US Department of Energy
Paducah Gaseous Diffusion Plant

# 2025



# Paducah Site
## Annual Site Environmental Report

FRNP-RPT-0404

Paducah Site

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**FRNP-RPT-0404**

# Paducah Site
# Annual Site Environmental Report 2025

August 2026

Prepared for the
US 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

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# Acronyms and Abbreviations

| | | |
|---|---|---|
| **A** | ALARA | as low as reasonably achievable |
| | ANSI | American National Standards Institute |
| | ASER | Annual Site Environmental Report |
| **B** | BCG | biota concentration guide |
| **C** | CAP-88 PC | Clean Air Act Assessment Package-1988 Personal Computer |
| | CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| | CEQ | Council on Environmental Quality |
| | *CFR* | *Code of Federal Regulations* |
| | CRD | Contractor Requirements Document |
| **D** | DOE | US Department of Energy |
| | DOECAP | DOE Consolidated Audit Program |
| | $DUF_6$ | depleted uranium hexafluoride |
| **E** | EISA | Energy Independence and Security Act |
| | EMS | Environmental Management System |
| | EPCRA | Emergency Planning and Community Right-to-Know Act |
| **F** | FFA | Federal Facility Agreement |
| | FRNP | Four Rivers Nuclear Partnership, LLC |
| | FY | fiscal year |
| **K** | *KAR* | *Kentucky Administrative Regulations* |
| | KDEP | Kentucky Department for Environmental Protection |
| | KDOW | Kentucky Division of Water |
| | KDWM | Kentucky Division of Waste Management |
| | KPDES | Kentucky Pollutant Discharge Elimination System |
| **M** | MCS | Mid-America Conversion Services, LLC |

| | | |
|---|---|---|
| | MCSA | Mission Conversion Services Alliance, LLC |
| | MEI | maximally exposed individual |
| **N** | NA | not applicable |
| | NEPA | National Environmental Policy Act |
| | NESHAP | National Emission Standards for Hazardous Air Pollutants |
| | NWD | North Wind Dynamics, LLC |
| **O** | OREIS | Oak Ridge Environmental Information System |
| **P** | PEGASIS | PPPO Environmental Geographic Analytical Spatial Information System |
| | PEMS | Project Environmental Measurements System |
| | PFAS | per- and polyfluoroalkyl substances |
| | PGDP | Paducah Gaseous Diffusion Plant |
| | PPA | property protection area |
| | PPPO | Portsmouth/Paducah Project Office |
| **Q** | QA | quality assurance |
| | QC | quality control |
| **R** | RCRA | Resource Conservation and Recovery Act |
| **S** | SST | Swift & Staley Inc. |
| | SWMU | solid waste management unit |
| **U** | US EPA | US Environmental Protection Agency |
| **W** | WKWMA | West Kentucky Wildlife Management Area |

# Request for Comments

The US Department of Energy requires an annual site environmental report from each of its sites. This *Paducah Site Annual Site Environmental Report 2025* presents the results from the various environmental monitoring programs and activities carried out during the year. This report is a public document that is distributed to government regulators, businesses, special interest groups, and members of the public. Please note that hyperlinks appear throughout this report to take the reader directly to the website or other locations where data, tables, or supporting documents can be found. These links were active at the time of publication, but may become inactive if items have moved or a website has been renamed.

This report is based on many environmental samples collected at or near the Paducah Site. Significant efforts were made to provide the data collected and details of the Paducah Site environmental management programs in a clear and concise manner. The editors of this report encourage comments in order to better address the needs of our readers in future Paducah Site environmental reports. You can complete a comment form online here.

If you prefer, written comments may be sent to the following address:

US Department of Energy
Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513

# Executive Summary

The US Department of Energy's (DOE's) Paducah Site is in a rural area of McCracken County, Kentucky, 10 miles west of Paducah and 3.5 miles south of the Ohio River. Constructed on a portion of a World War II-era munitions plant, the Paducah Site became one of three uranium enrichment plants serving both national security and the commercial sector.

Since 1988, DOE's Office of Environmental Management has been conducting cleanup operations at Paducah even as the site supported the commercial nuclear sector. DOE's activities at the Paducah Site include restoring impacts from past operations to protect human health and the environment (Figure ES.1); stabilizing infrastructure; removing radioactive and hazardous wastes from facilities; characterizing and disposing of waste stored or generated on-site; and deactivating and demolishing the gaseous diffusion plant and its support facilities.



**Figure ES.1. Deer emerging from the woods**

Each year, the Paducah Site prepares the Annual Site Environmental Report (ASER) according to the requirements of DOE Order 231.1B, *Environment, Safety, and Health Reporting*. The ASER is a key component of DOE's effort to keep the public informed about environmental conditions at the Paducah Site. This report and previous ASERs can be found here.

The ASER offers a detailed overview of environmental activities at Paducah, which are organized as follows:

**DOE conducts environmental monitoring to assess the potential impact of Paducah Site activities on public health and the environment. In 2025, measurements for direct radiation were taken on and around the Paducah Site; more than 2,000 samples of air, sediment, and water were collected and analyzed for radioactive and nonradioactive contaminants.**

Chapter 1: Introduction to the Paducah Site's history and mission

Chapter 2: Summary of compliance with laws and regulations

Chapter 3: Details of Paducah Site environmental management programs

Chapter 4: Types of radiological environmental monitoring conducted at the Paducah Site and the calculated impacts

Chapter 5: Nonradiological monitoring of air, surface water, and sediment

Chapter 6: Groundwater protection

Chapter 7: Actions to ensure the quality of information from field sampling to analytical laboratory to data management

DOE conducts environmental monitoring to evaluate and assess any unplanned releases. Major sampling efforts of environmental monitoring for 2025 are summarized below. Samples are taken from consistent locations when available for comparison.

- DOE monitored for radionuclides, trichloroethene, metals, and other water quality parameters under the Kentucky Pollutant Discharge Elimination System (KPDES) Permit and the Environmental Radiation Protection Program at 15 locations where surface water flows into Bayou Creek and Little Bayou Creek.
- External radiation was measured continuously at 64 locations. The measurements were reported quarterly.[1]
- Ambient air was sampled at nine locations, on-site and off-site, and was analyzed for radionuclides.
- Surface water samples were collected annually from two locations and quarterly from six locations, both on-site and off-site, and analyzed for radionuclides.
- Surface water samples were collected quarterly near on-site landfill locations and one off-site location.
- Sediment was sampled at six locations and analyzed for radionuclides and at 14 locations for polychlorinated biphenyls.
- Surface water sampling included testing fathead minnows and water fleas for chronic toxicity at two locations and acute toxicity at one location.
- More than 200 wells were sampled at varying frequencies to monitor corrective actions, movement of groundwater contaminants, and groundwater quality.
- Per- and polyfluoroalkyl substances (PFAS) sampling was conducted in 2025 from a variety of environmental media. The results will be available to the public at a future date.

**2025 Environmental Performance Summary**

DOE's monitoring performance at Paducah for 2025 is summarized below.

- Environmental monitoring data collected in 2025 are similar to data collected in previous years and indicate that radionuclides, metals, and other chemicals released by Paducah would only minimally affect human health and the environment.
- The calculated radiation dose from DOE activities at the Paducah Site that could be received by a maximally exposed individual (MEI) member of the public, which assumes exposure from all relevant pathways, was 0.39 millirem (mrem)[2]. The largest contributor to this calculated dose was the direct radiation pathway, or external radiation, which contributed 0.22 mrem to this total. Atmospheric releases, incidental ingestion of surface water, and incidental ingestion of sediment contributed the remainder of this calculated dose to the MEI. Figure ES.2 shows how the calculated MEI dose of 0.39 mrem, compares to the DOE annual dose limit of 100 mrem and to other common sources of radiation.

[1] The terms external radiation and direct radiation are used synonymously in this document.

[2] Previous years' external radiation dose calculations used the averages that included publicly inaccessible locations. Starting in 2024, the MEI dose is based on the publicly accessible locations outside the property protection area and DOE boundaries. The publicly accessible location with the maximum dose is assigned to the MEI for this pathway.

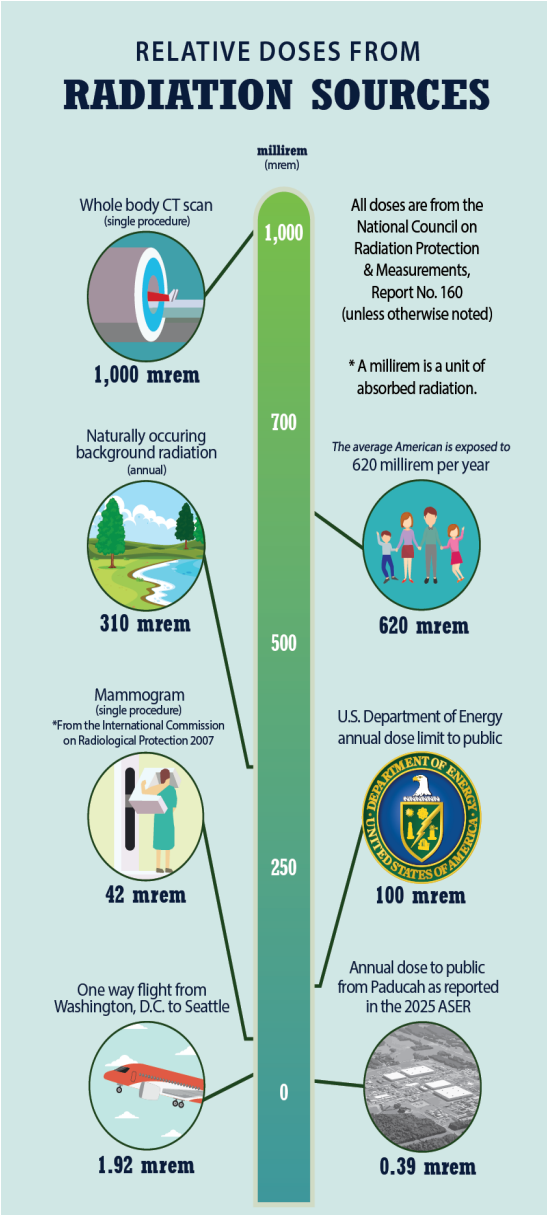



**Figure ES.2. Relative doses from radiation sources**

- In 2017, the Paducah Site began investigating the history of on-site use of PFAS compounds. Based on the most likely known potential source of PFAS contaminants (fire suppression chemicals), samples were collected in 2019 from 2 groundwater monitoring wells in the Fire Training Area and analyzed for 18 PFAS compounds. Analytical results indicate detectable levels of PFAS contamination in groundwater in the vicinity of the Fire Training Area.
- In 2025, the Paducah Site evaluated the presence of PFAS in potable water. Several results for perfluorooctanoic acid and perfluorooctanesulfonate exceed the US Environmental Protection Agency (US EPA) maximum contaminant levels established in April 2024 for select PFAS compounds. The results are similar to those found in the Ohio River, which is the raw water supply for the Paducah Site. PFAS found in the potable water most likely originate from the Ohio River and are unrelated to the Paducah Site water treatment process and/or distribution system. Compliance with the newly established maximum contaminant levels is required by April 2029. The Paducah Site is evaluating options to ensure compliance with this requirement on or before the regulatory due date.
- The Paducah Site has provided employees with commercially supplied bottled water for drinking for more than 10 years.
- DOE pays water bills for affected residences and businesses in areas where the groundwater either is known to be contaminated or has the potential to become contaminated with trichloroethene and technetium-99.
- Ambient air monitoring indicates that, as in past years, contaminant levels for radionuclides in air are not detected; are below DOE standards; or are within background levels.
- The 2025 radiological results for sediment are consistent with those measured during previous years.
- The Paducah Site received two Notices of Violation during 2025. NOV ENV20240003 was issued for the whole effluent toxicity permitted limits exceedance at KPDES Outfall 001 and NOV 2025-9092019 was issued for the public water system exceedance of turbidity at the combined filter effluent. Table ES.1 identifies the month when the Notices of Violation were received.

**Table ES.1. Notices of violation received monthly during 2025**

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | CY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NOV Received | 0 | 1 | 0 | 0 | 0 | **1** | 0 | 0 | 0 | 0 | 0 | 0 | 2 |

DOE and its contractors at Paducah are committed to enhancing environmental stewardship and reducing any impacts that Paducah Site cleanup operations may have on the environment. The Paducah Site implements sound stewardship practices in protecting land, air, water, and other natural or cultural resources potentially affected by its operations.

The chapters that follow this Executive Summary offer a more complete description of the environmental program at the Paducah Site.

# 1. Introduction

The Paducah Gaseous Diffusion Plant (PGDP) was constructed in the early 1950s and began enriching uranium in 1952. In fact, the Paducah Site was an active uranium enrichment facility until 2013. The Energy Policy Act of 1992 provided for the lease of the enrichment facilities to a commercial entity that operated the enrichment facilities from 1998 to 2013. In 2014, the leased facilities were returned to DOE control, and then a DOE contractor began managing the uranium enrichment facilities for DOE. These facilities are now undergoing deactivation in preparation for decommissioning.

DOE requires that environmental monitoring be conducted and documented for its facilities under DOE Order 231.1B, *Environment, Safety, and Health Reporting*. Several other laws, regulations, and DOE directives require compliance with environmental standards. The purpose of this ASER is to summarize 2025 environmental management activities, including effluent monitoring and environmental surveillance, at the Paducah Site; report on environmental compliance status; and highlight significant Paducah Site program efforts. References in this report to the Paducah Site generally mean the property, programs, and facilities at or near PGDP for which DOE has ultimate responsibility.

Environmental monitoring includes two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the direct measurement or the collection and analysis of samples of liquid and gaseous discharges to the environment. At the Paducah Site, environmental surveillance includes the direct measurement or the collection and analysis of samples of ambient air, surface water, groundwater, and sediment. Effluent monitoring and environmental surveillance are performed to characterize and quantify contaminants; assess radiation exposure; demonstrate compliance with applicable standards and permit requirements; and detect and assess the effects, if any, on the local population and environment. Samples are collected throughout the year and are analyzed for radioactivity, chemical constituents, and various physical properties.

DOE's overall goals for environmental management are to protect Paducah Site personnel, the environment, and the community, and to maintain full compliance with all current applicable environmental regulations. DOE operates the Paducah Site in a manner that controls and reduces exposures of the public, workers, and the environment to harmful chemicals and radiation.

This report fulfills the requirements of DOE Order 231.1B and DOE Order 458.1, *Radiation Protection of the Public and Environment*. Data and information contained in this report were collected in accordance with the Paducah Site environmental monitoring plan approved by DOE (FRNP 2025a). This report is not intended to provide the results of all sampling conducted at the Paducah Site. Additional data collected for other Paducah Site purposes, such as environmental remediation, remedial investigation reports, and waste management characterization sampling, are presented in other documents that have been prepared in accordance with applicable DOE guidance and federal or state laws. DOE intends the ASER to cover activities for each calendar year. Unless noted otherwise (i.e., fiscal year [FY]), readers can assume that, when 2025 is mentioned, the reference is for the calendar year.

Other documents are referenced in this report; where available, electronic hyperlinks to the documents are provided.

## 1.1 Site Location and History

The Paducah Site is in a rural area of McCracken County, Kentucky, 10 miles west of Paducah and 3.5 miles south of the Ohio River, as shown in Figure 1.1. The population of McCracken County is approximately 67,000. The major city in McCracken County (Paducah) has a population of approximately 27,000. Three small communities are located within 3 miles of the DOE property boundary at the Paducah Site: Heath and Grahamville to the east and Kevil to the southwest. The closest commercial

airport is Barkley Regional Airport, which is approximately 5 miles to the southeast of the DOE property boundary at the Paducah Site.

The plant occupies a 3,556-acre DOE-owned Site, approximately 1,427 acres of which are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA) (DOE 2025a). During World War II, Kentucky Ordnance Works operated its main process and some storage in an area southwest and west of the plant on what is now the WKWMA. WKWMA now consists of woodlands, meadows, and cultivated fields. Hunters and trappers of wildlife, such as rabbit, deer, quail, raccoon, squirrel, dove, turkey, waterfowl, and beaver, use the area, where fishing is also popular. The Kentucky Department of Fish and Wildlife Resources also sponsors field hunting trials for dogs in the WKWMA.

## 1.2 Environmental Setting

The Paducah Site is in the humid continental zone, where summers are warm (July averages 79°F) and winters are moderately cold (January averages 35°F). Yearly precipitation averages about 49 inches.

The Paducah Site is in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is about 15 miles upstream of the site, and the Ohio River joins the Mississippi River about 35 miles downstream. The Paducah Site is on a local drainage divide: surface water from the east side of the plant flows east-northeast toward Little Bayou Creek, and surface water from the west side of the plant flows west-northwest toward Bayou Creek. Bayou Creek is a perennial stream that flows toward the Ohio River along a 9-mile course. Little Bayou Creek, an intermittent stream, flows north toward the Ohio River along a 7-mile course. The two creeks converge 3 miles north of the plant before emptying into the Ohio River.

Flooding in the area is associated with Bayou Creek, Little Bayou Creek, and the Ohio River. Maps developed in support of the National Flood Insurance Program show a flood hazard within the DOE boundary at the Paducah Site but only slightly within the industrialized area (FEMA 2025). This flood hazard defines the 100-year flood line.

Several environmental studies were conducted in the area of the Paducah Site in the 1990s (CH2M HILL 1991, CH2M HILL 1992, COE 1994). These studies have been re-evaluated by recent projects and were determined to be consistent with current conditions. A study of about 12,000 acres in and around the Paducah Site found approximately 1,100 separate wetlands, totaling over 1,500 acres (COE 1994). More than 60 percent of the total wetland area is forested. Area soils are predominantly silty loams that are poorly drained, acidic, and have little organic content. Section 6.1 describes the local groundwater flow system at the Paducah Site.

Much of the Paducah Site has been affected by human activity. Vegetation communities on the reservation are indicative of old field succession with grassy fields, field scrub-shrub, and upland mixed hardwoods. The open grassland areas, most of which are managed by WKWMA personnel, are mowed periodically or burned to maintain early successional vegetation, which is dominated by members of the Compositae (flowering plants) family and various grasses. Corn, millet, milo, and soybeans are commonly cultivated for wildlife forage (CH2M HILL 1992).

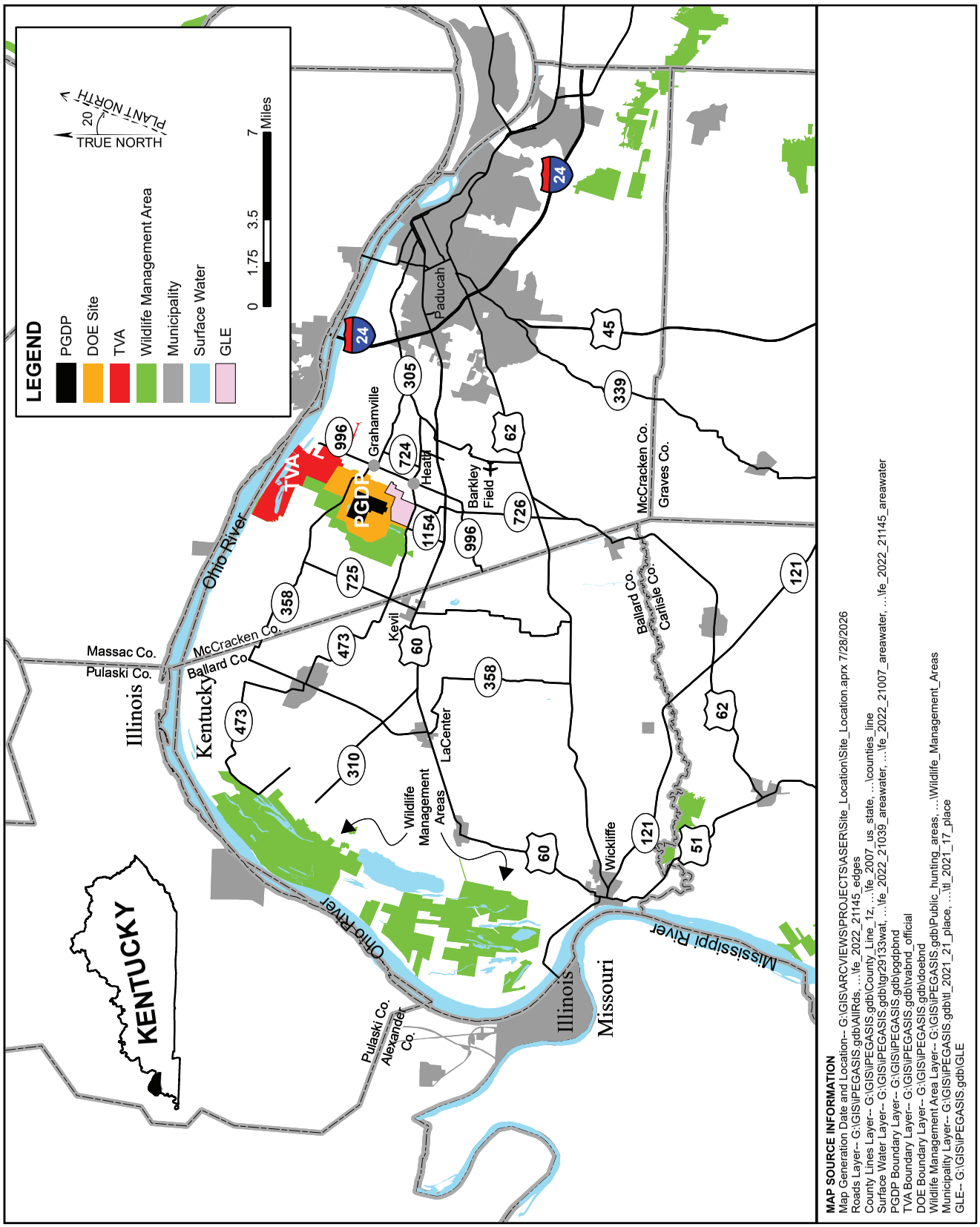



**Figure 1.1. Location of the Paducah Site**

Field scrub-shrub communities consist of sun-tolerant wooded species such as persimmon, maples, black locust, sumac, and oaks (CH2M HILL 1991). The undergrowth varies depending on the location of the woodlands. Wooded areas near maintained grasslands have an undergrowth dominated by grasses. Other communities have a thick undergrowth of shrubs, including sumac, pokeweed, honeysuckle, blackberry, and grape. Upland mixed hardwood communities feature a variety of upland and transitional species; dominant species include oaks, shagbark and shellbark hickory, and sugarberry (CH2M HILL 1991). The undergrowth varies from limited undergrowth for more mature stands of trees to dense undergrowth similar to that described for a scrub-shrub community.

Wildlife at the Paducah Site include species indigenous to hardwood forests, scrub-shrub, and open grassland communities. Rabbits, mice, opossum, vole, mole, raccoon, and deer frequent some nearby areas, and several groups of coyotes also live in areas around the Paducah Site. Aquatic habitats are used by muskrat and beaver. Results of the Site Investigation Phase 1 includes a list of representative species (CH2M HILL 1991). Birds include red-winged blackbirds, quail, sparrows, shrikes, mourning doves, turkeys, cardinals, meadowlarks, hawks, and owls. The Ohio River, which is 3.5 miles north of the Paducah Site, also serves as a major flyway for migratory waterfowl (DOE 1995a). Harvestable fish populations live in Bayou Creek, especially near the mouth of the creek at the Ohio River. Fish populations in Little Bayou Creek are in the minnow category (DOE 2024a).

A threatened and endangered species investigation identified federally listed, proposed, or candidate species potentially occurring at or near the Paducah Site (COE 1994). Updated information is obtained regularly from federal and Commonwealth of Kentucky sources. Potential habitat for 13 species of federal concern exists in the study area. Eleven of these species are listed as endangered under the Endangered Species Act of 1973, and two are listed as threatened, as shown in Table 2.5 in Section 2 of this report. While potential habitats for endangered species exist on DOE property, none of the federally listed or candidate species have been identified on DOE property at the Paducah Site.

## 1.3 Site Operations

DOE established the Portsmouth/Paducah Project Office (PPPO) on October 1, 2003, to provide focused leadership to the environmental management missions at the Portsmouth, Ohio, and Paducah, Kentucky, gaseous diffusion plants. The PPPO office opened in January 2004 in Lexington, Kentucky, which is located midway between the Kentucky and Ohio facilities. Although the PPPO Manager is based in the Lexington office, frequent and routine site interactions occur at both the Portsmouth and Paducah Sites. DOE also maintains a strong daily presence at both sites through its Portsmouth and Paducah Site Offices. The mission of PPPO is to conduct the safe, secure, compliant, and cost-effective environmental cleanup of the Portsmouth and Paducah Sites on behalf of the local communities and the American taxpayers. In addition to stabilization, deactivation, and infrastructure management of the gaseous diffusion plants, DOE's PPPO mission, as stated here, is to accomplish the following at the Portsmouth and Paducah Sites:

- Environmental remediation
- Waste management
- Depleted uranium hexafluoride ($DUF_6$) conversion
- Deactivation and decommissioning




**Figure 1.2. DOE Paducah Site entrance**

Figure 1.2 shows the entrance sign to the DOE Paducah Site. Figure 1.3 identifies the main Paducah Site and associated boundaries. Prime contractors working to support DOE missions at the Paducah Site include Mid-America Conversion Services, LLC (MCS), Swift & Staley Inc. (SST),[3] and Four Rivers Nuclear Partnership, LLC (FRNP). Note: MCS transitioned to Mission Conversion Services Alliance, LLC, (MCSA) and SST transitioned to North Wind Dynamics, LLC, (NWD) in October 2025. DOE operates two major programs at the Paducah Site: Environmental Management and the Uranium Program.

The Environmental Management Program includes the Environmental Restoration; Facility Stabilization, Deactivation, Decontamination and Demolition, and Infrastructure Optimization; and Waste Management Projects. Chapter 3 includes additional information on these activities.

The mission of the Environmental Restoration Project is to ensure that releases from past operations at the Paducah Site are investigated and that appropriate response actions are taken to protect human health and the environment in accordance with the Federal Facility Agreement (FFA) (US EPA 1998).

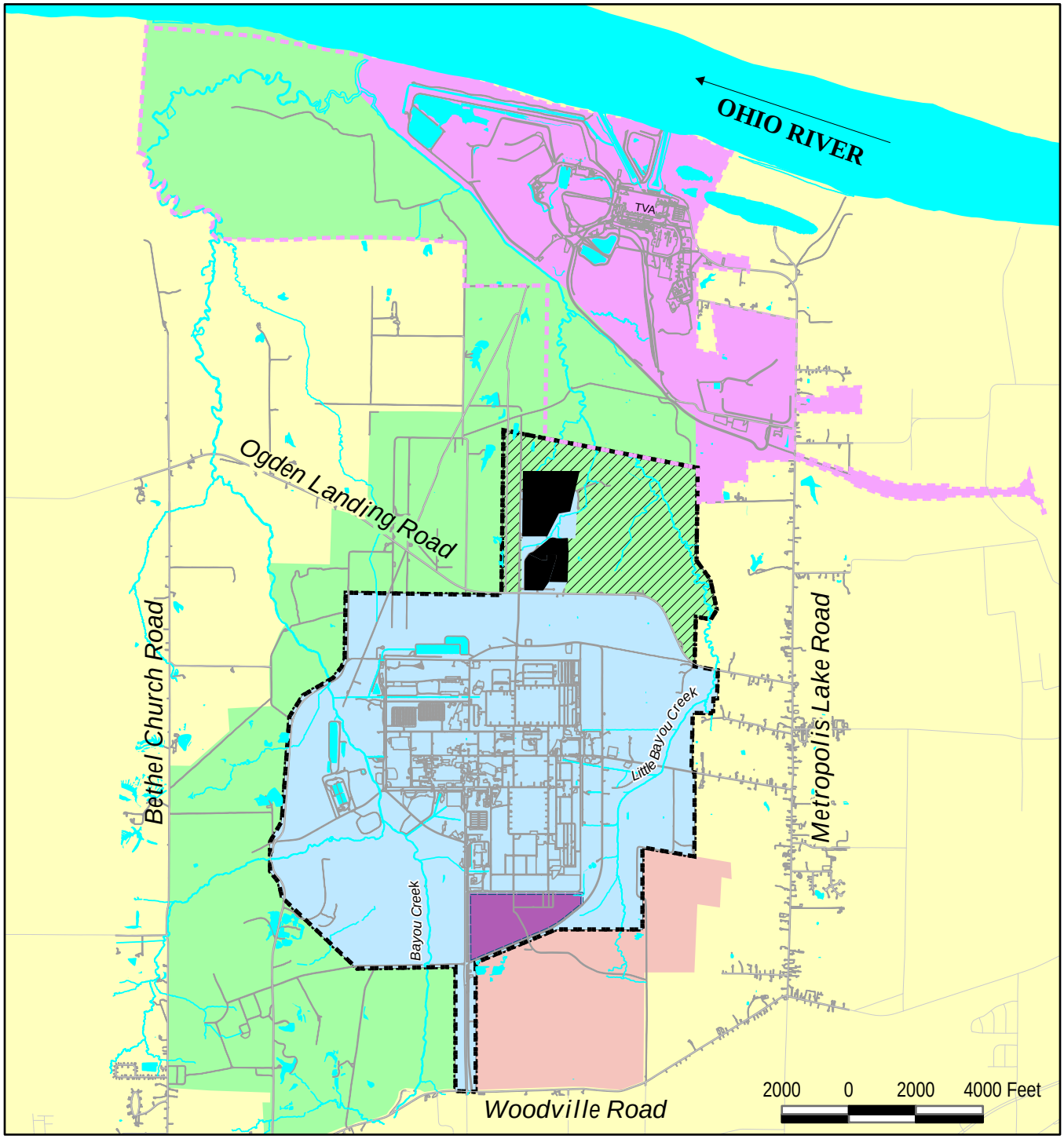
The mission of the Facility Stabilization, Deactivation, and Infrastructure Optimization Projects is to remove radioactive and hazardous materials from the facility, safely shut down facility systems, and optimize infrastructure that will continue to support the site.

The mission of the Waste Management Project is to characterize and dispose of waste stored and generated on-site in compliance with regulatory requirements and DOE orders.

The mission of Decontamination and Demolition is to tear down the former gaseous diffusion plant and its support facilities and dispose the demolition debris in compliance with regulatory requirements and DOE orders.

The major missions of the Uranium Program are to maintain safe, compliant storage of the DOE $DUF_6$ inventory until final disposition, to operate a facility for conversion of $DUF_6$ to a more stable oxide and hydrofluoric acid, and to manage the associated facilities and grounds.

[3] Swift & Staley Inc. was known as SST at the Paducah Site.




LAND USE ON DOE PROPERTY
- Industrial Use
- DOE Licensed to WKWMA for Recreation*
- Leasing Parcel A (Industrial Use)
- Waste Management Area (See Note)

LAND OWNERSHIP OUTSIDE DOE PROPERTY
- West Kentucky Wildlife Management Area
- TVA
- GLE (Industrial Use)
- Private Property

TRUE NORTH 20° PLANT NORTH

Note: These areas include landfills that are active or certified closed and under long-term custodial care (i.e., C-746 S&T, C-746-U). As such, these areas are not amenable to unrestricted future industrial use.
As new CERCLA decision documents or permits are issued with deed restrictions/LUCs for waste management areas this map will be updated to include those units.

MAP SOURCE INFORMATION
Map Generation Date and Location: 8/12/2026 G:\GIS\ARCVIEWS\PROJECTS\ASER\LandUse_20260729.aprx
Recreational: G:\gis\iPEGASIS.gdb\Wildlife_Management_Areas and G:\gis\iPEGASIS.gdb\doebnd
TVA Boundary: G:\gis\iPEGASIS.gdb\tvabnd_official
Industrial and Waste Management Areas: G:\gis\SHAPES\BOUNDS\Closed_to_Public_Access.shp and G:\gis\iPEGASIS.gdb\facilities (as specified)
Roads: G:\gis\iPEGASIS.gdb\AllRds
Surface Water & River: G:\gis\iPEGASIS.gdb\streams, ...\surface_water, ...\fr_2022_21145_areawater
GLE: G:\GIS\iPEGASIS.gdb\GLE
LPA, LPB, LPC: G:\GIS\ARCVIEWS\PROJECTS\LandLease\LPA

**Figure 1.3. General map of the Paducah Site**

# 2. Compliance Summary

This chapter provides a compliance summary for the Paducah Site with respect to environmental laws and regulations, DOE orders, and Executive orders. DOE and its contractors are responsible for environmental restoration; facility stabilization, deactivation, and infrastructure optimization; and waste management projects.

The FFA (US EPA 1998) outlines the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup activities at the Paducah Site. Under this agreement, DOE is the lead agency and both the US EPA and the Commonwealth of Kentucky, as co-signers, have authority for regulatory oversight under the agreement. The Kentucky Department for Environmental Protection (KDEP) also issues regulatory permits and oversees compliance with the applicable environmental laws and regulations for which they have implementation authority.

US EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards based on statutes passed by Congress. In most instances, US EPA has delegated regulatory authority to KDEP when the Commonwealth of Kentucky program meets or exceeds US EPA requirements.

## 2.1 Environmental Protection and Waste Management

The following sections discuss environmental protection, waste management activities, and compliance with US EPA and KDEP environmental laws, regulations, and permits at the Paducah Site.

### 2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA, commonly known as Superfund, was passed in 1980 and then amended in 1986 by the Superfund Amendments and Reauthorization Act. Under CERCLA, a site is investigated and remediated if it poses significant risk to human health or the environment.

The Superfund Amendments and Reauthorization Act amended CERCLA on October 17, 1986, to reflect US EPA's experience in administering the complex Superfund program. Important changes and additions included increasing the focus on human health problems posed by hazardous waste sites and encouraging greater participation by citizens in deciding how sites should be cleaned up. Section 3.5 describes DOE programs that engage citizens in cleanup decision-making for the Paducah Site.

DOE and US EPA Region 4 entered into an Administrative Consent Order in August 1988 under Sections 104 and 106 of CERCLA in response to the off-site groundwater contamination detected at the Paducah Site in July 1988. On May 31, 1994, the Paducah Site was placed on the US EPA National Priorities List, which includes sites across the nation designated by US EPA as the highest priority for remediation.

Section 120 of CERCLA requires federal agencies with facilities on the National Priorities List to enter into a FFA with US EPA. The FFA for the Paducah Site, which was signed February 13, 1998, by DOE, US EPA, and Kentucky Energy and Environment Cabinet, established a decision-making process for remediation of the Paducah Site and coordinates CERCLA remedial action requirements with Resource Conservation and Recovery Act (RCRA) corrective action requirements. DOE, US EPA, and KDEP agreed to terminate the CERCLA Administrative Consent Order, and any additional, related activities would be continued under the FFA. The FFA defines the process for all remediation activities undertaken at the Paducah Site. It includes requirements for implementing investigations; selecting and implementing

appropriate remedial and removal actions; and establishing priorities for the action and development of schedules, consistent with the priorities, goals, and objectives of the agreement.

Table 2.1 includes significant milestones completed under CERCLA and the FFA for 2025 at the Paducah Site.

**Table 2.1. CERCLA FFA significant milestones completed in 2025**

| Document or activity | Date completed |
|---|---|
| *Remedial Action Work Plan for the 2023 Optimization of the Northwest Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2509&D2 (DOE 2025b) | 1/14/2025 |
| *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2024 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0380 (FRNP 2025b) | 6/9/2025 |
| *Addendum to the Remedial Investigation Report for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2474&D2/A1 (DOE 2025c) | 6/13/2025 |
| "Record of Conversation Concerning Approval of Appendix C Scoping Document and Work Plan for the Deactivation and Decommissioning Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, DOE/LX/07-2514&D1" (DOE 2025d) | 7/10/2025 |
| *Geotechnical Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2507&D1/R1 (DOE 2025e) | 9/9/2025 |
| *Scoping Document and Work Plan for the Environmental Media Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2515&D2 (DOE 2025f) | 9/16/2025 |
| *Scoping Document and Work Plan for the Deactivation and Decommissioning Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2514&D2 (DOE 2025g) | 9/18/2025 |
| *Site Management Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky, Annual Revision—FY 2026*, DOE/LX/07-2526&D2 (DOE 2025h). | 12/18/2025 |

Acronyms:
FFA = Federal Facility Agreement
FY = fiscal year

## 2.1.2 Emergency Planning and Community Right-to-Know Act

Also referred to as Title III of the Superfund Amendments and Reauthorization Act, the Emergency Planning and Community Right-to-Know Act (EPCRA) requires the reporting of emergency planning information; hazardous chemical inventories; and releases to the environment. The Paducah Site, as a federal facility, is subject to these reporting requirements.

EPCRA's primary purpose is to increase the public's knowledge of and access to information regarding chemical hazards in their communities. To ensure proper and immediate responses to potential chemical hazards EPCRA Sections 302–303 require notifying state and local agencies within 60 days of when the amount of a substance on the list of extremely hazardous substances first exceeds its established threshold planning quantity. Notifications also are required if a revision to the list results in the facility exceeding the revised threshold planning quantity or if changes at the facility are relevant to emergency planning. These notifications are required within 60 days and 30 days, respectively, of the facility becoming subject to the requirements. The Paducah Site did not receive shipments, have production amounts, or make changes relevant to emergency planning that triggered Sections 302–303 reporting for 2025. EPCRA Section 304 requires immediate notification of releases of hazardous or extremely hazardous substances,

but because the Paducah Site had no releases at or above the minimum reportable quantities, Section 304 reporting was not required for 2025.

Sections 311–312 of EPCRA require businesses to report the safety data sheets, locations, and quantities of hazardous chemicals stored on-site (if they exceed specific reporting thresholds) to state and local governments to help communities prepare to respond to chemical spills and similar emergencies. EPCRA Section 311 requires a one-time submittal of safety data sheets of hazardous chemicals present on-site at or above the reporting threshold. No new hazardous chemicals met the reporting threshold at the Paducah Site in 2025. In Kentucky, EPCRA Section 312 requires reporting the locations and quantities of the subject chemicals. Specifically, facilities are required to report their possession of extremely hazardous substances stored at 500 pounds or the threshold planning quantity, whichever is less. In addition, facilities must report any hazardous chemical for which a safety data sheet is required under the Occupational Safety and Health Administration Hazard Communication Standard, and which is stored in the amount of 10,000 pounds or more. The chemicals stored at the Paducah Site by DOE contractors in 2025, and included in an EPCRA 312 Report, were aluminum oxide, argon, carbon, diesel fuel, calcium carbonate, calcium hydroxide, calcium oxide (Quicklime), carbon dioxide, cryogenic and gaseous nitrogen, dichlorotetrafluoroethane (Freon, R-114), liquid and solid ferric sulfate, fuel oil (No. 2), gasoline, hydrofluoric acid, lead acid batteries, oil, potassium hydroxide, propylene glycol, quartz, sodium carbonate, sulfuric acid (nonbattery), uranium hexafluoride, and uranium oxide (uranium hexafluoride was reported as a discretionary because radioactive substances are not subject to reporting under EPCRA Sections 311 and 312 [52 *Federal Register* 38344-01, October 15, 1987]).

