U.S. Department of Energy

Portsmouth Gaseous Diffusion Plant

Annual Site Environmental Report 2019

December 2020

U.S. Department of Energy
Portsmouth Gaseous Diffusion Plant
Annual Site Environmental Report – 2019
Piketon, Ohio

U.S. Department of Energy
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December 2020

By
Fluor-BWXT Portsmouth LLC, under Contract DE-AC30-10CC40017

FBP-ER-RCRA-WD-RPT-0349, Revision 2

This document has been approved for public release:

Samuel C. Eldridge (signature on file)	12/22/2020
Classification Office	Date

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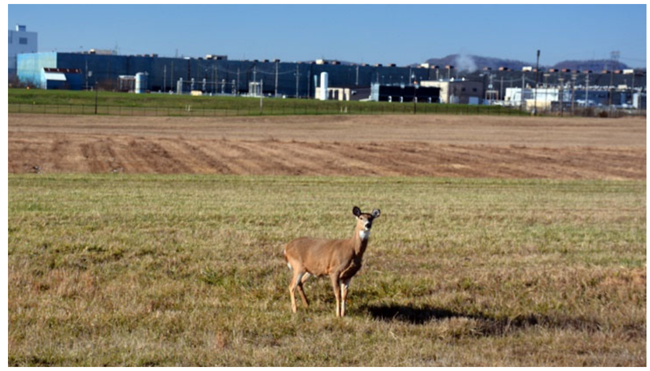
ACRONYMS AND ABBREVIATIONS

ACO	American Centrifuge Operating, LLC
ACP	American Centrifuge Plant
ALARA	as low as reasonably achievable
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Ci	curie
D&D	decontamination and decommissioning
DAS	Disposal Authorization Statement
D&D DFF&O	*The April 13, 2010 Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action, including the July 16, 2012 Modification thereto* (Ohio EPA 2012)
DOE	U.S. Department of Energy
dps	disintegration per second
DUF_6	depleted uranium hexafluoride
EMS	Environmental Management System
EPEAT	Electronic Product Environmental Assessment Tool
FBP	Fluor-BWXT Portsmouth LLC
IRM	interim remedial measure
kg	kilogram
lbs	pounds
LFRG	Low-level Waste Disposal Facility Review Group
LLW	low-level radioactive waste
µg/g	microgram per gram (equivalent to part per million)
µg/kg	microgram per kilogram (equivalent to part per billion)
µg/L	microgram per liter (equivalent to part per billion)
$\mu g/m^3$	microgram per cubic meter
MCS	Mid-America Conversion Services, LLC
mg/L	milligram per liter (equivalent to part per million)
mrem	millirem
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
Ohio EPA	Ohio Environmental Protection Agency
OREIS	Oak Ridge Environmental Information System
OSWDF	on-site waste disposal facility
OVEC	Ohio Valley Electric Corporation
PCB	polychlorinated biphenyl
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEMS	Project Environmental Measurements System
PK	Peter Kiewit
PMA	Portsmouth Mission Alliance, LLC

PORTS	Portsmouth Gaseous Diffusion Plant
ppb	part per billion
ppm	part per million
PPPO	Portsmouth/Paducah Project Office
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
SODI	Southern Ohio Diversification Initiative
TCE	trichloroethene
TLD	thermoluminescent dosimeter
TSCA	Toxic Substances Control Act
USEC	United States Enrichment Corporation
U.S. EPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (PORTS) is located on a 5.8-square-mile site in a rural area of Pike County, Ohio. The site is 2 miles east of the Scioto River. PORTS, which produced enriched uranium via the gaseous diffusion process from 1954 to 2001, is one of three former uranium enrichment plants used for national security and the commercial sector.



Deer at the Portsmouth Site

Since 1989 DOE's Office of Environmental Management (EM) has been conducting environmental cleanup at PORTS. DOE and its contractors' activities at the site include:

- Environmental remediation, or the cleanup of soil, groundwater and other environmental media from past operations;
- Decontamination and demolition of gaseous diffusion process buildings and associated facilities;
- Disassembly and removal of equipment, removal of wastes including asbestos, PCBs, and hazardous waste, and deactivation of utilities and other systems;
- Reuse and recycling of excess equipment, clean scrap materials, and other items with priority given to transfer to the local community;
- Characterization and disposal of wastes stored or generated on site, including monitoring and maintenance of closed landfills; and
- Conversion of depleted uranium hexafluoride cylinders.

DOE conducts environmental monitoring to assess the impact, if any, that site activities may have on public health and the environment. In 2019, more than 10,000 samples of air, water, external radiation, soil, sediment, vegetation, fish, and wildlife were collected from on and around PORTS and analyzed for radioactive and nonradioactive contaminants.

Each year DOE PORTS 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 PORTS. This report and previous ASERs can be found at www.energy.gov/pppo/downloads/portsmouth-annual-site-environmental-reports-0.

Chapters within the ASER provide a more detailed overview of the activities at PORTS, including:

Chapter 1: an introduction to the activities at the site;
Chapter 2: a summary of compliance with laws and regulations;
Chapter 3: details about environmental programs conducted on site;
Chapter 4: radiological environmental monitoring conducted at the site;
Chapter 5: non-radiological monitoring, such as metals and PCBs;
Chapter 6: groundwater monitoring; and
Chapter 7: a summary of the actions taken to ensure the quality of information collected from the monitoring programs.

Major components of the environmental monitoring completed by DOE in 2019 are summarized below:

- Discharges of radionuclides, chemicals, and other water quality parameters to Little Beaver Creek, the Scioto River, or other water bodies were measured at 11 locations called National Pollutant Discharge Elimination System (NPDES) outfalls.

- External radiation was measured continuously at 24 on and off-site locations. The measurements were collected quarterly.

- Ambient air was sampled at 16 locations on and off site and analyzed for radionuclides and/or fluoride.

- Surface water samples were collected semiannually from 14 locations on and off-site and analyzed for radionuclides.

- Sediment was sampled at 18 locations and analyzed for radionuclides, metals, and PCBs.

- Soil samples were collected at 15 locations, including on-site, fence line, off-site and background locations and analyzed for radionuclides.

