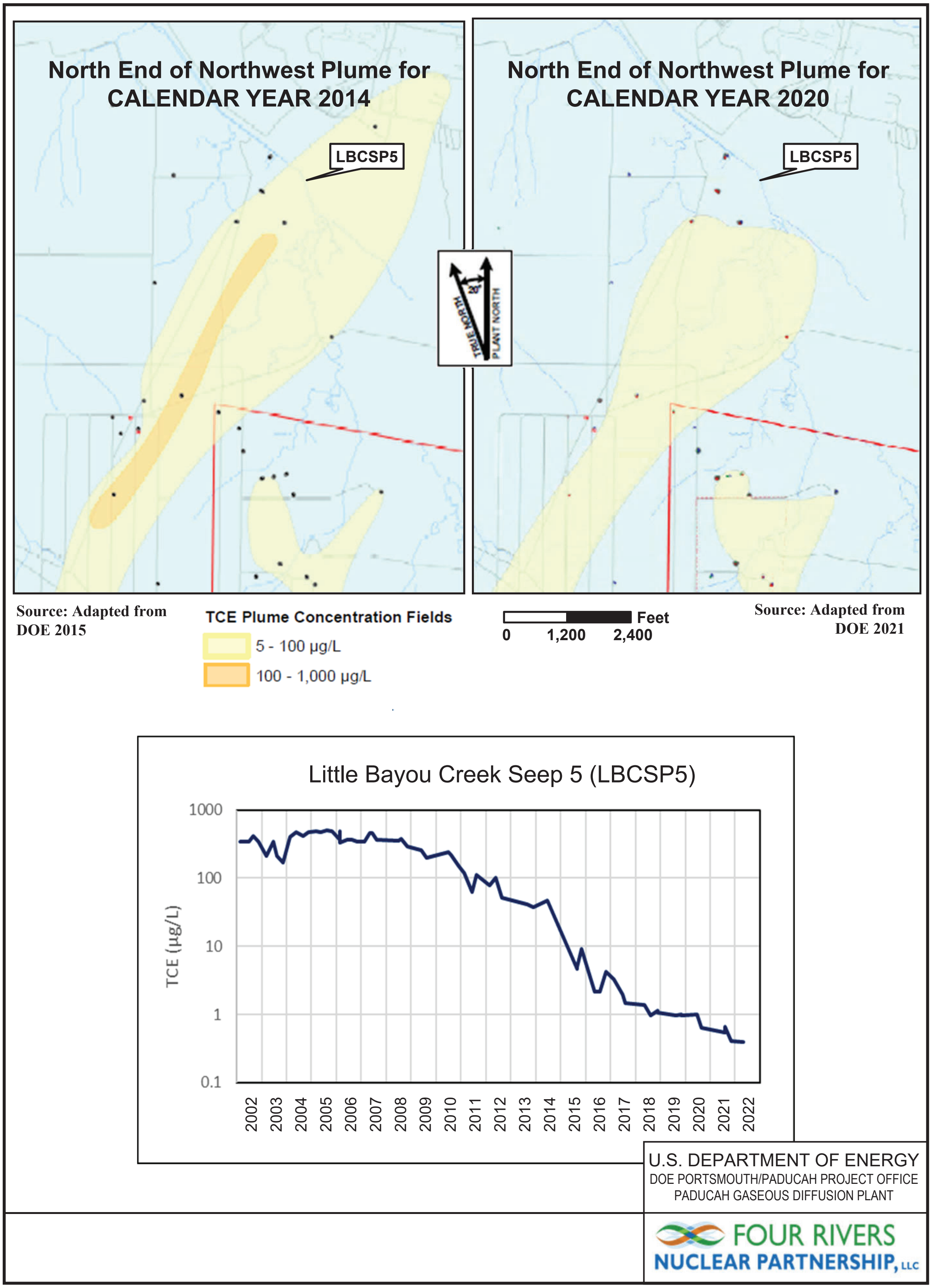
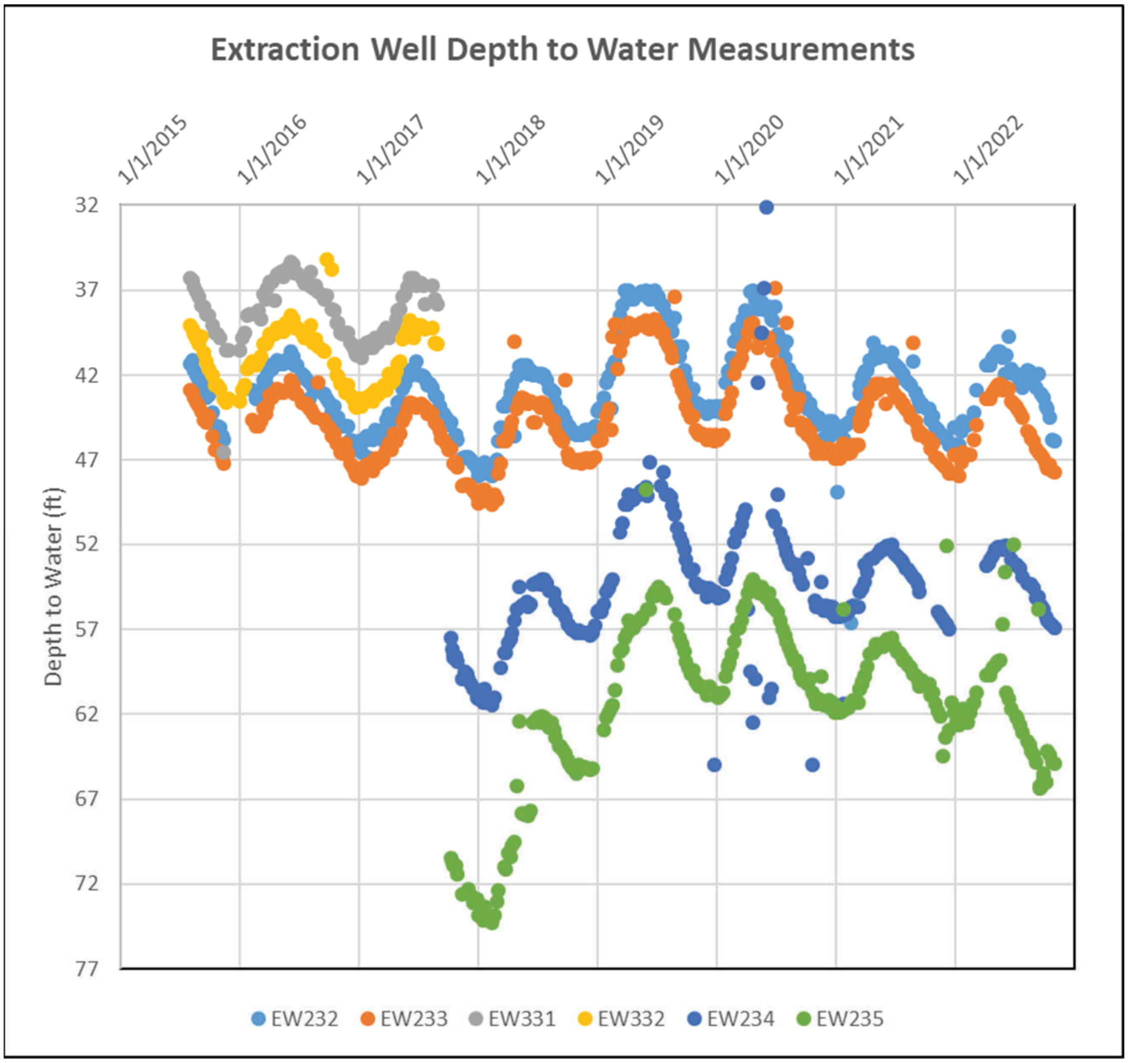