EPCRA Section 313 requires US EPA and each respective state to collect data annually on releases and transfers of certain toxic chemicals from industrial facilities and make the data available to the public. The Paducah Site submitted a Section 313 report for hydrofluoric acid for 2025. Table 2.2 summarizes the EPCRA reporting status for the Paducah Site for 2025.

**Table 2.2. Status of EPCRA reporting**

| EPCRA section | Description of reporting | Status* |
|---|---|---|
| EPCRA Sections 302–303 | Planning notification | Not required |
| EPCRA Section 304 | Extremely hazardous substance release notification | Not required |
| EPCRA Sections 311–312 | Material safety data sheet/chemical inventory | Yes |
| EPCRA Section 313 | Toxic release inventory reporting | Yes |

*An entry of yes, no, or not required is sufficient for the status.

Acronym:
EPCRA = Emergency Planning and Community Right-to-Know Act

### 2.1.3 Resource Conservation and Recovery Act

RCRA establishes regulatory standards for the characterization, treatment, storage, and disposal of solid and hazardous waste. Waste generators must follow specific requirements outlined in RCRA regulations for handling solid and hazardous wastes. Owners and operators of hazardous waste treatment, storage, and disposal facilities must obtain operating and post closure permits for waste treatment, storage, and disposal activities. The Paducah Site generates solid waste, hazardous waste, and mixed waste (hazardous waste mixed with radionuclides) and operates three permitted hazardous waste storage and treatment facilities: C-733 Waste Oil & Chemical Storage Facility, C-746-Q Hazardous & LLW [low level waste] Storage Facility, and C-752-A Waste Storage Facility. The closed C-404 Hazardous Waste Landfill must also meet the requirements of RCRA regulations and the Hazardous Waste Management Facility Permit.

The first RCRA Part A and Part B permit applications for storage and treatment of hazardous waste at the Paducah Site were submitted in the late 1980s. US EPA has authorized the Commonwealth of Kentucky to administer the RCRA-based program for treatment, storage, and disposal units. The current Hazardous

Waste Management Facility Permit was renewed by the Kentucky Division of Waste Management (KDWM) on November 12, 2025, and it expires on December 12, 2035.

The $DUF_6$ facility is registered as a large-quantity generator and manages hazardous waste under RCRA. In addition to required regulatory inspections, the $DUF_6$ facility is routinely inspected/assessed by DOE, internal management assessments, and by third-party independent assessments to ensure compliance with KDWM and US EPA requirements.

The current Hazardous Waste Management Facility Permit requires information to be submitted as part of the annual Hazardous Waste Report. This annual report contains the name and address of each facility that waste was shipped to during the previous calendar year, the name and address of the transporter for each waste shipment, the description and quantity of each waste stream shipped off-site, and a description of waste minimization efforts. DOE must report compliance issues as part of the annual Hazardous Waste Report submitted to KDWM. No issues were noted in 2025.

### 2.1.4 Federal Facility Compliance Act

The Federal Facility Compliance Act, which was enacted in October 1992, waived federal facilities' immunity from fines and penalties for violations of hazardous waste management as defined by RCRA. It also provided for the development of site treatment plans for treating DOE mixed waste (low-level hazardous and radioactive waste), and for the approval of such plans by the Commonwealth of Kentucky. As a result of the complex issues associated with the treatment of mixed waste, and after considering stakeholder input, DOE and KDEP signed an Agreed Order/Site Treatment Plan on September 10, 1997. The Site Treatment Plan facilitates compliance with the Federal Facility Compliance Act. For the reporting period of January 1, 2025 to December 31, 2025, no mixed low-level waste was added to the Site Treatment Plan (DOE 2026).

The Agreed Order requires that DOE implement a waste minimization and pollution prevention awareness program to minimize the amount of new waste generated at the Paducah Site each year. All projects at the Paducah Site are evaluated for waste minimization and pollution prevention opportunities. The following waste minimization and pollution activities at the Paducah Site are related to the Site Treatment Plan's waste management goals:

- Reducing the quantity of waste generated at their sources;
- Draining, decanting, drying, dewatering, evaporating, and otherwise removing liquid from waste when possible;
- Segregating, sorting, consolidating, and reducing the volume of like waste; and
- Reusing or recycling materials that otherwise would be managed as hazardous or radioactive mixed waste.

Chapter 3 lists the waste minimization and pollution prevention activities at the Paducah Site.

### 2.1.5 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to evaluate the potential environmental impact of certain proposed activities and to examine alternatives to proposed actions. Compliance with NEPA, as administered by DOE's NEPA Implementing Procedures [10 *Code of Federal Regulations* (*CFR*) Part 1021], ensures that agencies consider environmental values and factors in planning and making decisions. On January 20, 2025, President Donald Trump issued Executive Order 14154, *Unleashing American Energy*, which among other things rescinded Executive Order 11991, *Relating to Protection and Enhancement of Environmental Quality*, and directed the White House Council on Environmental Quality (CEQ) to "propose rescinding" its NEPA regulations in their entirety. Executive Order 14154 instructed CEQ to provide new guidance on NEPA implementation and convene a working group to revise agency-specific procedures for expedited permitting approvals. Citing both

Executive Order 14154 and recent court decisions, on February 25, 2025, CEQ published an interim final rule rescinding its NEPA regulations and opening a 30-day public comment period before finalizing the rescission. CEQ asserted that, under the Administrative Procedure Act, notice-and-comment rulemaking was not required for this action for several reasons, although it did provide a comment period and received over 100,000 comments. The effective date for the rescission is April 11, 2025. On January 8, 2026, the CEQ issued a final rule withdrawing its regulations implementing NEPA. Consequently, the DOE canceled most of its own NEPA regulations, replacing them with advisory guidelines.

In accordance with 10 *CFR* Part 1021, the Paducah Site conducts NEPA reviews for all proposed non-CERCLA actions and determines if they require the preparation of an environmental impact statement, an environmental assessment, or a categorical exclusion. The Paducah Site maintains records of all NEPA reviews. There were no environmental assessments or environmental impact statements completed at the Paducah Site in 2025. DOE policy requires its facilities to post online specific classes of categorical exclusions listed in 10 *CFR* Part 1021, *National Environmental Policy Act Implementing Procedures*, Appendix B to Subpart D. Categorical exclusions for the Paducah Site are posted on the DOE PPPO website here.

In accordance with Section 2.1 of DOE's most recent implementing procedure, NEPA does not apply to response actions taken under CERCLA because there is a functional equivalency between NEPA and CERCLA. CERCLA documents allow decision makers to consider the potential effects of proposed actions on the human environment. Chapter 3 discusses environmental restoration, waste disposition, and deactivation and decommissioning actions conducted under CERCLA.

The following is a brief discussion of historical NEPA actions at the Paducah Site.

PPPO initiated an environmental assessment in 2012 to assess the environmental impacts associated with the potential transfer of Paducah Site real property to third parties for possible economic development. On December 14, 2015, DOE issued a Finding of No Significant Impact. A copy of the final environmental assessment and finding can be found here.

In 2003, PPPO initiated an environmental impact statement for the proposed construction, operation, maintenance, and decontamination and decommissioning of a depleted $DUF_6$ conversion at three locations within the Paducah Site; transportation of depleted uranium conversion products and waste materials to a disposal facility; transportation and sale of the hydrogen fluoride produced as a conversion co-product; and neutralization of hydrogen fluoride to calcium fluoride and its sale or disposal in the event that the hydrogen fluoride product is not sold. The environmental impact statement also considers a no action alternative that assumes continued storage of $DUF_6$ at the Paducah Site (DOE/EIS-0359). PPPO initiated a supplemental environmental impact statement in 2018 to assess the environmental impacts of transporting and disposing of uranium oxide in DOE inventory resulting from $DUF_6$ conversion. After a public comment period, the statement was finalized and made available to the public on April 24, 2020 (DOE/EIS-0359-S1, DOE/EIS-0360-S1).

In 2019, PPPO initiated an environmental assessment of the impacts associated with transporting and disposing of waste and excess materials to support deactivation and other non-CERCLA activities. The environmental assessment analyzed the potential impacts of managing and disposing of 5,050,000 cubic feet of waste and excess materials over the next 12 years. On July 27, 2020, DOE issued the Finding of No Significant Impact (DOE 2020). On September 15, 2021, PPPO finalized a supplemental analysis that assessed the potential impacts of a new treatment facility and transfer facility for disposition of waste and materials (DOE 2021a). On July 17, 2023, PPPO finalized a second supplemental analysis that assessed the potential impacts of new treatment and/or disposal facilities and an additional accepted waste type (DOE 2023). No new impacts were identified. A copy of the final environmental assessment and associated supplement analysis can be found here.

### 2.1.6 Toxic Substances Control Act

The Toxic Substances Control Act was enacted in 1976 with two purposes: to ensure US EPA obtains information on the production, use, and environmental and health effects of chemical substances or mixtures; and to provide the means by which US EPA can regulate chemical substances and mixtures such as polychlorinated biphenyls, asbestos, chlorofluorocarbons, and lead.

The Paducah Site complies with polychlorinated biphenyls regulations (40 *CFR* Part 761) and the latest Modification to the Compliance Agreement between DOE and US EPA for the Toxic Substances Control Act (US EPA 2017a). Major activities performed in 2025 are documented in the annual compliance agreement report for PGDP and the polychlorinated biphenyls annual document and include summaries of air sampling results, spill cleanup activities, storage for disposal, building demolition wastes, polychlorinated biphenyls-contaminated slab cleanup and maintenance, off-site transportation and disposal of waste, and inventory of polychlorinated biphenyls articles (FRNP 2026a, FRNP 2026b).

## 2.2 Radiation Protection

The Paducah Site is subject to radiation protection statutes, regulations, and DOE standards designed to protect the health and safety of the public, the workforce, and the environment. The following sections discuss the site's compliance with radiation protection and radioactive waste management requirements. The Paducah Site maintains and implements programs and procedures to ensure compliance with the relevant laws and regulations described in the following sections. See Chapter 4 for additional information about radiation protection.

### 2.2.1 Atomic Energy Act of 1954

To ensure proper management of radioactive materials, the Atomic Energy Act of 1954 and its amendments delegate roles and responsibilities for controlling radioactive materials and nuclear energy primarily to DOE, the US Nuclear Regulatory Commission, and US EPA. Through the Atomic Energy Act, DOE regulates the control of radioactive materials under its authority, including the treatment, storage, and disposal of low-level radioactive waste from its operations. Because sections of this Act authorize DOE to establish radiation protection standards for itself and its contractors, DOE published a series of regulations, including 10 *CFR* Part 820, *Procedural Rules for DOE Nuclear Activities*; 10 *CFR* Part 830, *Nuclear Safety Management*; and 10 *CFR* Part 835, *Occupational Radiation Protection*. Other DOE directives to protect public health and the environment from potential risks associated with radioactive materials include the current revisions of DOE Order 458.1, *Radiation Protection of the Public and the Environment*, and DOE Order 435.1, *Radioactive Waste Management*. Paducah Site operations are subject to these regulations and directives.

**ALARA, which means "as low as reasonably achievable," is an approach to manage and control releases of radioactive material to the environment and exposure to the workforce and to members of the public so that levels are as low as is reasonable, taking into account societal, environmental, technical, economic, and public policy considerations.**

#### 2.2.1.1 By-Product Material

The Paducah Site has no by-product material as defined by Section 11e.(2) of the Atomic Energy Act. Material defined as Section 11e.(3) or 11e.(4) by-product material in the Atomic Energy Act, such as sealed radioactive sources, is managed under 10 *CFR* Part 835.

### 2.2.2 DOE Order 458.1, Radiation Protection of the Public and the Environment

DOE Order 458.1 establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE. This Order applies to all DOE elements and contractors performing work for DOE, as provided by law or contract, and as implemented by the appropriate contracting officer. DOE Order 458.1 was developed and issued under the authority of the Atomic Energy Act, as amended.

The objectives of DOE Order 458.1 include the following:

- To conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in this Order
- To ensure that potential radiation exposures to members of the public are as low as is reasonably achievable (ALARA)
- To control the radiological clearance of DOE real and personal property
- To ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and nonroutine radiological releases and to assess the radiation dose to members of the public
- To provide protection of the environment from the effects of radiation and radioactive material

Table 2.3 presents the standards (dose limits) for radiation protection of the public and the environment from DOE operations. While the public dose limit of 100 mrem/year (1 millisievert [mSv]/year) is the primary dose limit, other regulations control the dose that may be received through specific exposure pathways (see Appendix B for a discussion of exposure pathways). The air and water pathways are also regulated by US EPA as discussed in Sections 2.3 and 2.4 below. DOE Order 458.1 includes dose limits to protect aquatic and terrestrial plants and animals near radiological activities on the Paducah Site. The Order also regulates the dose that could be received by a member of the public from activities such as management, storage, and disposal of radioactive waste, as well as its unrestricted release to the public or clearance of real and personal property.

**Table 2.3. Radiation protection standards for the public and the environment from all routine DOE operations[a]**

| **All pathways (DOE Order 458.1)** | | |
|---|---|---|
| Exposure of members of the public will not cause a total effective dose exceeding 100 mrem (1 mSv) in a year (DOE Order 458.1, *Radiation Protection of the Public and the Environment*, Contractor Requirements Document [CRD] Attachment 1, Paragraph 2.b.). | Total effective dose[c] | |
| | mrem/year | *mSv/year* |
| Routine public dose | 100 | *1* |
| Temporary public dose under special circumstances, with specific authorization and justification[b] (DOE Order 458.1, CRD Attachment 1, Paragraph 2.c.). | > 100, < 500 | *> 1, < 5* |
| **Air pathway dose constraints (40 *CFR* § 61.92)** | | |
| Emissions of radionuclides shall not cause any member of the public to receive an effective dose equivalent of 10 mrem/year. | Effective dose equivalent[c] | |
| | mrem/year | *mSv/year* |
| | 10 | *0.1* |
| **Water pathway dose constraints (40 *CFR* § 141.66(d))** | | |
| The average annual dose equivalent to the total body or to any internal organ from beta particle and photon radioactivity from man-made radionuclides in drinking water shall not exceed 4 mrem/year. | Dose equivalent[c] | |
| | mrem/year | *mSv/year* |
| | 4 | *0.04* |

**Table 2.3. Radiation protection standards for the public and the environment from all routine DOE operations[a] (continued)**

| **Protection of biota (DOE Order 458.1, CRD Attachment 1, Paragraph 2.j.) Radiological activities must be conducted to protect populations of aquatic animals, terrestrial plants, and terrestrial animals.** | | |
|---|---|---|
| Screening values shown for the protection of biota are derived from DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. | Absorbed dose[c] | |
| | rad/day | *mGy/day* |
| Aquatic animal | 1 | *10* |
| Riparian animal | 0.1 | *1* |
| Terrestrial plant | 1 | *10* |
| Terrestrial animal | 0.1 | *1* |
| **Radioactive waste dose constraint (DOE Order 458.1, CRD Attachment 1, Paragraph 2.h.)** | | |
| Exposure from radioactive waste management, storage, and disposal activities shall be ALARA and meet dose constraint. | Total effective dose[c] | |
| | mrem/year | *mSv/year* |
| Public dose constraint | 25 | *0.25* |
| **Radioactive waste dose constraint (DOE Order 458.1, CRD Attachment 1, Paragraph 2.k.)** | | |
| Exposure from release of real (land and buildings) and personal property shall be controlled to be ALARA and meet dose constraints. | Total effective dose[c] | |
| | mrem/year | *mSv/year* |
| Public dose constraint from real property | 25 | *0.25* |
| Public dose constraint from personal property | 1 | *0.01* |

[a] Routine DOE operations imply normal, planned activities and do not include actual or potential accidental or unplanned releases.
[b] DOE PPPO may request specific authorization from DOE Headquarters for a temporary public dose greater than 100 mrem/year (1 mSv/year). The request must document the justification, alternative, and the application of the ALARA process.
[c] Dose units are those in the cited regulation, order, or standard.

Notes:
1. Excepts doses received from radon and its decay products in the air, from medical sources of radiation, by volunteers in medical research programs, from background radiation, and from occupational exposure under the Nuclear Regulatory Commission, Agreement State License, or to general employees under 10 *CFR* Part 835.
2. International dose units shown in *italics* are not provided in the order or rules, but are provided for information.

Acronyms:
ALARA = as low as reasonably achievable
CRD = contractor requirements document
*CFR* = *Code of Federal Regulations*
DOE = US Department of Energy
mGy = milligray
mSv = millisievert
mrem = millirem
PPPO = Portsmouth/Paducah Project Office

These radiation standards are dose limits, but they do not represent DOE's expected dose to the public and the environment. DOE Order 458.1 requires the ALARA process be applied to all routine radiological activities to further reduce radionuclide releases and resulting doses as much as possible.

### 2.2.2.1 Authorized Limits at the Paducah Site

DOE uses Authorized Limits to establish concentrations or quantities of residual radioactive material that protect human health and the environment. Authorized Limits ensure that doses to the public meet DOE standards and are ALARA, groundwater is protected, no future remediation is needed, and no radiological protection requirements are violated.

The following pre-approved Authorized Limits were documented in CP2-ES-0103/FR8, *Environmental Radiation Protection Program for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, which was reviewed and approved by DOE in 2025.

- For radium-226 and radium-228 in soil—5 pCi/gram (0.2 Bq/gram) in excess of background levels, averaged over 100 square meters, in the first 15 cm depth of the surface layer of soil; and 15 pCi/gram (0.56 Bq/gram) in excess of background levels, averaged over any subsequent 15 cm subsurface layer of soil, plus an ALARA assessment. If both thorium-230 and radium-226 or both

thorium-232 and radium-228 are present and not in secular equilibrium, the appropriate pre-approved Authorized Limit must be applied to the radionuclide with the higher concentration.

- Previously approved guidelines and limits may continue to be applied and used as pre-approved Authorized Limits until they are replaced or revised by pre-approved Authorized Limits issued by DOE.
- Pre-approved Authorized Limits for Release and Clearance of Volumetric Radioactivity of Personal Property found in DOE-STD-1241-2023, *Implementing Release and Clearance of Property Requirements*.

DOE developed DOE-STD-1241-2023, *Implementing Release and Clearance of Property Requirements*, which is a technical standard to assist DOE contractors in meeting release and clearance of property requirements that are provided in DOE O 458.1. This standard consolidates all previously published pre-approved Authorized Limits for surface contamination and includes newly approved volumetric pre-approved Authorized Limits.

In addition to pre-approved Authorized Limits, the following Authorized Limits were documented in CP2-ES-0103/FR8, *Environmental Radiation Protection Program for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, which was reviewed and approved by DOE in 2025:

- Release limits for hydrofluoric acid and calcium fluoride from $DUF_6$ conversion
- C-746-U Landfill Authorized Limits approval and implementation requirements
- Authorized Limits for the DOE-owned property outside the Limited Area in Paducah, Kentucky, approval and implementation requirements
- Authorized Limits for lube oil and dielectric fluids that allow for incineration at Veolia Environmental Services in Port Arthur, Texas, and Clean Harbors Environmental Services, Inc., in Deer Park, Texas
- Authorized Limits for Freon that allow for incineration at Clean Harbors Aragonite in Dugway, Utah; Clean Harbors El Dorado in El Dorado, Arkansas; and Veolia North America Port Arthur in Beaumont, Texas
- Authorized Limits for Paducah and Portsmouth Personal Property Being Dispositioned Through the Bulk Survey for Release Process for Disposal to the Carter Valley Landfill in Tennessee

### 2.2.3 DOE Order 435.1, Radioactive Waste Management

DOE Order 435.1 establishes requirements for managing high-level waste, transuranic waste, and low-level waste, including the radioactive component of mixed waste (high-level waste, transuranic waste, and low-level waste containing chemically hazardous constituents) in a safe manner that protects the worker, public health, and the environment. DOE Order 435.1 is a cradle-to-grave approach for managing waste that includes requirements for generating, storing, treating, and disposing of waste and for regulating and monitoring facilities during operations and after closure.

Radioactive waste is also managed to meet the requirements of other DOE orders, standards, and regulations, including 10 *CFR* Part 835, *Occupational Radiation Protection*; DOE Order 440.1B, W*orker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*; and DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

The Paducah Site manages low-level and transuranic waste, if produced, in compliance with DOE Order 435.1, using a number of on-site staging and storage units and off-site commercial treatment, storage and disposal facilities (specifically Energy*Solutions*, Perma-Fix Environmental Services, and

Waste Control Specialists) in addition to the Nevada National Security Site. Procedures for managing these wastes ensure compliance with this Order.

## 2.3 Air Quality and Protection

The Paducah Site is subject to air quality and protection statutes, regulations, and rules designed to protect the health and safety of the public and the environment. The following sections discuss the site's compliance with US EPA and KDEP requirements.

### 2.3.1 Clean Air Act

The Paducah Site complies with the Clean Air Act and its amendments, subsequent federal regulations, and Commonwealth of Kentucky rules by implementing programs, procedures, and permit requirements. Authority for enforcing compliance with the Clean Air Act and its amendments reside with US EPA Region 4, the Kentucky Division for Air Quality, or both. The Paducah Site has two programs that require air permits. The Environmental Remediation, Waste Management, and Decontamination and Decommissioning missions (identified as the Deactivation and Remediation Project) are combined under one air permit, and the $DUF_6$ conversion mission has a separate air permit.

The Deactivation and Remediation Project has identified the potential emission of hydrogen fluoride, a hazardous air pollutant, in excess of 10 tons per year. Kentucky Division for Air Quality, therefore, considers the project a major source and requires it to maintain a Title V Air Permit.

Activities performed as part of CERCLA projects, such as groundwater treatment systems, must meet the substantive requirements of the Clean Air Act for emissions associated with these CERCLA actions and these requirements are applied to the actions as applicable or relevant and appropriate requirements. All remediation projects are now subject to National Emission Standards for Hazardous Air Pollutants 40 *CFR* Part 63 Subpart GGGGG, N*ational Emission Standards for Hazardous Air Pollutants: Site Remediation*, for the total amount of hazardous air pollutants remediated. Initial compliance was reached in June 2024. For the Northwest Plume Groundwater Treatment System, the off-gas from the air stripper then passes through a carbon adsorption system to remove the trichloroethene before it discharges to the atmosphere. Groundwater from the Northwest Plume then travels through ion exchange resin beds for technetium-99 removal and does not impact air emissions. For the Northeast Plume Containment System, concentrations of trichloroethene are low enough that a carbon adsorption system is not required to keep emissions below regulatory levels.

The $DUF_6$ Conversion Facility emissions of hydrogen fluoride are limited to 9 tons per year, on a rolling 12-month basis. The $DUF_6$ Conversion Facility is assumed to be in compliance when all control devices for hydrogen fluoride are operating properly and when complying with operational parameters, as outlined within the requirements of the facility's Conditional Major Operating Air Permit.

### 2.3.2 National Emission Standards for Hazardous Air Pollutants Program

Airborne emissions of radionuclides from the Paducah Site are regulated under 40 *CFR* Part 61, Subpart H, known as the National Emission Standards for Hazardous Air Pollutants regulations. DOE also manages radionuclide air emissions according to the National Emission Standards for Hazardous Air Pollutants Management Plan for Emission of Radionuclides (FRNP 2026c). Radionuclide sources at the Paducah Site in 2025 were the deactivation projects for PGDP (C-310 Stack); $DUF_6$ Conversion Facility; groundwater pump-and-treat systems (Northeast Plume Containment System and Northwest Plume Groundwater Treatment System); C-409 Stabilization Building auxiliary systems, and fugitive and diffuse sources, which include building ventilation, uranium transfers, transport and disposal of waste, demolition of contaminated facilities, decontamination of contaminated equipment, and environmental remediation

activities. DOE maintains ambient air monitoring data to verify a low emission rate of radionuclides in ambient air in accordance with the National Emission Standards for Hazardous Air Pollutants Management Plan. Ambient air data were collected at nine locations surrounding the Paducah Site to measure radionuclides emitted from Site sources, including fugitive emissions. One of these nine locations is situated off-site in a nonimpacted area. Chapter 4 discusses the ambient air results in further detail. Airborne emissions of hazardous air pollutants from remediation projects at the Paducah Site are also regulated under 40 *CFR* Part 63, Subpart GGGGG, known as the National Emission Standards for Hazardous Air Pollutants regulations for source categories. The Paducah Site determines the total quantity of the hazardous air pollutants from all of the site remediations conducted during 2025. The amount of hazardous air pollutants remediated during this time was less than 1 megagram annually; therefore, remediation activities at the Paducah Site are subject to the recordkeeping requirements of this subpart only.

### 2.3.3 Hydrofluorocarbon Phasedown

Hydrofluorocarbons are greenhouse gases with very high global warming potentials and are used as refrigerants in fire suppression systems and certain scientific and electrical equipment. On October 1, 2021, US EPA began the implementation of hydrofluorocarbon phasedown requirements.

At the Paducah Site, hydrofluorocarbons are used for fire suppression systems in server rooms and for comfort cooling/heating. Hydrofluorocarbon refrigerants used at the Paducah Site are compliant with current regulations in 40 *CFR* Part 82 and any volumes removed as a result of maintenance activities are logged, properly contained, and recycled or disposed of. Approximately 261.8 pounds of hydrofluorocarbon refrigerants were purchased for the Paducah Site in 2025.

Future purchases of refrigerants will consider acceptable alternatives that have lower global warming potentials.

## 2.4 Water Quality and Protection

The Paducah Site is subject to water quality and protection statutes, regulations, and rules designed to protect the health and safety of the public and the environment. The following sections discuss the site's compliance with US EPA and KDEP requirements.

### 2.4.1 Clean Water Act

The Clean Water Act was established primarily through the passage of the Federal Water Pollution Control Act Amendments of 1972. The Clean Water Act set up four major programs for controlling water pollution: regulating point-source and storm water discharges into waters of the United States; controlling and preventing spills of oil and hazardous substances; regulating discharges of dredge and fill materials into waters of the United States; and providing financial assistance to construct publicly owned sewage treatment works.

#### 2.4.1.1 Kentucky Pollutant Discharge Elimination System

The Clean Water Act applies to all nonradiological DOE discharges to waters of the United States. At the Paducah Site, the regulations are applied through KPDES permits for effluent discharges to Bayou Creek and Little Bayou Creek. The Kentucky Division of Water (KDOW) issued KPDES Permit Number KY0004049 for Outfalls 001, 002, 004, 006, 008, 009, 010, 011, 012, 013, 015, 016, 017, 019, and 020. The KPDES permit calls for monitoring to indicate the effects of discharges to these streams.

KDOW issued a new KPDES permit for the Paducah Site on December 9, 2022. The new permit, which has the same permit number (KPDES Permit Number KY0004049), became effective on February 1, 2023, and expires at midnight on January 31, 2028. In September 2025, KDOW issued a permit modification to KPDES Permit Number KY0004049, which became effective on October 1, 2025. The permit modification identified DOE and FRNP as co-responsible parties to KPDES Outfalls 001, 002, 008, 009, 010, 011, 012, 015, 016, 019, and 020; and DOE and MCSA as co-responsible parties for KPDES Outfalls 004, 006, 013, and 017, with contributions to KPDES Outfalls 001, 008, and 010. Discharge monitoring reports are issued monthly and quarterly. The KPDES permit requires the development and implementation of a best management practices plan to prevent or minimize the potential release of pollutants. The best management practices include requirements for operations and are implemented through the Paducah Site Environmental Management System (EMS) and work control.

There was one KPDES permit exceedance during 2025. The exceedances consisted of one daily maximum total suspended solids exceedance (KPDES Outfall 004). Mitigation measures were implemented as appropriate and no further exceedances have occurred. DOE is currently in compliance with the KPDES permit. The KPDES exceedance for 2025 is detailed in Table 2.4.

**Table 2.4. KPDES exceedances in 2025**

| Outfall | Parameter | Number of permit exceedances | Number of months sampled | Number of months compliant | Percent compliance | Month of exceedance |
|---|---|---|---|---|---|---|
| 004 | Total Suspended Solids | 1 | 12 | 11 | 92% | November |

Acronym:
KPDES = Kentucky Pollutant Discharge Elimination System

## 2.4.2 CERCLA Outfall

Activities performed as part of CERCLA projects, such as groundwater treatment systems, are not subject to the administrative requirements under Clean Water Act. Instead, the substantive requirements of the Clean Water Act for discharges associated with these CERCLA actions are applied to the actions as applicable or relevant and appropriate. The *Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* requires sampling at CERCLA Outfall 001 (DOE 2021b). Parameters and frequencies for this outfall are weekly sampling for flow, pH, temperature, total suspended solids, oil and grease, total residual chlorine, trichloroethene, 1,1-dichloroethene; and quarterly sampling for chronic toxicity and technetium-99 (FRNP 2025a).

## 2.4.3 Storm Water Management and the Energy Independence and Security Act of 2007

The Energy Independence and Security Act (EISA) requires new construction projects greater than 5,000 square feet to maintain the predevelopment hydrology or restore it after construction. The Paducah Site will comply with this requirement by ensuring storm water flow will be maintained and managed at predevelopment levels during the construction of an energy-efficient building. Besides meeting EISA requirements, the Paducah Site audits energy and water usage. These audits typically cover the building shell, lighting, possible deployment of occupancy sensors, and leaking of old water fixtures. The findings of these audits are assessed and prioritized based on the mission of the Paducah Site.

### 2.4.4 Safe Drinking Water Act

The Paducah Site supplies its facilities with on-site potable water using the Ohio River as its raw water source. The potable water is used mostly for activities such as showering and cleaning. The Paducah Site also provides employees with commercially supplied bottled water for drinking. This system is regulated by the Safe Drinking Water Act, which sets requirements for water testing, treatment, and disinfection, as well as distribution system maintenance and operator training. In 2025, FRNP operated and managed the water treatment system in accordance with the Safe Drinking Water Act. FRNP maintains a water withdrawal permit from KDOW for up to 30 million gallons per day. Water is pumped from the Ohio River and treated for distribution on-site.

FRNP operated a nontransient, noncommunity water system regulated by KDOW. KDOW's requirement to submit monitoring plans to demonstrate compliance with regulations applies to this water system. FRNP monitors sampling locations in the nontransient, noncommunity water system in accordance with these plans and submits the results to KDOW.

There was one noncompliance during 2025 for the water system. The noncompliance was for exceeding 1.0 nephelometric turbidity units in a combined filter effluent sample collected on April 10, 2025. This was determined to be noncompliant by KDOW on June 13, 2025. The turbidity exceedance occurred only during a brief period on April 10, 2025, and it was caused by the failure of a raw water pump that is controlled by an outside company.

On April 10, 2024, US EPA released final enforceable standards for select per- and polyfluoroalkyl substances (PFAS) compounds in potable water for all community and noncommunity water systems. These standards establish maximum contaminant levels for six compounds. The compliance schedule is to be implemented over a period of five years based on the following activities:

- Within 3 years (by 2027)—Initial Monitoring Period—quarterly sampling within a 12-month period;
- At 3 years (by 2027)—Compliance Monitoring Period—frequency based on initial monitoring period results; and
- At 5 years (by 2029)—Full Compliance Period—must comply with all PFAS maximum contaminant levels.

FRNP met the Initial Monitoring Period requirement by completing the quarterly sampling within a 12-month period in September 2025.

KDOW conducted a routine surface inspection of the C-611 Water Treatment Plant on September 22, 2025. There were no deficiencies found.

The operation of the nontransient, noncommunity water system and the water withdrawal permit transitioned to MCSA on October 1, 2025.

## 2.5 Other Environmental Statutes

This section discusses the Paducah Site's compliance with applicable environmental statutes, regulations, and Executive orders.

### 2.5.1 Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened animals and plants and protects the ecosystems on which such species depend. At the Paducah Site, proposed projects are reviewed in conjunction with the EMS or the CERCLA process to determine if activities have the potential to impact these species. If necessary, project-specific field surveys are performed to identify threatened and endangered species and their habitats, and mitigating measures are designed as needed. When appropriate, DOE initiates consultation with the US Fish and Wildlife Service and Kentucky Department of Fish and Wildlife Resources before implementing a proposed project.

Table 2.5 includes 13 federally listed species that have been identified as potentially occurring at or near the Paducah Site. None of the threatened or endangered species have been reported as sighted on DOE property. No DOE projects at the Paducah Site during 2025 adversely impacted any of these identified species or their potential habitats.

**Table 2.5. Federally listed species potentially occurring near the Paducah Site***

| Group | Common name | Scientific name | Endangered species act status |
|---|---|---|---|
| Mammals | Gray bat | *Myotis grisescens* | Endangered |
| | Indiana bat | *Myotis sodalis* | Endangered |
| Clams | Clubshell | *Pleurobema clava* | Endangered |
| | Fanshell | *Cyprogenia stegaria* | Endangered |
| | Fat pocketbook | *Potamilus capax* | Endangered |
| | Longsolid | *Fusconaia subrotunda* | Threatened |
| | Orangefoot pimpleback | *Plethobasus cooperianus* | Endangered |
| | Pink mucket | *Lampsilis abrupta* | Endangered |
| | Rabbitsfoot | *Quadrula cylindrica* | Threatened |
| | Ring pink | *Obovaria retusa* | Endangered |
| | Rough pigtoe | *Pleurobema plenum* | Endangered |
| | Sheepnose mussel | *Plethobasus cyphyus* | Endangered |
| | Spectaclecase | *Cumberlandia monodonta* | Endangered |

*All listed species are identified as either an endangered or threatened species that is known or potentially located near the Paducah Site in McCracken County, Kentucky, by the US Fish and Wildlife Service (FWS 2026).

### 2.5.2 Impacts of Invasive Species

Executive Order 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, calls on government agencies to take steps to prevent the introduction and spread of invasive species and to support efforts to eradicate and control invasive species that are established. For example, DOE takes steps to minimize the spread of invasive Zebra mussels at raw-water intake lines. Migration of potentially invasive plant species are mitigated through routine Paducah Site maintenance, such as mowing and spraying for weeds.

### 2.5.3 Migratory Bird Treaty Act

The 2013 Memorandum of Understanding on Migratory Birds between DOE and the US Fish and Wildlife Service regarding Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, direct federal agencies to take certain actions to further implement the Migratory Bird Treaty Act of 1918, which is applicable to the Paducah Site. DOE takes measures to minimize impacts to migratory birds by avoiding disturbance of active nests. There was no intentional take of migratory birds during 2025. Work control documents implement this restriction.

### 2.5.4 Floodplain Management and Protection of Wetlands

Title 10 *CFR* Part 1022 establishes procedures for complying with Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*. DOE takes steps to minimize or eliminate any impacts to wetlands. During 2025, DOE prepared the *Floodplain Assessment for Proposed Transport Road Bridge Demolition at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2517&D1, to evaluate the potential impacts of deactivating, demolishing, and dispositioning the Transport Road Bridge over Bayou Creek at the Paducah Site. Work was performed in compliance with US Army Corps of Engineers Nationwide Permits, Section 401, Water Quality Certification, individual water quality permit, KDOW floodplain permit, and a McCracken County floodplain development permit.

### 2.5.5 National Historic Preservation Act

The National Historic Preservation Act of 1966 is the primary law governing a federal agency's responsibility to identify and protect historic properties that are defined as cultural resources included in or eligible for inclusion in the National Register of Historic Places. Historic properties include buildings of historic significance and archeological sites. PGDP buildings were assessed in the Cultural Resources Survey (BJC 2006a). Archeological resources will be addressed as undisturbed land is developed for Paducah Site use or if undisturbed sites are considered to be impacted by DOE operations.

The Cultural Resources Management Plan identified a historic district eligible for the National Register of Historic Places (BJC 2006b). The PGDP Historic District contains 101 contributing properties and is eligible for the National Register of Historic Places under National Register Criterion A for its military significance during the Cold War and for its role in commercial nuclear power development. The PGDP Historic District encompasses the area of the process buildings; switchyards; C-100 Administration Building; cooling towers and pump houses; security facilities; water treatment facilities; storage tanks; and support, maintenance, and warehouse buildings. The Cultural Resources Management Plan includes a map showing the location of these structures, along with the rationale for designating the area as an eligible historic district.

In 2025, two archaeological surveys were conducted. One survey was completed for approximately 87.4 acres at the Paducah Site using systematic screened shovel testing and visual inspections. One archaeological site was recorded, which was a historic farmstead/residence. The other survey was completed for approximately 206 acres at the Paducah Site using systematic screened shovel testing and visual inspections. Six archaeological sites and one non-site locality were recorded. The archeological sites were all late nineteenth through twentieth century farmsteads/residences. The non-site locality was the remains of a small bridge over Little Bayou Creek.

### 2.5.6 Asbestos Program

Numerous facilities at the Paducah Site contain asbestos materials. Compliance programs for managing asbestos include identifying asbestos materials, monitoring, abatement, and disposal. Procedures and program plans delineate the scope, roles, and responsibilities for maintaining compliance with applicable US EPA, Occupational Safety and Health Administration, and Kentucky regulatory requirements.

In 2025, nine structures were demolished at the Paducah Site. Prior to demolition, an asbestos inspection on each facility was conducted by a Certified Asbestos Inspector. Once an inspection was completed, a notification of intent was submitted to Kentucky for the demolition of the structure.

In 2025, a total of 35.63 tons of asbestos waste was disposed of in the C-746-U Contained Landfill.

## 2.5.7 Solid Waste Management

The Paducah Site disposes of a portion of its solid waste at its contained landfill facility, the Solid Waste C-746-U Contained Landfill, under Solid Waste Permit SW07300014, SW07300015, and SW07300045. Construction of the first five cells, or units, of the C-746-U Contained Landfill began in 1995 and was completed in 1996. The operation permit received from KDWM in November 1996 allows for 23 cells. Disposal of waste at the landfill began in February 1997. Operating and groundwater reports for the C-746-U Contained Landfill are submitted quarterly to KDWM. The landfill is permitted to accept all nonhazardous solid waste, including residential, commercial, institutional, industrial, and municipal waste; shredded tires; nonhazardous spill cleanup residue generated at the Paducah Site; and any materials that meet the Authorized Limits. Construction of Phases 6 and 7 of the landfill began on April 24, 2019, and was completed in August 2019. A Construction Progress Report was submitted to KDWM on September 9, 2019, and, after comments were addressed, KDWM approved the Construction Progress Report on September 27, 2019. A minor permit modification approved on May 21, 2021, by KDWM addresses leachate generation and storage capacity for Phases 6 and 7.