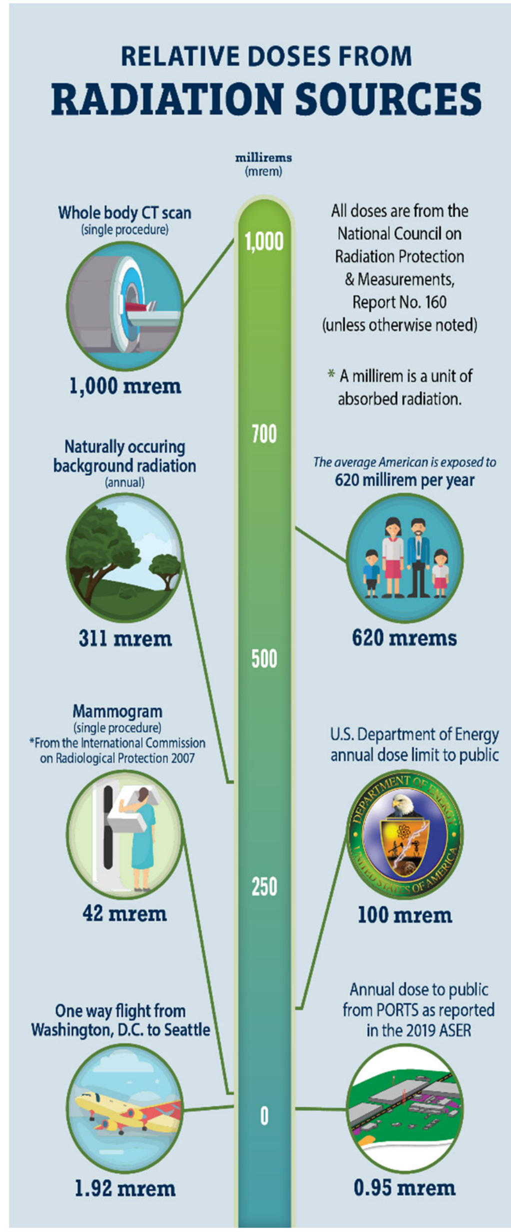
- Biota samples, including vegetation, deer, fish, food crops, milk, and eggs, were analyzed for radionuclides. Fish were also analyzed for PCBs.

- More than 300 wells were sampled at varying frequencies to monitor remedial actions, movement of groundwater contaminants, and groundwater quality.

2019 Environmental Performance Summary

In 2019, DOE's monitoring performance at PORTS is summarized below:

- Environmental monitoring data collected in 2019 were similar to data collected in recent years indicating radionuclides, metals, and other chemicals released by PORTS would have a minimal effect on human health and the environment.
- The dose of radiation (based on calculations) that could be received by a member of the public from all pathways of exposure was 0.95 millirem (mrem)/year, which is less than 1% of the DOE annual dose limit of 100 mrem/year.
- Concentrations of most contaminants detected within the groundwater plumes at PORTS were stable or decreasing in 2019. Concentrations of trichloroethene (TCE) or metals were increasing in a few wells in the monitoring areas. These areas continue to be closely monitored. Changing TCE concentrations in the X-701B monitoring area and near the Little Beaver Creek are being further investigated.
- Results for the residential water supply monitoring program indicated that PORTS has not affected drinking water wells outside the site boundaries.
- Ambient air monitoring contaminant levels for both radionuclides and fluoride continued to be either not detected, detected below DOE standards, or within background levels.
- Surface water monitoring contaminant levels for radionuclides at on-site and off-site locations upstream and downstream from PORTS continued to be either not detected or below DOE standards.
- Sampling of sediment in 2019 for metals indicated that no appreciable differences were evident in the concentrations upstream and downstream from PORTS. Contaminant levels for radionuclides were within background levels or below DOE standards.



- PCBs were detected in on-site sediment samples and are being addressed as a part of the ongoing site cleanup mission. Concentrations in off-site sediment samples were below the level of concern established by regional screening levels of the U.S. Environmental Protection Agency (EPA) and Ohio EPA.
- Contaminant levels for radionuclides in soil were within background levels or below DOE standards.
- Radionuclides were not detected in samples of deer, fish, food crops, milk, and eggs collected in 2019.

- In 2019, PCBs were detected in fish caught in on-site and off-site creeks within the range of concentrations detected in recent years. The detections were within the consumption advisory limits set by the Ohio Department of Health.

During 2019, PORTS reported the following:

- Five water discharge locations called NPDES outfalls exceeded discharge limits set by Ohio EPA for total suspended solids, which are soil and other particles in water that make the water cloudy. These exceedances were caused by a combination of excessive rainfall and operational issues. Operational issues were corrected immediately. Another outfall exceeded discharge limits for TCE. Equipment maintenance immediately corrected the issue.

- DOE's contractor instituted updated maintenance actions and policy enhancements in response to a Notice of Violation (NOV) from Ohio EPA related to three issues pertaining to the NPDES permit. These issues included the exceedances of the discharge limitation for total suspended solids that were discussed above.

- An inaccurate field measurement instrument for drinking water resulted in two NOVs from Ohio EPA. The instrument was replaced and manganese concentrations measured by the new instrument were confirmed to be less than secondary drinking water standards by both the PORTS on-site laboratory and an independent off-site analytical laboratory.

- An Ohio EPA Resource Conservation and Recovery Act (RCRA) inspection noted a visible oil stain beneath a transformer at the X-530 Switchyard, resulting in an NOV. DOE's contractor removed and properly disposed the first nine inches of contaminated ballast (similar to gravel) from beneath the transformer, installed drip collection systems on transformers to collect inadvertent leaks and prevent future releases to the environment, and developed and implemented an inspection program to monitor for oil leaks in the switchyard and drip collection systems.

DOE and its contractors at PORTS are committed to enhancing environmental stewardship and to reducing any impacts that site operations may cause to the environment. PORTS implements sound stewardship practices in the protection of land, air, water, and other natural or cultural resources potentially impacted by their operations. A report of progress in achieving specified Environmental Management System (EMS) goals is submitted annually to DOE Headquarters. The environmental stewardship scorecard for PORTS in fiscal year 2019 was green, which indicates standards for the Environmental Management System implementation were met.

A complete summary of the environmental programs can be found in the chapters following this Executive Summary.

1. INTRODUCTION

1.1 SUMMARY

The Portsmouth Gaseous Diffusion Plant (PORTS) is located on a 5.8-square-mile site in a rural area of Pike County, Ohio (see Figure 1.1). U.S. Department of Energy (DOE) activities at PORTS include decontamination and decommissioning (D&D) of the process buildings and associated facilities formerly used for the gaseous diffusion process of uranium enrichment, environmental restoration, waste management, and uranium operations. Fluor-BWXT Portsmouth LLC (FBP) is the DOE contractor that manages D&D of PORTS, which includes the three gaseous diffusion process buildings and other associated facilities. The Depleted Uranium Hexafluoride (DUF_6) Conversion Facility at PORTS began full scale operations in 2011 to manage the inventory of DUF_6, which was a product of the gaseous diffusion process. Mid-America Conversion Services, LLC (MCS) managed the DUF_6 Conversion Facility in 2019.

1.2 BACKGROUND INFORMATION

PORTS, which produced enriched uranium via the gaseous diffusion process from 1954 through 2001, is owned by DOE. In 1993, DOE leased the uranium production facilities at the site to United States Enrichment Corporation (USEC), which was established by the Energy Policy Act of 1992. USEC produced enriched uranium in the gaseous diffusion process facilities through 2001.

DOE is responsible for D&D of the gaseous diffusion process buildings and associated facilities, environmental restoration, waste management, and uranium operations. DOE contractors FBP, Portsmouth Mission Alliance, LLC (PMA), and MCS managed DOE programs at PORTS in 2019.

Figure 1.1 The Portsmouth Gaseous Diffusion Plant.
(looking from the north-northeast towards the south-southwest)

FBP managed the following activities:

- D&D of the former gaseous diffusion process building and associated facilities;
- environmental restoration of contaminated areas;
- monitoring and reporting on environmental compliance;
- disposition of D&D waste and legacy radioactive waste;
- security forces;
- uranium management; and
- operation of the site's waste storage facilities.