Figure 10. Northern Extent of Northwest Plume



Optimized Northwest Plume Containment System
- EW232
- EW233

Original Northeast Plume Containment System
- EW331
- EW332

Optimized Northeast Plume Containment System
- EW234
- EW235

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

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 11. Depth-to-Water Measurements in Extraction Wells

6. REFERENCES

CH2M HILL 1991. *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/ER-4, CH2M HILL, Paducah, KY.

CH2M HILL 1992. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-03/1991/1, CH2M HILL, Paducah, KY.

DOE (U.S. Department of Energy) 1993. *Record of Decision for Interim Remedial Action for the Northwest Dissolved Phase Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1143&D4, U.S. Department of Energy, Paducah, KY, July.

DOE 1995. *Northwest Plume Preliminary Characterization Summary Report*, DOE/OR/07-1339/V1&D2, U.S. Department of Energy, Paducah, KY, July.

DOE 2009. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Groundwater Aquifer for Calendar Year 2007 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, PRS/PROJ/0046/R1, U.S. Department of Energy, Paducah, KY, April.

DOE 2015. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2014 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-ENR-0146, LATA Environmental Services of Kentucky, LLC, Kevil, KY, June.

DOE 2019a. *Compilation of Meeting Summaries and White Papers (2017–2018)*, DOE/LX/07-2437&D1, U.S. Department of Energy, Paducah, KY, December.

DOE 2019b. *CY 2018 Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2426&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2021. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2020 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0175, Four Rivers Nuclear Partnership, LLC, Paducah, KY, July.

THIS PAGE INTENTIONALLY LEFT BLANK