During 2025, DOE placed approximately 556.36 tons of solid waste in the C-746-U Contained Landfill using the C-746-U landfill Authorized Limits. The C-746-U landfill waste acceptance criteria includes established volume and surface Authorized Limits that govern disposal. Authorized Limits for the C-746-U Contained Landfill were established in 2003 and have been maintained since that time. The latest revision was approved by DOE in 2019 (DOE 2019). Waste streams disposed of in the C-746-U Contained Landfill during 2025 include building demolition debris, asbestos-containing materials, and other dry materials generated during deactivation activities (which were characteristically similar to dry active waste, but verified to meet Authorized Limits for residual radioactivity prior to disposal). Table 2.6 summarizes Authorized Limit disposal at the C-746-U Contained Landfill during 2025 and the cumulative totals since Authorized Limit disposal began in May 2003.

**Table 2.6. C-746-U Contained Landfill Authorized Limit disposal through 2025**

| | Inventory control 1/1/2025 to 12/31/2025 | Total activity from disposal 5/21/2003 to 12/31/2025 | | | |
|---|---|---|---|---|---|
| Isotope | Activity (curies) | Activity (curies) | Source term limit (curies) | Percent utilized | Available inventory (Assuming sole nuclide) (curies) |
| Americium-241 | 1.98E-05 | 1.16E-02 | 79 | 0.01 | 76.0 |
| Cesium-137 | 1.80E-05 | 1.20E-02 | 43 | 0.03 | 41.4 |
| Neptunium-237 | 4.73E-05 | 1.53E-02 | 12 | 0.13 | 11.6 |
| Plutonium-238 | 3.21E-06 | 2.50E-03 | 88 | 0.00 | 84.7 |
| Plutonium-239/240 | 5.04E-05 | 2.77E-02 | 162 | 0.02 | 155.9 |
| Technetium-99 | 3.31E-03 | 1.47E+00 | 117 | 1.26 | 112.6 |
| Thorium-228 | 2.98E-05 | 7.50E-02 | 9 | 0.83 | 8.7 |
| Thorium-230 | 3.73E-04 | 2.89E-01 | 230 | 0.13 | 221.4 |
| Thorium-232 | 3.78E-05 | 7.50E-02 | 9 | 0.83 | 8.7 |
| Uranium-234 | 1.02E-03 | 5.13E-01 | 360 | 0.14 | 346.5 |
| Uranium-235 | 4.60E-05 | 2.53E-02 | 15 | 0.17 | 14.4 |
| Uranium-238 | 1.51E-03 | 6.68E-01 | 360 | 0.19 | 346.5 |
| | | | | **Total % Activity Used*:** | **3.74** |
| | | | | **Remaining % Activity Available*:** | **96.26** |

Note: Specific landfill information regarding open cells and available air space may be found in most recent C-746-U Contained Landfill annual survey report that is reported to Kentucky annually.
*The "Total % Activity Used" summation and "Remaining % Activity" vary by 0.01% from the individual isotope "% Inventory Used" totals due to calculation spreadsheet rounding.

## 2.6 Energy and Water Efficiency

DOE and its contractors implement numerous energy and water efficiency requirements, including the *National Energy Conservation Policy Act*; the Energy Policy Acts of 1992 and 2005; and the EISA of 2007.

### 2.6.1 Energy and Water Efficiency Goals

The Paducah Site is working to make its operations more environmentally friendly and sustainable. While there are guidelines for High Performance Federal Buildings that encourage energy efficiency and other efficiency practices, none of the current buildings at the Paducah Site fully meet these specific guidelines. No large renovation projects are viable at this time for buildings at the Paducah Site, but the site continues to implement small upgrades as opportunities arise such as maintenance replacements of lighting, heating, ventilation, and air conditioning units.

Paducah Site contractors use EMSs that follow the International Organization for Standardization 14001:2015, *Environmental Management Systems*, as platforms for supporting DOE energy and water efficiency goals. Measurable objectives are established that align with environmental policy, compliance requirements, energy and water efficiency goals, risks/opportunities, and stakeholder goals. Progress is tracked throughout the year. Site EMSs are part of respective integrated management system plans, which provide a coordinated and integrated approach to performing work safely and in a manner that protects the environment.

Paducah Site contractors use a multifaceted approach to implement energy and water efficiency practices and projects and increase awareness of energy and water efficiency opportunities in the workplace. Unique challenges exist at PGDP, because some facilities are more efficient than others, depending on the facility purpose and age. Given the age and complexity of the facilities, the Paducah Site continues to place priority on reducing energy use and cost, while exploring energy solutions that are effective for both life cycle and cost. With optimization of utilities, facility deactivation, and reductions in the PGDP footprint through disposition, building energy intensity reductions have been and will continue to be realized.

The PGDP FY 2025 energy and water efficiency achievements include the following.

- Space utilization practices were implemented to consolidate employee office areas.
- PGDP dispositioned nine small structures/trailers in FY 2025, representing a footprint reduction of approximately 18,995 square feet.
- Approximately 156,000 pounds of refrigerant Freon (R-114) were processed at an off-site treatment and disposal facility.
- PGDP was able to use smaller and more efficient raw water pumps, which are more energy efficient and pump less water.
- The C-709 Plant Laboratory Annex and C-710 Technical Services Building were deactivated to a level where personnel were moved from the facilities and steam heating was no longer needed to support building operations.

## 2.7 Other Major Environmental Issues and Actions

The following sections summarize environmental release reporting and permits for the Paducah Site.

### 2.7.1 Continuous Release Reporting

Section 103(a) of CERCLA requires that hazardous substance releases in excess of a reportable quantity be reported immediately to the National Response Center. Section 103(f)(2) provides relief from the

Section 103(a) reporting requirement for hazardous substance releases that are continuous, stable in quantity and rate, and already have been reported. Notice of such releases must be given annually or when there is any statistically significant increase in the quantity of hazardous substance released. Releases of this nature typically are included in the Superfund Amendments and Reauthorization Act Title III reports and notifications listed in Section 2.7. There were no continuous releases in 2025.

### 2.7.2 Unplanned Reportable Quantity Releases

There were no unplanned releases of material above a reportable quantity in 2025.

### 2.7.3 Enforcement and Compliance History Online

US EPA's Enforcement and Compliance History Online web tool provides environmental regulatory compliance and enforcement information for regulated facilities nationwide. FRNP monitors several facilities in the web tool that represent the Paducah Site. The facility names are listed in the web tool as "Four Rivers Nuclear Partnership, LLC," "Mission Conversion Service Alliance-Four Rivers Nuclear WPT," "Paducah Gaseous Diffusion Plant," and "US Enrichment Corp Paducah Gaseous Diffusion Plant." The Facility Registry Service identification numbers are 110070378294, 110051926831, 110060257671, and 110009258980, respectively. The addresses for the facilities are identified as 5511 Hobbs Road, Paducah, Kentucky (for 110070378294 and 110051926831); 5600 Hobbs Road, Mail Stop 7437, Paducah, Kentucky (for 110060257671); and 5600 A Hobbs Road, Paducah, Kentucky (for 110009258980).

### 2.7.4 Summary of Permits

Table 2.7 summarizes the Paducah Site environmental permits maintained at the Paducah Site in 2025.

**Table 2.7. Permits maintained at the Paducah Site for 2025**

| Permit type | Issued by | Permit number | Issued to |
|---|---|---|---|
| **State Agency Interest ID No. 3059** | | | |
| **Clean Water Act** | | | |
| KPDES | KDOW | KY0004049 | DOE/FRNP/MCS to MCSA* |
| Permit to withdraw public water | KDOW | 0900 | FRNP to MCSA* |
| Water treatment registration | KDOW | Public Water System KY0732457 | FRNP to MCSA* |
| **Clean Air Act** | | | |
| Conditional Major Operating Air Permit | KDAQ | F-21-018 R2 | MCS to MCSA* |
| Title V Air Permit | KDAQ | V-21-011 R2, R3, R4 | FRNP |
| **RCRA—solid waste** | | | |
| Residential Landfill (closed) | KDWM | SW07300014 | DOE/FRNP |
| Inert Landfill (closed) | KDWM | SW07300015 | DOE/FRNP |
| Solid Waste Contained Landfill (construction/operation) | KDWM | SW07300045 | DOE/FRNP |
| **RCRA—hazardous waste** | | | |
| Hazardous Waste Management Facility Permit | KDWM | KY8-890-008-982 | DOE/FRNP |

* Note: MCS transitioned to MCSA in October 2025.

Acronyms:
DOE = US Department of Energy
FRNP = Four Rivers Nuclear Partnership, LLC
ID = identification
KDAQ = Kentucky Division for Air Quality
KDOW = Kentucky Division of Water
KDWM = Kentucky Division of Waste Management
KPDES = Kentucky Pollutant Discharge Elimination System
MCS = Mid-America Conversion Services, LLC
MCSA = Mission Conversion Services Alliance, LLC
RCRA = Resource Conservation and Recovery Act

# 3. Environmental Programs and Activities

This chapter summarizes the environmental programs and activities at the Paducah Site, including environmental management, energy and water efficiency, waste management, environmental restoration and remediation, and public awareness.

## 3.1 Environmental Management System

The Paducah Site has developed and implemented an EMS to protect air, water, land, and other natural or cultural resources that may be impacted by DOE operations. Environmental protection programs at the Paducah Site conform to the six core elements of International Organization for Standardization 14001:2015: leadership, planning, support, operation, performance evaluation, and improvement.

The EMS integrates environmental protection, environmental compliance, pollution prevention, and continuous improvement in planning and execution throughout all work areas and is incorporated in the Integrated Safety Management System established by DOE Policy 450.4A, *Integrated Safety Management Policy*.

Environmental aspects (e.g., air pollutants, radionuclide release/protection of the public and the environment, storm water affects from equipment, runoff, spills) are evaluated annually by the DOE Contractor. These significant environmental aspects, along with the environmental policy, are then used to formulate objectives and targets, which are used as goals for the improvement of environmental performance at the Paducah Site.

DOE and its contractors are committed to regulatory compliance, pollution prevention, enhancing environmental stewardship, and reducing any impacts Paducah Site operations may cause to the environment. These are accomplished through the successful implementation of an EMS program.

## 3.2 Energy and Water Efficiency Program

This report provides information on the requirements and responsibilities of managing energy and water efficiency on the Paducah Site. These include ensuring DOE carries out its missions in a manner that addresses national energy security and global environmental challenges while advancing reliable, and efficient energy for the future; initiating wholesale cultural change to factor energy and water reductions in all of DOE's corporate management decisions; and ensuring that DOE achieves the energy and water efficiency goals established in its Site energy and water efficiency plan, pursuant to any applicable laws, regulations, and Executive orders. The original baseline for energy and water efficiency tracking was completed in 2008. In 2013, production came to a close under the United States Enrichment Corporation and the leased facilities at PGDP were returned to DOE in October 2014. With the return of the leased facilities, the DOE Environmental Management site footprint increased; therefore, FY 2015 serves as the most representative baseline year to track energy and water efficiency at the Paducah Site. Energy and water efficiency data are uploaded and tracked in the web-based DOE Energy and Water Dashboard.

## 3.3 Environmental Management and Waste Management Activities

Environmental and waste management activities at the Paducah Site include the waste minimization and pollution prevention program; the $DUF_6$ cylinder program; and stabilization, deactivation, and infrastructure optimization projects. The following sections describe these critical efforts.

### 3.3.1 Pollution Prevention

The pollution prevention program (which includes waste minimization) at the Paducah Site provides guidance and objectives for minimizing waste generation. The program is set up to comply with RCRA and the Pollution Prevention Act, as well as applicable Commonwealth of Kentucky and US EPA rules, DOE orders, Executive orders, and the Site Treatment Plan. All Paducah Site projects are evaluated for waste minimization and pollution prevention opportunities. In 2025, recycled materials included oils, coolant, paper, toner cartridges, nonradiological scrap metal, aluminum cans, light bulbs, batteries, tires, plastics, cardboard, and used electronics. The program strives to minimize waste using source reduction, segregation, reuse of materials, recycling, and procurement of recycled-content products. Program goals and objectives include the following:

- Eliminate or reduce the amount and toxicity of all waste generated at the site.
- Comply with federal and state regulations and DOE requirements for waste minimization.
- Reuse or recycle materials when possible.
- Identify waste reduction opportunities.
- Integrate waste minimization and pollution prevention technologies in ongoing projects.
- Coordinate recycling programs.
- Track and report results.

As part of these efforts, NWD offers excess reusable items to the Paducah Area Community Reuse Organization.

In 2025, the following items and their respective approximate quantities were recycled or diverted at the Paducah Site as outlined in the Paducah Site Treatment Plan (DOE 2026). This list does not include all recycling efforts at the Paducah Site, only the potential hazardous waste that was diverted.

- 48,885 pounds of scrap metal
- 18,317 pounds of carbon
- 82,582 pounds of miscellaneous items, which includes reused metal bins/boxes, filing cabinets, pallet racks, tables, chairs, refrigerators, heaters, ground-penetrating radar, scarifiers, small cylinders, scale platform, metal poles, test weights, crane attachment, trailers with generators, post boxes, power tools, battery charger, and various excess chemicals
- 30,420 pounds of various batteries
- 656 pounds of various light bulbs

### 3.3.2 Depleted Uranium Hexafluoride Cylinder Program

A coproduct of the uranium enrichment process, $DUF_6$ is a solid at ambient temperatures and is stored in large metal cylinders. At the end of 2025, the Paducah Site managed an inventory of 49,493 $DUF_6$ cylinders in its cylinder storage yards.

The mission of the $DUF_6$ cylinder program is to safely store the DOE-owned $DUF_6$ inventory until its ultimate disposition. DOE has an active cylinder management program that includes cylinder and cylinder yard maintenance, routine inspections, and other program activities such as cylinder corrosion studies. The program maintains a cylinder inventory database that houses all cylinder inspection data.

The $DUF_6$ Conversion Facility converts the inventory of $DUF_6$ to uranium oxide, a more stable form of uranium, and hydrofluoric acid, which is sold for commercial use. During 2025, MCS/MCSA converted approximately 5,077.59 metric tons of $DUF_6$. Section 4.9 discusses the off-site shipment of these conversion products.

### 3.3.3 Facility Stabilization, Deactivation, and Infrastructure Optimization

Stabilization and deactivation projects during 2025 at the Paducah Site involve isolating utilities, removing and compliantly disposing of hazardous materials from facilities, and downgrading radiological facilities to make them ready for demolition. Significant 2025 Paducah Site accomplishments in the C-333 Process Building included successful completion of segmenting all 497 converters, removal of known deposits, and air-gapping the C-333 Process Building from other process buildings; successful characterization of all process gas equipment systems and sub-components remaining within the facility to include remaining converter segmented parts; preparing waste for future disposition while continuing efforts to prepare the C-333 Process Building for future demolition; and initiated characterization efforts in the C-337 Process Building to support process gas inventory and development of characterization strategies.

## 3.4 Environmental Restoration and Remediation

The environmental remediation program executes environmental investigations and implements environmental response actions. It also supports deactivation and decommissioning of facilities, projects designed to demonstrate or test advancements in remedial technologies, and other projects related to actions that protect human health and the environment.

In 2025, activated carbon from the Paducah Site was packaged for off-site regeneration and one shipment was made. The Solid Waste Management Unit (SWMU) 211-A remediation project involved the use of *in situ* bioremediation technologies to treat trichloroethene contamination at the SWMU 211-A site. Sampling results of performance monitoring wells indicated a reduction of volatile organic compounds as compared to baseline values. The reduction of volatile organic compound contamination is expected to continue for several years as long as suitable subsurface conditions are present. Testing indicates that subsurface conditions are stable and the dechlorination of volatile organic compounds continued during 2025.

Federal and state approval was received for the following environmental remediation documents during 2025:

- *Site Management Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky, Annual Revision—FY 2026*, DOE/LX/07-2526&D2 (DOE 2025h)
- *Remedial Action Work Plan for the 2023 Optimization of the Northwest Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2509&D2 (DOE 2025b)
- *Geotechnical Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2507&D1/R1 (DOE 2025e)
- *Operation and Maintenance Plan for the Northwest Storm Water Control Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2044&D1/R5 (DOE 2025i)
- *Addendum to the Remedial Investigation Report for the C-400 Complex Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2474&D2/A1 (DOE 2025c)

- "Record of Conversation Concerning Approval of Appendix C Scoping Document and Work Plan for the Deactivation and Decommissioning Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, DOE/LX/07-2514&D1" (DOE 2025d)
- *Scoping Document and Work Plan for the Environmental Media Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2515&D2 (DOE 2025f)
- *Scoping Document and Work Plan for the Deactivation and Decommissioning Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2514&D2 (DOE 2025g)
- *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2024 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, FRNP-RPT-0380 (FRNP 2025b)

## 3.5 Public Awareness Program

DOE and its contractors are committed to enhancing public awareness and community and educational outreach. The Paducah Citizens Advisory Board and the DOE Paducah Environmental Information Center are two avenues through which DOE interacts with the public.

A comprehensive Community Relations Plan exists for DOE activities at the Paducah Site (DOE 2024b). Some activities, such as community involvement and recent cleanup mission achievements, were publicized using media releases and through guided public tours in 2025. The following sections discuss many of the other DOE programs and their status.



**Figure 3.1. DOE Science Bowl competition**

### 3.5.1 Community and Educational Outreach

As part of its community outreach program, DOE continued to engage students throughout the region in STEM education, including the Paducah Area Chamber of Commerce West Kentucky Launch Experience where approximately 750 middle school students were given hands-on demonstrations in groundwater sampling, engineering principles, and technology utilized at the Paducah Site.

DOE and its contractors also engage students through the annual DOE Science Bowl. The Science Bowl is a quick-recall, fast-paced, question-and-answer contest that quizzes students on their knowledge of biology, chemistry, earth and space science, energy, mathematics, and physics. In 2025, approximately 190 students participated in the DOE Science Bowl (Figure 3.1).

In 2025, DOE hosted more than 30 educators at the Paducah Site through the Educator Externship program in conjunction with the Paducah Area Chamber of Commerce Leadership Center. The program demonstrated how teachers can apply real-life work exercises to the subjects they teach in the classroom. Subject matter experts from the Paducah Site led hands-on activities to help educators better understand DOE's mission and the many skills needed to perform the work.

In addition to the outreach in the classroom, DOE awarded Murray State University in Murray, Kentucky, a grant to support the cleanup of the site with the goal of providing information that DOE and the public can use when engaging in the decision-making process for the future. As part of this grant, Murray State University and DOE have partnered to continue the student ASER program with McCracken County High School, providing the students involved with the project a tour of the site and access to subject matter experts to simplify the complex data into a format more accessible to the community.

### 3.5.2 Citizens Advisory Board

The Paducah Citizens Advisory Board is a site-specific advisory board chartered by DOE under the Federal Advisory Committees Act. The board has up to 15 members who represent the general public from Western Kentucky and Southern Illinois. The Citizens Advisory Board also includes liaison members representing US EPA Region 4, Kentucky Division of Waste Management under the Kentucky Energy and Environment Cabinet, and Kentucky Department of Fish and Wildlife Resources. The board seeks to reflect the concerns of the communities affected by the environmental management of the site. Additional information on the Citizens Advisory Board can be found here.

The Paducah Citizens Advisory Board works to achieve its mission through its subcommittee structure, and each year the board holds a planning meeting to determine how best to address its mission. Executive committee members participate in administrative meetings to prepare board members and subcommittees for the task of advising DOE. The work plan for the Citizens Advisory Board was developed to address project priorities selected by the board, with guidance from DOE (PGDP CAB 2025).

The educational series for FY 2025 addressed the following topics: overview of the site's strategic vision, summary of the 2024 ASER and student ASER program, Federal Site Life-Cycle Estimate process, and the status of land transfers and leases of property from the DOE Paducah Site were among the topics of interest to the board. Progress continued on implementation of the holistic strategy for environmental cleanup, termed Decision 2029, which was implemented in 2024. This strategy, in agreement with US EPA and KDEP, seeks to integrate and accelerate Paducah Site clean-up decisions for environmental media, deactivation and demolition, and waste disposal by up to 25 years.

### 3.5.3 Paducah Environmental Information Center

The public has access to the electronic version of the Paducah Site's administrative records and programmatic documents at the Paducah Environmental Information Center located at the Emerging Technology Center, Room 221, 5100 Alben Barkley Drive, Paducah, Kentucky. The Paducah Environmental Information Center is open Monday through Friday from 8:00 a.m. to 12:00 p.m. by appointment. The Paducah Environmental Information Center's phone number is (270) 554-3004.

Documents for public comment also are placed in the McCracken County Public Library, 555 Washington Street, Paducah, Kentucky. The library is open Monday through Thursday from 9:00 a.m. to 7:00 p.m., Friday and Saturday from 9:00 a.m. to 5:00 p.m., and Sunday from 1:00 p.m. to 5:00 p.m.

The Paducah Environmental Information Center and other public web pages related to DOE work at the Paducah Site can be accessed here and here.

# 4. Environmental Radiological Protection and Monitoring

Each year, the Paducah Site estimates the potential radiological dose to the public from Site operations and effluents. Estimates are calculated to confirm that no individual could have received a dose that exceeded the limits established by DOE or US EPA for the protection of the public. This section includes estimates of the maximum potential dose to the public, plants, and animals (biota) from Paducah Site activities.

To help readers understand the information in this section, Appendix B, *Introduction to Radiation*, answers the following questions:

- What is radiation?
- What is a radionuclide?
- What are some radionuclides of concern?
- What is radioactivity and how is it measured?
- What is dose and how is it measured?
- How are radioactivity and dose reported?
- What is an exposure pathway?
- What radiation sources and doses are we exposed to?
- What are the potential health effects of radiation exposure?

## 2025 Highlights

The paragraphs below summarize the radiological dose a member of the public, known as the MEI, could have received from the Paducah Site, assuming exposure from all relevant pathways. The largest contributor to the calculated dose is the direct radiation pathway, or external radiation. Atmospheric releases, incidental ingestion of surface water, and incidental ingestion of sediment contributed to the dose that could be received by the MEI. DOE assumes the groundwater pathway does not contribute to the dose from the Paducah Site because DOE ensures all potentially impacted residents can access a public water supply.

As in previous years, the estimated potential dose from the Paducah Site to the MEI was well below applicable US EPA standards and DOE public dose limits and represents a very small fraction of the estimated 620 mrem members of the public receive annually from natural and man-made sources.

Total dose from all pathways: The calculated dose of radiation a member of the public could receive from all pathways of exposure was 3.9E-01 mrem, which is approximately 0.4 percent of the DOE annual dose limit of 100 mrem. See Section 4.2 for additional information.

Dose from the air pathway: US EPA regulates annual radionuclide air emissions and sets a limit of 10 mrem per year at the maximally exposed off-site receptor. The total annual dose from airborne emissions from the Paducah Site was 3.4E-03 mrem, or 0.034 percent of the US EPA limit. See Section 4.3 for additional information.

Dose from the surface water pathway: Dose from the surface water pathway is evaluated by how much it contributes to the DOE total dose limit of 100 mrem per year from all relevant pathways. The estimated

dose from incidental ingestion of surface water from the Paducah Site was 1.2E-01 mrem, which is 0.12 percent of the DOE annual dose limit of 100 mrem. Drinking water was not considered an exposure pathway because the Ohio River was not used as a drinking water source and groundwater was not considered an exposure pathway because DOE provided public water to potentially impacted residents. See Section 4.4 for additional information.

Dose from the sediment pathway: Like surface water, dose from the sediment pathway is evaluated by its contribution to the DOE total dose limit of 100 mrem per year from all relevant pathways. The estimated dose from incidental ingestion of sediment from the Paducah Site was 4.0E-02 mrem. This level is 0.04 percent of the DOE annual dose limit of 100 mrem. See Section 4.5 for additional information.

Dose from the direct radiation pathway: Dose from direct radiation is also evaluated by its contribution to the DOE total dose limit of 100 mrem per year from all relevant pathways. The estimated external radiation dose from the Paducah Site was 2.2E-01 mrem, which represents 0.2 percent of the DOE annual dose limit of 100 mrem and 0.9 percent of the 25 mrem radioactive waste public dose constraint. This pathway represents 56.4 percent of the dose to the public from Paducah Site operations. See Section 4.6 for additional information.

Dose to Biota: Biota dose modeling indicates that the plants and animals living on or near the Paducah Site are not exposed to doses in excess of the DOE biota dose standard. See Section 4.7 for additional information.

## 4.1 Environmental Radiological Program

Routine DOE operations at the Paducah Site result in releases of radioactive materials to the environment through atmospheric and liquid pathways. These releases may result in a radiation exposure to the public. In accordance with DOE Order 458.1, *Radiation Protection of the Public and the Environment*, DOE has an environmental surveillance program that includes radiological monitoring of pathways that may contribute to the overall dose to the public. Surveillance includes analyses of surface water, groundwater, sediment, external radiation, and ambient air. The goals of the environmental radiological program are as follows:

- To conduct radiological activities so that exposure to members of the public is within the dose limits established by DOE Order 458.1
- To control the radiological clearance of DOE real and personal property
- To ensure that potential radiation exposures to members of the public are ALARA
- To monitor routine and nonroutine radiological releases and to assess the radiation dose to members of the public
- To protect the environment from the effects of radiation and radioactive material

## 4.2 Radiological Dose

DOE Order 458.1 establishes 100 mrem per year above background levels as the total annual dose limit to a member of the public. This established limit is consistent with Nuclear Regulatory Commission and *Kentucky Administrative Regulations* dose limits for the public. DOE Order 458.1 also limits dose from management and storage of radioactive waste to 25 mrem per year. DOE operations at the Paducah Site contribute to the yearly public dose through radiological releases and external radiation. DOE controls emissions and effluents to maintain releases at levels that are ALARA. The DOE Consolidated Audit Program (DOECAP) Accreditation Program provides DOE sites with the assurance that a contracted

commercial laboratory is fully capable of providing accurate data analysis. The DOECAP Accreditation Program requires third-party assessments, which assure that environmental sample analysis is performed using proven methods; provide valid, reliable, and defensible data; and manage waste streams responsibly. The assessments are conducted by one of three DOECAP Accreditation Program-approved third-party accreditation bodies and are assessed to the most recent version of the *Department of Defense and Department of Energy Quality Systems Manual for Environmental Laboratories* (DoD 2023). To confirm that doses to the public and biota are below established limits (see Table 2.3), the Paducah Site calculates annual dose estimates using effluent release data, external radiation monitoring data, and environmental monitoring data combined with relevant site-specific data such as meteorological conditions and population characteristics. These dose calculations use various computer codes, permit conditions, and guidance from DOE-HDBK-1216-2015 Change Notice 1 (Reaffirmed 2022), *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, to model the environmental dispersion of radionuclides that originate from on-site activities. Background radiation of natural cosmic and terrestrial origin and radiation from man-made activity (including medical doses) are subtracted from radiological measurements to determine the Paducah Site dose to the public.

### 4.2.1 Dose Assessment Methodology

Radiological dose assessments are modeled for exposure pathways applicable to the Paducah Site using methods consistent with the requirements of DOE Order 458.1 and other guidance, including the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, commonly referred to as the Risk Methods Document (DOE 2024a). First, measurements or estimates of radionuclide concentrations in liquid and air released from the Paducah Site are assembled for the calendar year. Afterward, models approved by US EPA and DOE (or factors derived from those models) are used to estimate the total effective dose to the MEI and the collective total effective dose to the population within a 50-mile radius of the Paducah Site.

To determine compliance with the DOE public dose requirements, the Paducah Site calculates potential off-site doses from Paducah Site air and liquid effluent releases of radioactive materials for the MEI and the population living within a 50-mile radius. DOE Order 458.1 states that the pathway and exposure assumptions for the MEI are to be reasonable and should neither underestimate nor substantially overestimate the dose. The MEI at the Paducah Site is established based on lifestyle assumptions for radiological exposure from each of the pathways for an individual who lives near the Paducah Site at the location where the highest concentration of radionuclides in air has been modeled; consumes milk, meat, and vegetables produced at that location; and spends time swimming in Bayou Creek or Little Bayou Creek. Dose is expected to represent an upper limit for exposure because certain activities, such as swimming in nearby creeks, are assumed to occur but are not expected. Atmospheric releases, direct radiation, incidental ingestion of surface water, and sediment pathways contributed to the Paducah Site operations MEI dose.

The ingestion of groundwater is not an exposure route because residents with groundwater wells in the Water Policy area of the Paducah Site are provided with municipal water for their drinking water source. Because groundwater is not used as a drinking water source, it is not considered in the dose to the MEI. Similarly, groundwater as a drinking water source is not considered in the calculation of dose to the surrounding population.

Surface water leaving the Paducah Site includes precipitation runoff from cylinder yards, landfills, and effluents from Paducah Site processes such as the Northeast Plume Containment System, the C-611 Water Treatment Plant, the C-612 Northwest Plume Groundwater Treatment System, the C-613 Sedimentation Basin, and the C-615 Sewage Treatment Plant. Discharges from the Paducah Site flow into Bayou Creek and Little Bayou Creek, and both creeks then flow into the Ohio River. The dose

to the general public from the drinking water pathway is calculated by assuming water is ingested at the nearest public water withdrawal location, which is Cairo, Illinois; however, on October 15, 2022, Cairo, Illinois, stopped using the Ohio River as a source of public drinking water and changed over to a groundwater well. Because Cairo, Illinois, does not use the Ohio River as a drinking water source, ingestion of surface water leaving the Paducah Site is not a realistic exposure pathway and, therefore, there is no dose to the MEI or surrounding population of Cairo, Illinois.

Surface water for irrigating crops is assumed to come from an uncontaminated source and not from either Bayou Creek or Little Bayou Creek because water flow in these creeks is too low for irrigation, compared to the Ohio River. Furthermore, Little Bayou Creek does not support aquatic life for consumption and few game-size fish could be caught from Bayou Creek, except during a backwater event when a large number of fish enter the creek from the Ohio River. Eating fish from the creeks is not included in dose for these reasons.

The MEI dose from incidental sediment and surface water ingestion pathways is based on assumptions for wading (i.e., sediment) and swimming (i.e., surface water) in Bayou Creek and Little Bayou Creek. Dose associated with airborne releases is calculated for the MEI located at the nearest neighbor to the plant.

### 4.2.2 Dose Summary

Table 4.1 summarizes the potential dose to the MEI and the estimated collective population dose. The monitoring results in this table demonstrate the continued effectiveness of radiological control measures practiced at the Paducah Site.

**Table 4.1. Summary of potential radiological dose to the public from the Paducah Site, 2025**

| Pathway[a] | Dose to MEI (mrem)[b] | Percent of DOE 100 mrem per year limit | Estimated collective population dose (person-rem) | Population within 50 miles |
|---|---|---|---|---|
| Atmospheric releases[c] | 3.4E-03 | 0.0034 | 3.1E-02 | ~504,000 |
| Ingestion of groundwater[d] | [d] | [d] | [d] | |
| Ingestion of drinking water[d] | [d] | [d] | [d] | |
| Incidental ingestion of surface water | 1.2E-01 | 0.12 | [e] | |
| Incidental ingestion of sediment | 4.0E-02 | 0.04 | 6.0E-03[f] | 150 |
| Direct radiation | 2.2E-01 | 0.2 | 3.3E-02[f] | 150 |
| All relevant pathways[a,b,g] | 3.9E-01 | 0.4 | 7.1E-02 | |

Note: Shaded areas indicate blank spaces.

[a] Pathways are defined in previous sections.
[b] Maximum allowable exposure from all sources is 100 mrem per year (DOE Order 458.1), which is consistent with 902 *KAR* 100:019, Section 8.(1)(a).
[c] Doses associated with atmospheric releases also include ingestion pathways considered in the Clean Air Act Assessment Package-1998 Personal Computer (CAP-88 PC) food chain modeling routines.
[d] Ingestion of groundwater and ingestion of drinking water were not viable pathways for exposure to the MEI because neither pathway was used as a drinking water source.
[e] Incidental ingestion of surface water in plant creeks and ditches is not applicable for calculating collective dose to residents who reside within 50 miles of the Paducah Site. Collective dose is not calculated for the incidental ingestion pathway because it is unlikely that a population of individuals would swim repeatedly in either Bayou Creek or Little Bayou Creek. Because this pathway is more likely to involve individuals, it is more suitable for the MEI dose calculation.
[f] Population dose for direct radiation and incidental ingestion of sediment is based on a representative assumption using the estimated visitors hiking in WKWMA only.

**Table 4.1. Summary of potential radiological dose to the public from the Paducah Site, 2025 (continued)**

[g] The dose to the MEI from all relevant pathways is calculated by summing the dose from individual pathways. The all-pathways dose is considered to be an upper bound of the expected dose to the MEI because no single individual would receive the sum of the calculated pathway doses due to the dose being calculated for exposure at varying locations and any individual's varying activity patterns.

Acronyms:
CAP-88 PC = Clean Air Act Assessment Package-1988 Personal Computer
DOE = US Department of Energy
*KAR* = *Kentucky Administrative Regulations*
MEI = maximally exposed individual
mrem = millirem
rem = roentgen equivalent man
WKWMA = West Kentucky Wildlife Management Area

## 4.3 Air Monitoring and Estimated Dose

DOE operations result in airborne releases from various sources, including CERCLA remedial actions. Radionuclide sources evaluated at the Paducah Site in 2025 included the C-310 Stack, Northwest Plume Groundwater Treatment System, Northeast Plume Containment System Treatment Units, C-409 Laboratory Hood, the $DUF_6$ Conversion Facility, building exhaust vents, and fugitive emissions.

### 4.3.1 Air Monitoring

Specific activities that could generate fugitive emissions include the transport and disposal of waste, decontamination of equipment, and most environmental remediation activities. Ambient air monitoring, which monitors fugitive emissions from all Paducah Site operations (including $DUF_6$ Conversion Facility operations), uses nine continuous air monitors surrounding the Paducah Site, including one that collects data from a background location. Figure 4.1 shows the locations of these air monitors. The FY 2026 environmental monitoring plan describes the radiological constituents analyzed for the Paducah Site (FRNP 2025a).

***For radionuclides at the Paducah Site, the effective dose equivalent is assumed to equal the effective dose. January 2020 guidance from DOE's Office of Public Radiation Protection (AU-22) states, "AU-22 considers the reported CAP-88 PC dose to be a very close approximation of a modeled equivalent dose result and well within the uncertainty bounds of the dose estimate." The DOE guidance is available here.***

Airborne radionuclide emissions are regulated by US EPA under the Clean Air Act and its implementing regulations. DOE facilities are subject to 40 *CFR* Part 61, Subpart H, *National Emission Standards for Hazardous Air Pollutants*, which contains the national standards for emissions of radionuclides other than radon from DOE facilities. The applicable standard is a maximum of 10 mrem (0.1 mSv) effective dose equivalent to any member of the public in any year.

Table 4.2 shows the estimates of radionuclide atmospheric releases in curies, a unit of measure for radioactivity.

### 4.3.2 Air Estimated Dose

Airborne radioactive materials released in 2025 from the stacks and diffuse sources at the Paducah Site (see Table 4.2) were modeled using the US EPA-approved CAP-88 PC, Version 4.1.1, computer program. This air dispersion model estimates effective dose equivalents based on the ingestion, inhalation, air immersion, and ground surface pathways, including the consumption of vegetables, milk, and meat.

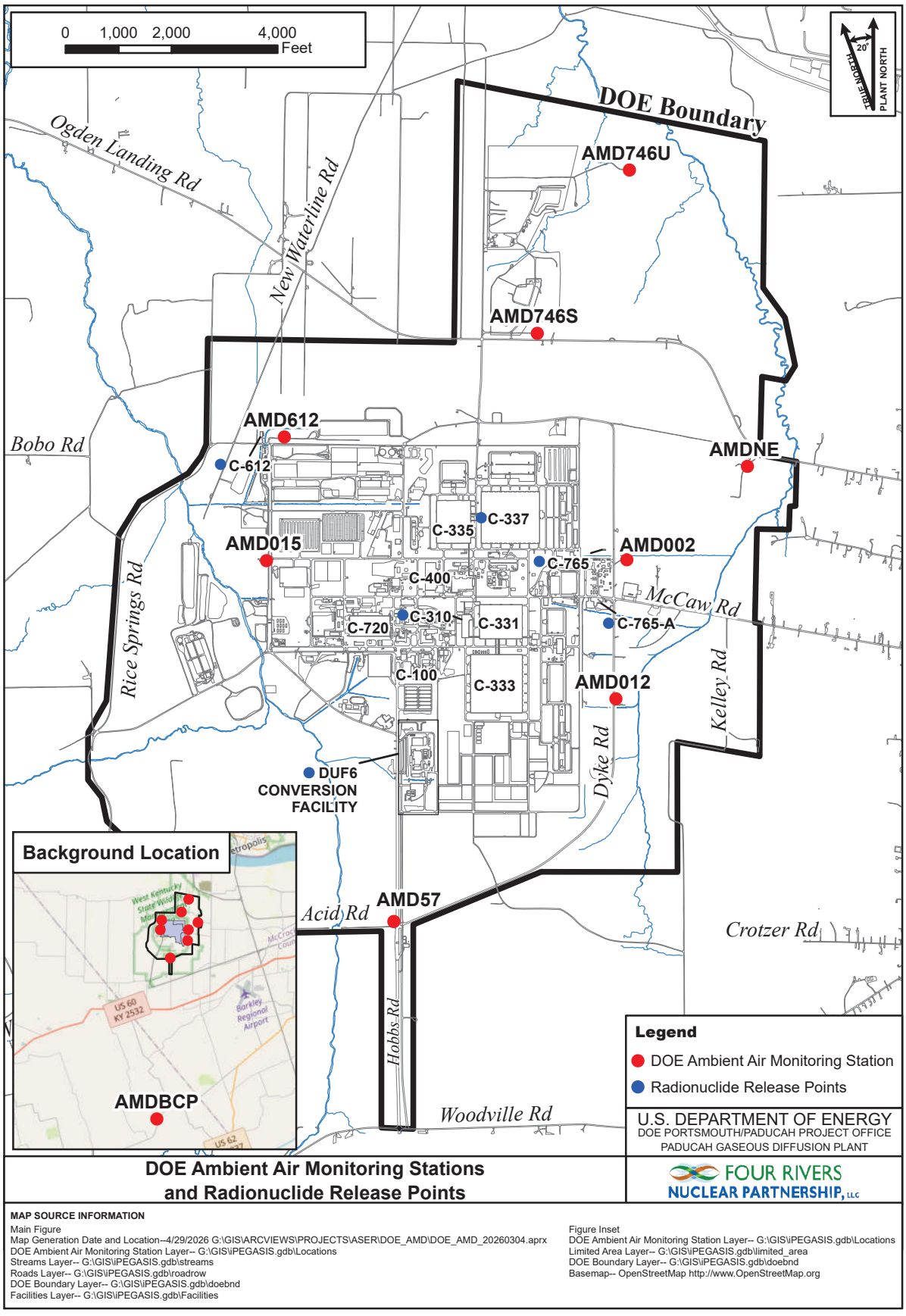



**Figure 4.1. Air monitoring locations and radionuclide release points**

**Table 4.2. Radionuclide atmospheric releases (in curies) for the Paducah Site**

| Radionuclide | Group A: Northwest Plume Groundwater Treatment System C-612 | Group B: Northeast Plume Containment System Treatment Unit C-765 | Group C: Northeast Plume Containment System Treatment Unit C-765-A | Group D: C-310* Stack | Group E: $DUF_6$ Conversion Facility | Group F: Seal Exhaust/ Wet Air Group | Group G: C-409 Hood | Total Site Emissions |
|---|---|---|---|---|---|---|---|---|
| Technetium-99 | 1.84E-05 | 6.66E-06 | 1.80E-07 | 0.00E+00 | 0.00E+00 | 4.47E-09 | 0.00E+00 | 2.52E-05 |
| Uranium-234 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.54E-03 | 5.83E-08 | 8.60E-09 | 3.96E-12 | 2.54E-03 |
| Uranium-235 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.73E-04 | 2.66E-09 | 4.54E-10 | 0.00E+00 | 1.73E-04 |
| Uranium-238 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.36E-03 | 1.43E-07 | 4.52E-09 | 2.24E-12 | 2.36E-03 |
| Neptunium-237 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.74E-11 | 0.00E+00 | 4.74E-11 |
| Plutonium-239 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.26E-12 | 0.00E+00 | 2.26E-12 |
| Thorium-230 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.84E-10 | 0.00E+00 | 1.84E-10 |
| Thorium-231 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.81E-08 | 0.00E+00 | 0.00E+00 | 6.81E-08 |
| Thorium-234 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.22E-06 | 0.00E+00 | 0.00E+00 | 6.22E-06 |
| Protactinium-234m | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.22E-06 | 0.00E+00 | 0.00E+00 | 6.22E-06 |
| **Total** | 1.84E-05 | 6.66E-06 | 1.80E-07 | 5.07E-03 | 1.27E-05 | 1.83E-08 | 6.20E-12 | 5.11E-03 |

* The Alternate Monitoring Procedure for Title V Permit V-21-011 R4, requires the use of maximum values and reports a worst-case scenario.