PMA managed the following facility support services:

- computer and telecommunications services;
- security;
- training;
- records management;
- fleet management;
- non-nuclear facility preventive and corrective maintenance;
- grounds and road maintenance;
- snow removal; and
- janitorial services.

In 2019, MCS managed the DUF_6 Conversion Facility, including surveillance and maintenance of DUF_6 cylinders and environmental compliance and monitoring activities associated with operation of the facility. DUF_6, which is a product of the uranium enrichment process, is stored in cylinders on site. The DUF_6 Conversion Facility converts DUF_6 into uranium oxide and aqueous hydrogen fluoride. The uranium oxide is made available for beneficial reuse, storage, or disposal, and the aqueous hydrogen fluoride is sold for reuse.

USEC, Inc. (the parent company of USEC) became Centrus Energy Corp. (Centrus) in 2014 after a financial restructuring. A Centrus affiliate, American Centrifuge Operating, LLC (ACO), continues to lease facilities at PORTS that were intended for the development of gaseous centrifuge uranium enrichment technology. ACO currently has a U.S. Nuclear Regulatory Commission (NRC) materials license for a demonstration facility on the leased premises. In 2016, the American Centrifuge Lead Cascade Facility (Lead Cascade) was shut down and all Lead Cascade decommissioning activities completed. In 2018, a final status radiological survey demonstrated that the Lead Cascade areas met regulatory radiological criteria for unrestricted use and the more restrictive Lead Cascade License Application limits. In 2019, DOE awarded a contract to Centrus to demonstrate production of high-assay, low-enriched uranium for advanced nuclear reactors. At the end of 2019, the ACO NRC materials license remained active and no NRC-regulated materials were present at the Lead Cascade.

This report is intended to fulfill the requirements of DOE Order 231.1B, *Environment, Safety and Health Reporting*. This DOE Order requires development of an annual site environmental report that includes information on regulatory compliance, environmental programs, radiological and non-radiological monitoring programs, groundwater programs, and quality assurance. The Annual Site Environmental Report also provides the means by which DOE demonstrates compliance with the radiation protection requirements of DOE Order 458.1 *Radiation Protection of the Public and the Environment*.

This report is not intended to present all of the monitoring data at PORTS. Additional data collected for other site purposes, such as D&D, environmental restoration, and waste management, are presented in other documents that have been prepared in accordance with applicable legal agreements and regulations. These data are presented in other reports, such as the *2019 Groundwater Monitoring Report* (DOE 2020), which are available at the PORTS Environmental Information Center.

1.3 DESCRIPTION OF SITE LOCALE

PORTS is located in a rural area of Pike County, Ohio, on a 5.8-square-mile site. The site is 2 miles east of the Scioto River in a small valley running parallel to and approximately 120 feet above the Scioto River floodplain. Figure 1.2 depicts the plant site within the State of Ohio and its immediate environs.

Pike County has approximately 27,772 residents (U.S. Census Bureau 2020). Scattered rural development is typical; however, the county contains a number of small villages such as Piketon and Beaver that lie within a few miles of the plant. The county's largest community, Waverly, is about 10 miles north of the plant and has a population of about 4,236 residents (U.S. Census Bureau 2020). The nearest residential center in this area is Piketon, which is 1 to 4 miles north of the plant and has a population of about 2,140 (U.S. Census Bureau 2020). A number of residences are located adjacent to the plant boundary.

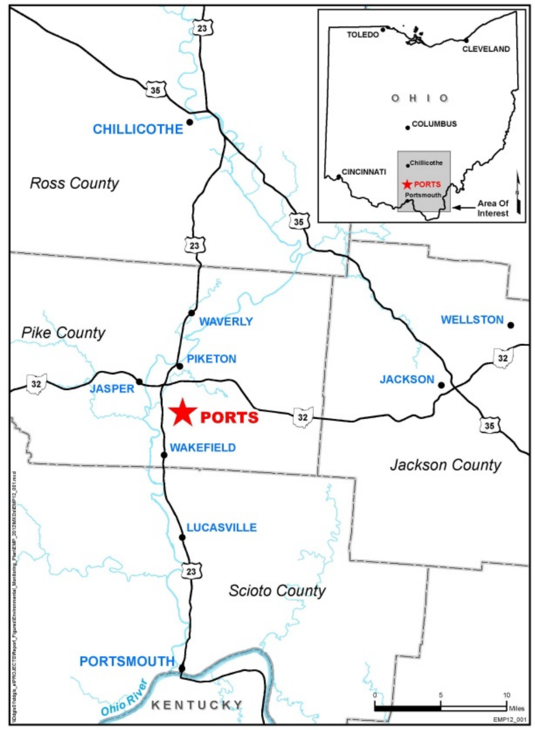


Figure 1.2. Location of PORTS.

Additional cities within 50 miles of the plant are Portsmouth (population 20,158), 22 miles south; Chillicothe (population 21,722), 27 miles north; and Jackson (population 6,230), 18 miles east (U.S. Census Bureau 2020). The total population within 50 miles of the plant is approximately 662,000 persons, which includes people on the outskirts of Cincinnati and Columbus, Ohio; Ashland, Kentucky; and Huntington, West Virginia.

1.4 DESCRIPTION OF SITE OPERATIONS

DOE, through its managing contractors, is responsible for D&D of the gaseous diffusion uranium enrichment buildings and associated facilities, environmental restoration, and waste management associated with DOE activities. DOE is also responsible for uranium management, which includes the DUF_6 Conversion Facility.

D&D includes the gaseous diffusion process buildings and associated facilities subject to *The April 13, 2010 Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action, including the July 16, 2012 Modification thereto* (D&D DFF&O) [Ohio Environmental Protection Agency (Ohio EPA) 2012]. D&D activities can consist of deactivation of equipment; removal and cleaning of process residues from equipment, structures, and piping; and dismantlement, demolition, and removal of equipment, structures, piping, and concrete foundations. The D&D Program is also responsible for conducting an evaluation of alternatives for disposition of waste generated by D&D.

The goal of the Environmental Restoration Program is to verify that releases from past operations at PORTS are thoroughly investigated and that, if applicable, remedial actions are taken to protect human health and the environment. Environmental restoration is the investigation and remediation of environmental contamination associated with the past operation of the gaseous diffusion uranium enrichment facilities. Remedial investigations and remedial actions define the nature and extent of environmental contamination, evaluate the potential risk to public health and the environment, remediate areas of environmental contamination, and monitor/evaluate ongoing remedial actions.

Waste management includes managing wastes generated by DOE activities at PORTS, including wastes generated by D&D, environmental restoration, the DUF_6 Conversion Facility, and other DOE site activities. Wastes must be identified and stored in accordance with all environmental regulations. The responsible DOE contractor also arranges the transportation and disposal of wastes. The goal of the Waste Management Program is to manage waste from the time it is generated to its ultimate treatment, recycling, or disposal in accordance with all applicable regulations and DOE Orders.

DOE is also responsible for uranium management, which includes management of uranium product, coordination of the DUF_6 program, and warehousing of other uranium materials such as normal uranium hexafluoride, uranium oxides, and uranium metal.