Acronym:
$DUF_6$ = depleted uranium hexafluoride

Site-specific data for 2025 (radionuclide releases in curies per year) were entered in the CAP-88 PC program, along with on-site meteorological data. Table 4.3 provides the effective dose to the MEI for each individual point source in mrem received in a calendar year. Due to location differences, emission rates, and other factors, the MEI for each point source could differ from the MEI for the cumulative impacts from all sources.

**Table 4.3. Dose calculations for airborne releases for 2025**

| Emission sources | Effective dose equivalent to the MEI for each source (mrem) | Dose to the MEI for the plant (mrem) |
|---|---|---|
| C-310 Stack | 3.40E-03 | 3.40E-03 |
| Seal Exhaust/Wet Air Group | 6.00E-09 | 6.00E-09 |
| Northwest Plume Groundwater Treatment System C-612 | 1.30E-05 | 4.60E-06 |
| Northeast Plume Containment System Treatment Unit C-765 | 3.40E-06 | 1.40E-06 |
| Northeast Plume Containment System Treatment Unit C-765-A | 8.10E-08 | 3.40E-08 |
| C-409 Hood | 5.90E-12 | 4.80E-12 |
| $DUF_6$ Conversion Facility | 1.40E-07 | 1.00E-07 |
| Total from All Sources | | 3.41E-03 |

Acronyms:
MEI = maximally exposed individual
mrem = millirem
$DUF_6$ = depleted uranium hexafluoride

The individual who would receive the maximum hypothetical cumulative dose from all pathways, known as the MEI, was calculated to receive an effective dose equivalent of 3.41E-03 mrem, which is below the National Emission Standards for Hazardous Air Pollutants standard of 10 mrem per year. Table 4.4 shows the collective effective dose to the entire population (approximately 504,000 persons per 2020 US Census data) within 50 miles of the Paducah Site, as estimated by the CAP-88 PC program (Table 4.5).

**Table 4.4. Calculated radiation dose from airborne releases for the Paducah Site for 2025**

| Effective dose to MEI (mrem) | Percent of NESHAP 10 mrem/year limit | Collective effective dose (person-rem) |
|---|---|---|
| 3.41E-03 | 0.034 | 3.13E-02 |

Acronyms:
MEI = maximally exposed individual
mrem = millirem
NESHAP = National Emission Standards for Hazardous Air Pollutants
rem = roentgen equivalent man

**Table 4.5. Comparison of potential radiological dose for the atmospheric releases pathway**

| Atmospheric Releases[a] | 2021[a] | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|
| Dose to MEI in mrem[b] | 4.9E-03 | 1.4E-03 | 3.03E-03 | 6.50E-03 | 3.41E-03 |
| Percent of DOE 100 mrem per year limit | 0.0049% | 0.0014% | 0.003% | 0.0065% | 0.0034% |
| Percent of NESHAP 10 mrem per year limit | 0.049% | 0.014% | 0.03% | 0.065% | 0.034% |
| Estimated collective dose in person-rem[b,c] | 5.5E-02 | 2.0E-02 | 3.78E-02 | 7.33E-02 | 3.13E-02 |
| Population within 50 miles[d] | ~534,000 | ~534,000 | ~504,000 | ~504,000 | ~504,000 |

[a] C-310 Stack use for deactivation began in March 2021.
[b] Maximum allowable exposure from all sources is 100 mrem per year (DOE Order 458.1), which is consistent with 902 KAR 100:019, Section 8.(1)(a).
[c] Doses associated with atmospheric releases also include ingestion pathways considered in the CAP-88 PC food chain modeling routines.
[d] Entire population within 50 miles of the Paducah Site.

Acronyms:
CAP-88 PC = Clean Air Act Assessment Package 1988 Personal Computer
DOE = US Department of Energy
MEI = maximally exposed individual
mrem = millirem
NESHAP = National Emission Standards for Hazardous Air Pollutants
rem = roentgen equivalent man

A detailed summary of this emissions data can be found in the National Emissions Standard for Hazardous Air Pollutants Annual Report for 2025 (FRNP 2026d).

## 4.4 Liquid Discharge Monitoring and Estimated Dose

The Paducah Site monitors effluent and surface water runoff for radiological constituents to protect human health and the environment.

### 4.4.1 Surface Water

Radioactive contaminants released to surface water may remain dissolved or suspended as particulates in surface water; may be deposited in sediment, on the ground, or on vegetation by irrigation; may be absorbed into plants and animals; or may infiltrate to the groundwater.

Surface water leaving the Paducah Site includes precipitation runoff from cylinder yards, landfills, and effluent from Paducah Site processes such as the Northeast Plume Containment System, the C-611 Water Treatment Plant, the C-612 Northwest Plume Groundwater Treatment System, the C-613 Sedimentation Basin, and the C-615 Sewage Treatment Plant. Discharges from the Paducah Site flow into Bayou Creek and Little Bayou Creek, and both creeks then flow into the Ohio River.

DOE Order 458.1 requires DOE to control and manage radionuclides from its activities in liquid discharges and sets guidelines for allowable concentrations of radionuclides in effluents to protect public health. The dose limits set by DOE Order 458.1 are the legal limits, but are not DOE's expectation for dose to the public and the environment. DOE Order 458.1 requires application of the ALARA process to all routine radiological activities to optimally reduce radionuclide releases and resulting doses. The Paducah Site achieves this protection by ensuring concentrations of radionuclides in effluents are

ALARA. Ingestion limits for all radionuclides are calculated using the composite derived concentration standard value found in DOE-STD-1196-2022, *Derived Concentration Technical Standard*.

The ingested water derived concentration standard value for a radionuclide is the concentration of the radionuclide in water that is calculated, or derived, to result in an annual dose of 100 mrem to a person. That is, if the person's entire annual drinking water intake contained a radionuclide at the derived concentration standard level, that person would receive 100 mrem. The derived concentration standard is different for each radionuclide because of differences in radiation type, radioactive energy, and half-life.

The Environmental Radiation Protection Program monitors effluent and surface water runoff for radiological constituents to observe potential contamination released to the receiving streams and tributaries from plant operations. Sampling locations were selected to support the analysis of site-specific radiation exposure pathways. Locations were prioritized for areas of public access, introduction of plant effluents to the environment, and verification of the effectiveness of the Paducah Site effluent control and monitoring.

Radionuclides were analyzed monthly at 14 surface water locations by KPDES-permitted outfalls shown in Figure 4.2: K001ERPP, K002ERPP, K004ERPP, K008ERPP, K009ERPP, K010ERPP, K011ERPP, K012ERPP, K013ERPP, K015ERPP, K016ERPP, K017ERPP, K019ERPP, and K020ERPP, except as noted below.

- K019ERPP samples only collected in January, April, and August when the C-746-U Contained Landfill sedimentation pond was discharged.

Radionuclide analysis was performed quarterly at these locations, which are shown in Figure 4.2.

- Little Bayou Creek surface water locations (L10, L11, and L241)
- Bayou Creek surface water location (L5)
- North-South Diversion Ditch surface water location (L14DWN)
- Ohio River location upstream of the Paducah Site (L29A)

Radionuclide analysis was performed annually at these locations, which are shown in Figure 4.2.

- Bayou Creek location upstream of the Paducah Site (L1), which was chosen for comparisons of data generated as part of the Environmental Radiation Protection Program effluent and surface water runoff monitoring effort.
- Ohio River location just downstream of the Paducah Site (L30).

Surface water runoff was sampled at the C-746-S, C-746-T, and C-746-U Landfills (L135, L136, L150, L154, and L351) to meet permit requirements; samples were analyzed for alpha and beta activity.

The surface water sampling locations with the maximum detectable radionuclides are shown in Table 4.6.

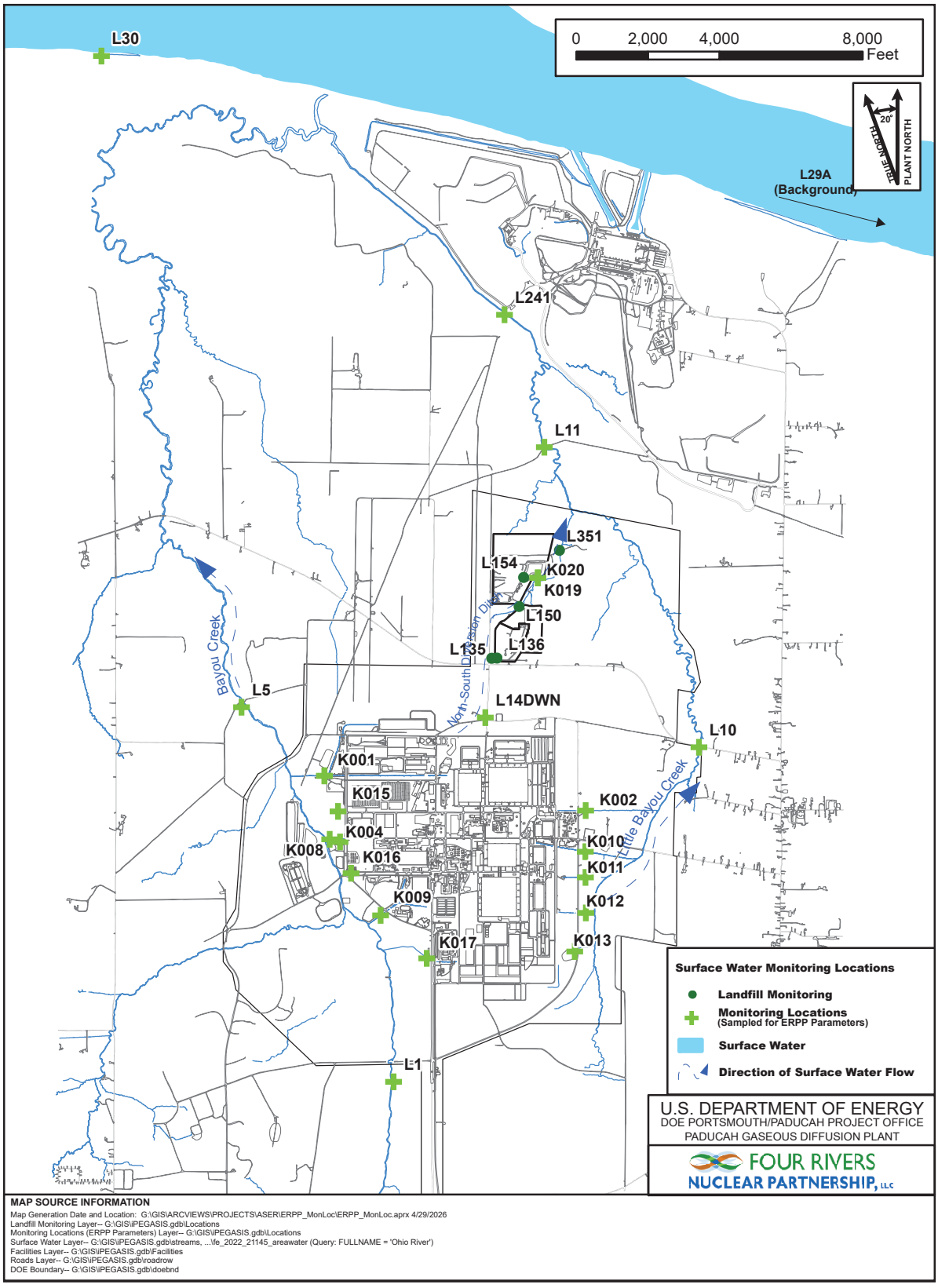



**Figure 4.2. Surface water monitoring locations**

**Table 4.6. Maximum detected radionuclides in surface water samples**

| Sample location | Radionuclide | Maximum detected (pCi/L) |
|---|---|---|
| K008 | Technetium-99 | 2.32E+01 |
| K015ERPP | Uranium-234 | 1.65E+01 |
| K015ERPP | Uranium-235 | 3.04E+00 |
| K011ERPP | Uranium-238 | 9.30E+01 |

Acronym:
pCi/L = picocuries per liter

### 4.4.2 Outfall C001

In addition to monitoring surface water under DOE orders, the KPDES permit, and the solid waste landfills permit, DOE conducted surface water monitoring as a separate program under CERCLA for effluent from the Northeast Plume Containment System via Outfall C001. This outfall was monitored for technetium-99, according to the *Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2018). Results from C001 are not used to calculate dose because it is a direct discharge from a treatment system.

### 4.4.3 Drinking Water

Surface water was not used as a drinking water source. Because surface water was not used as a drinking water source, it was not considered in the calculation of the dose to the MEI. Similarly, surface water as a drinking water source was not considered in the calculation of dose to the surrounding population.

### 4.4.4 Landfill Leachate

Leachate collected from the C-746-U and C-746-S landfills was sampled routinely and compared to DOE Order 458.1 limits. This data was used to determine programmatic management of landfill leachate. Leachate was treated and discharged through permitted outfalls at the site, which were also monitored for compliance with KPDES permit limits.

### 4.4.5 Groundwater

DOE has numerous groundwater monitoring wells, which are described in Chapter 6. Groundwater wells that supplied drinking water to residents in the Water Policy area of the Paducah Site have been abandoned or taken out of service, and the houses are provided with public drinking water. As a result, groundwater was not an exposure route because it was not a source of drinking water. Because groundwater was not used as a drinking source, it was not considered in the calculation of the dose to the MEI. Similarly, groundwater as a drinking water source was not considered in the calculation of dose to the surrounding population.

### 4.4.6 Incidental Ingestion of Surface Water

Dose to the MEI was based on incidental ingestion of surface water from swimming in Bayou Creek and Little Bayou Creek and their tributaries, including outfall locations. This scenario represents an upper limit for exposure because the dose is based on swimming, which is an unlikely activity for both Bayou Creek and Little Bayou Creek. For example, the manager of the WKWMA noted in an interview that any contact with water would be brief and would be limited to wading across creeks. A health assessment by the Agency for Toxic Substances and Disease Registry states, "…there is very little swimming, wading, or other human activity in Bayou and Little Bayou Creeks." Finally, the Kentucky Department of Fish and Wildlife Resources did not identify swimming (as compared to limited fishing and traversing incidental to hunting) as a recreational use of Little Bayou or Bayou Creeks in recreational

usage information provided in 1995 or in the 2014 recreational usage update. The recreational usage information is found in Appendix E of the Risk Methods Document (DOE 2024a).

The method recommended in DOE-HDBK-1216-2015 Change Notice 1 (Reaffirmed 2022), *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, was implemented to determine dose to the MEI for incidental ingestion of surface water. The ingestion assumptions, based on the Risk Methods Document, Table B.5, are that a hypothetical person may swim (at most) 45 days a year for 2.6 hours a day, with an incidental ingestion rate of 0.092 liters per hour, and be in different locations throughout the wildlife management area (DOE 2024a). Table A.10 of that document provides site-specific screening levels for receptors due to site-related radionuclides. Sample results from each surface water sample location were averaged for that location, and the average sample result was then used in the calculation to determine a dose at each surface water sample location. Results from reference location L1 were subtracted from other sample results to arrive at a dose associated with Paducah Site releases at each surface water sample location. When calculated reference location dose results were less than zero, a value of 0.0E+00 mrem was used for the reference result in the calculation to determine the annual dose minus background. When a calculated radionuclide's specific dose was less than zero, a value of 0.0E+00 mrem was used for that radionuclide specific result in the calculation to determine the annual estimated dose for incidental ingestion of surface water for each sample location. The sample location with the maximum estimated dose was assigned to the MEI. Table 4.7 shows the calculated dose at each surface water sample location.

Based on Table 4.7 results, the surface water location with the maximum calculated dose was K011ERPP located downstream of KPDES Outfall 011. This location flows into Little Bayou Creek.

**Table 4.7. Surface water dose**

| Sample location | Am-241 | Cs-137 | Np-237 | Pu-238 | Pu-239/240 | Tc-99 | Th-230 | U-234 | U-235 | U-238 | Sample location dose (mrem) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| K001 | | | | | | 2.33E-04 | | | | | 2.33E-04 |
| K001ERPP | 0.00E+00 | | 0.00E+00 | 1.39E-05 | 2.67E-04 | 2.63E-04 | 6.80E-04 | 2.02E-03 | 3.65E-04 | 5.25E-03 | 8.86E-03 |
| K002 | | | | | | 1.28E-06 | | | | | 1.28E-06 |
| K002ERPP | | | | | | | | 6.39E-04 | 1.35E-05 | 9.19E-04 | 1.57E-03 |
| K004ERPP | 0.00E+00 | 7.70E-04 | 0.00E+00 | 4.99E-04 | 1.93E-05 | 7.98E-05 | 1.42E-03 | 2.18E-03 | 3.53E-04 | 2.47E-03 | 7.79E-03 |
| K008 | | | | | | 1.54E-04 | | | | | 1.54E-04 |
| K008ERPP | 0.00E+00 | 5.13E-04 | 0.00E+00 | 0.00E+00 | 7.98E-04 | | 0.00E+00 | 8.83E-03 | 7.50E-04 | 9.73E-03 | 2.06E-02 |
| K009 | | | | | | 0.00E+00 | | | | | 0.00E+00 |
| K009ERPP | 0.00E+00 | | 0.00E+00 | 0.00E+00 | 2.51E-04 | | 0.00E+00 | 7.10E-04 | 6.60E-05 | 2.03E-03 | 3.05E-03 |
| K010 | | | | | | 0.00E+00 | | | | | 0.00E+00 |
| K010ERPP | 8.14E-04 | | 0.00E+00 | 0.00E+00 | 7.73E-04 | | 0.00E+00 | 8.20E-04 | 2.59E-05 | 3.76E-03 | 6.19E-03 |
| K011 | | | | | | 8.93E-06 | | | | | 8.93E-06 |
| **K011ERPP** | 0.00E+00 | | 0.00E+00 | 0.00E+00 | 7.91E-04 | | 1.06E-03 | 1.33E-02 | 1.92E-03 | 1.02E-01 | **1.19E-01** |
| K012 | | | | | | 0.00E+00 | | | | | 0.00E+00 |
| K012ERPP | 0.00E+00 | | 0.00E+00 | 0.00E+00 | 1.58E-03 | | 1.71E-04 | 3.08E-04 | 2.85E-04 | 1.52E-03 | 3.87E-03 |
| K013 | | | | | | 0.00E+00 | | | | | 0.00E+00 |
| K013ERPP | | | | | | | | 5.22E-05 | 0.00E+00 | 6.64E-04 | 7.17E-04 |
| K015 | | | | | | 1.93E-04 | | | | | 1.93E-04 |
| K015ERPP | 2.68E-04 | 3.76E-04 | 0.00E+00 | 0.00E+00 | 5.76E-04 | | 5.34E-04 | 1.61E-02 | 2.09E-03 | 6.51E-02 | 8.50E-02 |
| K016 | | | | | | 3.67E-05 | | | | | 3.67E-05 |
| K016ERPP | 2.71E-04 | 7.64E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | | 0.00E+00 | 3.86E-04 | 0.00E+00 | 1.31E-03 | 2.73E-03 |
| K017 | | | | | | 0.00E+00 | | | | | 0.00E+00 |
| K017EPP | | | | | | | | 1.09E-03 | 2.13E-05 | 1.45E-03 | 2.57E-03 |
| K019 | | | | | | 4.64E-05 | | | | | 4.64E-05 |
| K019ERPP | | | | | | | | 1.84E-04 | 0.00E+00 | 0.00E+00 | 1.84E-04 |
| K020 | | | | | | 2.49E-05 | | | | | 2.49E-05 |
| K020ERPP | | | | | | | | 3.98E-03 | 3.39E-04 | 1.75E-02 | 2.18E-02 |

**Table 4.7. Surface water dose (continued)**

| Sample location | Am-241 | Cs-137 | Np-237 | Pu-238 | Pu-239/240 | Tc-99 | Th-230 | U-234 | U-235 | U-238 | Sample location dose (mrem) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L1 (reference location) | 6.84E-04 | 0.00E+00 | 1.93E-03 | 9.80E-04 | 0.00E+00 | 0.00E+00 | 3.60E-03 | 2.26E-04 | 1.59E-04 | 1.83E-04 | 7.77E-03 |
| L5 | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | | 1.12E-03 | 1.14E-04 | 1.60E-03 | 2.83E-03 |
| L10 | | | | | | 3.17E-04 | | 5.92E-04 | 5.27E-04 | 5.63E-03 | 7.06E-03 |
| L11 | | | | | | 1.14E-04 | 1.90E-03 | 3.38E-04 | 3.14E-04 | 3.53E-03 | 6.20E-03 |
| L14DWN | | | | | | 1.51E-04 | | 2.55E-03 | 5.01E-04 | 2.44E-03 | 5.65E-03 |
| L241 | | | | | | 1.44E-04 | | 8.11E-04 | 2.37E-04 | 2.78E-03 | 3.98E-03 |

Acronyms:
Am = americium
Cs = cesium
mrem = millirem
Np = neptunium
Pu = plutonium
Tc = technetium
Th = thorium
U = uranium

### 4.4.7 Incidental Ingestion of Surface Water Estimated Dose

Dose from the surface water pathway is evaluated by its contribution to the DOE limit for the total dose from all pathways of 100 mrem per year. Collective population dose was not calculated for the incidental ingestion of surface water pathway because it is unlikely that a population of individuals would repeatedly swim in either Bayou Creek or Little Bayou Creek. Because this pathway is more likely to involve individuals, it is more appropriate for the MEI dose calculation.

The estimated dose to the MEI from incidental ingestion of surface water releases from the Paducah Site was 1.2E-01 (1.19E-01) mrem. This level is 0.12 percent of the DOE annual dose limit of 100 mrem from all pathways to members of the public. This result is consistent with previous results shown in Table 4.8.

**Table 4.8. Comparison of potential radiological dose for incidental ingestion of surface water pathway**

| Incidental ingestion of surface water | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|
| Dose to MEI (mrem) | 7.1E-02 | 4.1E-02 | 1.2E-01 | 1.6E-01 | 1.2E-01 |
| Percent of DOE 100 mrem per year limit | 0.07 | 0.04 | 0.12 | 0.16 | 0.12 |

Acronyms:
DOE = US Department of Energy
MEI = maximally exposed individual
mrem = millirem

## 4.5 Sediment and Soil Monitoring and Estimated Dose

Sediment is an important constituent of the aquatic environment. Radionuclides transported by water can adhere to suspended organic and inorganic solids or can be assimilated by plants and animals. Suspended solids, dead biota, and excreted waste matter settle to the bottom and become part of the organic substrata that support the bottom-dwelling community of organisms. As a result, sediments can have a significant impact on aquatic ecology by serving as a repository for radioactive substances that pass from bottom-feeding biota to higher levels of the food chain. A single sediment sample can represent information that would require many water samples, spaced over a period of time, to reconstruct. Sediment collects, concentrates, and stores specific kinds of contaminants at specific locations. Concentrations of contaminants in sediments represent the combined amounts of the contaminants accumulated in water over some preceding period of time.

### 4.5.1 Sediment Monitoring

Sediment sampling at the Paducah Site in 2025 included radiological and nonradiological constituents. Sediment sampling for nonradiological constituents is discussed in Chapter 5. Sampling locations, shown in Figure 4.3, were selected to facilitate the analysis of site-specific radiation exposure pathways and to indicate the accumulation of undissolved radionuclides in the aquatic environment.

Sampling locations were selected to represent areas of public access, introduction of plant effluents to the environment, any unplanned release, and to verify the effectiveness of the Paducah Site's effluent monitoring. Areas removed or remediated as part of a 2010 removal action for contaminated sediment associated with the Surface Water Operable Unit are also noted in Figure 4.3 (DOE 2011).

Results from radiological analysis of the annual sediment samples are shown in Table 4.9. The radiological results for 2025 are similar in magnitude to those from previous years. Location S20 is located in Bayou Creek near the DOE boundary and provides background concentrations for radiological sediment sampling. Location S1 is in Bayou Creek within the DOE boundary surrounding the Paducah Site. Location S2 is downstream at Little Bayou Creek, near the DOE boundary. Location S27 is in Little Bayou Creek within the DOE boundary. Location S33 is in Bayou Creek, north of the DOE boundary, and Location S34 is in Little Bayou Creek, north of the DOE boundary.

### 4.5.2 Sediment Estimated Dose

In calculating dose to the MEI, it was assumed that exposure to contaminated sediment in Bayou Creek and Little Bayou Creek could occur during hunting and other recreational activities by incidentally ingesting the sediment. The ingestion assumption assumes that an individual, referred to as an adult recreational user, would wade at one creek location every other day during the hunting season (104 days per year) and ingest a small amount of sediment (100 milligrams per day) during each visit.

A dose was then calculated using the methods in the Risk Methods Document, which includes the ingestion, inhalation, and external gamma pathways (DOE 2024a). Table A.8 of that document provides site-specific soil screening levels for receptors due to site-related radionuclides. Results from the background location, S20, were subtracted from other sample results to arrive at a dose associated with Paducah Site releases. When calculated background dose results were less than zero, a value of 0.0E+00 mrem was used for that background result in the calculation to determine the annual dose minus background. When a calculated radionuclide's specific dose was less than zero, a value of 0.00E+00 mrem was used for that radionuclide-specific result in the calculation to determine the annual estimated dose for incidental ingestion of sediment. Location S1 dose was calculated by averaging the dose from the S1 sample results and the S1 duplicate sample results. The sample location with the maximum estimated dose was assumed to represent the MEI dose received from this pathway. Table 4.10 presents the estimated annual dose for the incidental ingestion of sediment for each location sampled.

Based on the dose estimates in Table 4.10, the maximum estimated dose was calculated at location S2, which is located downstream in Little Bayou Creek near the DOE boundary.

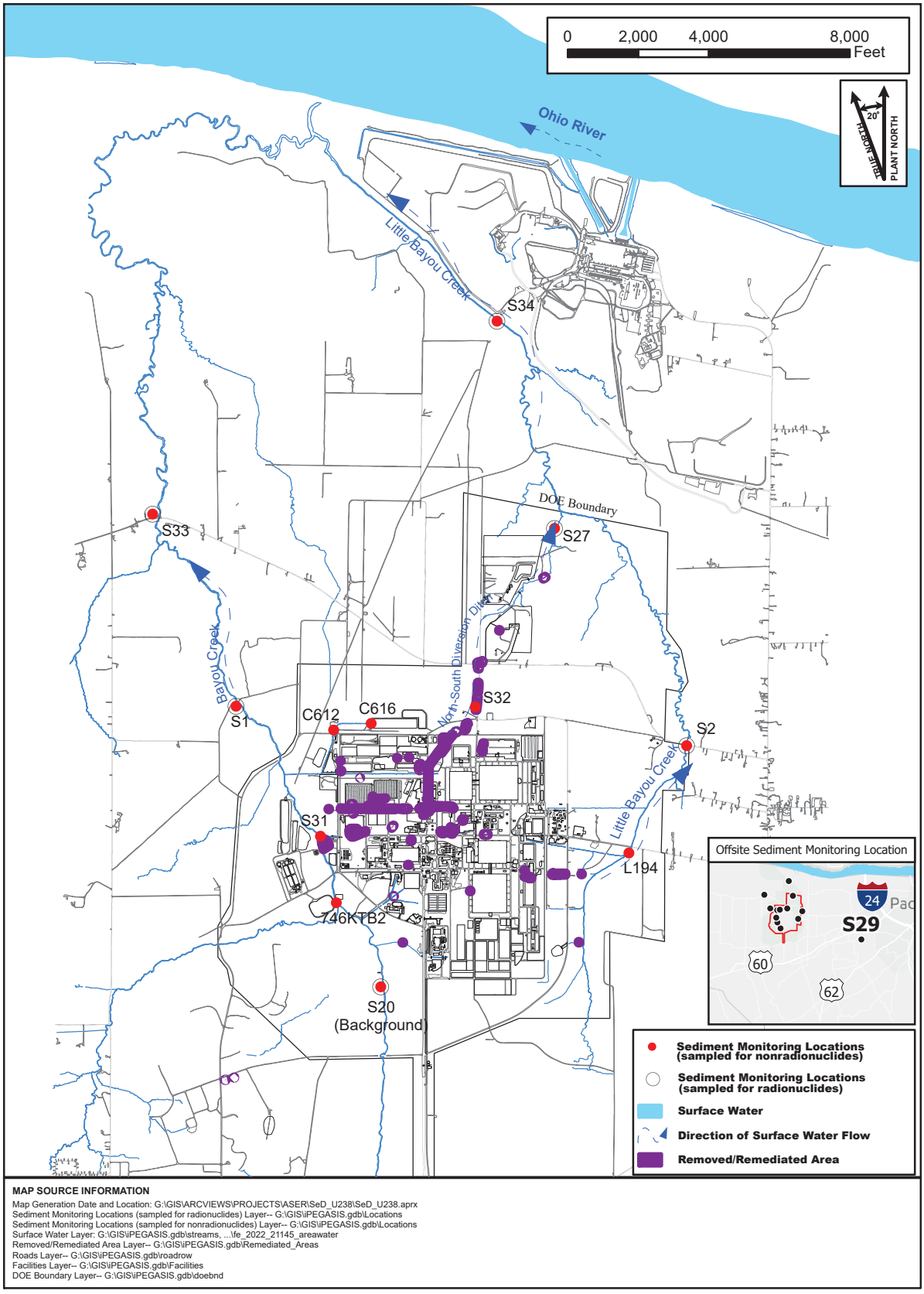



**Figure 4.3. Sediment monitoring locations**

**Table 4.9. Radiological results for sediment sampling in picocuries per gram[a,b,c]**

| Parameter | S1 | S1 (duplicate) | S1 (average) | S2 | S20 (background) | S27 | S33 | S34 |
|---|---|---|---|---|---|---|---|---|
| Alpha | 7.50E+00 | 8.06E+00 | 7.78E+00 | 6.49E+00 | 1.37E+01 | 9.13E+00 | 1.09E+01 | 1.37E+01 |
| Beta | 1.49E+01 | 1.27E+01 | 1.38E+01 | 1.00E+01 | 1.66E+01 | 1.09E+01 | 2.00E+01 | 1.72E+01 |
| Americium-241 | 8.95E-02 | -1.03E-02 | 3.96E-02 | 3.05E-03 | 1.17E-01 | -9.96E-02 | -1.36E-02 | 1.64E-01 |
| Cesium-137 | 3.29E-02 | 1.66E-04 | 1.65E-02 | 1.54E-02 | 6.64E-03 | 1.14E-02 | 8.57E-02 | 1.12E-02 |
| Neptunium-237 | 1.54E-01 | 4.15E-03 | 7.91E-02 | -6.78E-02 | -1.91E-02 | 1.76E-01 | -2.58E-02 | -5.46E-02 |
| Plutonium-238 | 9.11E-02 | 5.16E-02 | 7.14E-02 | 1.03E-01 | -1.32E-01 | -2.86E-01 | -1.48E-02 | 4.41E-02 |
| Plutonium-239/240 | 9.10E-02 | 2.23E-01 | 1.57E-01 | 3.03E-02 | 6.42E-02 | 4.81E-02 | 4.95E-02 | 9.06E-02 |
| Technetium-99 | 4.66E+00 | 3.83E+00 | 4.25E+00 | 5.54E-01 | 6.63E-01 | 4.15E+00 | 4.43E-01 | 6.72E-01 |
| Thorium-230 | 8.92E-01 | 5.86E-01 | 7.39E-01 | 8.92E-01 | 1.33E+00 | 1.07E+00 | 1.00E+00 | 1.79E+00 |
| Total Uranium | 6.94E+00 | 3.58E+00 | 5.26E+00 | 6.23E+00 | 2.00E+00 | 4.36E+00 | 2.02E+00 | 3.55E+00 |
| Uranium-234 | 2.72E+00 | 1.53E+00 | 2.13E+00 | 1.28E+00 | 8.12E-01 | 6.64E-01 | 9.74E-01 | 9.91E-01 |
| Uranium-235 | 1.54E-01 | 8.89E-02 | 1.21E-01 | 3.58E-01 | 2.93E-01 | 1.41E-01 | 4.42E-02 | -1.66E-01 |
| Uranium-238 | 4.06E+00 | 1.96E+00 | 3.01E+00 | 4.59E+00 | 8.90E-01 | 3.55E+00 | 9.99E-01 | 2.55E+00 |

[a] Negative values are possible and observed regularly with radiological data.
[b] Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count.
[c] Shaded values are less than the laboratory reporting limit.

**Table 4.10. 2025 annual dose estimates in millirem for incidental ingestion of sediment**

| Parameter | S1 | S2 | S20 | S27 | S33 | S34 |
|---|---|---|---|---|---|---|
| Am-241 | 0.00E+00 | 0.00E+00 | 1.20E-03 | 0.00E+00 | 0.00E+00 | 4.82E-04 |
| Cs-137 | 1.99E-03 | 1.76E-03 | 1.34E-03 | 9.58E-04 | 1.59E-02 | 9.18E-04 |
| Np-237 | 5.10E-03 | 0.00E+00 | 0.00E+00 | 1.14E-02 | 0.00E+00 | 0.00E+00 |
| Pu-238 | 6.61E-04 | 9.54E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.08E-04 |
| Pu-239/240 | 9.34E-04 | 0.00E+00 | 6.46E-04 | 0.00E+00 | 0.00E+00 | 2.66E-04 |
| Tc-99 | 1.12E-04 | 0.00E+00 | 2.07E-05 | 1.09E-04 | 0.00E+00 | 2.80E-07 |
| Th-230 | 0.00E+00 | 0.00E+00 | 1.13E-02 | 0.00E+00 | 0.00E+00 | 3.90E-03 |
| U-234 | 2.54E-03 | 9.05E-04 | 1.57E-03 | 0.00E+00 | 3.13E-04 | 3.46E-04 |
| U-235 | 0.00E+00 | 2.79E-03 | 1.26E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| U-238 | 1.91E-02 | 3.33E-02 | 8.02E-03 | 2.40E-02 | 9.82E-04 | 1.50E-02 |
| **Total (mrem)** | **3.04E-02** | **3.97E-02** | **3.66E-02** | **3.64E-02** | **1.72E-02** | **2.13E-02** |

Acronyms:
Am = americium mrem = millirem Pu = plutonium Th = thorium
Cs = cesium Np = neptunium Tc = technetium U = uranium

The estimated dose to the MEI from incidental ingestion of sediment was 4.0E-02 (3.97E-02) mrem. This level is 0.04 percent of the DOE annual dose limit of 100 mrem per year from all pathways to members of the public.

The estimated collective population dose was calculated by multiplying the MEI dose by the total estimated number of visitors (hiking) in the WKWMA annually (150 persons) and dividing by 1,000 to convert mrem to rem. The resulting collective population dose for this pathway was 6.0E-03 (5.96E-03) person-rem. Both the MEI and collective population doses are consistent with the results shown in Table 4.11.

**Table 4.11. Comparison of potential radiological dose for incidental ingestion of sediment pathway**

| Incidental ingestion of sediment | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|
| Dose to MEI (mrem) | 1.6E-01 | 3.0E-02 | 9.8E-02 | 7.8E-02 | 4.0E-02 |
| Percent of DOE 100 mrem per year limit | 0.160 | 0.03 | 0.098 | 0.078 | 0.04 |
| Estimated collective population dose (person-rem)* | 2.4E-02 | 4.4E-03 | 1.5E-02 | 1.2E-02 | 6.0E-03 |
| Population within 50 miles* | 150 | 150 | 150 | 150 | 150 |

*Population dose for incidental ingestion of sediment is based on a representative assumption using the estimated visitors hiking in WKWMA only (DOE 2024a).

Acronyms:
DOE = US Department of Energy
MEI = maximally exposed individual
mrem = millirem
rem = roentgen equivalent man
WKWMA = West Kentucky Wildlife Management Area

## 4.6 External Radiation Monitoring and Estimated Dose

External radiation exposure from DOE's operations at the Paducah Site potentially contributes to the overall dose to the public. This report refers to this as the direct radiation pathway. External radiation exposure is defined as exposure attributed to radioactive sources outside the body, such as cosmic radiation. Sources of external radiation at the Paducah Site include the cylinder storage yards, the operations inside the cascade building, and small items such as instrument calibration sources. Cylinder storage yards have the greatest potential to contribute to the public dose because of their proximity to publicly accessible areas.