2. COMPLIANCE SUMMARY

2.1 SUMMARY

In 2019, DOE and/or the responsible DOE contractor (FBP and MCS) held permits for discharge of water to surface streams, air emission permits, and a permit for the storage of hazardous wastes. FBP is responsible for the National Pollutant Discharge Elimination System (NPDES) outfalls and air emission permits that were associated with the gaseous diffusion plant. MCS is responsible for activities associated with the DUF_6 Conversion Facility. Centrus is responsible for compliance activities directly associated with the American Centrifuge Plant (ACP).

FBP and MCS are responsible for preparing a number of reports for compliance with various applicable environmental regulations. These reports may include all or a subset of the following reports (for MCS): an annual groundwater monitoring report, a biennial hazardous waste report, an annual polychlorinated biphenyl (PCB) document log, an annual summary of radionuclide air emissions and the associated dose to the public from these emissions, annual or biennial reports of specified non-radiological air emissions, a monthly report of NPDES monitoring data, an annual hazardous chemical inventory, and an annual toxic chemical release inventory. Additional information on each of these reports is provided within this chapter.

DOE activities at PORTS are inspected regularly by the federal, state, and local agencies responsible for enforcing environmental regulations at PORTS. FBP received four Notices of Violation from Ohio EPA in 2019. Two of these Notices of Violation related to the operation of PORTS drinking water system. Both Notices of Violation were due to an exceedance of the secondary drinking water standard for manganese: 0.05 milligram per liter (mg/L). Secondary drinking water standards are non-health-based guidelines for managing the aesthetic qualities of drinking water (such as taste, color, or odor). The reported exceedance began in March and ended in April resulting in two Notices of Violation. The exceedance was not due to issues with water quality, but was caused by an inaccurate field measurement instrument. The instrument was replaced and manganese concentrations measured by the new instrument were confirmed by the PORTS on-site laboratory and an independent off-site analytical laboratory. All manganese concentrations were less than the secondary drinking water standard (0.05 mg/L). No further actions were required.

As a result of the Resource Conservation and Recovery Act (RCRA) inspection performed by Ohio EPA on June 25-26, 2019, FBP received a Notice of Violation due to failure to clean up oil that had been released to the environment in the X-530 Switchyard. During the inspection, Ohio EPA observed visible oil stains beneath one of the transformers.

To resolve the violation, FBP completed the following actions:

- removed and properly disposed the first nine inches of contaminated ballast (similar to gravel) from beneath the transformer,

- installed drip collection systems on transformers to collect inadvertent leaks and prevent future releases to the environment, and

- developed and implemented an inspection program to monitor for oil leaks in the switchyard and drip collection systems.

A complete cleanup of the X-530 Switchyard will be completed in the future as part of D&D of PORTS. No further actions were required.

FBP received a Notice of Violation from Ohio EPA in June 2019 related to the three issues pertaining to the NPDES permit. The issues and the responses from FBP are summarized below:

- **Exceedances of permit limitations for total suspended solids at multiple NPDES outfalls.** FBP reviewed the causes for the exceedances at each outfall. Maintenance to potentially mitigate future exceedances was identified and scheduled. Changes to operating procedures to mitigate discharges of suspended solids and additional control of upstream activities that could contribute to discharge of suspended solids were implemented. Excessive rainfall in the beginning of 2019 was also a contributing factor to the exceedances.

- **Violation of general permit conditions at the X-611B Lime Sludge Lagoon (FBP NPDES Outfall 005) that resulted in visible lime sludge deposits in Little Beaver Creek.** FBP implemented changes to the operating procedures for discharges from the X-611B Lime Sludge Lagoon to further control the discharge of suspended solids, which include lime sludge, from the lagoon. FBP is committed to reducing the lime sludge in the discharge to the extent possible given the operating requirements at the Lime Sludge Lagoon.

- **Failure to notify Ohio EPA of the significant change in the discharge from the X-611B Lime Sludge Lagoon after lime sludge deposits were discovered in Little Beaver Creek.** The lime sludge deposits were discovered on May 28, 2019 and reported to Ohio EPA on May 30, 2019 after a preliminary investigation of the field conditions, the cause of the residue, and the extent of the residue. FBP agreed to work to improve communications with the Ohio EPA Southeast District Office and to provide direct notification to the Southeast District Office of any conditions that may impact the quality of water being discharged in accordance with the NPDES permit.

2.2 COMPLIANCE INTRODUCTION

DOE is responsible for the D&D Program, Environmental Restoration Program, Waste Management Program, uranium operations, and maintenance of all facilities not leased to Centrus. FBP is responsible for air emission permits and NPDES outfalls associated with the former gaseous diffusion plant operations. MCS is responsible for activities associated with the DUF_6 Conversion Facility.

Centrus is responsible for compliance activities directly associated with the ACP including NPDES outfalls and management of wastes generated by their current operations.

DOE and/or DOE contractors (FBP and MCS) held two NPDES permits for discharge of water to surface streams, numerous air emission permits, and a RCRA Part B permit for the storage of hazardous wastes. Appendix A lists the active environmental permits and registrations held by DOE and/or DOE contractors (FBP and MCS) at the end of 2019.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at PORTS. Primary regulatory agencies include Ohio EPA and the U.S. Environmental Protection Agency (U.S. EPA). These agencies issue permits, review compliance reports, conduct joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

DOE and/or DOE contractors conduct self-assessments to identify environmental issues and consult the regulatory agencies to identify the appropriate actions necessary to achieve and maintain compliance.

2.3 COMPLIANCE STATUS

This section discusses the DOE compliance status at PORTS with respect to environmental laws and regulations, DOE Orders, and Executive Orders.

2.3.1 Environmental Restoration and Waste Management

This section discusses the DOE compliance status at PORTS with Ohio EPA and U.S. EPA regulations pertaining to environmental restoration and waste management.

2.3.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

PORTS is not on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List of sites. However, D&D of PORTS is proceeding in accordance with the D&D DFF&O and CERCLA. The D&D DFF&O describes the regulatory process for D&D of the gaseous diffusion process buildings and associated facilities that are no longer in use. Chapter 3, Section 3.2 of this report, provides additional information about the D&D Program.

Environmental remediation, or the cleanup of soil, groundwater and other environmental media contaminated by PORTS, has been conducted in accordance with the Consent Decree with the State of Ohio, issued on August 29, 1989 and the U.S. EPA Administrative Order by Consent, issued on September 29, 1989 (amended in 1994 and 1997 and terminated on February 13, 2017). Ohio EPA oversees environmental remediation activities at PORTS under the RCRA Corrective Action Program and CERCLA Program. Chapter 3, Section 3.3 of this report, provides additional information on the Environmental Restoration Program.

Section 103 of CERCLA requires notification to the National Response Center if hazardous substances are released to the environment in amounts greater than or equal to the reportable quantity. Reportable quantities are listed in CERCLA and vary depending on the type of hazardous substance released. During 2019, DOE contractors had no reportable quantity releases of hazardous substances subject to Section 103 notification requirements.

2.3.1.2 Emergency Planning and Community Right-To-Know Act

The Emergency Planning and Community Right-To-Know Act of 1986, also referred to as the Superfund Amendments and Reauthorization Act Title III, requires reporting of emergency planning information, hazardous chemical inventories, and releases to the environment. Emergency Planning and Community Right-To-Know Act reports are submitted to federal, state, and local authorities.

For emergency planning purposes, facilities must submit information on chemicals present on site above specified quantities (called the threshold planning quantity) to state and local authorities. When a new chemical is brought on site or increased to exceed the threshold planning quantity, information about the new chemical must be submitted to state and local authorities within three months.

Section 304 of the Emergency Planning and Community Right-To-Know Act requires reporting of off-site reportable quantity releases to state and local authorities**.** During 2019, FBP and MCS had no off-site reportable quantity releases subject to Section 304 reporting requirements.

The Hazardous Chemical Inventory Report includes the identity, location, storage information, and hazards of the chemicals present on site in amounts above the threshold planning quantities specified by U.S. EPA. This report is submitted annually to state and local authorities. Table 2.1 lists the chemicals reported by the PORTS site, which included DOE contractors or lessees (FBP, PMA, MCS, and Centrus) for 2019:

Table 2.1. Chemicals reported in the Hazardous Chemical Inventory Report for 2019

1,2-propanediol	hydrogen fluoride	sodium chloride
aluminum oxide	lime calcium oxide	sodium hydroxide
aluminum oxide hydrate	lubricating oils	sulfuric acid
argon	methanol	triuranium octaoxide
asbestos	mineral oils	uranium oxide
carbon dioxide	nitric acid	uranium hexafluoride
citric acid	nitrogen	uranium metal
diesel fuel #2 (ultralow sulfur)	PCBs	uranium tetrafluoride
ethylene glycol	perfluoro-1,3-dimethylcyclohexane	
fluorotrichloromethane (CFC-11)	petroleum distillates	
gasoline	potassium hydroxide	

The Toxic Chemical Release Inventory is sent annually to U.S. EPA and Ohio EPA. This report details releases to the environment of specified chemicals when they are manufactured, processed, or otherwise used by the entire site in amounts that exceed threshold quantities specified by U.S. EPA. For this report, U.S. EPA defines a release to include on-site treatment, off-site disposal, and recycling conducted in accordance with regulations.

For 2019, DOE contractors reported the permitted release and/or off-site treatment of two chemicals:

- hydrogen fluoride: approximately 36 pounds (lbs) released to the air from the DUF_6 Conversion Facility; and

- nitrate compounds: approximately 34,000 lbs released to the Scioto River through permitted NPDES outfalls (from water treatment).

2.3.1.3 Resource Conservation and Recovery Act

RCRA regulates the generation, accumulation, storage, transportation, and disposal of solid and hazardous wastes. “Solid wastes,” as defined by Ohio EPA, can be solids, liquids, sludges, or other materials. Hazardous wastes are a subset of solid wastes, and are designated as hazardous by Ohio EPA because of various chemical properties, including ignitability, corrosivity, reactivity, and toxicity.

Hazardous waste. DOE and FBP hold a permit to store hazardous waste at PORTS. The permit, often called a Part B Permit, was issued to DOE and the responsible DOE contractor in 1995, and renewed by Ohio EPA in 2001 and 2011. The permit governs the storage of hazardous waste and includes requirements for waste identification, inspections of storage areas and emergency equipment, emergency procedures, training requirements, and other information required by Ohio EPA.

Facilities such as PORTS that generate or store hazardous waste are required to submit a biennial report to Ohio EPA (in even-numbered years) that covers waste shipped in the previous odd-numbered year (i.e., waste shipped in even-numbered years no longer requires reporting). DOE submitted the report for calendar year 2019 to Ohio EPA in February 2020. This biennial 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. Chapter 3, Section 3.4, Waste Management Program, provides additional information on wastes from DOE activities at PORTS that were recycled, treated, or disposed in 2019.

RCRA also requires groundwater monitoring at certain hazardous waste management units. As discussed in Chapter 6, groundwater monitoring requirements at PORTS have been integrated into one document, the *Integrated Groundwater Monitoring Plan* (DOE 2017c). Hazardous waste management units monitored in accordance with the *Integrated Groundwater Monitoring Plan* include the X-749 Contaminated Materials Disposal Facility (northern portion), X-231B Southwest Oil Biodegradation Plot (Quadrant I Groundwater Investigative [5-Unit] Area), X-701C Neutralization Pit (Quadrant II Groundwater Investigative [7-Unit] Area), X-701B Former Holding Pond, X-701B retention basins, X-744Y Waste Storage Yard (X-701B area), X-230J7 Holding Pond (X-701B area), X-616 Former Chromium Sludge Surface Impoundments, and X-735 RCRA Landfill (northern portion). Chapter 6 discusses the groundwater monitoring requirements for these units.

A groundwater report that summarizes the results of monitoring completed in accordance with the *Integrated Groundwater Monitoring Plan* is submitted annually to Ohio EPA (DOE 2020). Chapter 6 discusses these monitoring results for 2019.

MCS is regulated as a small quantity hazardous waste generator. Small quantity hazardous waste generators are subject to requirements for generation and accumulation of hazardous waste. These requirements include proper waste identification, use of appropriate containers, availability of emergency equipment, and specified shipment information.

Solid waste disposal facilities. Groundwater monitoring may be required at closed solid waste disposal facilities, such as landfills. Groundwater monitoring requirements for the closed X-734 Landfills, X-735 Industrial Solid Waste Landfill, and X-749A Classified Materials Disposal Facility are included in the *Integrated Groundwater Monitoring Plan* (DOE 2017c). Chapter 6 discusses the groundwater monitoring results for these units in 2019. There are no solid waste landfills currently operating at PORTS.

2.3.1.4 Federal Facility Compliance Act

Waste that is a mixture of RCRA hazardous waste and low-level radioactive waste (LLW) is currently stored at PORTS. RCRA hazardous waste is subject to Land Disposal Restrictions, which with limited exceptions do not allow the storage of hazardous waste for longer than one year. The Federal Facility Compliance Act, enacted by Congress in 1992, allows for the storage of mixed hazardous/LLW for longer than one year because treatment for this type of waste is not readily available. The Act also requires federal facilities to develop and submit site treatment plans for treatment of mixed wastes. On October 4, 1995, Ohio EPA issued a Director's Final Findings and Orders allowing the storage of mixed waste beyond one year and approving the proposed Site Treatment Plan. An annual update to the Site Treatment Plan is required by these Director's Final Findings and Orders. The annual update to the Site Treatment Plan for fiscal year 2019 was submitted to Ohio EPA in December 2019.

2.3.1.5 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) regulates the use, storage, and disposal of PCBs, which are most commonly found in older electrical power system components, such as transformers and capacitors. The PCB transformers and capacitors that were present in the gaseous diffusion process buildings have been removed from service. Twelve pole-mounted PCB transformers were in service within the PORTS facility at the end of 2019.

An annual document log is prepared to meet TSCA regulatory requirements. The document log provides an inventory of PCB items in use, in storage as waste, and shipping/disposal information for PCB items disposed in 2019. The *2019 PCB Document Log for the Portsmouth Gaseous Diffusion Plant* was prepared in June 2020. Approximately 317 tons of PCB waste (gross weight) was generated in 2019. Approximately 247 tons of PCB waste (gross weight) was shipped for disposal in 2019. Waste contaminated with PCBs was generated during 2019 through D&D activities in the process buildings and other areas.