### 4.6.1 External Radiation Monitoring

The external radiation monitoring program is designed to provide data on external radiation exposure from DOE operations to members of the public. The primary factor in selecting the monitoring locations was the potential for a member of the public to be exposed to external radiation. Locations were also chosen for accessibility, representative exposure potentially received by members of the public, and area monitoring for individuals passing through the Paducah Site.

A surveillance network of environmental dosimeters monitored locations inside the Paducah Site security fence and at the perimeter of the Paducah Site, in addition to outfalls, ditches, and background locations. Environmental dosimeters were also placed in areas that historically received the highest radiation exposure. Figure 4.4 shows the environmental dosimeter locations.

In 2025, the network used vendor-supplied environmental dosimeters that meet American National Standards Institute (ANSI) N545-1975, *Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry (Environmental Applications)*, and ANSI/Health Physics Society N13.37-2014, *Environmental Dosimetry-Criteria for System Design and Implementation*, in 64 locations to measure external gamma radiation; and vendor-supplied US Department of Energy Laboratory Accredited Program-accredited environmental dosimeters in seven locations to measure external neutron radiation. Vendor-supplied dosimeters were returned to the vendor so that the dosimeters could be processed following their internal processes, protocols, and quality control (QC) routines. Vendors then provided reports of the results. The network of environmental dosimeter locations, along with analysis of their data, monitored changes in external radiation measures over the year.

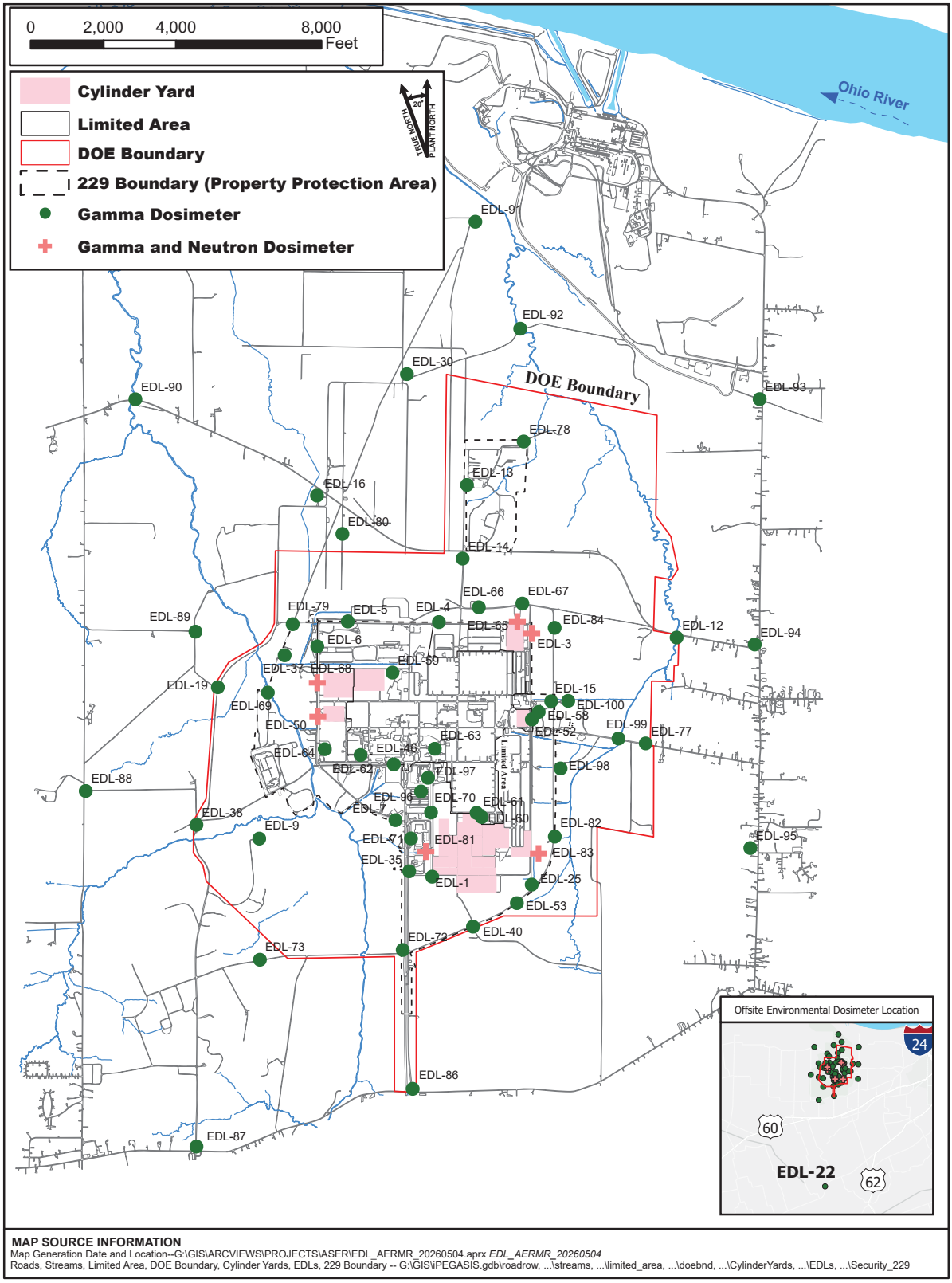



**Figure 4.4. Environmental dosimeter locations**

### 4.6.2 External Radiation Estimated Dose

The *2025 Annual External Radiation Monitoring Report Paducah Gaseous Diffusion Plant, Paducah, Kentucky* presents a detailed summary of monitoring results (FRNP 2026e). In 2025, 14 out of 64 monitoring locations showed results statistically above the background level. All of these locations were, historically, the areas with the highest measured results throughout the monitoring period. These locations were adjacent to or in close proximity of the uranium hexafluoride cylinder storage yards inside the property protection area (PPA) boundary, which are not regularly accessible to the public. This means the potential external radiation dose calculated from these locations would not represent the actual public external radiation dose. In previous years, an average of these locations was used and assigned to the MEI, which was conservative, but not realistic. Beginning in 2024, a more realistic scenario was used to assign the MEI dose based on the publicly accessible locations outside the PPA and DOE boundaries. The publicly accessible location with the maximum dose is assigned to the MEI for this pathway.

The public can access the area between the PPA and DOE boundaries because DOE licenses a portion of the Paducah Site to the Kentucky Department of Fish and Wildlife Resources for recreational uses. This area is known as the WKWMA. There are no residences within this area but it is open to the public for recreational uses.

The environmental dosimeter locations not accessible to the public, but closest to the PPA boundary, that showed results statistically above background were locations 25, 53, 82, and 83.

Because dose is inversely proportional to the square of the distance from the source, the potential dose to a member of the public was determined by using the shortest distance between these environmental dosimeter locations and the closest point to the PPA boundary. This calculation showed the maximum dose at the PPA boundary was determined to be adjacent to location 82 at 4.06E+00 mrem. Once the dose at the PPA boundary was calculated, the Risk Methods Document was used to determine a reasonable maximum exposure. The Risk Methods Document, Table B.5 lists an adult recreational user exposure frequency of 104 days per year and exposure duration of 10 hours per day (DOE 2024a). Using this information, the calculated dose at the PPA boundary was determined by the following equation.

**(4.06 mrem × 104 days per year × 10 hours per day) ÷ (365 days per year × 24 hours per day) = 0.482 mrem**

Because this location was only open to the public for 169 days before DOE removed access, the potential annual dose was adjusted as shown.

**0.482 mrem × (169 days ÷ 365 days) = 0.223 mrem**

A member of the public would receive a potential effective dose of 2.23E-01 mrem per year along the PPA boundary at location 82.

The MEI dose of 2.23E-01 mrem represents 0.22 percent of the DOE annual dose limit of 100 mrem per year from all pathways to members of the public and 0.9 percent of the 25 mrem per year radioactive waste public dose constraint.

The estimated collective population dose was calculated by multiplying the MEI dose by the total estimated number of visitors (hiking) in the WKWMA annually (150 persons) and dividing by 1,000 to convert mrem to rem. The resulting collective population dose for this pathway was 3.3E-02 person-rem.

Both the MEI and collective population doses are shown in Table 4.12.

**Table 4.12. Comparison of potential radiological dose for the direct radiation pathway**

| Direct radiation pathway | 2021 | 2022 | 2023 | 2024 | 2025[a] |
|---|---|---|---|---|---|
| MEI calculated dose (mrem) | 2.1E+00 | 1.8E+00 | 6.3E-01 | 1.1E+00 | 2.2E-01 |
| Percent of DOE 25 mrem per year radioactive waste public dose constraint | 8.5% | 7.1% | 2.5% | 4.5% | 0.9% |
| Percent of DOE 100 mrem per year limit | 2.1% | 1.8% | 0.63% | 1.1% | 0.22% |
| Estimated collective population dose (person-rem) | 3.2E-01 | 2.7E-01 | 9.4E-02 | 1.7E-01 | 3.3E-02 |
| Population within 50 miles[b] | 150 | 150 | 150 | 150 | 150 |

[a] In 2025, the MEI location changed from location 40, which is the dose shown for years 2021 through 2024, to location 82. The change in the MEI location for 2025 is due to DOE removal of public access to areas between the PPA boundary and the DOE boundary.
[b] Population dose for direct radiation is based on a representative assumption, using only the estimated number of visitors hiking in the WKWMA (DOE 2024a).

Acronyms:
DOE = US Department of Energy
MEI = maximally exposed individual
Mrem = millirem
PPA = property protection area
rem = roentgen equivalent man
WKWMA = West Kentucky Wildlife Management Area

## 4.7 Monitoring of Plants and Animals and Estimated Dose

Wildlife and farm-raised animal products, including meat, eggs, and milk may become contaminated when animals ingest contaminated water, sediment, or other animals, or through direct contact with contaminated areas. The subsequent ingestion of these products by humans can contribute to public dose. As discussed in Section 4.3, dose calculations estimate a portion of airborne radionuclides is deposited in soil, ingested by animals, and taken up by food crops. As a result, ground surface pathways include consumption of vegetables, milk, and meat. Irrigation and deposition through waterborne radionuclides are incomplete pathways because nearby residences use municipal water for household purposes.

### 4.7.1 Wildlife Monitoring

Wildlife from the DOE Paducah Site have been sampled in past years for nonradiological and radiological constituents. Deer were monitored annually for many years, and data were used to assess Paducah Site dose. During FY 2011, DOE performed an extensive review of data sets from 20 years of deer monitoring events. As a result of the 2011 review, DOE eliminated deer monitoring in 2012 because of a continued lack of detection results and because deer travel in a large radius, they are not good candidates for monitoring impacts from the Paducah Site.

### 4.7.2 Wildlife Estimated Dose

This wildlife exposure route and associated dose is captured in the food chain models associated with the CAP-88 PC program.

### 4.7.3 Biota Monitoring

Radionuclides from both natural and man-made sources may be found in environmental media such as water, sediments, and soils. Contaminants may accumulate in animals from eating contaminated feed, drinking contaminated water, and breathing contaminated air, and in fish when they eat contaminated food and live in contaminated waters. Because plant and animal populations residing in or near, or taking food or water from these media may be exposed to a greater extent than humans, DOE prepared technical standard DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial*

*Biota*. This standard provides methods and guidance for evaluating doses from ionizing radiation to populations of aquatic animals, riparian animals (those that live along banks of streams or rivers), terrestrial plants, and terrestrial animals.

Because both measured concentrations and bioconcentration factors associated with radionuclides of concern at the Paducah Site in animals and fish are low, DOE does not perform routine site-specific pathway assessments, including biota sampling. Biota sampling used to be conducted as part of the KPDES permit; however, KDOW eliminated the requirement of biota sampling due to the negative impact to the aquatic community.

### 4.7.4 Biota Estimated Dose

DOE Order 458.1 requires that sites use DOE-STD-1153-2019 to evaluate dose to biota. The Paducah Site used the general screening phase described in this standard to determine if radiation doses to aquatic and terrestrial biota were in compliance with the specified dose limits (see Table 2.3).

The RESRAD-BIOTA computer model (Version 1.8) is a calculation tool provided by DOE for implementing the technical standard. It compares existing radionuclide concentration data from environmental sampling with biota concentration guide (BCG) screening values to estimate maximum doses to biota.

Dose to biota was evaluated for Bayou Creek and Little Bayou Creek using the sampling locations shown in Figures 4.2 and 4.3. Data obtained from water sample location L5 and sediment sample location S1 were used to represent water and sediment, respectively, in Bayou Creek. Data obtained from water sample location L11 and sediment sample location S27 were used to represent water and sediment in Little Bayou Creek, respectively. KPDES Outfalls 019 and 020, which flow into Little Bayou Creek, were not considered due to their intermittent flow. Locations L11 and S27 also represent a section of Little Bayou Creek that is downstream of its confluence with the North-South Diversion Ditch. The creek at this point is more substantial and more likely to support aquatic life than upstream areas.

In accordance with the graded approach described in DOE-STD-1153-2019, a general screening phase from water and sediment sampling locations on Bayou Creek and Little Bayou Creek was conducted using the maximum radionuclide concentration data with no background subtraction. If the radionuclide concentration data was below the laboratory detection limit, then the maximum radionuclide concentration below the laboratory detection limit was used. Data were entered in the RESRAD-BIOTA computer model to calculate dose to biota from Paducah Site operations. The value for each radionuclide was divided by its corresponding BCG value to calculate a partial fraction for each radionuclide in each medium (water or sediment). Partial fractions for each medium were added to produce a sum of fractions. Each assessment identified the limiting organism (i.e., the organism that is most sensitive to the potential radiological dose). The sum of the fractions (or ratios) from each assessment was calculated and evaluated against the recommended biota dose rate criteria.

The sum of the fractions for the sediment-limiting organism in Bayou Creek was determined by summing the ratios for sediment in Table 4.13 where the limiting organism is noted as “yes.” In Table 4.13, only the riparian animal has ratios for sediment with the limiting organism noted as “yes.” Adding these numbers together equals 2.49E-03. The sum of the fractions for the water-limiting organism was determined by summing the ratios for water in Table 4.13 where the limiting organism is noted as “yes.” In Table 4.13, the aquatic animal and riparian animal have ratios for water with the limiting organism noted as “yes.” Adding these numbers together equals 1.40E-01. In order to determine the total sum of the fractions for the limiting organisms in Bayou Creek, the sum of the fractions for the sediment-limiting organism is added to the sum of the fractions for the water-limiting organism; the calculation would be 2.49E-03 + 1.40E-01 = 1.42E-01

or 0.142. Because 0.142 is less than 1.0, the dose to aquatic animal, riparian animal (i.e., animal that lives along the creek bank), terrestrial animal, and terrestrial plant does not exceed the recommended dose rate criteria and is in compliance with the DOE biota dose standard.

**Table 4.13. Bayou Creek evaluation of dose to aquatic and terrestrial biota**

| Radionuclide | Water | | | | Sediment | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Concentration (pCi/L) | BCG (pCi/L) | Ratio | Limiting organism | Concentration (pCi/g) | BCG (pCi/g) | Ratio | Limiting organism | Ratio |
| **Aquatic animal** | | | | | | | | | |
| Am-241 | NA | 4.38E+02 | 0.00E+00 | Yes | 8.95E-02 | 6.80E+05 | 1.32E-07 | No | 1.32E-07 |
| Cs-137 | 5.37E-01 | 1.05E+03 | 5.11E-04 | No | 3.29E-02 | 4.93E+04 | 6.67E-07 | No | 5.12E-04 |
| K-40 | 2.29E+01 | 2.90E+03 | 7.90E-03 | No | NA | 5.79E+04 | 0.00E+00 | No | 7.90E-03 |
| Np-237 | 8.03E-01 | 6.85E+01 | 1.17E-02 | Yes | 1.54E-01 | 7.86E+04 | 1.96E-06 | No | 1.17E-02 |
| Pu-238 | -3.26E-02 | 1.76E+02 | -1.85E-04 | Yes | 9.11E-02 | 3.95E+06 | 2.31E-08 | No | -1.85E-04 |
| Pu-239 | 9.16E-02 | 1.87E+02 | 4.90E-04 | Yes | 2.23E-01 | 7.05E+06 | 3.16E-08 | No | 4.90E-04 |
| Tc-99 | 7.95E+00 | 2.47E+06 | 3.22E-06 | No | 4.66E+00 | 4.59E+05 | 1.02E-05 | No | 1.34E-05 |
| Th-230 | NA | 2.57E+03 | 0.00E+00 | Yes | 8.92E-01 | 2.74E+06 | 3.26E-07 | No | 3.26E-07 |
| Th-234 | 1.04E+02 | 2.66E+05 | 3.91E-04 | Yes | NA | 4.32E+04 | 0.00E+00 | No | 3.91E-04 |
| U-234 | 2.09E+00 | 2.02E+02 | 1.03E-02 | Yes | 2.72E+00 | 3.03E+06 | 8.98E-07 | No | 1.03E-02 |
| U-235 | 5.77E-01 | 2.18E+02 | 2.65E-03 | Yes | 1.54E-01 | 1.10E+05 | 1.40E-06 | No | 2.65E-03 |
| U-238 | 2.18E+00 | 2.24E+02 | 9.73E-03 | Yes | 4.06E+00 | 4.29E+04 | 9.46E-05 | No | 9.83E-03 |
| **Riparian animal** | | | | | | | | | |
| Am-241 | NA | 1.46E+03 | 0.00E+00 | No | 8.95E-02 | 5.15E+03 | 1.74E-05 | Yes | 1.74E-05 |
| Cs-137 | 5.37E-01 | 4.27E+01 | 1.26E-02 | Yes | 3.29E-02 | 3.13E+03 | 1.05E-05 | Yes | 1.26E-02 |
| K-40 | 2.29E+01 | 2.49E+02 | 9.20E-02 | Yes | NA | 4.42E+03 | 0.00E+00 | Yes | 9.20E-02 |
| Np-237 | 8.03E-01 | 1.16E+04 | 6.92E-05 | No | 1.54E-01 | 7.63E+03 | 2.02E-05 | Yes | 8.94E-05 |
| Pu-238 | -3.26E-02 | 5.51E+02 | -5.92E-05 | No | 9.11E-02 | 5.73E+03 | 1.59E-05 | Yes | -4.33E-05 |
| Pu-239 | 9.16E-02 | 6.22E+02 | 1.47E-04 | No | 2.23E-01 | 5.87E+03 | 3.80E-05 | Yes | 1.85E-04 |
| Tc-99 | 7.95E+00 | 6.67E+05 | 1.19E-05 | Yes | 4.66E+00 | 4.14E+04 | 1.13E-04 | Yes | 1.24E-04 |
| Th-230 | NA | 1.39E+04 | 0.00E+00 | No | 8.92E-01 | 1.04E+04 | 8.58E-05 | Yes | 8.58E-05 |
| Th-234 | 1.04E+02 | 3.80E+06 | 2.74E-05 | No | NA | 4.32E+03 | 0.00E+00 | Yes | 2.74E-05 |
| U-234 | 2.09E+00 | 6.84E+02 | 3.06E-03 | No | 2.72E+00 | 5.27E+03 | 5.16E-04 | Yes | 3.57E-03 |
| U-235 | 5.77E-01 | 7.37E+02 | 7.83E-04 | No | 1.54E-01 | 3.79E+03 | 4.06E-05 | Yes | 8.24E-04 |
| U-238 | 2.18E+00 | 7.57E+02 | 2.88E-03 | No | 4.06E+00 | 2.49E+03 | 1.63E-03 | Yes | 4.51E-03 |
| **Terrestrial animal** | | | | | | | | | |
| Am-241 | NA | 2.02E+05 | 0.00E+00 | No | 8.95E-02 | 3.65E+25 | 2.45E-27 | No | 2.45E-27 |
| Cs-137 | 5.37E-01 | 5.99E+05 | 8.96E-07 | No | 3.29E-02 | 3.65E+25 | 9.01E-28 | No | 8.96E-07 |
| K-40 | 2.29E+01 | 1.93E+06 | 1.19E-05 | No | NA | 3.65E+25 | 0.00E+00 | No | 1.19E-05 |
| Np-237 | 8.03E-01 | 6.49E+06 | 1.24E-07 | No | 1.54E-01 | 3.65E+25 | 4.22E-27 | No | 1.24E-07 |
| Pu-238 | -3.26E-02 | 1.89E+05 | -1.72E-07 | No | 9.11E-02 | 3.65E+25 | 2.50E-27 | No | -1.72E-07 |
| Pu-239 | 9.16E-02 | 2.01E+05 | 4.56E-07 | No | 2.23E-01 | 3.65E+25 | 6.11E-27 | No | 4.56E-07 |
| Tc-99 | 7.95E+00 | 1.54E+07 | 5.16E-07 | No | 4.66E+00 | 3.65E+25 | 1.28E-25 | No | 5.16E-07 |
| Th-230 | NA | 4.52E+05 | 0.00E+00 | No | 8.92E-01 | 3.65E+25 | 2.44E-26 | No | 2.44E-26 |
| Th-234 | 1.04E+02 | 4.31E+06 | 2.41E-05 | No | NA | 3.65E+25 | 0.00E+00 | No | 2.41E-05 |
| U-234 | 2.09E+00 | 4.05E+05 | 5.16E-06 | No | 2.72E+00 | 3.65E+25 | 7.45E-26 | No | 5.16E-06 |
| U-235 | 5.77E-01 | 4.20E+05 | 1.37E-06 | No | 1.54E-01 | 3.65E+25 | 4.22E-27 | No | 1.37E-06 |
| U-238 | 2.18E+00 | 4.06E+05 | 5.37E-06 | No | 4.06E+00 | 3.65E+25 | 1.11E-25 | No | 5.37E-06 |

**Table 4.13. Bayou Creek evaluation of dose to aquatic and terrestrial biota (continued)**

| Radionuclide | Water | | | | Sediment | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Concentration (pCi/L) | BCG (pCi/L) | Ratio | Limiting organism | Concentration (pCi/g) | BCG (pCi/g) | Ratio | Limiting organism | Ratio |
| **Terrestrial plant** | | | | | | | | | |
| Am-241 | N/A | 6.80E+08 | 0.00E+00 | No | 8.95E-02 | 3.65E+26 | 2.45E-28 | No | 2.45E-28 |
| Cs-137 | 5.37E-01 | 4.93E+07 | 1.09E-08 | No | 3.29E-02 | 3.65E+26 | 9.01E-29 | No | 1.09E-08 |
| K-40 | 2.29E+01 | 5.79E+07 | 3.96E-07 | No | NA | 3.65E+26 | 0.00E+00 | No | 3.96E-07 |
| Np-237 | 8.03E-01 | 7.86E+07 | 1.02E-08 | No | 1.54E-01 | 3.65E+26 | 4.22E-28 | No | 1.02E-08 |
| Pu-238 | -3.26E-02 | 3.95E+09 | -8.25E-12 | No | 9.11E-02 | 3.65E+26 | 2.50E-28 | No | -8.25E-12 |
| Pu-239 | 9.16E-02 | 7.05E+09 | 1.30E-11 | No | 2.23E-01 | 3.65E+26 | 6.11E-28 | No | 1.30E-11 |
| Tc-99 | 7.95E+00 | 4.59E+08 | 1.73E-08 | No | 4.66E+00 | 3.65E+26 | 1.28E-26 | No | 1.73E-08 |
| Th-230 | NA | 2.74E+09 | 0.00E+00 | No | 8.92E-01 | 3.65E+26 | 2.44E-27 | No | 2.44E-27 |
| Th-234 | 1.04E+02 | 4.32E+07 | 2.41E-06 | No | NA | 3.65E+26 | 0.00E+00 | No | 2.41E-06 |
| U-234 | 2.09E+00 | 3.03E+09 | 6.90E-10 | No | 2.72E+00 | 3.65E+26 | 7.45E-27 | No | 6.90E-10 |
| U-235 | 5.77E-01 | 1.10E+08 | 5.25E-09 | No | 1.54E-01 | 3.65E+26 | 4.22E-28 | No | 5.25E-09 |
| U-238 | 2.18E+00 | 4.29E+07 | 5.08E-08 | No | 4.06E+00 | 3.65E+26 | 1.11E-26 | No | 5.08E-08 |

Notes:
1. Shaded values are less than the laboratory detection limit.
2. NA in this table indicates that the radionuclide was not analyzed. Ratios were not included and not summed for radionuclides that were not analyzed.

Acronyms:
Am = americium
BCG = biota concentration guide
Cs = cesium
K = potassium
NA = not applicable
Np = neptunium
pCi/g = picocuries per gram
pCi/L = picocuries per liter
Pu = plutonium
Tc = technetium
Th = thorium
U = uranium

The sum of the fractions for the sediment-limiting organism in Little Bayou Creek was determined by summing the ratios for sediment in Table 4.14 where the limiting organism is noted as "yes." Ratios where the limiting organism is noted as "yes" that have negative values are truncated to zero before summing. In Table 4.14, only the riparian animal has ratios for sediment with the limiting organism noted as "yes." Adding these numbers together equals 1.83E-03. The sum of the fractions for the water-limiting organism was determined by summing the ratios for water in Table 4.14 where the limiting organism is noted as "yes." In Table 4.14, the aquatic animal and riparian animal have ratios for water with the limiting organism noted as "yes." Adding these numbers together equals 1.87E-02. In order to determine the total sum of the fractions for the limiting organisms in Little Bayou Creek, the sum of the fractions for the sediment-limiting organism is added to the sum of the fractions for the water-limiting organism; the calculation would be 1.83E-03 + 1.87E-02 = 2.06E-02 or 0.0206. Because 0.0206 is less than 1.0, the dose to aquatic animal, riparian animal (i.e., animal that lives along the creek bank), terrestrial animal, and terrestrial plant does not exceed the recommended dose rate criteria and is in compliance with the DOE biota dose standard.

**Table 4.14. Little Bayou Creek evaluation of dose to aquatic and terrestrial biota**

| Radionuclide | Water | | | | Sediment | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Concentration (pCi/L) | BCG (pCi/L) | Ratio | Limiting organism | Concentration (pCi/g) | BCG (pCi/g) | Ratio | Limiting organism | Ratio |
| **Aquatic animal** | | | | | | | | | |
| Am-241 | NA | 4.38E+02 | 0.00E+00 | Yes | -9.96E-02 | 6.80E+05 | -1.46E-07 | No | -1.46E-07 |
| Cs-137 | NA | 1.05E+03 | 0.00E+00 | No | 1.14E-02 | 4.93E+04 | 2.31E-07 | No | 2.31E-07 |
| Np-237 | NA | 6.85E+01 | 0.00E+00 | Yes | 1.76E-01 | 7.86E+04 | 2.24E-06 | No | 2.24E-06 |
| Pu-238 | NA | 1.76E+02 | 0.00E+00 | Yes | -2.86E-01 | 3.95E+06 | -7.24E-08 | No | -7.24E-08 |
| Pu-239 | NA | 1.87E+02 | 0.00E+00 | Yes | 4.81E-02 | 7.05E+06 | 6.82E-09 | No | 6.82E-09 |
| Tc-99 | 1.29E+01 | 2.47E+06 | 5.22E-06 | No | 4.15E+00 | 4.59E+05 | 9.04E-06 | No | 1.43E-05 |
| Th-230 | 1.84E+00 | 2.57E+03 | 7.16E-04 | Yes | 1.07E+00 | 2.74E+06 | 3.91E-07 | No | 7.16E-04 |
| U-234 | 7.65E-01 | 2.02E+02 | 3.79E-03 | Yes | 6.64E-01 | 3.03E+06 | 2.19E-07 | No | 3.79E-03 |
| U-235 | 5.22E-01 | 2.18E+02 | 2.39E-03 | Yes | 1.41E-01 | 1.10E+05 | 1.28E-06 | No | 2.40E-03 |
| U-238 | 2.65E+00 | 2.24E+02 | 1.18E-02 | Yes | 3.55E+00 | 4.29E+04 | 8.28E-05 | No | 1.19E-02 |

**Table 4.14. Little Bayou Creek evaluation of dose to aquatic and terrestrial biota (continued)**

| Radionuclide | Water | | | | Sediment | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Concentration (pCi/L) | BCG (pCi/L) | Ratio | Limiting organism | Concentration (pCi/g) | BCG (pCi/g) | Ratio | Limiting organism | Ratio |
| **Riparian animal** | | | | | | | | | |
| Am-241 | NA | 1.46E+03 | 0.00E+00 | No | -9.96E-02 | 5.15E+03 | -1.93E-05 | Yes | -1.93E-05 |
| Cs-137 | NA | 4.27E+01 | 0.00E+00 | Yes | 1.14E-02 | 3.13E+03 | 3.64E-06 | Yes | 3.64E-06 |
| Np-237 | NA | 1.16E+04 | 0.00E+00 | No | 1.76E-01 | 7.63E+03 | 2.31E-05 | Yes | 2.31E-05 |
| Pu-238 | NA | 5.51E+02 | 0.00E+00 | No | -2.86E-01 | 5.73E+03 | -4.99E-05 | Yes | -4.99E-05 |
| Pu-239 | NA | 6.22E+02 | 0.00E+00 | No | 4.81E-02 | 5.87E+03 | 8.19E-06 | Yes | 8.19E-06 |
| Tc-99 | 1.29E+01 | 6.67E+05 | 1.93E-05 | Yes | 4.15E+00 | 4.14E+04 | 1.00E-04 | Yes | 1.20E-04 |
| Th-230 | 1.84E+00 | 1.39E+04 | 1.32E-04 | No | 1.07E+00 | 1.04E+04 | 1.03E-04 | Yes | 2.35E-04 |
| U-234 | 7.65E-01 | 6.84E+02 | 1.12E-03 | No | 6.64E-01 | 5.27E+03 | 1.26E-04 | Yes | 1.24E-03 |
| U-235 | 5.22E-01 | 7.37E+02 | 7.08E-04 | No | 1.41E-01 | 3.79E+03 | 3.72E-05 | Yes | 7.45E-04 |
| U-238 | 2.65E+00 | 7.57E+02 | 3.50E-03 | No | 3.55E+00 | 2.49E+03 | 1.43E-03 | Yes | 4.93E-03 |
| **Terrestrial animal** | | | | | | | | | |
| Am-241 | NA | 2.02E+05 | 0.00E+00 | No | -9.96E-02 | 3.65E+25 | -2.73E-27 | No | -2.73E-27 |
| Cs-137 | NA | 5.99E+05 | 0.00E+00 | No | 1.14E-02 | 3.65E+25 | 3.12E-28 | No | 3.12E-28 |
| Np-237 | NA | 6.49E+06 | 0.00E+00 | No | 1.76E-01 | 3.65E+25 | 4.82E-27 | No | 4.82E-27 |
| Pu-238 | NA | 1.89E+05 | 0.00E+00 | No | -2.86E-01 | 3.65E+25 | -7.84E-27 | No | -7.84E-27 |
| Pu-239 | NA | 2.01E+05 | 0.00E+00 | No | 4.81E-02 | 3.65E+25 | 1.32E-27 | No | 1.32E-27 |
| Tc-99 | 1.29E+01 | 1.54E+07 | 8.38E-07 | No | 4.15E+00 | 3.65E+25 | 1.14E-25 | No | 8.38E-07 |
| Th-230 | 1.84E+00 | 4.52E+05 | 4.07E-06 | No | 1.07E+00 | 3.65E+25 | 2.93E-26 | No | 4.07E-06 |
| U-234 | 7.65E-01 | 4.05E+05 | 1.89E-06 | No | 6.64E-01 | 3.65E+25 | 1.82E-26 | No | 1.89E-06 |
| U-235 | 5.22E-01 | 4.20E+05 | 1.24E-06 | No | 1.41E-01 | 3.65E+25 | 3.86E-27 | No | 1.24E-06 |
| U-238 | 2.65E+00 | 4.06E+05 | 6.53E-06 | No | 3.55E+00 | 3.65E+25 | 9.73E-26 | No | 6.53E-06 |
| **Terrestrial plant** | | | | | | | | | |
| Am-241 | NA | 6.80E+08 | 0.00E+00 | No | -9.96E-02 | 3.65E+26 | -2.73E-28 | No | -2.73E-28 |
| Cs-137 | NA | 4.93E+07 | 0.00E+00 | No | 1.14E-02 | 3.65E+26 | 3.12E-29 | No | 3.12E-29 |
| Np-237 | NA | 7.86E+07 | 0.00E+00 | No | 1.76E-01 | 3.65E+26 | 4.82E-28 | No | 4.82E-28 |
| Pu-238 | NA | 3.95E+09 | 0.00E+00 | No | -2.86E-01 | 3.65E+26 | -7.84E-28 | No | -7.84E-28 |
| Pu-239 | NA | 7.05E+09 | 0.00E+00 | No | 4.81E-02 | 3.65E+26 | 1.32E-28 | No | 1.32E-28 |
| Tc-99 | 1.29E+01 | 4.59E+08 | 2.81E-08 | No | 4.15E+00 | 3.65E+26 | 1.14E-26 | No | 2.81E-08 |
| Th-230 | 1.84E+00 | 2.74E+09 | 6.72E-10 | No | 1.07E+00 | 3.65E+26 | 2.93E-27 | No | 6.72E-10 |
| U-234 | 7.65E-01 | 3.03E+09 | 2.52E-10 | No | 6.64E-01 | 3.65E+26 | 1.82E-27 | No | 2.52E-10 |
| U-235 | 5.22E-01 | 1.10E+08 | 4.75E-09 | No | 1.41E-01 | 3.65E+26 | 3.86E-28 | No | 4.75E-09 |
| U-238 | 2.65E+00 | 4.29E+07 | 6.18E-08 | No | 3.55E+00 | 3.65E+26 | 9.73E-27 | No | 6.18E-08 |

Notes:
1. Shaded values are less than the laboratory detection limit.
2. NA in this table indicates that the radionuclide was not analyzed. Ratios were not included and not summed for radionuclides that were not analyzed.
3. Ratios for the limiting organism where the limiting organism is noted as "yes" that have negative values are truncated to zero before determining the sum of fractions.

Acronyms:
Am = americium
BCG = biota concentration guide
Cs = cesium
NA = not applicable
Np = neptunium
pCi/g = picocuries per gram
pCi/L = picocuries per liter
Pu = plutonium
Tc = technetium
Th = thorium
U = uranium

## 4.8 Unplanned Radiological Releases

There were no unplanned radiological releases at the Paducah Site in 2025.

## 4.9 Release of Property Containing Residual Radioactive Material

Real property is land and anything permanently attached to it, such as fences and buildings, and includes things attached to buildings such as lighting and plumbing fixtures. The Paducah Site transferred Leasing

Parcel A in August 2025, but clearance of real property has not yet taken place. As a result, this section addresses clearance of personal property (defined as any property other than real property) containing residual radioactive material, which is any radioactive material that remains in or on soil, air, water, equipment, or structures at a site after DOE activities have stopped.

DOE contractors use the processes, guidelines, and limits found in DOE Order 458.1 and associated guidance for the clearance of property with residual radioactive material. Release criteria for surface contamination limits, as specified in DOE Order 458.1, are used for the clearance of objects with the potential for surface contamination, while specific authorized limits have been derived to control whether items with potential volumetric radioactivity are released. Property that may contain residual radioactive material will not be cleared from the Paducah Site unless the property is demonstrated to be within acceptable limits. Property clearance requirements are governed by procedures established by each DOE contractor. Authorized limits for the Paducah Site are presented in Section 2.2.2.1. The type and quantity of releases for Paducah Site contractors are discussed below.

In 2025, Paducah Site contractors authorized (with concurrence from DOE) 1,741 releases of personal property that were surveyed for contamination. Several of these releases supported reuse and recycling efforts. These releases were in support of deactivation and remediation contractor, infrastructure operations, and $DUF_6$ Conversion Facility operations and included heavy equipment, vehicles, mowers, miscellaneous equipment and parts, furniture, electronics, fire extinguishers containers, tanks, activated carbon, batteries, company-issued laundry, industrial hygiene samples, boxes of records, waste items, and items classified as excess. Approximately 156,740 pounds of Freon (R-114) were shipped for treatment in 2025 under DOE-approved Authorized Limits. The measurements and historical data associated with the materials supported the unconditional radiological release of the materials and equipment and indicated that levels were below the release criteria for surface contamination limits specified in 10 *CFR* Part 835 Appendix D, DOE Order 458.1, DOE-STD-1241-2023, or other DOE-approved limits. If survey measurements exceeded 80 percent of the specified release limit, the measurements were independently verified.

The $DUF_6$ Conversion Facility converts the inventory of $DUF_6$ to uranium oxide, a more stable form of uranium, and hydrofluoric acid. The hydrofluoric acid is sold for commercial use and shipped off-site. Each shipment must meet the authorized limit of less than 3 pCi/mL of total uranium activity. During 2025, approximately 894,328 gallons of hydrofluoric acid were shipped off-site, and the total uranium activity of each shipment was below the detection limit of 0.00128 pCi/mL. The measurements and historical data associated with the materials supported the unconditional radiological release of the materials and equipment and indicated that levels were below the release criteria for surface contamination limits specified in 10 *CFR* Part 835 Appendix D, DOE Order 458.1, DOE-STD-1241-2023, or other DOE-approved limits. The $DUF_6$ Conversion Facility did not release any items above 50 percent of the release level, so no independent verifications were needed or performed.

# 5. Environmental Nonradiological Programs

The Paducah Site's environmental monitoring activities cover both radiological and nonradiological contaminants. Chapter 4 discusses radiological monitoring, and this chapter describes the results of the Paducah Site's monitoring of potential nonradiological contaminants in air, surface water, sediment, and biota.

## 5.1 Air Monitoring

No active emission points at the Paducah Site require nonradiological air monitoring.

## 5.2 Surface Water Monitoring

The Paducah Site meets the Clean Water Act regulations through its KPDES permit for effluent discharges to Bayou Creek and Little Bayou Creek. The KDOW issued KPDES Permit No. KY0004049 to DOE and FRNP for KPDES Outfalls 001, 002, 004[4], 006[5], 008, 009, 010, 011, 012, 013[6], 015, 016, 017[7], 019, and 020. Effluent from the Northwest Plume pump-and-treat operation discharges through Outfall 001 to Bayou Creek. In addition to the KPDES permit, a CERCLA outfall (C001) related to the Northeast Plume pump-and-treat operation discharges to Little Bayou Creek. Surface water from the C-613 Sedimentation Basin, a storm water control facility that collects storm water runoff from the northwestern portion of the Paducah Site, is measured for pH, turbidity, and total suspended solids (per the Northwest Storm Water Control Facility Operation and Maintenance Plan) prior to its discharge to KPDES Outfall 001 (DOE 2025i). Samples are collected quarterly to confirm the pH, turbidity, and total suspended solids measurements. In addition, KDWM specifies in landfill permit SW07300014, SW07300015, and SW07300045 that surface runoff will be analyzed to ensure landfill constituents are not discharging into nearby receiving streams. Storm water discharge from the KDWM-permitted solid waste landfill is sampled under the KPDES permit.