A Uranium Enrichment TSCA Compliance Agreement between DOE and U.S. EPA, effective in 1992 and modified in 2017, addresses PCB management issues at PORTS including:

- the use, management, storage, and disposal of PCBs in ventilation duct gaskets and its associated collection and containment system;

- a negotiated schedule for clean-up, removal, and management of PCB wastes and contaminated items; and

- on-going air monitoring and management of PCB spill clean-ups.

Annual reports of progress made toward milestones specified in the TSCA Compliance Agreement are submitted to U.S. EPA. DOE was in compliance with the requirements and milestones of this TSCA Compliance Agreement during 2019.

The DUF_6 Conversion Facility stores and processes cylinders containing DUF_6 that may have paint containing greater than 50 parts per million (ppm) of PCBs present on the outside of the cylinders. The cylinders are stored in the X-745C, X-745E and X-745G Cylinder Storage Yards. The cylinders are stored in accordance with an agreement with U.S. EPA that includes monitoring of PCBs in surface water and sediment in drainage basins downstream from the cylinder storage yards. Chapter 5, Sections 5.4.2 and 5.5.2 provide the results of this surface water and sediment sampling, respectively.

2.3.1.6 Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides were used by DOE contractors in 2019.

2.3.2 Radiation Protection

This section discusses the DOE compliance status with DOE Orders pertaining to radiation protection and management of radioactive waste.

2.3.2.1 DOE Order 458.1, *Radiation Protection of the Public and the Environment*

The purpose of DOE Order 458.1 is to establish requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE pursuant to the Atomic Energy Act of 1954, as amended. The objectives of DOE Order 458.1 are:

- conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in the Order and are as low as reasonably achievable, and

- ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and assess the radiation dose to members of the public.

DOE Order 458.1 requires that off-site radiation doses do not exceed 100 millirem (mrem)/year above background for all exposure pathways. Chapter 4 provides the dose calculations or monitoring results that demonstrate compliance with this DOE Order.

2.3.2.2 DOE Order 435.1, *Radioactive Waste Management*

The objective of DOE Order 435.1 is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. DOE Order 435.1 applies to all high-level waste, transuranic waste, and LLW, including the radioactive component of mixed waste for which DOE is responsible. Only LLW and mixed LLW are found at PORTS. Chapter 3, Section 3.4 provides additional information about the DOE Waste Management Program at PORTS.

An on-site waste disposal facility (OSWDF) has been selected per the record of decision for waste disposition for disposal of waste generated by D&D that meets criteria for on-site disposal (see Chapter 3, Section 3.2.2). The DOE Low-level Waste Disposal Facility Review Group (LFRG) has completed an independent review of the design and planned operation of the OSWDF as presented in a Performance Assessment and Composite Analysis and determined compliance with performance objectives in DOE Order 435.1. PORTS received a Disposal Authorization Statement (DAS) for design and construction of the OSWDF from the DOE Office of Site Restoration in 2015. This DAS requires completion of the construction, along with a comparison of the as-built facility to that reviewed, and satisfaction of the conditions in the DAS, as verified by the LFRG, prior to issuance of the DAS for Operations.

2.3.3 Air Quality and Protection

This section discusses the DOE compliance status with U.S. EPA and Ohio EPA regulations pertaining to air emissions (both radionuclides and non-radiological pollutants) and stratospheric ozone protection. Chapter 4, Figure 4.3 is a map of the PORTS ambient air monitoring locations.

2.3.3.1 Clean Air Act

FBP is responsible for numerous air emission sources associated with the former gaseous diffusion production facilities and support facilities. These sources, which included the boilers at the X-600 Steam Plant Complex (prior to demolition in 2013), emitted more than 100 tons per year of non-radiological air pollutants specified by Ohio EPA, which caused DOE to become a major source of air pollutants as defined in Title 40 of the *Code of Federal Regulations* (CFR) Part 70. Ohio EPA issued the final Title V Air Permit to FBP in 2014. The X-600 Steam Plant Complex has been demolished and is no longer operating.

FBP is required to submit quarterly Title V Deviation Reports that document any deviations from requirements of the Title V permit. These quarterly reports are summarized in an annual Title V Compliance Certification. In 2019, FBP did not have any deviations from the Title V Permit requirements.

Ohio EPA requires an annual report called the Ohio EPA Fee Emissions Report to report emissions of selected non-radiological air pollutants. U.S. EPA requires an annual report of greenhouse gas emissions. Chapter 5, Section 5.3.1 provides more information about these reports and the reported emissions for FBP in 2019.

In 2019, MCS was responsible for four permitted sources associated with the DUF_6 Conversion Facility. The Annual Permit Evaluation Report for the MCS air emission sources did not report any deviations from applicable emission limits or control requirements for the emission points from the facility's three process lines. There were three deviations from the limitation to maintain negative pressure for the heating, ventilation and air conditioning system for the DUF_6 Conversion Facility. These deviations occurred during periods of planned maintenance when the facility was not operating; therefore, there was no impact to the environment. Chapter 5, Section 5.3.1, provides more information about air emissions from MCS in 2019.

Appendix A lists the FBP and MCS air emission sources at PORTS. Radiological air emissions from the DOE air emission sources are discussed in Chapter 4 and non-radiological air emissions are discussed in Chapter 5.

2.3.3.2 Clean Air Act, Title VI, Stratospheric Ozone Protection

DOE has instituted a record-keeping system consisting of forms and labels to comply with the Title VI record-keeping and labeling requirements. These requirements affect all areas that use ozone-depleting substances, such as Freon. The service record and retrofit or retirement plan forms apply to units with a capacity of more than 50 lbs. The refrigeration equipment disposal log and associated appliance disposal label are used by all units regardless of capacity. The technicians who service equipment under DOE control are trained in accordance with U.S. EPA requirements.

2.3.3.3 National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from DOE Facilities (40 CFR Part 61, Subpart H) requires DOE to submit an annual report for radiological emissions from DOE air emission sources.

In 2019, it was discovered that an error was made during preparation of the annual NESHAP report in the calculation of dose at the ambient air monitoring stations. The error involved the misapplication of the conversion factor converting concentration to dose. In 2014 and 2016, an additional error was found in compiling radiological emissions from the FBP point sources. The mistakes were also reported in the respective Annual Site Environmental Reports in the summaries of NESHAP information. Errata pages were prepared for the respective Annual Site Environmental Reports and Data Reports to correct the errors. The errata pages are available with the respective original report on the DOE Portsmouth/Paducah Project Office (PPPO) web site (energy.gov/pppo).

DOE contractors FBP and MCS were both responsible for radiological air emission sources. Chapter 4, Section 4.3.2, provides the radiological dose calculations from these emissions.

FBP sources. In 2019, FBP was responsible for numerous air emission sources including 1) continuously monitored vents in the X-330 and X-333 Process Buildings and the X-344A Uranium Hexafluoride Sampling Building; 2) room ventilation exhausts and/or pressure relief vents associated with the X-710 Technical Services Building, X-705 Decontamination Facility, and the XT-847 Glove Box; and 3) the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities.