Surface water monitoring locations at the Paducah Site and the monitoring program under which they are sampled routinely are shown in Figure 5.1 and Table 5.1, respectively. Figure 5.1 shows trends for trichloroethene results in selected surface water monitoring locations over the last five years. Table 5.1 also shows the reporting for each of these programs. Chapter 2 describes permit exceedances for 2025. Monitoring results are available through the PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS) website, which can be accessed here, and are summarized in Table 5.2.

This report does not include surface water sampling for project-specific decommissioning and environmental remediation projects or nonroutine sampling events.

[4] Permit Number KY0004049 also includes MCSA as a permittee for KPDES Outfall 004.
[5] Permit Number KY0004049 also includes MCSA as a permittee for KPDES Outfall 006.
[6] Permit Number KY0004049 also includes MCSA as a permittee for KPDES Outfall 013.
[7] Permit Number KY0004049 also includes MCSA as a permittee for KPDES Outfall 017.

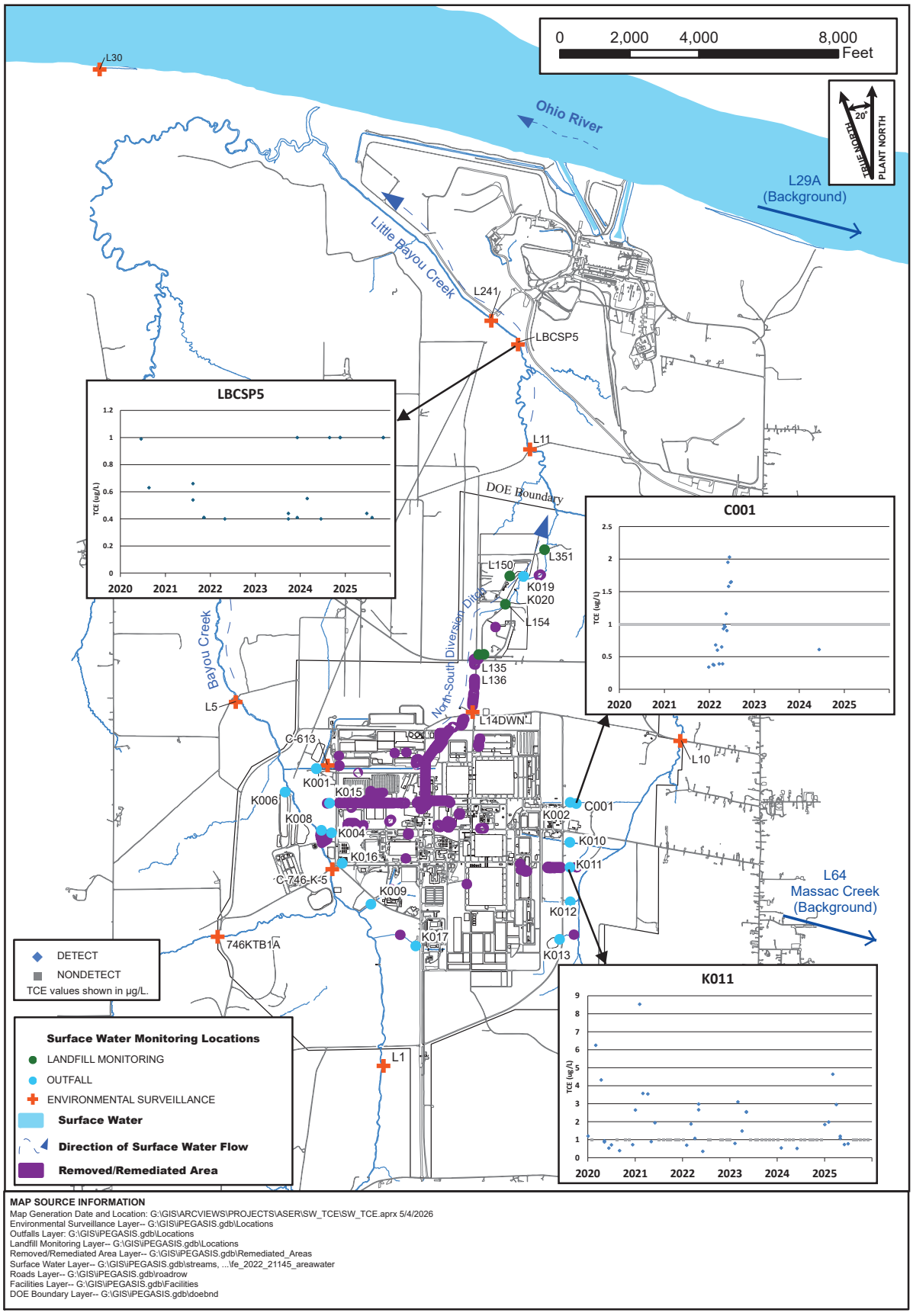



**Figure 5.1. Surface water and seep monitoring locations with trichloroethene trends**

**Table 5.1. Summary of surface water monitoring at the Paducah Site**

| Program and reporting location | Locations (see Figure 5.1) |
|---|---|
| **Effluent watershed monitoring program** | |
| C-746-S and C-746-T Landfills surface water quarterly compliance monitoring reports:<br>First Quarter 2025 (January–March)<br>Second Quarter 2025 (April–June)<br>Third Quarter 2025 (July–September)<br>Fourth Quarter 2025 (October–December) | L135, L136, L154[a] |
| C-746-U Contained Landfill surface water quarterly compliance monitoring reports:<br>First Quarter 2025 (January–March)<br>Second Quarter 2025 (April–June)<br>Third Quarter 2025 (July–September)<br>Fourth Quarter 2025 (October–December) | L150, L154[a], L351 |
| **KPDES** discharge monitoring reports | K001, K002, K004, K006, K008, K009, K010, K011, K012, K013, K015, K016, K017, K019, K020 |
| **C-613 Northwest Storm Water Control Facility** reported to KDWM via electronic mail | C-613 |
| **Environmental surveillance watershed monitoring program** | |
| Surface water | 746KTB1A, C746K-5, L1[b], L10[b], L11[b], L241[b], L29A[b], L30[b], L5[b], L14DWN[b] |
| Seep | LBCSP5 |
| **Northeast Plume Effluent** semiannual FFA progress reports:<br>Second Half of FY 2025 (Data reported January–June 2025)<br>First Half of FY 2026 (Data reported July–December 2025) | C001 |

[a] Location is listed for C-746-S, C-746-T, and C-746-U landfills.
[b] Locations are sampled to support the Environmental Radiation Protection Program.

Acronyms:
FFA = Federal Facility Agreement
FY = fiscal year
KDWM = Kentucky Division of Waste Management
KPDES = Kentucky Pollutant Discharge Elimination System

**Table 5.2. Ranges of detected analytes in 2025 surface water samples**

| Analyte | Range |
|---|---|
| **Anions** | |
| Chloride (µg/L) | 267–67,900 |
| Sulfate (µg/L) | 1,560–74,800 |
| **Wet chemistry parameters** | |
| Biochemical oxygen demand (µg/L) | 3,440–18,800 |
| Chemical oxygen demand (µg/L) | 14,100–62,600 |
| Dissolved solids (µg/L) | 55,000–377,000 |
| Hardness—Total as $CaCO_3$ (µg/L) | 14,700–261,000 |
| Nonsettleable solids (µg/L) | 12,000–17,200 |
| Settleable solids (µg/L) | 2,500–540,000 |
| Suspended solids (µg/L) | 600–540,000 |
| Total organic carbon (µg/L) | 5,680–18,600 |
| Total solids (µg/L) | 10,800–451,000 |
| **Volatile organic compounds** | |
| Trichloroethene (µg/L) | 0.41–4.64 |
| **Polychlorinated biphenyls** | |
| PCB-1248 (µg/L) | 0.0503–0.062 |
| PCB-1254 (µg/L) | 0.0346–0.0496 |
| Total polychlorinated biphenyls (µg/L) | 0.0503–0.0967 |

**Table 5.2. Ranges of detected analytes in 2025 surface water samples (continued)**

| Analyte | Range |
|---|---|
| **Other organics** | |
| Oil and grease (µg/L) | 1,350–5,100 |
| **Metals** | |
| Aluminum (µg/L) | 22–183 |
| Barium (µg/L) | 41.8–61.9 |
| Calcium (µg/L) | 11,000–30,600 |
| Copper (µg/L) | 1.18–2.79 |
| Iron (µg/L) | 49.8–2,470 |
| Magnesium (µg/L) | 2,640–5,290 |
| Manganese (µg/L) | 39.7–131 |
| Mercury (µg/L) | 0.00559–0.0237 |
| Nickel (µg/L) | 0.601–1.04 |
| Phosphorous (µg/L) | 20–1,400 |
| Potassium (µg/L) | 2,400–6,240 |
| Sodium (µg/L) | 1,430–58,000 |
| Uranium (µg/L) | 0.25–328 |
| Zinc (µg/L) | 15.4–133 |

Acronyms:
PCB = polychlorinated biphenyl

## 5.3 Sediment Monitoring

Sediment monitoring locations are shown in Figure 4.3. Additional monitoring results are available through the PEGASIS website, which can be accessed here. Sediment sampling is only conducted for radionuclides and polychlorinated biphenyls. Total polychlorinated biphenyls were detected in sediment during 2025 at levels from 5.67 µg/kg to 81.7 µg/kg. The potential risks and hazards from exposure to polychlorinated biphenyls at these concentrations are within CERCLA's acceptable risk range. US EPA's generally acceptable risk range is $10^{-4}$ to $10^{-6}$ for carcinogenic risk and below the hazard index of 1 for noncarcinogens (US EPA 1999). According to the Risk Methods Document, the no action level[8] for total polychlorinated biphenyls is 179 µg/kg, and the action level[9] is 17,900 µg/kg for the recreational user (DOE 2024a). The recreational user is used for comparison because it is the most reasonably anticipated scenario.

## 5.4 Biological Monitoring

Biological monitoring, which involves fish or benthic macroinvertebrate sampling, was not required in 2025 under the specifications listed in the KPDES permit. Aquatic or biological monitoring of Bayou Creek and Little Bayou Creek began in 1987. The permit initially required sampling of fish and benthic macroinvertebrates in the receiving creeks, as well as chronic and acute toxicity sampling at the KPDES outfalls. After years of collecting fish and benthic macroinvertebrate samples, a permit renewal issued by KDOW in 2009 eliminated the requirements for fish and benthic macroinvertebrate sampling because continued sampling may have a detrimental effect on the stream's ecology. The chronic and acute toxicity sampling remained a KPDES permit condition. DOE continued the benthic macroinvertebrate sampling efforts through 2010 to provide data for future ecological assessments but eliminated the sampling in 2011. Chronic and acute toxicity sampling, which are still required by the KPDES permit, are the two basic types of whole effluent toxicity testing. They describe the aggregate toxic effects of the

[8] The no action level is the concentration that represents the lesser of an excess lifetime cancer risk of $10^{-6}$ and a hazard index of 0.1.
[9] The action level is the concentration that represents the lesser of an excess lifetime cancer risk of $10^{-4}$ and a hazard index of 3.

whole effluent wastewater discharge as measured by an organism's response upon exposure to the sample. These tests replicate the total effect of environmental exposure of aquatic life to toxic pollutants in an effluent without requiring the identification of the specific pollutants.

Signs are posted along Bayou and Little Bayou Creeks to warn members of the public about the possible risks posed by recreational contact with these waters, stream sediments, and fish caught in the creeks.

## 5.5 Fire Protection Management and Planning

Fire protection management and planning at the Paducah Site follows the *Paducah Site Wildland Fire Management Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky* (FRNP 2023). The program includes fire prevention and hazard mitigation efforts including training, work restrictions, mowing of combustible vegetation, safe facility location, and fire protection design considerations. If a wildland fire was to occur, a multiagency response would be activated to bring all available firefighting and related emergency response functions to bear and combat the fire promptly, minimizing the risk of fire exposure to the public, Paducah Site personnel, and critical facilities and programs.

MCSA is responsible for wildland fire management of all DOE owned property, except for 521 acres licensed to WKWMA as of October 2025. West McCracken Fire Department is responsible for the area licensed to WKWMA.

## 5.6 Recreational Hunting and Fishing

Permitted recreational activities in WKWMA include turkey hunting, horseback riding, hiking, dog training and trials, hunting with a gun for small game, bow hunting for deer, mountain biking, and nature hiking. Additional information regarding hunting seasons and hunting and fishing limits is available from the Kentucky Department of Fish and Wildlife Resources website, which can be accessed here.

# 6. Groundwater Protection Programs

Groundwater monitoring at the Paducah Site is required by a combination of state and federal regulations, legal agreements with KDEP, and DOE orders. More than 300 monitoring wells and residential wells are used to track the flow of groundwater and to identify and measure groundwater contaminants.

The results of the Paducah Site Investigation (Phase 1) in 1991 determined the primary off-site contaminants in the Regional Gravel Aquifer, which is the primary aquifer for local groundwater users, were trichloroethene and technetium-99 (CH2M HILL 1991). Trichloroethene was used until 1993 as an industrial degreasing solvent, and technetium-99 is a fission by-product contained in nuclear power reactor returns that were brought on-site through 1976 for the re-enrichment of uranium-235 (DOE 2001). Known or potential sources of trichloroethene and technetium-99 include former test areas, spills, leaks, buried waste, and leachate from contaminated scrap metal previously stored on-site.

Investigations of the on-site source areas of trichloroethene at the Paducah Site are ongoing. The main source and highest concentration of trichloroethene contamination in the groundwater is near the C-400 Cleaning Building. Trichloroethene has a low solubility and a higher density than water and is a dense nonaqueous-phase liquid. Because of these characteristics, trichloroethene typically sinks through the subsurface and may form pools in the aquifer. The pools make treatment difficult because they are not accessible and slowly release contaminants into the groundwater over time.

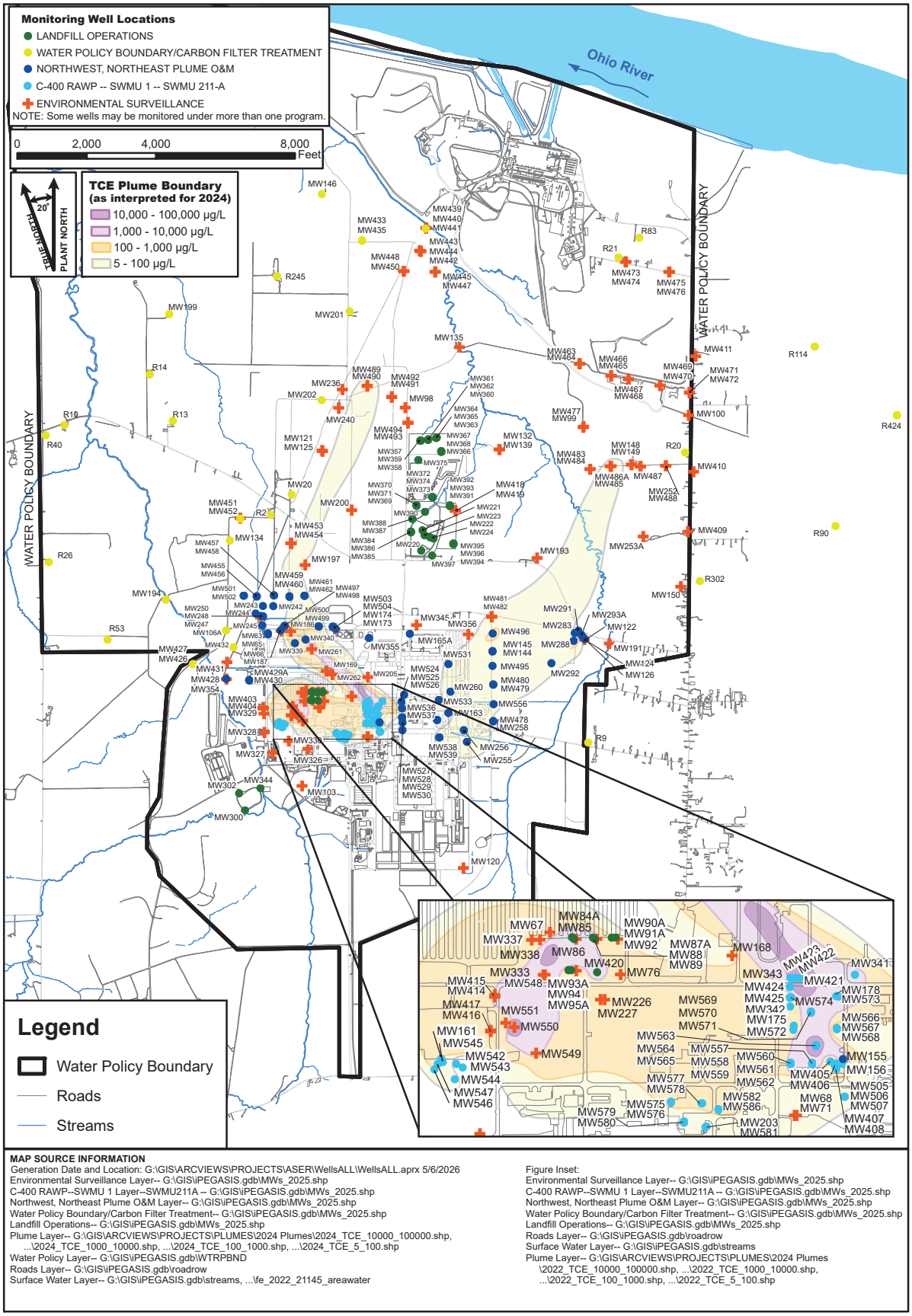
Groundwater monitoring detects the presence of contaminants at the Paducah Site, including the types and concentrations of contaminants. Analysis of the sampling data determines the nature and extent of the contamination. Data obtained from groundwater monitoring and knowledge of the groundwater movement at the plant, support the decision-making process for the ultimate disposition of the contaminants. Figure 6.1 shows monitoring wells sampled in 2025 and the trichloroethene plume associated with the Paducah Site (FRNP 2025b). See Section 6.3 for additional information on plumes associated with the Paducah Site. Visit the PEGASIS website, which can be accessed here, to view historical data for monitoring wells and groundwater locations at the Paducah Site.

## 6.1 Geology and Uses of Groundwater

The local groundwater flow systems at the Paducah Site (from shallowest to deepest) are the Terrace Gravel flow system, the Upper Continental Recharge System, the Regional Gravel Aquifer, and the McNairy Formation flow system. Additional water-bearing zones monitored at the Paducah Site are the Eocene Sands and the Rubble Zone, which is the weathered upper portion of the Mississippian bedrock. Figure 6.2 illustrates these components.

Groundwater flow originates south of the Paducah Site within the Eocene Sands and the Terrace Gravel. Groundwater within the Terrace Gravel discharges to local streams and recharges the Regional Gravel Aquifer. The predominant groundwater flow through the Upper Continental Recharge System is downward, also recharging the Regional Gravel Aquifer. From the site, groundwater generally flows northward in the Regional Gravel Aquifer toward the Ohio River, which is the local base level for the system. Groundwater in the McNairy Formation system beneath the Paducah Site also flows northward to discharge into the Ohio River.

Additional information on the geology and hydrogeology of the Paducah Site can be found in the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (MMES 1992). A revision of the sitewide groundwater flow model was completed in 2016 (DOE 2017).




**MAP SOURCE INFORMATION**

Generation Date and Location: G:\GIS\ARCVIEWS\PROJECTS\ASER\WellsALL\WellsALL.aprx 5/6/2026
Environmental Surveillance Layer-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
C-400 RAWP--SWMU 1 Layer--SWMU211A -- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Northwest, Northeast Plume O&M Layer-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Water Policy Boundary/Carbon Filter Treatment-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Landfill Operations-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Plume Layer-- G:\GIS\ARCVIEWS\PROJECTS\PLUMES\2024 Plumes\2024_TCE_10000_100000.shp, ...\2024_TCE_1000_10000.shp, ...\2024_TCE_100_1000.shp, ...\2024_TCE_5_100.shp
Water Policy Layer-- G:\GIS\iPEGASIS.gdb\WTRPBND
Roads Layer-- G:\GIS\iPEGASIS.gdb\roadrow
Surface Water Layer-- G:\GIS\iPEGASIS.gdb\streams, ...\fe_2022_21145_areawater

Figure Inset:
Environmental Surveillance Layer-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
C-400 RAWP--SWMU 1 Layer--SWMU211A -- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Northwest, Northeast Plume O&M Layer-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Water Policy Boundary/Carbon Filter Treatment-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Landfill Operations-- G:\GIS\iPEGASIS.gdb\MWs_2025.shp
Roads Layer-- G:\GIS\iPEGASIS.gdb\roadrow
Surface Water Layer-- G:\GIS\iPEGASIS.gdb\streams
Plume Layer-- G:\GIS\ARCVIEWS\PROJECTS\PLUMES\2024 Plumes\2022_TCE_10000_100000.shp, ...\2022_TCE_1000_10000.shp, ...\2022_TCE_100_1000.shp, ...\2022_TCE_5_100.shp

**Figure 6.1. Monitoring wells sampled in 2025**

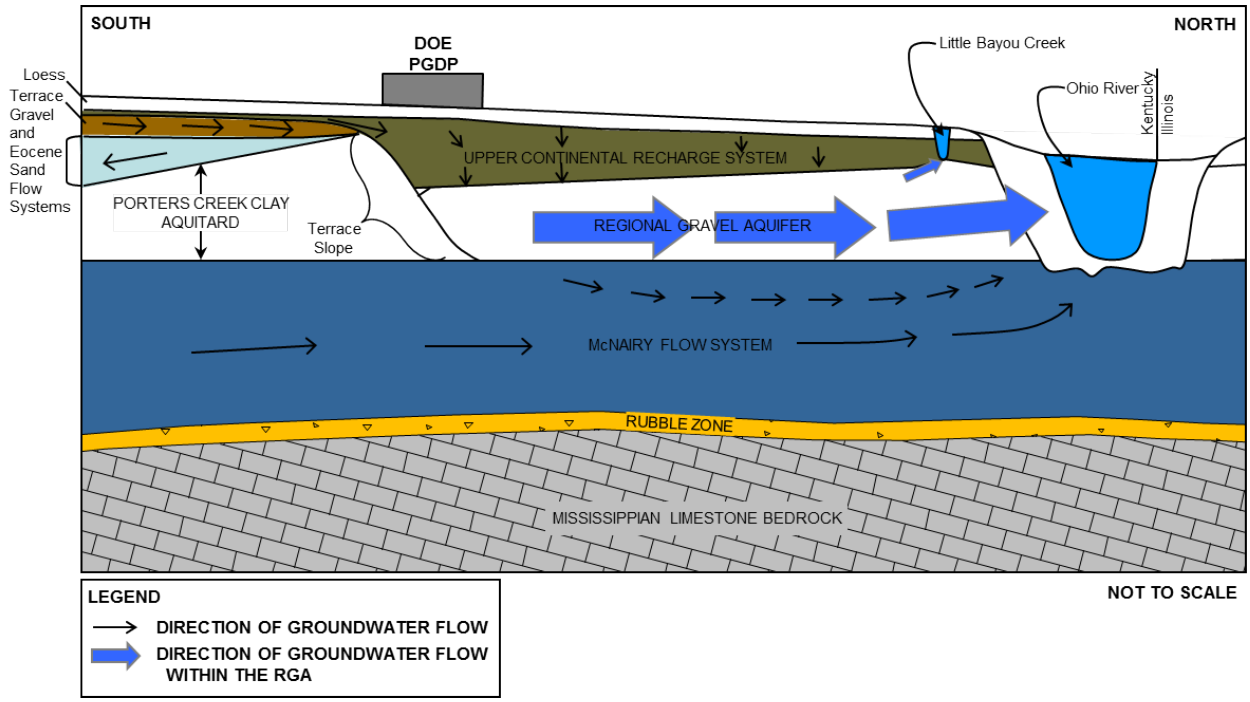



**Figure 6.2. Paducah Site groundwater flow system and water-bearing zones**

The WKWMA and some lightly populated farmlands are in the immediate vicinity of the Paducah Site. Homes near the Paducah Site are sparsely located along rural roads. Two communities, Grahamville and Heath, lie within 2 miles east of the plant.

Historically, groundwater was the primary source of drinking water for residents and businesses near the plant area. In areas where the groundwater either is known to be contaminated or has the potential to become contaminated, DOE has provided water hookups to public water since 1994 and pays water bills for affected residences and businesses. An educational mailer was developed in 2016 and has been updated, as necessary, and mailed to residents and businesses annually in an effort to ensure that the public is aware of the groundwater contamination.

## 6.2 Groundwater Monitoring Programs

Monitoring wells are used extensively at the Paducah Site to assess groundwater quality. The primary objectives of the site's groundwater monitoring program are obtaining data to determine baseline and current conditions of groundwater quality and quantity; demonstrating compliance with and implementation of all applicable regulations and DOE orders; providing data to allow early detection of groundwater pollution or contamination; identifying existing and potential groundwater contamination sources and maintaining surveillance of these sources; and providing data for making decisions about waste disposal on land-based units and the management and protections of groundwater resources. The groundwater monitoring program consists of routine compliance and facility monitoring designed to ensure protection of public health and the environment.

Two documents outline the sitewide approach to groundwater monitoring: the Groundwater Protection Plan (FRNP 2024) and the Paducah Site environmental monitoring plan (FRNP 2025a). A total of 310 monitoring wells and residential wells were sampled in accordance with DOE orders and federal, state, and local requirements during 2025. Table 6.1 lists the monitoring programs that include well sampling. This table also shows the number of wells sampled in each flow system, each program (note

that some wells are sampled under more than one program), and the reporting location for each program. Monitoring results are available through the PEGASIS website, which can be accessed here.

**Table 6.1. Summary of groundwater monitoring at the Paducah Site for 2025**

| Program and reporting location | Number of wells[a] | | | | | |
|---|---|---|---|---|---|---|
| | Terrace Gravel/ Eocene Sands | Upper Continental Recharge System | Regional Gravel Aquifer | McNairy Formation flow system | Rubble Zone | Total |
| **Groundwater monitoring program for landfill operations** | | | | | | |
| C-746-S and C-746-T Landfills wells quarterly compliance monitoring reports: First quarter 2025 (January–March) Second quarter 2025 (April–June) Third quarter 2025 (July–September) Fourth quarter 2025 (October–December) | 0 | 5 | 14 | 0 | 0 | 19[b] |
| C-746-U Landfill wells quarterly compliance monitoring reports: First quarter 2025 (January–March) Second quarter 2025 (April–June) Third quarter 2025 (July–September) Fourth quarter 2025 (October–December) | 0 | 9 | 12 | 0 | 0 | 21 |
| C-404 Landfill wells (required by permit) semiannual C-404 groundwater monitoring reports: C-404 Hazardous Waste Landfill May 2025 Semiannual Groundwater Report (October 2024–March 2025) C-404 Hazardous Waste Landfill November 2025 Semiannual Groundwater Report (April 2025–September 2025) | 0 | 4 | 5 | 0 | 0 | 9 |
| C-404 Landfill wells (not committed) | 0 | 0 | 17 | 0 | 0 | 17 |
| C-746-K Landfill wells FFA semiannual progress reports: Second half of FY 2025 (data reported January–June 2025) First half of FY 2026 (data reported July–December 2025) | 2 | 0 | 1 | 0 | 0 | 3 |
| **Northeast Plume operations and maintenance program** FFA semiannual progress reports: (see links above) | | | | | | |
| Quarterly optimization wells | 0 | 0 | 34 | 0 | 0 | 34 |
| Semiannual optimization wells | 0 | 0 | 2 | 0 | 0 | 2 |
| **Northwest Plume operations and maintenance program** FFA semiannual progress reports: (see links above) | | | | | | |
| Semiannual wells | 0 | 0 | 28 | 0 | 0 | 28 |
| Quarterly wells | 0 | 0 | 5 | 0 | 0 | 5 |
| **C-400 Cleaning Building interim remedial action monitoring wells** FFA semiannual progress reports: (see links above) | | | | | | |
| Semiannual wells | 0 | 0 | 14 | 0 | 0 | 14 |
| Annual wells | 0 | 0 | 20 | 0 | 0 | 20 |

**Table 6.1. Summary of groundwater monitoring at the Paducah Site for 2025 (continued)**

| Program and reporting location | Number of Wells[a] | | | | | |
|---|---|---|---|---|---|---|
| | Terrace Gravel/ Eocene Sands | Upper Continental Recharge System | Regional Gravel Aquifer | McNairy Formation flow system | Rubble Zone | Total |
| **Former Oil Landfarm SWMU 1 monitoring wells** CERCLA Five-Year Review | | | | | | |
| Semiannual wells | 0 | 0 | 7 | 0 | 0 | 7 |
| **SWMU 211-A Remedial Action monitoring wells** CERCLA Five-Year Review | | | | | | |
| Semiannual wells | 0 | 12 | 16 | 0 | 0 | 28 |
| **Water Policy Boundary monitoring program** ASER | | | | | | |
| Northwestern wells (quarterly) | 0 | 0 | 23 | 0 | 0 | 23 |
| Northeastern wells (annual) | 0 | 0 | 7 | 0 | 0 | 7 |
| **Environmental surveillance groundwater monitoring program** ASER | | | | | | |
| Annual wells | 0 | 3 | 26 | 0 | 0 | 29 |
| Biennial wells | 0 | 2 | 56 | 3 | 3 | 64 |
| Semiannual wells | 0 | 0 | 7 | 5 | 0 | 12 |
| Quarterly wells | 0 | 0 | 0 | 0 | 0 | 0 |
| Geochemical wells | 0 | 0 | 35 | 0 | 0 | 35 |

[a] Some wells are sampled under more than one program. Inclusion in this table does not mean a particular well(s) will be sampled during the period of the ASER report.
[b] Regional Gravel Aquifer wells MW369, MW370, MW372, and MW373 are sampled with the C-746-U Contained Landfill sampling events; these four wells are not counted in the sampling event for the C-746-S&T Landfills but are reported in the Compliance Monitoring Reports for the C-746-U and C-746-S&T Landfills.

Acronyms:
ASER = annual site environmental report MW = monitoring well
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
FFA = Federal Facility Agreement SWMU = solid waste management unit
FY = fiscal year

## 6.3 Groundwater Monitoring Results

Groundwater monitoring at the Paducah Site supports programs for general environmental surveillance, current and inactive landfills, groundwater plume pump-and-treat operations, the C-400 Cleaning Building Interim Remedial Action monitoring, and area residential wells. The Environmental Surveillance Groundwater Monitoring Program is reviewed each year and modified, as appropriate, to continue to delineate the boundaries of the contaminant plumes over time. Groundwater monitoring results from all sampling efforts conducted by the Paducah Site are compiled in the Paducah Oak Ridge Environmental Information System (OREIS) database. Analytical results of interest may be requested by emailing PegasisAdmins@pad.pppo.gov and data can be viewed on the PEGASIS website, which can be accessed here. Table 6.2 summarizes detected analytes from monitoring well groundwater samples (typically station names that begin with MW or R) in 2025.

**Table 6.2. Ranges of detected analytes in 2025 monitoring well groundwater samples**

| Analyte | Range |
|---|---|
| **Volatile organics (µg/L)** | |
| 1,1,2-Trichloroethane | 0.42–4.05 |
| 1,1-Dichloroethane | 0.41–20.7 |
| 1,1-Dichloroethene | 0.34–600 |
| 1,2-Dichloroethane | 0.58–1.62 |
| 2-Butanone | 6–6 |
| 2-Hexanone | 1.7–1.7 |
| Acetone | 2.41–19.5 |
| Benzene | 1.28–1.38 |
| Carbon tetrachloride | 0.35–132 |
| Chloroform | 0.35–816 |
| *cis*-1,2-Dichloroethene | 0.34–1,990 |
| Methane | 18.8–18.8 |
| Methylene chloride | 0.58–6.19 |
| Tetrachloroethene | 0.35–3.9 |
| Toluene | 0.45–0.45 |
| *trans*-1,2-Dichloroethene | 0.34–6.85 |
| Trichloroethene | 0.34–19,900 |
| Vinyl chloride | 0.85–96.9 |
| **Polychlorinated biphenyls (µg/L)** | |
| PCB-1242 | 0.0422–0.0508 |
| PCB-1254 | 0.0411–0.0411 |
| Polychlorinated biphenyls | 0.0411–0.0508 |
| **Radionuclides** | |
| Alpha activity (pCi/L) | 5.5–5.5 |
| Beta activity (pCi/L) | 4.7–1,140 |
| Radium-226 (pCi/L) | 0.488–0.878 |
| Radium-228 (pCi/L) | 4.73–12.6 |
| Technetium-99 (pCi/L) | 7.23–42,000 |
| Thorium-230 (pCi/L) | 2.96–2.96 |
| Tritium (pCi/L) | 266–266 |
| Uranium-234 (pCi/L) | 0.745–0.745 |
| Uranium-235 (µg/L) | 0.0024–0.0151 |
| Uranium-238 (pCi/L) | 0.426–0.716 |
| Uranium-238 (µg/L) | 0.495–2.09 |
| **Wet chemistry (µg/L)** | |
| Alkalinity—Total as $CaCO_3$ | 48,700–199,000 |
| Chemical oxygen demand (COD) | 9,280–34,500 |
| Cyanide | 1.93–55.9 |
| Dissolved solids | 119,000–666,000 |
| Total organic carbon (TOC) | 346–6,540 |
| Total organic halides (TOX) | 3.38–135 |

| Analyte | Range |
|---|---|
| **Anions (µg/L)** | |
| Bromide | 123–882 |
| Chloride | 623–145,000 |
| Fluoride | 62.3–947 |
| Iodide | 465–483 |
| Nitrate as Nitrogen | 88.4–4,480 |
| o–Phosphate as Phosphorous | 92.2–261 |
| Sulfate | 634–849,000 |
| **Metals (µg/L)** | |
| Aluminum | 19.7–4,250 |
| Arsenic | 2.01–45.2 |
| Barium | 21–505 |
| Beryllium | 0.202–0.202 |
| Boron | 6.26–2,760 |
| Cadmium | 0.301–0.805 |
| Calcium | 4,880–218,000 |
| Chromium | 3.11–4,340 |
| Cobalt | 0.305–9.95 |
| Copper | 0.348–15 |
| Iron | 33–91,400 |
| Lead | 0.513–35.2 |
| Magnesium | 2,790–48,600 |
| Manganese | 1.02–15,700 |
| Mercury | 0.085–1.87 |
| Molybdenum | 0.212–7.39 |
| Nickel | 0.616–683 |
| Potassium | 105–21,100 |
| Selenium | 1.59–15 |
| Silica | 18,400–24,600 |
| Silver | 0.549–0.549 |
| Sodium | 11,800–129,000 |
| Uranium | 0.068–3.2 |
| Vanadium | 3.31–10.7 |
| Zinc | 3.32–22.9 |
| Arsenic, Dissolved | 2.04–37 |
| Barium, Dissolved | 20.5–525 |
| Chromium, Dissolved | 3.16–663 |
| Lead, Dissolved | 0.698–1.81 |
| Mercury, Dissolved | 0.584–0.584 |
| Selenium, Dissolved | 1.51–2.69 |
| Uranium, Dissolved | 0.07–2.91 |

The Paducah Site groundwater plume maps are used in planning to optimize the site groundwater cleanup. These maps depict the general footprint of the trichloroethene and technetium-99 contamination in the Regional Gravel Aquifer and also convey the general magnitude and distribution of contamination within the plumes above the maximum contaminant level. For additional descriptions of the Paducah Site plumes, please see *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional*

*Gravel Aquifer for Calendar Year 2024 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FRNP 2025b). Records of decision are in place under the Groundwater Operable Unit for the following projects:

- SWMU 91 (DOE 1998)
- Northwest Plume (DOE 1993 and DOE 2010)
- Northeast Plume (DOE 1995b and DOE 2015)
- C-400 Cleaning Building source area (DOE 2005)
- Southwest Plume (DOE 2012)

The documents can be found here in the Paducah Environmental Information Center.

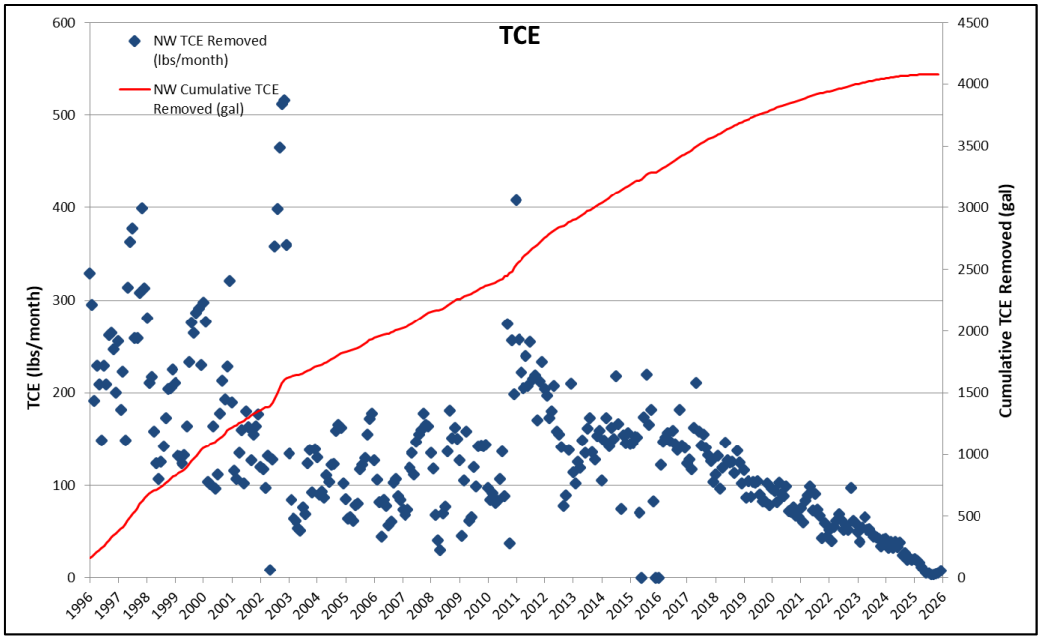
Table 6.3 lists the cumulative trichloroethene removed from environmental media, such as groundwater and soils, through 2025. The graphs shown in Figures 6.3 and 6.4 illustrate the cumulative trichloroethene removed from liquid by the Northwest Plume Groundwater Treatment System and the Northeast Plume Containment System, respectively, through 2025. Figure 6.5 shows the locations of groundwater contamination sources and treatment systems.

**Table 6.3. Cumulative trichloroethene removed at Paducah**

| Source area | Cumulative trichloroethene removed (gallons)[a] | Cumulative trichloroethene removed (pounds)[a] |
|---|---|---|
| Northwest Plume Pump-and-Treat | 4,079[b] | 49,401[b] |
| Northeast Plume Pump-and-Treat | 382[b] | 4,626[b] |
| C-400 Six-Phase Treatability Study | 1,900 | 23,009 |
| C-400 Phase I | 535 | 6,479 |
| C-400 Phase IIa | 1,137 | 13,769 |
| Southwest Plume (SWMU 1) | 24[c] | 291[c] |
| Other sources (SWMU 91, LASAGNA) | 246 | 2,979 |
| Total | 8,303 | 100,558 |

[a] Trichloroethene values may contain other volatile organic compounds.
[b] Cumulative through December 31, 2025.
[c] Removed during deep soil mixing operations.

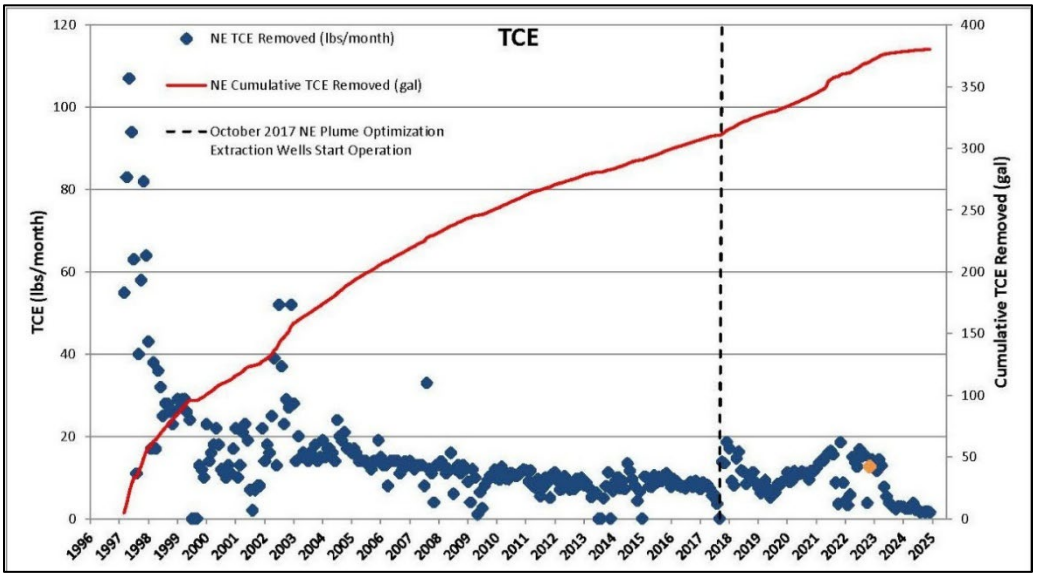
Acronyms:
LASAGNA = Lasagna *in situ* Remediation Technology
SWMU = solid waste management unit




Source: DOE 2025j

Acronyms
NW = northwest TCE = trichloroethene

**Figure 6.3. Northwest Plume groundwater treatment system trichloroethene removed**




Source: DOE 2025j

Note:
- Trichloroethene influent data was not collected from EW234 and EW235 for November 2022. The average useable data for the rest of the reporting period [July 2022—December 2022 (282 µg/L)] was used to calculate pounds of trichloroethene removed.

Acronyms
NE = northeast TCE = trichloroethene

**Figure 6.4. Northeast Plume containment system trichloroethene removed**

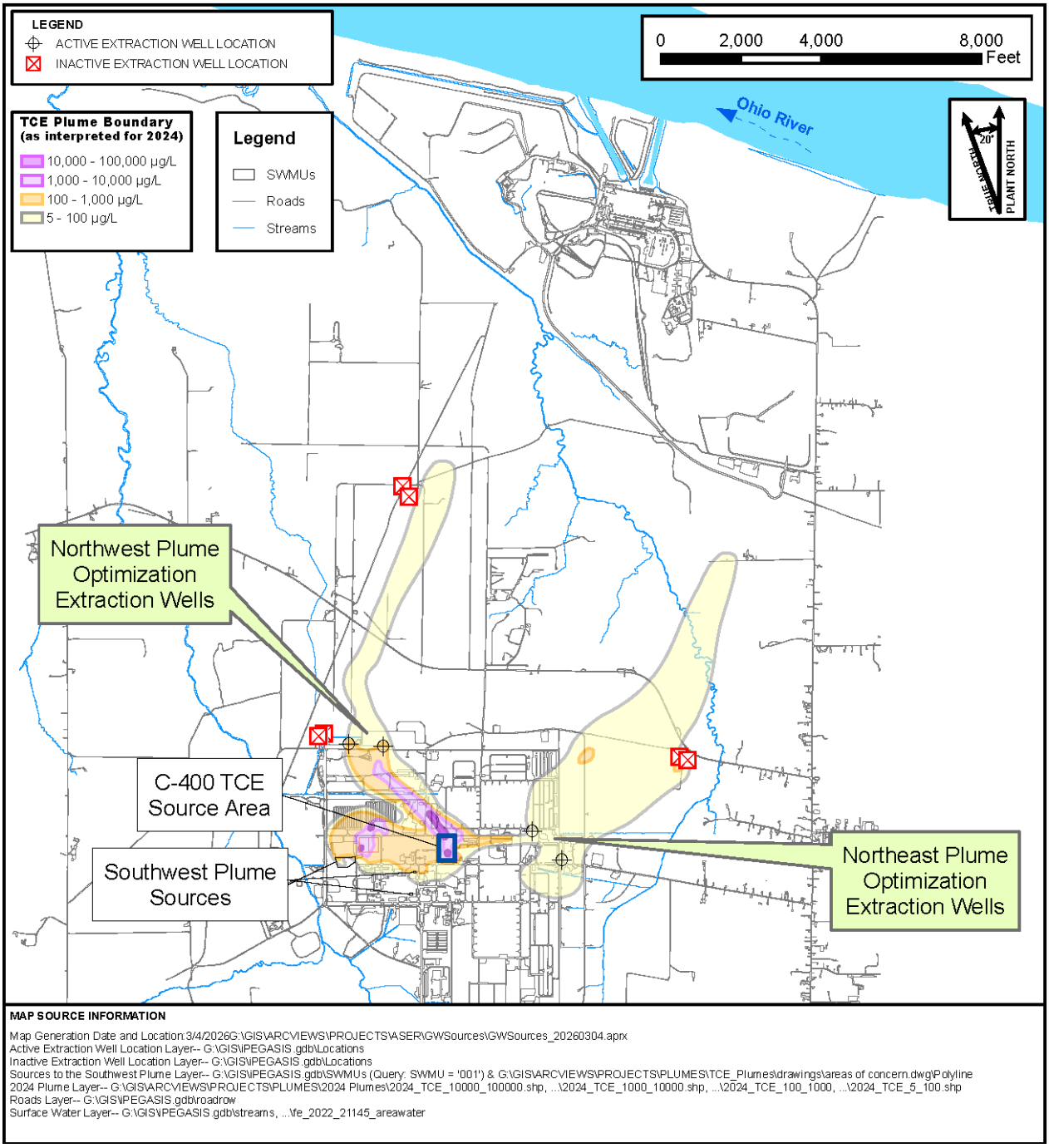



**Figure 6.5. Locations of groundwater contamination sources and treatment systems**

The C-404 Hazardous Waste Landfill is subject to semiannual groundwater monitoring and statistical analyses of the data, in accordance with the Hazardous Waste Management Facility Permit.

The Kentucky Solid Waste Facility (401 *KAR* 47:030 § 6) maximum contaminant level exceedances for the C-746-S&T and C-746-U landfills for 2025 are listed in Table 6.4. Groundwater monitoring is required on a quarterly basis.

**Table 6.4. Summary of maximum contaminant level exceedances for C-746-S&T and C-746-U Landfills in 2025**

| Upper Continental Recharge System | Upper Regional Gravel Aquifer | Lower Regional Gravel Aquifer |
|---|---|---|
| | **C-746-S&T Landfills** | |
| none | MW387: beta activity | none |
| | **C-746-U Landfill** | |
| none | none | none |

Acronym:
MW = monitoring well

To support the evaluation of whether there is evidence that the C-746-U Contained Landfill was contributing to groundwater contamination in the area of the landfill, the concentrations from monitoring well samples in the vicinity of the C-746-U Contained Landfill of a broad range of parameters were screened against benchmarks, such as background concentrations and maximum contaminant levels. A Groundwater Assessment Report documented that there was no evidence indicating a release from the C-746-U Contained Landfill (LATA Kentucky 2013). The data used to support this assessment were groundwater analyses of quarterly and semiannual monitoring for the period of 2002 through 2012 and the focused sampling of October 2006. The report found that the beta activity (associated with technetium-99) and trichloroethene in the wells are not landfill-related but originate upgradient of the C-746-S&T and C-746-U landfills.

Statistical analyses also are used to evaluate compliance monitoring wells at the C-746-S and C-746-T landfill, the C-746-U landfill, and the C-404 Hazardous Waste Landfill. Each report lists any statistical exceedance that is found. Reports for each landfill are listed in Table 6.1.

## 6.4 Emerging Contaminants

Federal and state regulatory agencies continue to develop regulatory approaches for PFAS and emerging contaminants, such as perfluorooctane sulfonate, perfluorooctanoic acid, perchlorates, 1,4-dioxane, and other persistent contaminants that may be present at DOE sites.

### 6.4.1 Per- and polyfluoroalkyl substances

The release of PFAS into the environment is a topic of growing public health and environmental concern. PFAS are a class of man-made chemicals that have been manufactured and used in a variety of industries since the 1940s. These chemicals are very persistent in the environment and tend to bioaccumulate in food chains. Because of their breadth of use and environmental longevity, PFAS can be found in surface water, groundwater, soil, and air—from remote rural areas to densely-populated urban centers.

DOE initially used PFAS when they were first produced on an industrial scale for use in uranium separation activities during the Manhattan Project. PFAS are found in commercial products (notably in firefighting foams) that have been used at DOE sites. DOE is actively researching historical and current uses in its production, research, and fire safety activities to identify applications that may have involved environmental release of PFAS.

As emerging contaminants, federal and state agencies are developing reliable and consistent methods to characterize PFAS in the environment and guidance to facilitate cleanup of contaminated groundwater; researching methods for treatment and disposal of PFAS-containing materials and developing new tools and materials to communicate information about PFAS. US EPA maintains a website, which can be accessed here.

In recognition of the need for a comprehensive departmental approach to PFAS, DOE issued the *PFAS Strategic Roadmap: DOE Commitments to Action 2022–2025* (DOE 2022a) (PFAS Roadmap). In October 2022, DOE also released its *Initial Assessment of Per- and Polyfluoroalkyl Substances at the Department of Energy Sites* (DOE 2022b). This report summarizes DOE's current knowledge about PFAS uses and releases based on surveys performed at DOE sites across the country. All of DOE's publicly available resources on the topic of PFAS can be accessed here.

The Paducah Site began investigating the history and on-site use of PFAS compounds in 2017. Interviews with Paducah Site staff, including the fire chief, indicated that aqueous film-forming foams had not been used to fight a fire at the Paducah Site in the last 30 years approximately, but it had been used in fire training exercises at the C-207 Fire Training Area.

In 2018, PFAS sampling at the fire training area was added to the Paducah Site environmental monitoring plan for sampling and analysis in 2019. Analytical results indicate detectable levels of PFAS contamination in groundwater for 12 of the 18 PFAS compounds analyzed in the vicinity of the fire training area. Results ranged from 1 nanogram/liter (ng/L), also commonly referred to as parts per trillion, to 128,000 ng/L. These analytical results were added to the publicly available data repository (i.e., PEGASIS).

On March 22, 2019, the Kentucky governor signed Kentucky General Assembly Senate Bill 104, which banned the use of firefighting foam that contained PFAS for training and testing purposes. This law went into effect on July 15, 2020. In August 2021, the Paducah Site fire department replaced all aqueous film-forming foam containing PFAS with a new biodegradable nonhazardous foam. The former supply of aqueous film-forming foam (625 gallons), comprised of containers of unused product and fire extinguishers, was declared waste and was properly stored until suitable treatment and disposal methods were identified. This volume of aqueous film-forming foam was shipped off-site for treatment and disposal in April 2025.

In addition to the aqueous film-forming foam previously used by firefighters, other sources of potential aqueous film-forming foams at the Paducah Site include material in tanks and piping at the C-600 Utility Plant. These components were part of two fire suppression systems that formerly were connected to two fuel oil-storage tanks. The two fire suppression systems were taken out of service in May 2015 and December 2017, respectively. The volume of residual material and the C-600 Utility Plant tanks were removed in 2025.

In 2022, the Paducah Site began a project to evaluate for the presence of PFAS in environmental media, which included potable water, at the site. The first samples were collected in November 2022 (round 1) and a second sampling activity was conducted in January 2023 (round 2). These analytical results were added to the publicly available data repository (i.e., PEGASIS).

Multiple PFAS compounds were detected in Paducah Site potable water. Detected results ranged from 3.85 ng/L to 7.53 ng/L. All results for perfluorooctanoic acid and perfluorooctanesulfonate exceeded the US EPA maximum contaminant level goals (i.e., 0 ng/L for both). Some results for perfluorooctanoic acid and perfluorooctanesulfonate exceeded the US EPA maximum contaminant levels (i.e., 4 ng/L for both). On April 10, 2024, US EPA released final enforceable standards for select PFAS compounds in potable water. The compliance schedule is discussed in Section 2.4.4. The Paducah Site has until April 2029 to comply with the maximum contaminant levels. Currently, the site is conducting quarterly sampling as required by the new regulations.

The Paducah Site permitted water treatment plant treats water sourced from the Ohio River for potable use across the site. The Paducah Site potable water results are consistent with 2021 ambient

concentrations reported by the Ohio River Valley Water Sanitation Commission for the Ohio River and also as reported by a nearby municipal water supplier, Paducah Water, which sources its water from the Ohio River at a location upstream of the Paducah Site intake. These results (which are similar to the PFAS concentrations in Ohio River water and the Paducah Water results) indicate that the PFAS detections in Paducah Site potable water originate from the Ohio River.

Additional PFAS sampling was conducted in 2023, 2024, and 2025. The goal of the sampling was to assess potential PFAS concentrations in Paducah Site groundwater, groundwater treatment systems influents and effluents, treated water from the C-611 Water Treatment Plant (potable water), effluent from the wastewater treatment plant, surface water, and landfill leachate. The results will be available to the public at a future date.

### 6.4.2 1,4-Dioxane

The synthetic industrial chemical 1,4-dioxane may be found in groundwater at sites contaminated with certain chlorinated solvents because of its persistence and widespread use as a stabilizer for chlorinated solvents. 1,4-Dioxane is also a byproduct present in many consumer goods including paint strippers, dyes, greases, antifreeze, deodorant, shampoos, and cosmetics; and it is also present in some food supplements, food containing residues from packaging adhesives; or on food crops treated with pesticides that contain 1,4-dioxane. Synonyms for 1,4-dioxane include dioxane, dioxan, p-dioxane, diethylene dioxide, diethylene oxide, diethylene ether, and glycol ethylene ether (US EPA 2017b).

Sampling and analysis for 1,4-dioxane has been conducted at the Paducah Site on a project-specific basis. The most recent 1,4-dioxane data were collected as part of the C-400 Cleaning Building remedial investigation. There were low-level detections in approximately 1 percent of all samples collected. Contaminated groundwater from this area is captured by the Paducah Site groundwater extraction systems.

# 7. Quality Assurance

The Paducah Site maintains a quality assurance (QA)/QC program to verify the integrity of data generated by the environmental monitoring program. Each aspect of the monitoring program, from sample collection to data reporting, must comply with quality requirements and assessment standards. Requirements and guidelines for the QA/QC program at the Paducah Site are established by the following:

- DOE Order 414.1E, *Quality Assurance*
- EM-QA-001, Rev 1, *Environmental Management Quality Assurance Program*
- CP2-QA-1000, *Quality Assurance Program Description for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*
- Commonwealth of Kentucky and federal regulations and guidance from US EPA
- ANSI
- American Society of Mechanical Engineers
- American Society for Testing and Materials
- American Society for Quality Control

The QA/QC program specifies organizational and program elements for equipment, design, documents, data, nonconformances, and records. DOE emphasizes planning, implementing, and assessing activities and implementing effective corrective actions as necessary. Project and subcontract documents specify program requirements to ensure they are included in project-specific planning documents such as QA plans.

The Paducah Site uses laboratories audited through the DOECAP. DOECAP audits the performance and qualifications of environmental analytical laboratories and commercial waste treatment, storage, and disposal facilities to support complex-wide DOE mission activities.

The environmental monitoring QA project plan defines how each element of the environmental monitoring program relates to key quality and data management requirements. The QA project plan is an appendix to the environmental monitoring plan (FRNP 2025a).

The Paducah programmatic QA project plan, which is based on the *Uniform Federal Policy for Quality Assurance Project Plans*, was implemented in 2013 and updated in 2024 (DOE 2024c). The following procedures further ensure quality:

- Field forms are maintained in accordance with CP3-RD-0010, *Records Management Process*.
- Communication and documentation between the sample management office and field sampling personnel are conducted according to CP3-ES-5007, *Data Management Coordination*.
- Sample labels and chain-of-custody forms are completed according to CP3-ES-2709, *Chain-of-Custody Forms, Sample Labels, and Custody Seals*.
- Data assessment is conducted by a data reviewer and a project reviewer according to CP3-ES-5003, *Quality Assured Data*.
- Sample data forms are prepared according to CP3-ES-2700, *Sample and Miscellaneous Data Forms*.

The environmental monitoring QA project plan and the procedures cited above cover data collected from January 2025 through December 2025. The plan also includes training requirements, sample custody, procedures, and instrument calibration and maintenance.

## 7.1 Field Sampling

Efforts to ensure the quality of field samples begin with planning for sampling activities and programs and continue in the field as measurements are taken and samples are collected according to the protocols specified for the specific sampling activity. The following sections describe elements crucial to field sample quality.

### 7.1.1 Data Quality Objectives and Sample Planning

From the start of any sampling program, data quality objectives play an important role in determining the number of samples, location of sampling sites, sampling methods, sampling schedules, and coordinating sampling and analytical resources to meet critical completion times. These sampling program criteria are documented in the Paducah Site environmental monitoring plan (FRNP 2025a). This plan is evaluated and modified each FY, as appropriate, using the data quality objectives methodology and following US EPA's data quality objectives guidance found here.

Each sampling location and sample collected are assigned a unique identification number. Each segment of the identification number sequence designates information on where the sample was collected. To implement the data quality objectives, an analytical statement of work for the analytical laboratory is generated from the Project Environmental Measurements System (PEMS), an electronic database that manages and streamlines field-generated and laboratory-generated data. Information in PEMS includes sample identification numbers, sampling locations, sampling methods, analytical parameters, analytical methods, and sample container and preservative requirements. The information in PEMS is used to produce sample bottle labels and chain-of-custody forms for each sampling event.

### 7.1.2 Field Measurements

Field measurements for the groundwater and surface water monitoring program include water level measurements, pH, conductivity, flow rate, turbidity, temperature, dissolved oxygen, total residual chlorine, Eh (approximate), and barometric pressure. Environmental conditions, such as ambient temperature and weather, are recorded as well. Field measurements are collected, recorded on appropriate sample data forms, and then entered into PEMS.

### 7.1.3 Sampling Procedures

Samples are collected using procedures specific to the media (surface water, groundwater, sediment, or air filters), which are written to comply with US EPA-approved sampling methods. Information recorded during a sampling event consists of the sample identification number, station or location, date collected, time collected, and the person who performed the sampling. This information, which is documented on a sample data form, on a chain-of-custody form, and on the sample container label, then is entered directly in PEMS. Chain-of-custody forms are maintained from the point of sampling, and the samples are protected properly until they are placed in the custody of an analytical laboratory.

### 7.1.4 Field Quality Control Samples

The QC program for both groundwater and environmental monitoring activities specifies a minimum target rate for field QC samples of 1 per 20 environmental samples. Table 7.1 shows the types of field QC samples that are collected and analyzed. Analytical results of field QC samples are evaluated to determine whether the sampling activities biased the sample results.

**Table 7.1. Types of quality control samples**

| Field QC samples | Laboratory QC samples |
|---|---|
| Field blanks[a] | Laboratory duplicates |
| Field duplicates | Reagent blanks |
| Trip blanks[a] | Matrix spikes[b] |
| Equipment rinsates[c] | Matrix spike duplicates |
| | Performance evaluations |
| | Laboratory control sample |

[a] Blanks = Samples of deionized water used to assess potential contamination from a source other than the media being sampled.
[b] Spikes = Samples that have been mixed with a known quantity of a chemical to measure overall method effectiveness during the analysis process, as well as possible sample/matrix interferences.
[c] Rinsates = Samples of deionized water that have been used to rinse the sampling equipment. The water is collected after completion of decontamination and prior to sampling. It is used to assess adequate decontamination of sampling equipment.

Acronym:
QC = quality control

## 7.2 Analytical Quality Assurance

The following sections describe the methods and procedures that ensure the laboratory analysis of samples meet quality standards, as well as the criteria for selecting off-site laboratories to analyze samples from the Paducah Site.

### 7.2.1 Analytical Procedures

When available and appropriate for the sample matrix, methods from US EPA's SW-846 Compendium are used for sample analysis. Analytical methods are defined in the FY 2026 environmental monitoring plan (FRNP 2025a). When SW-846 methods are not available, the Paducah Site uses other nationally recognized methods such as those developed by DOE and the American Society for Testing and Materials. An analytical statement of work for laboratory services identifies the analytical methods to be used for a set of samples. Using guidance from US EPA, laboratories document the steps in handling and analyzing samples, reporting results, and following chain-of-custody procedures.

### 7.2.2 Laboratory Quality Control Samples

Laboratory QC samples are prepared and analyzed according to the requirements of the analytical methods used. Table 7.1 identifies the types of laboratory QC samples. If samples do not meet the QC acceptance criteria, then appropriate action is taken as specified by the analytical method, or the analytical data are qualified accordingly.

### 7.2.3 Independent Quality Control

The Paducah Site is required by DOE and US EPA to participate in independent QC programs. The Paducah Site also participates in performance evaluation testing studies for its self-performed analytical services through industry standard vendors and/or control programs. These programs, which are conducted by US EPA, DOE, and commercial laboratories, generate data that are recognized as objective measures, enabling participating laboratories and government agencies to periodically review their performance. Data that do not meet acceptable criteria are investigated and documented according

to formal procedures. Although participation in certain programs is mandatory, the degree of participation is voluntary so that each laboratory can select parameters of particular interest to that facility.

KDOW requires laboratories that analyze samples for KPDES permit compliance to hold a Kentucky Wastewater Laboratory certification. Two laboratories and the FRNP sampling organization had this certification in 2025. Additional information about Kentucky Wastewater Laboratory certification can be found here.

### 7.2.4 Laboratory Audits and Accreditation

Laboratories used by FRNP participate in the DOECAP Accreditation Program, which certifies and accredits environmental laboratories through third-party organizations, including the American Association for Laboratory Accreditation, Perry Johnson Laboratory Accreditation, Inc., International Accreditation Service, and the ANSI National Accreditation Board. This certification ensures that the laboratories comply with the appropriate regulations, methods, and procedures. Audit findings are documented, and corrective action plans are developed by the laboratory and evaluated for acceptance by the accrediting body. Once corrective action plans are closed and accreditation is approved, the certificate of accreditation that includes the scope and period of accreditation will be provided to the laboratory. FRNP reviews the audit reports and certificates of accreditation with scope every two years for compliance with FRNP requirements. Laboratories that do not participate in the DOECAP Accreditation Program are audited by FRNP for compliance with DOE O 414.1E and CP3-QA-2001, *Approved Supplier Selection, Evaluation, Approved Supplier Maintenance*.

Analytical laboratories on the approved suppliers list that were used by the Paducah Site in 2025 include GEL Laboratories, LLC, Charleston, South Carolina; ALS Global in Cincinnati, Ohio, and in Salt Lake City, Utah; Southwest Research Institute in San Antonio, Texas; Pace Analytical Services, LLC, in Mt. Juliet, Tennessee, in Peoria, Illinois, and in Madisonville, Kentucky; Eurofins Environment Testing in Earth City, Missouri (St. Louis), and Arvada, Colorado (Denver); and EMSL Analytical, Inc., in Cinnaminson, New Jersey.

Waste treatment, storage, and disposal facilities that were on the approved suppliers list and were used by the Paducah Site in 2025 include Calgon Carbon Corporation in Township, Pennsylvania; Veolia Environmental Services Technical Solutions in Beaumont, Texas; Perma-Fix (Diversified Scientific Services, LLC) in Kingston, Tennessee, (Northwest) in Richland, Washington, in Gainesville, Florida, and Environmental Services in Oak Ridge, Tennessee; Clean Harbors, LLC, in Deer Park and LaPorte, Texas, in Greenbrier, Tennessee, in Reidsville, North Carolina, in Cincinnati, Ohio, and in El Dorado, Arkansas; Cleanlites Recycling in Cincinnati, Ohio; Arcwood Environmental (formerly Heritage Thermal Services) in East Liverpool, Ohio; Waste Control Specialists in Andrews, Texas; and Energy*Solutions* in Clive, Utah, and the Energy*Solutions* Bear Creek Processing Facility in Oak Ridge, Tennessee.

## 7.3 Data Management

Data must be managed properly so users can retrieve it easily and rely on its integrity. The following sections identify the databases that the Paducah Site relies on to house critical data and describe the systems and methods used to screen, validate, verify, and assess data from environmental sampling.

### 7.3.1 Project Environmental Measurements System

The data generated from sampling events are stored in PEMS, a consolidated site data system for tracking and managing data. The system is used to manage field-generated data, import laboratory-generated data, input data assessment codes and validation codes identified during the data review process, and transfer

data to the Paducah OREIS database for reporting. PEMS uses references and code lists to ensure consistency and standardization of the data.

### 7.3.2 Paducah OREIS

The Paducah OREIS database consolidates data generated by the environmental monitoring program. Data consolidation consists of activities necessary to prepare the evaluated data for the users. PEMS files containing the assessed data are transferred from PEMS to Paducah OREIS for future use. The Sample Management Office Manager is responsible for notifying the project team and other data users of the available data. Data used in reports that are distributed to external agencies, such as quarterly landfill reports and this ASER, are obtained from Paducah OREIS and have completed the data review process, which is documented in *Paducah Gaseous Diffusion Plant Data Management Plan* (DOE 2024d). Project-specific data sets are prepared during report writing and are included with reports, as appropriate. Environmental data loaded in Paducah OREIS have been assessed, verified, and validated, if applicable, as specified in CP3-ES-5003, *Quality Assured Data*.

### 7.3.3 PEGASIS

PEGASIS provides dynamic mapping and displays of environmental monitoring data. It allows members of the public to access environmental sampling data and site-specific geographic information system features through the Internet. It includes analytical sample results from environmental studies, restoration reports, supporting documents, and maps. Environmental data from Paducah OREIS is loaded in PEGASIS each quarter. PEGASIS does not contain data related to waste, deactivation, demolition, or facility characterization. Public access to PEGASIS is available here.

### 7.3.4 Electronic Data Deliverables

A results only electronic data deliverable is requested for all samples analyzed by each laboratory. The results and qualifier information from the electronic data deliverable are checked, as is the format of all fields provided. Discrepancies are reported immediately to the laboratory so they can make corrections or issue new electronic data deliverables. Approximately 10 percent of the electronic data deliverables are checked randomly to verify that the laboratory continues to provide adequate electronic data deliverables.

### 7.3.5 Data Packages

A Level IV data package is requested from the laboratory when data validation is to be performed on a specific sampling event or media. All data packages received from the laboratory are tracked, reviewed, and maintained in a secure environment. Tracked information includes the sample delivery group number, date received, receipt of any electronic data deliverable, and comments. The contents of the data package and the chain-of-custody forms are compared, and any discrepancies are identified. Discrepancies are reported immediately to the laboratory and to data validators. All data packages are submitted electronically to the Document Management Center for permanent storage.

### 7.3.6 Laboratory Contractual Screening

Laboratory contractual screening is the process of evaluating a set of data against the requirements specified in the analytical statement of work to ensure that all requested information is received. The contractual screening includes a review of the chain-of-custody form, analytes requested, method used, units, holding times, and reporting limits achieved. The contractual screening is conducted electronically once data are received from the analytical laboratory. Any deviation from the analytical statement of work is identified and documented.

### 7.3.7 Data Verification, Validation, and Assessment

Data verification is the process for comparing a data set against a set standard or contractual requirement. Verification is performed electronically, manually, or both. Data verification includes contractual screening and other criteria specific to the data. Data are flagged as necessary. Verification codes are stored in PEMS and transferred with the data to Paducah OREIS.

Data validation is performed for a data set by a qualified individual who is independent from sampling, laboratory, project management, or other decision-making personnel. Data validation evaluates how well the laboratory adheres to the requirements of the analytical method. Validation codes are stored in PEMS and transferred with the data to Paducah OREIS. A minimum of 5 percent of the total data packages from routine sampling events are validated programmatically. All of the selected data packages are validated at a rate of 100 percent. A total of 91 packages of environmental monitoring data were validated in 2025.

Data assessment assures that the type, quality, and quantity of data are appropriate for its intended use based on the data quality objectives. It allows data users to determine that a decision (or estimate) can be made with the desired level of confidence, given the quality of the data set. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100 percent to ensure data are useable. The data assessment is conducted by trained technical personnel in conjunction with other project team members. Assessment codes are stored in PEMS and transferred with the data to Paducah OREIS. Data are made available for reporting from Paducah OREIS once the data assessment is complete and associated documentation is stored in the project files. Rejected data that are identified in the data assessment and/or data validation process are noted as rejected in Paducah OREIS.

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# Appendix A: Glossary

# Appendix A Glossary

**accuracy**—The closeness of the result of a measurement to the true value of the quantity.

**air stripper**—Equipment that bubbles air through water to remove volatile organic compounds from the water.

**alkalinity**—The capacity of an aqueous solution to neutralize an acid. Alkalinity measurements are important in determining the sensitivity of a body of water to acid inputs such as acidic pollution from rainfall or wastewater.

**alpha activity**—The rate of emission of alpha particles from a given material.

**alpha particle**—A positively charged particle emitted from the nucleus of an atom; it has the same charge and mass as that of a helium nucleus (two protons and two neutrons).

**ambient air**—The surrounding atmosphere as it exists around people, plants, and structures.

**analyte**—The specific component that is being measured in a chemical analysis.

**analytical detection limit**—The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

**anion**—A negatively charged ion.

**aquifer**—A permeable layer of sand, gravel, or rock below the ground surface that is capable of yielding quantities of groundwater to wells and springs.

**atom**—Smallest unit of an element capable of entering into a chemical reaction.

**average—**A measure of the central tendency, or middle, of a group of numbers.

**background radiation**—Naturally-occurring radiation that includes cosmic radiation, terrestrial radiation, and internal radiation.

**beta activity**—The rate of emission of beta particles from a given material.

**beta particle**—A negatively charged particle emitted from the nucleus of an atom during radioactive decay. It has a mass and charge equal to those of an electron.

**biota**—Animal and plant life.

**blank**—A control sample that is identical in principle to the sample of interest, except the substance being analyzed is absent. In such cases, the measured value for the substance being analyzed is believed to be a result of artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. US EPA does not permit the subtraction of blank results in US EPA-regulated analyses.

**calibration**—Determining the variance from a standard of accuracy of a measuring instrument to ascertain what correction factors are necessary.

**categorical exclusion**—A class of actions that either individually or cumulatively do not have a significant effect on the human environment and therefore do not require preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act.

**chain-of-custody**—A process that documents custody and control of a sample through sample collection, transportation, and analysis.

**chemical oxygen demand**—Indicates the quantity of oxidizable materials present in water, and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

**closure**—Formal shutdown of a hazardous waste management facility under the Resource Conservation and Recovery Act or Comprehensive Environmental Response, Compensation, and Liability Act.

**compliance**—Fulfillment of the applicable requirements of a plan or schedule ordered or approved by a government authority.

**Comprehensive Environmental Response, Compensation, and Liability Act**—Legislation that provides for liability, compensation, cleanup, and emergency response for hazardous substances released to the environment and the cleanup of inactive hazardous waste disposal sites.

**concentration**—The amount of a substance contained in a unit volume or mass of a sample.

**conductivity**—A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

**confluence**—The point at which two or more streams meet; the point where a tributary joins the main stream.

**contaminant**—Any substance that enters a system, such as the environment, food, or the human body, where it is not normally found. Contaminants include substances that spoil food, pollute the environment, or cause other adverse effects.

**contamination**—Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

**cosmic radiation**—Ionizing radiation with very high energies that originates outside the earth's atmosphere. Cosmic radiation contributes to natural background radiation.

**count**—A measure of the radiation from an object or device; the signal that announces an ionization event within a counter.

**curie**—A unit of radioactivity, defined as the quantity of any radioactive nuclide that has $3.7 \times 10^{10}$ (37 billion) disintegrations per second.

**decay, radioactive**—The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

**decontamination and decommissioning**—Removing equipment, demolishing buildings, disposing of waste, and investigating potential contamination in areas that are no longer part of current operations.

**derived concentration standard**—A derived concentration value for a radionuclide in a specified environmental medium (e.g., air or water) that would result in a dose in that medium of 100 mrem in a year to a gender- and age-weighted reference person using DOE approved dose coefficients and assuming continuous exposure. Derived concentration standard values represent concentrations at the point of discharge and do not account for attenuation along the pathway before reaching the receptor, therefore, if they are implemented to assist with determining dose to the public from a pathway, then an ALARA analysis is required. While the derived concentration standard values can be used in assessing the magnitude of the dose to the public, they are not recommended for use in public dose estimates as they are likely to produce doses that are overly conservative. For this reason, they are not used to demonstrate compliance with DOE radiation protection dose limits. A detailed pathway analysis is required for calculating public radiation doses resulting from DOE activities.

**dose**—In this document, dose is used exclusively to refer to a radiological dose, defined as the energy imparted to matter by ionizing radiation. Dose can also refer to chemical dose, but chemical dose is not discussed in this report.

> **effective dose**—A measure of the potential biological risk of health effects due to exposure to radiation measured in millirem (1 millirem = 0.01 millisievert). In this document, the term effective dose is often shortened to dose.
>
> **population dose**—The sum of the effective doses to all persons in a specified population measured in units of person-rem (or person-sievert).
>
> **absorbed dose**—The total amount of energy absorbed per unit mass (the amount of energy deposited in body tissue) as a result of exposure to radiation. The unit of absorbed dose is the rad, equal to 0.01 joule per kilogram in any medium (1 rad = 0.01 gray).

**downgradient**—The direction that groundwater flows; similar to downstream for surface water.

**downgradient well**—A well installed downgradient of a site that may be capable of detecting migration of contaminants from a site.

**duplicate sample**—A sample collected from the same location at the same time and using the same sampling device (if possible) as the regular sample.

**effluent**—A liquid or gaseous discharge to the environment.

**effluent monitoring**—The collection and analysis of samples or measurement of liquid and gaseous effluents to characterize and quantify the release of contaminants, assess radiation exposures to the public, and demonstrate compliance with applicable standards.

**Environmental Restoration**—A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities (decontamination and decommissioning) contaminated as a result of nuclear-related activities.

**exposure (radiation)**—The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is exposure to ionizing radiation that takes place at a person's workplace. Population exposure is the exposure to the total number of persons who inhabit an area.

**external radiation**—Exposure to ionizing radiation when the radiation source is located outside the body.

**gamma ray**—High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to x-rays except for the source of the emission.

**groundwater**—Any water found below the land surface.

**half-life, radiological**—The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life; half-lives can range in duration from less than a second to many millions of years.

***in situ***—In its original place. Describes field measurements taken without removing the sample from its original location, or remediation performed while the contaminated media, such as groundwater or soil, remains below the surface or in place.

**industrial solid waste landfill**—A type of landfill that exclusively disposes of solid waste generated by manufacturing or industrial operations.

**interim remedial measure**—Cleanup activities initiated after it has been determined that contamination or waste disposal practices pose an immediate threat to human health or the environment. These measures are implemented until a more permanent solution can be made.

**internal radiation**—Occurs when radionuclides enter the body, for example, by ingestion of food or liquids, by inhalation, or through an open wound.

**irradiation**—Exposure to external radiation.

**isotopes**—Forms of an element having the same number of protons but differing numbers of neutrons in their nuclei.

**maximally exposed individual**—A hypothetical individual who—because of realistically assumed proximity, activities and habits—would receive the highest radiation dose, taking into account all pathways, from a given event, process, or facility. Defined by DOE Order 458.1.

**maximum contaminant level**—The maximum permissible level of a contaminant in drinking water provided by a public water system.

**maximum contaminant level goal**—A nonenforceable health goal set to allow for a margin of safety, which establishes the highest level of a contaminant found in drinking water that is not expected to cause adverse health effects.

**migration**—The transfer or movement of a material through air, soil, or groundwater.

**millirem**—The dose that is one-thousandth of a rem.

**monitoring**—The process of periodically measuring the quantity and quality of factors that can affect the environment or human health to regulate and control potential impacts.

**nuclide**—An atom specified by atomic weight, atomic number, and energy state.

**outfall**—The point of conveyance, such as a drain or pipe, of wastewater or other effluents into a ditch, pond, or river.

**part per billion**—A unit measure of concentration equivalent to the weight to volume ratio expressed as microgram per liter (μg/L) or the weight to weight ratio of microgram per kilogram (μg/kg).

**part per million**—A unit measure of concentration equivalent to the weight-to-volume ratio expressed as milligrams per liter (mg/L), the weight to weight ratio expressed as milligrams per kilogram (mg/kg), or the weight to weight ratio expressed as micrograms per gram (μg/g).

**perfluoroalkyl and polyfluoroalkyl substances**—A group of manmade chemicals, collectively abbreviated as PFAS, used in nonstick products, such as Teflon®, water- and stain-repellant fabrics, and firefighting foam, among others. PFAS are also used in the aerospace, automotive, construction, electronics, and military industries. Certain types of PFAS may have negative health effects for humans and the environment.