Radiological emissions from the vents in the X-330 and X-333 Process Buildings and the X-344A Uranium Hexafluoride Sampling Building were measured by continuous monitoring, if in use. Emissions from the room ventilation exhausts and vents (if in use) were estimated based on operating data and U.S. EPA emission factors. Emissions from the groundwater treatment facilities were estimated based on quarterly influent/effluent sampling and quarterly throughput. Total radiological airborne emissions from FBP sources in 2019 were 0.08568 curie (Ci) (8.568E-02 Ci).

MCS sources. In 2019, MCS was responsible for emissions from the DUF_6 Conversion Facility. Emissions from the DUF_6 Conversion Facility were based on continuous monitoring of the conversion building stack. Total radiological airborne emissions from the DUF_6 Conversion Facility in 2019 were 0.0000478 Ci (4.78E-05 Ci).

2.3.4 Water Quality and Protection

This section discusses the DOE compliance status with U.S. EPA and Ohio EPA regulations pertaining to water quality and protection.

2.3.4.1 Clean Water Act

DOE contractors FBP and MCS held NPDES permits during 2019 that allowed discharges of water to surface streams. FBP was responsible for 18 monitoring locations identified in the FBP NPDES permit.

Nine outfalls discharge directly to surface water, six outfalls discharge to another outfall before leaving the site, and three other locations that are not outfalls were also monitored. Chapter 4, Section 4.3.4.1, and Chapter 5, Section 5.4.1.1, provide additional information on the FBP NPDES outfalls. Chapter 4, Figure 4.4 is a map of the PORTS NPDES outfalls.

The MCS NPDES permit allows the discharge of process wastewaters from the DUF_6 Conversion Facility. The MCS NPDES permit provides monitoring requirements for MCS Outfall 001 that are only effective when process wastewater is being discharged through the outfall. The permit also includes requirements for MCS Outfall 602, which are effective when process wastewater is being discharged to the sanitary sewer system that flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No process wastewater was discharged through MCS Outfall 001 in 2019. Chapter 4, Section 4.3.4, and Chapter 5, Section 5.4.1.2, provide additional information on the MCS NPDES outfalls.

Data required to demonstrate compliance with the NPDES permits are submitted to Ohio EPA in monthly discharge monitoring reports (see Chapter 5, Section 5.4.1.1). Thirty permit limitations associated with the FBP NPDES permit were exceeded during 2019 (see Chapter 5, Section 5.4.1.1). The overall FBP NPDES compliance rate for 2019 was 98%. FBP received a Notice of Violation from Ohio EPA in June 2019 for violations of the NPDES permit. Section 2.4.2 provides more information about this Notice of Violation.

There were no exceedances of MCS permit limitations in 2019; therefore, the overall MCS NPDES compliance rate for 2019 was 100%.

Most of the FBP NPDES outfalls are also monitored for radionuclides (see Chapter 4, Section 4.3.4). The MCS outfalls are not monitored for radionuclides.

Stormwater runoff, water from precipitation that flows over land and is not absorbed into the ground, is regulated under the Clean Water Act because it can accumulate debris, chemicals, or other pollutants that affect water quality. Stormwater Pollution Prevention Plans are prepared for the site industrial activities under the FBP NPDES permit. Construction activities are covered by the NPDES Construction Stormwater General Permit. The Stormwater Pollution Prevention Plans include descriptions of the activities and the controls to be used to minimize impacts to stormwater runoff.

Stormwater management and drainage design will be part of site redevelopment after D&D and remediation are completed.

2.3.4.2 Safe Drinking Water Act

In 2019, FBP was responsible for operation of the PORTS drinking water system. Drinking water systems are 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. The Safe Drinking Water Act also sets health-based standards for naturally-occurring and man-made contaminants that may be found in drinking water.

PORTS obtains its drinking water from two water supply well fields west of PORTS in the Scioto River Valley buried aquifer near the Scioto River. Ohio EPA provides the parameters and schedule for sampling the drinking water for various parameters, for example: nitrate, lead, disinfection byproducts, total coliform, and chlorine. Sampling results are submitted to Ohio EPA in a monthly report. Section 2.4.2 provides information about two Notices of Violation received by FBP related to operation of the PORTS drinking water system.

2.3.5 Other Environmental Statutes

This section discusses the DOE compliance status with other applicable environmental statutes and regulations including underground storage tank regulations and the Endangered Species Act.

2.3.5.1 Underground storage tank regulations

The Underground Storage Tank Program is managed in accordance with the Ohio State Fire Marshal's Bureau of Underground Storage Tank Regulations. Underground storage tanks in the former gaseous diffusion plant buildings and associated facilities are owned by DOE. In 2019, FBP was responsible for five tanks and Centrus was responsible for one tank. These tanks include five diesel fuel tanks ranging in size from 2500 to 20,000 gallons and a 20,000 gallon gasoline tank. The registrations for these tanks are renewed annually.

2.3.5.2 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires evaluation of the environmental impacts of activities at federal facilities and of activities funded with federal dollars.

DOE has a formal program dedicated to compliance pursuant to DOE Order 451.1B*, National Environmental Policy Act Compliance Program*. Restoration actions, waste management, enrichment facilities maintenance, and other activities are evaluated to determine the appropriate level of evaluation and documentation. No environmental assessments or environmental impact statements were completed during 2019.

Routine operation and maintenance activities are also evaluated to assess potential environmental impacts. Activities not regulated under CERCLA may be covered under a categorical exclusion or other NEPA determination as defined in the regulations. These activities are considered routine and have no significant individual or cumulative environmental impacts. DOE has implemented a policy to post online specific classes of categorical exclusions as found in 10 CFR Part 1021, Appendix B to Subpart D. Categorical exclusions for PORTS are posted on the DOE PPPO website (energy.gov/pppo).

2.3.5.3 Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened wildlife and plants, and the habitat on which such species depend. When appropriate, formal consultations are made with the U.S. Fish and Wildlife Service and the Ohio Department of Natural Resources.

A study was conducted in 2013 to identify the potential presence of the federally-endangered Indiana bat (*Myotis sodalis*) and the northern long-eared bat (*Myotis septentrionalis*), in the northeastern area of PORTS that is the location for the OSWDF (see Chapter 3, Section 3.2.2). The study did not identify the presence of the federally-endangered Indiana bat in the study area. Both foraging and roosting activities were identified for the northern long-eared bat, which is listed as a threatened species. In 2015, the U.S. Fish and Wildlife Service issued a Biological Opinion that the OSWDF is not likely to jeopardize the continued existence of the northern long-eared bat.

An additional study was conducted in 2019 to assess the potential presence of the Indiana bat and the northern long-eared bat in areas where tree clearing was proposed. No Indiana bats and one northern long-eared bat were identified during the study. The U.S. Fish and Wildlife Service concurred with DOE in October 2019 that the tree-clearing activities, as proposed, were not likely to adversely affect the northern long-eared bat. Measures continue to be implemented during construction and operation of the OSWDF and other D&D activities to minimize potential impacts to bats.