**person-rem**—A unit of measure for the collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

**pH**—A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 7, neutral solutions have a pH equal to 7, and basic solutions have a pH from 7 to 14.

**polychlorinated biphenyls**—Man-made chemicals that range from oily liquids to waxy solids. Polychlorinated biphenyls were used in hundreds of industrial and commercial applications due to their chemical properties until production in the United States ceased in 1977. Polychlorinated biphenyls have been demonstrated to cause a variety of adverse health effects in animals and may cause cancer and other adverse health effects in humans.

**quality assurance**—Any action in environmental monitoring to demonstrate the reliability of monitoring and measurement data.

**quality control**—The routine application of procedures to obtain the required standards of performance in monitoring and measurement processes.

**rad**—The unit of absorbed dose deposited in a volume of material.

**radioactivity**—The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

**radionuclide**—A radioactive nuclide capable of spontaneously transforming into other nuclides by changing its nuclear configuration or energy level. This transformation is accomplished by emitting photons or particles.

**rem**—The unit used to measure dose (absorbed dose in rads multiplied by the radiation quality factor). Dose is frequently reported in millirem (mrem), which is one-thousandth of a rem.

**remediation**—The correction or cleanup of a site contaminated with waste. See Environmental Restoration.

**reportable quantity**—A release to the environment that exceeds the quantity that must be reported as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

**Resource Conservation and Recovery Act**—Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

**riparian**—Related to the banks of a river or wetlands adjacent to rivers and streams.

**source**—A point or object from which radiation or contamination emanates.

**Superfund**—The program operated under the legislative authority of the Comprehensive Environmental Response, Compensation, and Liability Act and Superfund Amendments and Reauthorization Act that funds and conducts US EPA emergency and long-term removal and remedial actions.

**surface water**—All water on the surface of the earth, as distinguished from groundwater.

**suspended solids**—Particles suspended in water, such as silt or clay, which can be trapped by a filter.

**terrestrial radiation**—Ionizing radiation emitted from radioactive materials in the earth's soils such as potassium-40, radon, thorium, and uranium. Terrestrial radiation contributes to natural background radiation.

**transuranics**—Elements, such as americium, plutonium, and neptunium, that have atomic numbers (the number of protons in the nucleus) greater than 92, which is the number of protons in uranium. All transuranics are radioactive.

**trichloroethene**—A colorless liquid used in many industrial applications as a cleaner or solvent; one of many chemicals that is classified as a volatile organic compound. High levels of trichloroethene may cause health effects such as liver and lung damage and abnormal heartbeat; moderate levels may cause dizziness or headache. The US EPA Integrated Risk Information System characterizes trichloroethene as carcinogenic to humans by all routes of exposure. This conclusion is based on convincing evidence of a causal association between trichloroethene exposure in humans and kidney cancer.

**trip blank**—A quality control sample of water that accompanies sample containers to the field sampling location where environmental samples are collected, then back to the analytical laboratory to determine whether environmental samples have been contaminated during transport or shipment or by site conditions. A trip blank is required for collection of samples analyzed for volatile organic compounds.

**turbidity**—A measure of the concentration of sediment or suspended particles in a liquid.

**upgradient**—In the opposite direction of groundwater flow; similar to upstream for surface water.

**upgradient well**—A well installed upgradient of a site to provide data to compare to a downgradient well to determine whether the site is affecting groundwater quality.

**volatile organic compounds**—Organic, or carbon-containing, compounds that evaporate readily at room temperature. These compounds are present in solvents, degreasers, paints, thinners, and fuels. Due to factors including widespread industrial use, they are commonly found as contaminants in soil and groundwater. Volatile organic compounds include trichloroethene, vinyl chloride, benzene, and dichloroethenes.

**weighting factor for radiation**—In radiation, the factor by which an absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to an

exposed person. The weighting factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

**weighting factor for tissue**—A tissue-specific number that represents the fraction of the total potential health risk resulting from uniform, whole body irradiation to the specific organ or tissue such as bone marrow, lungs, or thyroid.

**wetland**—An area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, floodplains, fens, and similar areas. A jurisdictional wetland is one that falls under state or federal regulatory authority; a non-jurisdictional wetland does not.

# Appendix B:
# Introduction to Radiation

# Appendix B Introduction to Radiation

The information presented in this appendix summarizes concepts pertaining to radiation and radioactivity that the reader may find useful in understanding and interpreting the radiological information presented in this Annual Site Environmental Report (ASER).

## B.1 What is Radiation?

Radiation is energy (Figure B.1). It can come from unstable atoms that undergo radioactive decay, or it can be produced by machines. Radiation travels from its source in the form of energy waves or particles. There are two kinds of radiation: non-ionizing radiation and ionizing radiation.

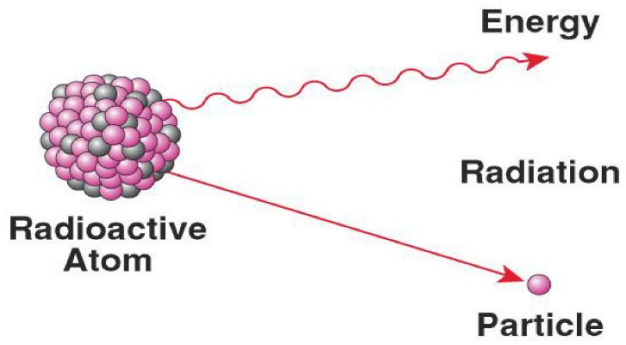



**Figure B.1. Radioactive atom showing ionizing radiation**

### Non-Ionizing radiation

Non-ionizing radiation has enough energy to move atoms in a molecule around or cause them to vibrate but not enough to remove electrons from atoms. Examples of this kind of radiation are radio waves, visible light, and microwaves.

### Ionizing radiation

Ionizing radiation has so much energy that it can knock electrons out of atoms, a process known as ionization. Examples of ionizing radiation include alpha and beta particles, gamma rays, and x-rays. Ionizing radiation can affect atoms in living things and cause biological damage that is potentially harmful to human health. Ionizing radiation comes from x-ray machines, cosmic particles from outer space, and radioactive elements. Radioactive elements emit ionizing radiation as their atoms undergo radioactive decay. As used in this ASER and the remainder of this appendix, the term radiation refers only to ionizing radiation.

### Radioactive decay

Radioactive decay is the emission of energy in the form of ionizing radiation. The ionizing radiation that is emitted can include alpha particles, beta particles, and gamma rays.

## Types of ionizing radiation

### *Alpha particles*

Alpha particles are positively charged and are made up of two protons and two neutrons that are emitted from the atom's nucleus during radioactive decay. Alpha particles come from the heaviest radioactive elements such as uranium, radium, and polonium. Although alpha particles are very energetic, they are so heavy that they use up their energy over short distances and are unable to travel very far from the atom. Alpha particles can be stopped by thin layers of materials, such as the outer layer of your skin or a sheet of paper (see Figure B.2).

The health effect from exposure to alpha particles depends on how a person is exposed. Because alpha particles lack the energy to penetrate even the outer layer of skin, exposure to the outside of the body is not a major concern. Inside the body, however, they can be very harmful. If alpha particles are inhaled or swallowed, or get into the body through a cut, they can damage sensitive living tissue. Examples of alpha emitting-radionuclides include radioactive atoms of uranium, plutonium, and americium.

### *Beta particles*

Beta particles are small, fast-moving particles with a negative electrical charge that are emitted from an atom's nucleus during radioactive decay. These particles are emitted by certain unstable atoms such as tritium, carbon-14, and strontium-90. Beta particles travel farther in air than alpha particles but can be stopped by a layer of clothing or by a thin layer of a substance such as aluminum foil, plastic, or wood (see Figure B.2).

The ability of beta particles to penetrate matter increases with energy. Some beta particles are capable of penetrating the skin and causing damage such as skin burns; however, as with alpha particles, beta particles are most hazardous when they are inhaled or swallowed. An example of a beta-emitting radionuclide is technetium.

### *Gamma rays*

Gamma rays are weightless packets of energy called photons. Unlike alpha and beta particles, which have both energy and mass, gamma rays are pure energy. Gamma rays are similar to visible light but have much higher energy. Gamma rays are often emitted along with alpha or beta particles during radioactive decay.

Gamma rays are a radiation hazard for the entire body. They can easily penetrate barriers, such as skin and clothing, which can stop alpha and beta particles. Gamma rays have so much penetrating power that several inches of a dense material (like lead or even a few feet of concrete) may be required to stop them (see Figure B.2). Gamma rays can pass completely through the human body, and they can cause damage to tissue and cells as they pass through. An example of a gamma-emitting radionuclide is cesium.

### *X-rays*

Because of their use in medicine, almost everyone has heard of x-rays. X-rays are similar to gamma rays in that they are photons of pure energy. X-rays and gamma rays have the same basic properties but come from different parts of the atom. X-rays are emitted from the processes outside the nucleus, and gamma rays originate inside the nucleus. X-rays are also generally lower in energy and, therefore, are less penetrating than gamma rays. X-rays can be produced naturally or by machines using electricity.

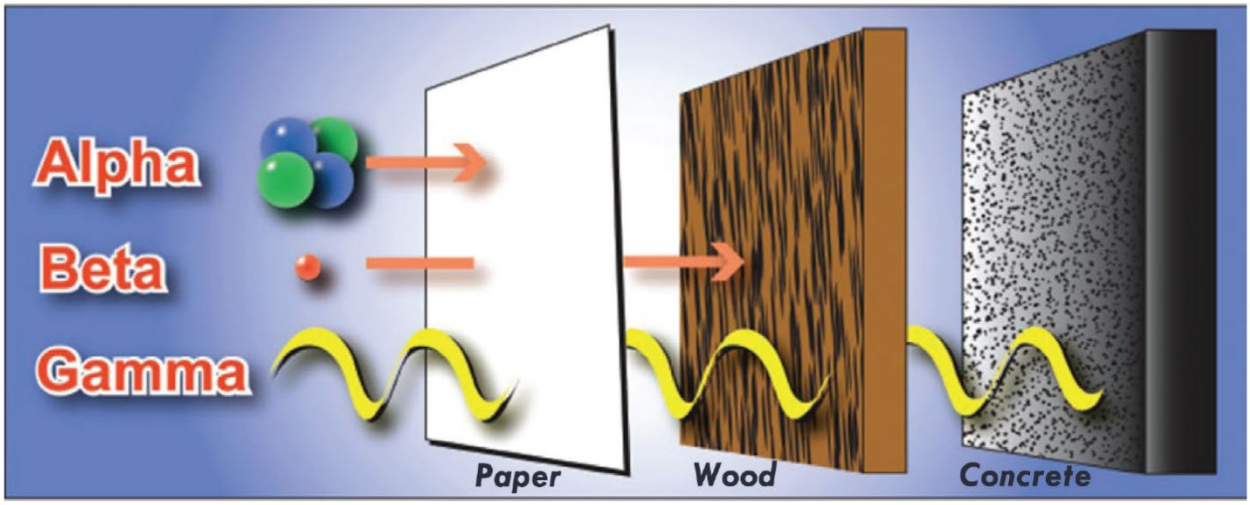



**Figure B.2. Comparison of penetrating ability of alpha, beta, and gamma radiation**

## B.2 What is a Radionuclide?

Elements in the periodic table can take on several forms. Some of these forms are stable; other forms are unstable. The most stable form of an element is usually the most common in nature; however, all elements have an unstable form. Unstable forms emit ionizing radiation and are radioactive. Some elements have no stable form and are always radioactive such as uranium. Elements that emit ionizing radiation are called radionuclides.

When a radionuclide decays, it transforms into a different atom called a decay product. These atoms keep transforming into new decay products until they reach a stable state and are no longer radioactive. Radionuclides that decay in more than one step are called series radionuclides. The series of decay products created by these radionuclides is called a decay chain. Each series has its own unique decay chain.

Every radionuclide has a specific decay rate, which is measured in terms of half-life. Radioactive half-life is the time required for half of the radioactive atoms present to decay. Some radionuclides have half-lives of mere seconds, but others have half-lives of hundreds, millions, or billions of years.

Radionuclides in this report are expressed in different ways but each expression identifies the same radionuclide. For example, a common radionuclide of uranium may be expressed as uranium-238 or U-238.

## B.3 What are Some Radionuclides of Concern?

Some radionuclides of concern include uranium-234, uranium-235, uranium-238, thorium-230, technetium-99, plutonium-238, plutonium-239, plutonium-240, neptunium-237, americium-241, and cesium-137. Appendix C lists these radionuclides along with their associated half-lives.

## B.4 What is Radioactivity and How is it Measured?

As radionuclides decay, they emit one or more types of radiation at characteristic energies that can be measured and used to identify the radionuclide. Detection instruments measure the quantity of radiation

emitted over a specified time. The number of decay events (nuclear transformations) over a fixed time can be calculated from this measurement.

Radioactivity is measured in curies (Ci) or becquerels (Bq). One Ci, based on the rate of decay of one gram of radium-226, is defined as the quantity of any radionuclide that undergoes an average transformation rate of 37 billion transformations per second. In the International System of Units, one Bq is equal to one transformation per second. In this ASER, radioactivity is usually expressed in Ci.

## B.5 What is Dose and How is it Measured?

The possible effects of radiation must be measured to determine its potential to cause damage. The amount of energy absorbed by a material that receives radiation is measured in rads. A rad is 100 ergs of radiation energy absorbed per gram of material. Dose is a means of expressing the amount of energy absorbed, taking into account the effects of different kinds of radiation.

Alpha, beta, and gamma radiation affect the body to different degrees. Each type of radiation is given a quality factor that indicates the amount of human cell damage it can cause, compared with equal amounts of other ionizing radiation energy. Alpha particles cause 20 times as much damage to internal tissues as x-rays, so alpha radiation has a quality factor of 20 compared to gamma rays, x-rays, and beta particles, each of which has a quality factor of one.

The unit of dose measurement to humans is the roentgen equivalent man (rem). The number of rem is equal to the number of rads, multiplied by a quality factor for each type of radiation. For radiation protection purposes, 1 rem of any type of radiation has the same damaging effect.

Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides inside the body are called internal exposures. This distinction is important because external exposure occurs only as long as a person is near the radionuclide; simply leaving the area of the source will stop the exposure. Internal exposure continues as long as the radionuclide remains inside the body. Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. To enable radiation protection specialists to express exposures to portions of the body (and the accompanying doses) in terms of an equal dose to the whole body, the concept of effective dose was developed.

Unless otherwise noted, the generic term dose used in this report is the total effective dose to a person, which includes both the effective dose that can be attributed to sources outside the body and the committed effective dose from radionuclides deposited inside the body, which is based on a lifetime accumulated dose. For an adult, the lifetime accumulated dose is based on 50 years. Using the total effective dose allows doses from different types of radiation and to different parts of the body to be expressed on the same basis.

## B.6 How are Radioactivity and Dose Reported?

### Scientific notation

Concentrations of radionuclides detected in the environment are typically quite small. Scientific notation is used to express numbers that are very small or very large. A very small number may be expressed with a negative exponent, for example 1.5E-03 (or $1.5 \times 10^{-3}$). To convert this number to its decimal form, move the decimal point left by the number of places equal to the exponent. In this example, moving the decimal point 3 places to the left shows that the number 1.5E-03 may also be expressed as 0.0015. For large numbers with a positive exponent, such as 1.5E+06 (or $1.5 \times 10^{6}$), move the decimal point to the

right by the number of places equal to the exponent. In this case, 1.5E+06 may also be written as 1,500,000, or 1.5 million. Units for very small and very large numbers are often expressed with a prefix. For example, the prefix kilo (abbreviated as k) means 1,000 of a given unit. One kilometer, therefore, equals 1,000 meters. Table B.1 defines the values of radiation-related prefixes used in this ASER.

**Table B.1. Commonly used numerical prefixes**

| Multiple | Decimal equivalent | Prefix | Symbol |
|---|---|---|---|
| $10^{-3}$ | 0.001 | milli | m |
| $10^{-6}$ | 0.000001 | micro | μ |
| $10^{-12}$ | 0.000000000001 | pico | p |

### Concentrations of radioactivity in environmental sample media

Radiological environmental samples identify the concentration of radioactivity using the following units of measure:

- Air samples use the term microcuries per milliliter (μCi/mL).
- Liquid samples use the term picocuries per liter (pCi/L).
- Sediment samples use the term picocuries per gram (pCi/g).
- Radiation exposure measured by environmental dosimeters uses the term millirem (mrem).

### Dose

This ASER expresses dose in standard units, followed by the equivalent International System of Units, or SI units, in parentheses when applicable. SI is the official system of measurement used internationally to express units of radioactivity and radiation dose. The basic SI unit of radioactivity is the becquerel (Bq), which is equivalent to one nuclear disintegration per second. Multiply the number of curies by $3.7 \times 10^{10}$ to obtain the equivalent number of becquerels. The concept of dose may also be expressed using the SI units: gray (Gy) for absorbed dose (1 Gy = 100 rad) and sievert (Sv) for effective dose (1 Sv = 100 rem). Table B.2 shows the names and symbols for measurements used to describe radioactivity and dose.

**Table B.2. Names and symbols for units of radioactivity and radiological dose**

| Symbol | Name |
|---|---|
| Ci | curie ( 1 Ci = $3.7 \times 10^{10}$ disintegrations per second) |
| pCi | picocurie (1 pCi = $1 \times 10^{-12}$ Ci) |
| rad | radiation absorbed dose (100 rad = 1 Gy) |
| mrem | millirem (1 mrem = $1 \times 10^{-3}$ rem) |
| Bq | Becquerel (1 Bq = 1 disintegration per second) |
| Sv | Sievert (1 Sv = 100 rem) |
| mSv | millisievert ($1 \times 10^{-3}$ Sv) |
| Gy | Gray (1 Gray = 100 rad) |
| mGy | milligray (1 mGy = $1 \times 10^{-3}$ Gy) |

## B.7 What is an Exposure Pathway?

An exposure pathway is how a radioactive material is released to the environment, transported to a receptor (a person, animal, or plant), and comes into contact with a receptor. Figure B.3 illustrates common exposure pathways. Most people come into contact with released radioactive material via one of the following routes:

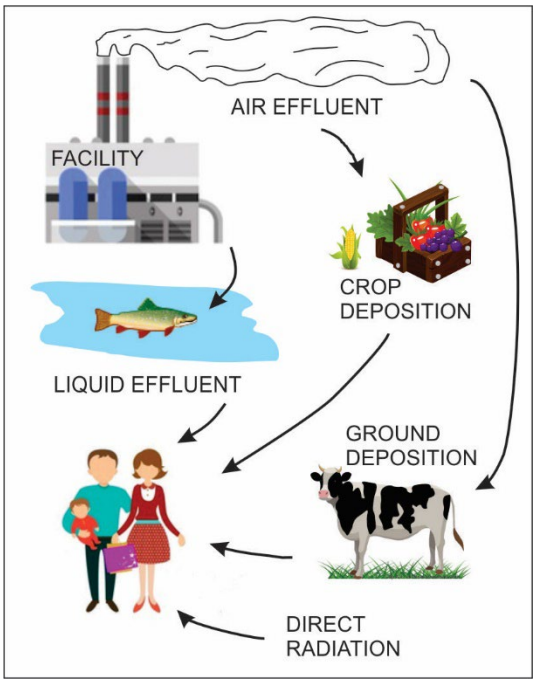


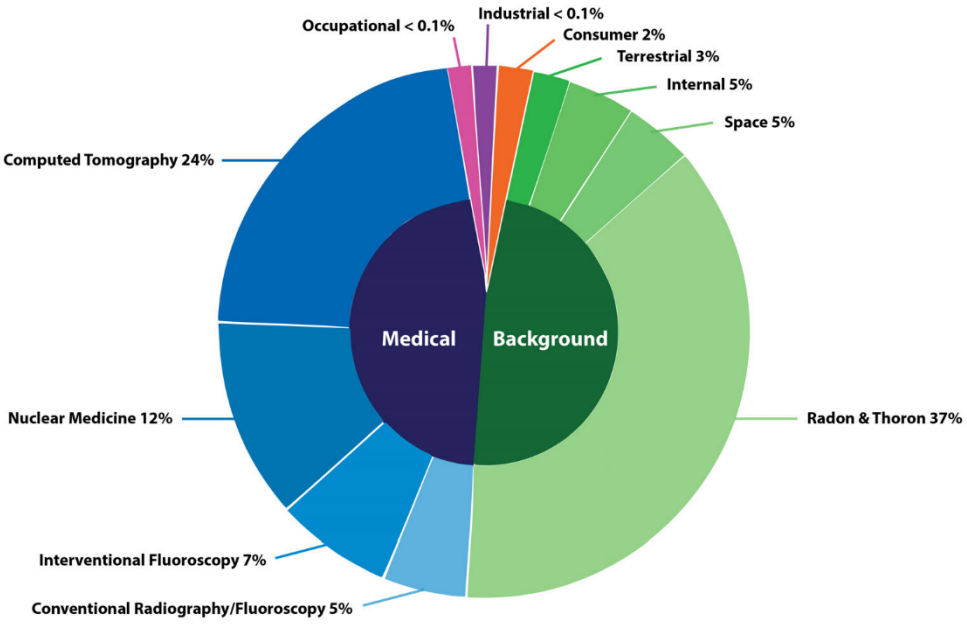

**Figure B.3. Potential exposure pathways**

- Inhaling gases and particulates
- Ingesting vegetables, crops, wild game, milk, and fish
- Ingesting surface water and groundwater
- Absorbing the material through the skin (also called dermal absorption)
- External exposure to ionizing radiation

## B.8 What Radiation Sources and Doses are we Exposed to?

Sources of radiation are around us at all times. Everyone is routinely exposed to radiation from natural sources, such as minerals in the ground, and man-made sources such as medical x-rays. Radiation has the same effect on people, whether it is natural or man-made. According to the National Council on Radiation Protection and Measurements Report No. 160, *Ionizing Radiation Exposure of the Population of the United States*, the average annual radiation dose per person in the US is about 620 mrem (6.2 mSv). Figure B.4 shows the various sources of exposure and the contributions of these sources to the total collective dose for the US population in 2006. Actual doses vary depending on such factors as geographic location, building ventilation, and personal habits.

To estimate your average annual yearly dose from the most significant sources of ionizing radiation, use the online calculator on the US EPA website, which can be found here.




Average Annual Radiation Dose

| Sources | Radon & Thoron | Computed Tomography | Nuclear Medicine | Interventional Fluoroscopy | Space | Conventional Radiography/ Fluoroscopy | Internal | Terrestrial | Consumer | Occupational | Industrial |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Units | | | | | | | | | | | |
| mrem (United States) | 228 mrem | 147 mrem | 77 mrem | 43 mrem | 33 mrem | 33 mrem | 29 mrem | 21 mrem | 13 mrem | 0.5 mrem | 0.3 mrem |
| mSv (International) | 2.28 mSv | 1.47 mSv | 0.77 mSv | 0.43 mSv | 0.33 mSv | 0.33mSv | 0.29 mSv | 0.21 mSv | 0.13 mSv | 0.005 mSv | 0.003 mSv |

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

**Figure B.4. Sources of radiation exposure**

## Natural sources of radiation

Naturally occurring radioactive minerals in the ground, soil, and water produce background radiation, which accounts for 50 percent of the radiation received by the US population. The human body even contains some of these naturally occurring radioactive minerals. Cosmic radiation from space also contributes to the background radiation around us. Natural background radiation levels can vary significantly from place to place and in the same location over time. The paragraphs below provide more detail on natural sources of background radiation.

### *External exposure from space (cosmic radiation)*

The earth's atmosphere and magnetic shield protect us from cosmic radiation. Earth's magnetic shield is strongest at the equator and weakest near the poles. The magnetic shield diverts most of the cosmic radiation around the earth. Earth's atmosphere shields us from most of the remaining cosmic radiation that travels to earth. People who live at a higher altitude, like Denver, Colorado, are exposed to slightly more cosmic radiation than people who live at a lower altitude.

Cosmic radiation also produces cosmogenic radionuclides by the interaction of cosmic radiation within the atmosphere or in the earth. The energy from this cosmic radiation blasts apart atoms in the earth's atmosphere and continuously produces radionuclides such as tritium, beryllium-7, sodium-22, and carbon-14. Cosmogenic radionuclides, particularly tritium and carbon-14, have been measured in humans, animals, plants, soil, polar ice, surface rocks, sediments, the ocean floor, and the atmosphere. The average annual radiation exposure from cosmic radiation is about 33 mrem.

### *External exposure from terrestrial radiation (primordial radionuclides)*

The primordial radionuclides detected today are billions of years old. The external radiation dose to a person from primordial radionuclides comes from radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Uranium and thorium, which are naturally found in the earth, are the main source of terrestrial radiation. Trace amounts of uranium, thorium, and their decay products can be found everywhere. Terrestrial radiation dose levels vary by location, but areas with higher concentrations of uranium and thorium in surface soils generally have higher dose levels. The average annual radiation exposure from terrestrial radiation is about 21 mrem.

### *Internal exposure from inhalation of radon, thoron, and their decay products*

Radon is an inert gas that comes from the natural breakdown of uranium in soil, rock, and water. Radon can accumulate in buildings and can get into the air we breathe through cracks, crevices, openings in the foundation or from bricks, and other building materials. Radon gas is not visible and has no odor or taste. It is the second leading cause of lung cancer in the United States after smoking. As shown in Figure B.3, radon, thoron, and their decay products are responsible for most of the annual effective dose (about 228 mrem) from background radiation produced by naturally occurring radionuclides. Radon levels vary widely across the United States. State programs work in partnership with US EPA to provide education and awareness of the health hazards caused by radon.

### *Internal exposures from radionuclides in the body*

Traces of radioactive materials can be found in our bodies; they include potassium-40, the thorium-232 series, and the uranium-238 series. The primary source is potassium-40, which is found in food we ingest—primarily fruits and vegetables. Radionuclides from the thorium-232 and uranium-238 series are found in food and water we ingest. Our bodies contain small amounts of radiation because the body metabolizes the nonradioactive and radioactive forms of potassium and other elements in the same way.

## Man-made sources of radiation

In addition to natural sources of radiation, most people are exposed to man-made sources of radiation through medical procedures and consumer products.

### *Medical*

Medical sources are the main source of exposure to the average American from man-made radiation, making up 48 percent of the total dose. This total does not include dose from radiation therapy used in the treatment of cancer, which is typically many times larger. The average annual effective dose from medical sources is roughly 300 mrem and includes medical imaging and nuclear medicine.

Medical imaging

Radiation is used in many medical imaging procedures, which deliver x-ray beams to a specific part of the body, creating a digital image or film that shows the structures inside—like bones, tissues, and organs. Healthcare providers can use these images to find out what is causing the health problem (diagnostics) or to guide treatment. Medical imaging does not distribute radionuclides uniformly throughout the body, so the concept of effective dose, which relates the significance of exposure of organs and body parts to the effect on the entire body, is useful in making comparisons. Medical imaging tests which use ionizing radiation are as follows:

- Computed tomography (CT): This medical imaging test uses x-rays to create cross-sectional pictures, like slices, inside selected areas of the body from different angles. The images can show internal organs, blood vessels, soft tissues, and bones. CT scans combine a series of x-ray images

into a three-dimensional picture. Common uses of CT scans include checking for tumors, infections, blood clots, and internal bleeding. These tests provide an average annual effective dose of 147 mrem.

- Interventional fluoroscopy: This uses x-rays to create a real-time image to guide small instruments, such as catheters through blood vessels, or other pathways in the body. This process provides an average annual effective dose of 43 mrem.
- Conventional radiography and fluoroscopy: Radiography is the use of x-ray machines by health care providers and dentists to pass x-ray beams through a part of the body to produce images of the tissues, organs, bones, or teeth inside. Fluoroscopy is a medical technique that takes real-time moving images of internal structures in the body by placing a patient between a fluorescent screen and an x-ray source. These processes provide an average annual effective dose of 33 mrem.

Nuclear medicine

Nuclear medicine uses radioactive material inside the body to see how organs or tissue are functioning (diagnostic) or to target and destroy damaged or diseased organs or tissues (treatment). Nuclear medicine does not distribute radionuclides uniformly throughout the body, so the concept of effective dose, which relates the significance of exposure of organs and body parts to the effect on the entire body, is useful in making comparisons. The average annual dose from nuclear medicine is 77 mrem.

For most diagnostic procedures, a tracer containing the radioactive material is injected, swallowed, or inhaled. Then the healthcare provider or radiologist uses a radiation detector to see how much of the tracer is absorbed or how it reacts in the organ or tissue. This gives the healthcare provider information on how well the organ or tissue is functioning. Common uses of nuclear medicine for diagnosis include scans of the heart, lung, kidneys, gallbladder, and thyroid.

When nuclear medicine is used in treatment, the tracer targets a harmful organ or tissue and radioactivity damages or stops growth of its cells. Two common uses of nuclear medicine for treatment include radioactive iodine therapy and brachytherapy, a form of radiation treatment where a sealed radiation source is placed inside or next to the area requiring treatment.

***Consumer products and activities***

The average annual effective dose to an individual from consumer products and activities is about 13 mrem. Cigarette smoke accounts for 35 percent of the dose from consumer products and activities. Building materials account for 27 percent of this dose. Commercial air travel accounts for 26 percent, mining and agriculture account for 6 percent, miscellaneous consumer-oriented products account for 3 percent, combustion of fossil fuels accounts for 2 percent, and highway and road construction materials account for 0.6 percent.

***Industrial and occupational***

Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; transportation of radioactive materials; and mineral extraction facilities. The average annual radiation exposure to the general public from these sources has been estimated at less than 1 mrem per year.

## B.9 What are the Potential Health Effects of Radiation Exposure?

The three primary pathways by which people may be exposed to radiation are direct exposure, inhalation, and ingestion. Exposure from radiation may be from a source outside the body (external exposure) or from radioactive particles that have been taken in by breathing or eating and have become lodged inside

the body (internal exposure). Radionuclides that are taken in are not distributed the same way throughout the body. Radionuclides of strontium, plutonium, and americium concentrate in the skeleton, while iodine concentrates in the thyroid. Some radionuclides, such as tritium, carbon-14, or cesium-137, however, are distributed throughout the body.

The human body has mechanisms that repair damage from exposure to radiation, but these repair processes are not always successful. Living tissue in the human body can be damaged by ionizing radiation. The severity of the damage depends upon several factors such as the following:

- The amount of exposure (low or high)
- The duration of the exposure (long-term—known as chronic, or short-term—known as acute)
- The type of radiation (alpha, beta, or gamma radiations of various energies)
- The sensitivity of the human (or organ) receiving the radiation

The greatest risk from exposure to ionizing radiation is cancer. Much of our knowledge about the risk is based on studies of more than 100,000 survivors of the atomic bombs in Hiroshima and Nagasaki, Japan, at the end of World War II. Studies of radiation industry workers and people receiving large doses of medical radiation are also important sources of information. Scientists have gained the following important information from these studies:

- The chance of developing cancer (not the seriousness or severity of the cancer) increases as the radiation dose increases.
- Cancers caused by radiation do not appear until years after the radiation exposure.
- Some people are more likely to develop cancer from radiation exposure than others.
- For people who receive low doses of radiation, the risk of cancer from radiation exposure is so small that it is not distinguishable from cancer caused by exposure to chemicals, genetics, smoking, or diet.

# Appendix C:
# Radionuclide and Chemical Names

# Appendix C Radionuclide and Chemical Names

**Table C.1. Names and abbreviations for elements and chemical constituents**

| Constituent | Symbol | Constituent | Symbol |
|---|---|---|---|
| Aluminum | Al | Mercury | Hg |
| Ammonia | $NH_3$ | Nickel | Ni |
| Antimony | Sb | Nitrogen | N |
| Arsenic | As | Nitrate ion | $NO_{3-}$ |
| Barium | Ba | Nitrite ion | $NO_{2-}$ |
| Beryllium | Be | Phosphate ion | $PO_4^{2-}$ |
| Cadmium | Cd | Potassium | K |
| Calcium | Ca | Selenium | Se |
| Chromium | Cr | Silver | Ag |
| Cobalt | Co | Sodium | Na |
| Copper | Cu | Sulfate ion | $SO_{4-}$ |
| Iron | Fe | Thallium | Tl |
| Lead | Pb | Uranium | U |
| Magnesium | Mg | Vanadium | V |
| Manganese | Mn | Zinc | Zn |

**Table C.2. Selected names, abbreviations, and half-life for radionuclides**

| Radionuclide | Symbol | Half-life (years) |
|---|---|---|
| Americium-241 | Am-241 | 432.2 |
| Cesium-137 | Cs-137 | 30.1671 |
| Neptunium-237 | Np-237 | 2,144,000 |
| Plutonium-238 | Pu-238 | 87.7 |
| Plutonium-239 | Pu-239 | 24,110 |
| Plutonium-240 | Pu-240 | 6,564 |
| Technetium-99 | Tc-99 | 211,100 |
| Thorium-228 | Th-228 | 1.9116 |
| Thorium-230 | Th-230 | 75,380 |
| Thorium-232 | Th-232 | 14,050,000,000 |
| Uranium-233 | U-233 | 159,200 |
| Uranium-234 | U-234 | 245,500 |
| Uranium-235 | U-235 | 704,000,000 |
| Uranium-236 | U-236 | 23,420,000 |
| Uranium-238 | U-238 | 4,468,000,000 |

Source: DOE-STD-1196-2022, *Derived Concentration Technical Standard*, Table 9.

Note:
Not all of the radionuclides listed above are found at the Paducah Site.

# Appendix D:
# Units of Measure

# Appendix D Units of Measure

Due to differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. This list of units of measure and conversion factors is intended to help readers make approximate conversions to other units, as needed, for specific calculations and comparisons.

**Table D.1. Units of measure and their abbreviations**

| | | | |
|---|---|---|---|
| becquerel | Bq | micrometer | µm |
| British thermal unit | Btu | millicurie | mCi |
| centimeter | cm | milligram | mg |
| curie | Ci | milliliter | mL |
| day | d | millimeter | mm |
| degrees Celsius | °C | million | M |
| degrees Fahrenheit | °F | million gallons per day | MGD |
| disintegrations per minute | dpm | millirad | mrad |
| foot | ft | millirem | mrem |
| gallon | gal | milliroentgen | mR |
| gallons per minute | gal/min | millisievert | mSv |
| gram | g | minute | min |
| gray | Gy | nanogram | ng |
| gross square feet | gsf | parts per billion | ppb |
| hectare | ha | parts per million | ppm |
| hour | h | parts per trillion | ppt |
| inch | in. | picocurie | pCi |
| joule | J | pound | lb |
| kilocurie | kCi | pound mass | lbm |
| kilogram | kg | pounds per square inch | psi |
| kilometer | km | pounds per square inch gauge | psig |
| kilowatt | kW | quart | qt |
| linear feet | LF | radiation absorbed dose | rad |
| liter | L | roentgen | R |
| megajoule | MJ | roentgen equivalent man | rem |
| megawatt | MW | second | S |
| megawatt-hour | MWh | sievert | Sv |
| meter | m | standard unit (pH) | SU |
| metric tons | MT | ton (2,000 lb) | ton |
| microcurie | µCi | yard | yd |
| microgram | µg | year | yr |

**Table D.2. Quantitative prefixes**

| | | | |
|---|---|---|---|
| exa | $\times 10^{18}$ | atto | $\times 10^{-18}$ |
| peta | $\times 10^{15}$ | femto | $\times 10^{-15}$ |
| tera | $\times 10^{12}$ | pico | $\times 10^{-12}$ |
| giga | $\times 10^{9}$ | nano | $\times 10^{-9}$ |
| mega | $\times 10^{6}$ | micro | $\times 10^{-6}$ |
| kilo | $\times 10^{3}$ | milli | $\times 10^{-3}$ |
| hecto | $\times 10^{2}$ | center | $\times 10^{-2}$ |
| deka | $\times 10^{1}$ | decic | $\times 10^{-1}$ |

**Table D.3. Unit conversions**

| Unit | Conversion | Equivalent | Unit | Conversion | Equivalent |
|---|---|---|---|---|---|
| **Length** | | | | | |
| in. | × 2.54 | cm | cm | × 0.394 | in. |
| ft | × 0.305 | m | m | × 3.28 | ft |
| mile | × 1.61 | km | km | × 0.621 | mile |
| **Area** | | | | | |
| acre | × 0.405 | ha | ha | × 2.47 | acre |
| $ft^2$ | × 0.093 | $m^2$ | $m^2$ | × 10.764 | $ft^2$ |
| $mile^2$ | × 2.59 | $km^2$ | $km^2$ | × 0.386 | $mile^2$ |
| **Volume** | | | | | |
| $ft^3$ | × 0.028 | $m^3$ | $m^3$ | × 35.31 | $ft^3$ |
| qt (US liquid) | × 0.946 | L | L | × 1.057 | qt (US liquid) |
| gal | × 3.7854118 | L | L | × 0.264172051 | gal |
| **Concentration** | | | | | |
| ppb | × 1 | µg/kg | µg/kg | × 1 | ppb |
| ppm | × 1 | mg/kg | mg/kg | × 1 | ppm |
| ppb | × 1 | µg/L | µg/L | × 1 | ppb |
| ppm | × 1 | mg/L | mg/L | × 1 | ppm |
| **Weight** | | | | | |
| lb | × 0.4536 | kg | kg | × 2.205 | lb |
| lbm | × 0.45356 | kg | kg | × 2.2046226 | lbm |
| ton, short | × 907.1847 | kg | kg | × 0.00110231131 | ton, short |
| **Temperature** | | | | | |
| °C | °F = (9/5)°C + 32 | °F | °F | °C = (5/9) (F–32) | °C |
| **Activity** | | | | | |
| Bq | $\times 2.7 \times 10^{-11}$ | Ci | Ci | $\times 3.7 \times 10^{10}$ | Bq |
| Bq | × 27 | pCi | pCi | × 0.037 | Bq |
| mSv | × 100 | mrem | mrem | × 0.01 | mSv |
| Sv | × 100 | rem | rem | × 0.01 | Sv |
| nCi | × 1,000 | pCi | pCi | × 0.001 | nCi |
| $mCi/km^2$ | × 1 | $nCi/m^2$ | $nCi/m^2$ | × 1 | $mCi/km^2$ |
| dpm/L | $\times 0.45 \times 10^9$ | $\mu Ci/cm^3$ | $\mu Ci/cm^3$ | $\times 2.22 \times 10^9$ | dpm/L |
| pCi/L | $\times 10^{-9}$ | µCi/mL | µCi/mL | $\times 10^9$ | pCi/L |
| $pCi/m^3$ | $\times 10^{12}$ | $\mu Ci/cm^3$ | $\mu Ci/cm^3$ | $\times 10^{12}$ | $pCi/m^3$ |