2.3.5.4 National Historic Preservation Act

The National Historic Preservation Act of 1966 (NHPA) is the primary law governing the protection of historic properties. NHPA reviews consider both architectural and archeological properties. Coordination and/or consultation with the State Historic Preservation Office and other stakeholders are made as a part of the reviews. The cultural resources of three broad time periods of occupation of the PORTS property have been assessed: the prehistoric era (occupation by Native Americans until approximately 1650), the historic era (occupation by Native Americans and early settlers from 1650 through 1952) and the DOE era (from 1952 to the present).

Fifty-four prehistoric archaeological sites have been identified on PORTS property. Each of these sites was investigated, and four of the sites included sufficient artifacts such as tools, earth ovens, and pottery to be determined eligible for inclusion on the National Register of Historic Places. One of the sites eligible for inclusion on the National Register of Historic Places was located in the northeast corner of PORTS in the support area for the OSWDF. DOE worked with the State Historic Preservation Office and Tribal Nations to develop a data recovery approach for this area so that artifacts and other information could be recovered from the area (approximately 1 acre) prior to construction activities. Field work, including hand excavation of selected areas, was completed in 2015. No significant artifacts were found. A technical report documenting the data recovery processes and results was submitted to the State Historic Preservation Office in 2017. A summary-level report intended for a general audience was submitted to the State Historic Preservation Office in 2019.

Sixty-one historic era sites have been identified on PORTS property. Most of these sites were farmstead/residential sites, and investigations of the farmstead/residential sites determined that the sites were not eligible for inclusion on the National Register of Historic Places. Two sites, the Holt Cemetery and Mount Gilead Church and Cemetery are treated as if they are eligible for the National Register.

DOE has worked with the State Historic Preservation Office, Advisory Council on Historic Preservation, Tribal Nations, and individual members of the public interested in historic preservation to determine how best to document the DOE era of site history, that is, the history associated with the buildings and other areas that are part of D&D. The NHPA review for site D&D was performed as a part of the CERCLA process. The PORTS Virtual Museum (portsvirtualmuseum.org) preserves photos, video, oral histories, and other information associated with operation, remediation, and D&D of PORTS. The records of decision for process buildings and waste disposition (see Chapter 3, Section 3.2) list the activities selected to preserve the history associated with the PORTS site.

The following activities selected to preserve the history of the PORTS site have been completed:

- a Comprehensive Summary Report summarizing all NHPA-related investigations (FBP 2014);

- a Historic Context Report that documents the history of operations and facilities at PORTS from 1952 through the end of the Cold War (DOE 2017e); and

- expansion of the PORTS virtual museum to include information on prehistoric activities.

Activities selected to preserve the history of the PORTS site and document ongoing activities are:

- collection and evaluation of items recovered from PORTS facilities for potential future display;
- public outreach to local school districts and others; and
- panoramic and aerial photographs taken at regular intervals.

2.3.5.5 Archaeological and Historic Preservation Act and Archaeological Resources Protection Act

The Archaeological and Historic Preservation Act and the Archaeological Resources Protection Act require the Secretary of the Department of Interior to report to Congress on various federal archaeological activities. The Archaeological Resources Protection Act requires federal land managers to provide archaeology program information to the Secretary of the Interior for this report; information for PORTS is included in the overall DOE headquarters report.

2.3.6 DOE Order 436.1 *Departmental Sustainability*

DOE Order 436.1, *Departmental Sustainability*, requires development and implementation of an Environmental Management System (EMS) in order to protect air, water, land, and other natural or cultural resources potentially impacted by DOE operations.

FBP serves as the coordinating contractor for EMS implementation among the DOE site contractors (FBP, PMA, and MCS). A report of progress in achieving specified EMS goals is submitted annually to DOE Headquarters. These EMS goal areas, specified in Executive Order 13963 (see Section 2.3.7.2), include objectives related to the following:

- reduction of greenhouse gas emissions,
- reduction of energy consumption and intensity in site buildings,
- increased use of clean or renewable energy,
- enhanced water use efficiency and management,
- fleet management to reduce petroleum use and/or increase alternative fuel/vehicle use,
- sustainable acquisition, and
- pollution prevention and waste reduction.

In 2019, the environmental scorecard prepared for DOE PORTS (FBP, PMA, and MCS) was green, which indicates that standards for EMS implementation have been met with at least 80% of the goal areas for fiscal year 2019 addressed in the EMS. Some of the EMS goal areas are not applicable to PORTS because the facility is not operating and is preparing for D&D.

Chapter 3, Section 3.5, provides information about the DOE Environmental Sustainability Program at PORTS.

2.3.7 Executive Orders

Executive Orders are issued by the President to various federal agencies, including DOE. This section discusses the DOE compliance status at PORTS with Executive Orders pertaining to the environment.

2.3.7.1 Executive Order 11988, *Floodplain Management,* and Executive Order 11990, *Protection of Wetlands*

Title 10 of the CFR Part 1022 establishes policy and procedures for compliance with Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*.

A site-wide wetland survey report was completed and submitted to the Corps of Engineers in 1996. The 1996 survey identified 41 jurisdictional wetlands and four non-jurisdictional wetlands totaling 34.36 acres at PORTS.

A wetland and stream assessment was completed in 2013 for the northeast area of PORTS where the OSWDF is being constructed. DOE is developing mitigation strategies for wetlands and streams that will be impacted by the construction of the OSWDF in accordance with CERCLA requirements.

2.3.7.2 Executive Order 13834, *Efficient Federal Operations*

Executive Order 13834, *Efficient Federal Operations*, prioritizes meeting energy and environmental statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment. Existing activities that are part of compliance with DOE Order 436.1 (see Section 2.3.6) and the DOE Environmental Sustainability Program at PORTS (see Chapter 3, Section 3.5) support this executive order. These existing activities include improving energy and water use efficiency; encouraging site-wide recycling and material reuse; and increasing the use of alternative fuel and alternative fuel vehicles.

Green and sustainable remediation is the abatement, cleanup, or use of methods to contain, remove, or destroy contaminants while seeking to minimize the environmental, economic, and social costs of the remediation. FBP is incorporating green and sustainable remediation into the D&D activities discussed in Chapter 3. Actions being taken to support green remediation include efficient movement of materials to reduce fuel usage, efforts to minimize water usage and control runoff, and recycling/reuse of materials.

2.4 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

This section summarizes environmental inspections of DOE activities at PORTS during 2019 and the results of these inspections.

2.4.1 Environmental Program Inspections

During 2019, six inspections of DOE activities at PORTS were conducted by federal, state, or local agencies. Table 2.2 lists these inspections.

Table 2.2. Environmental inspections of DOE activities at PORTS for 2019

Date	DOE contractor	Agency	Type	Notices of Violation
April 22	FBP	Ohio EPA	Closed solid waste units, interim remedial measures, and groundwater treatment facilities	None
June 25-26	FBP	Ohio EPA	RCRA compliance	See Section 2.4.2
August 19	MCS	U.S. EPA	Clean Water Act compliance	None
August 19-22	FBP	U.S. EPA	RCRA and Clean Water Act compliance	None
September 17	FBP	Ohio EPA/Pike County Health District	Closed solid waste landfills (X-735, X-749, X-749A)	None
December 2 & 10	MCS	Ohio EPA	RCRA compliance	None

2.4.2 Notices of Violation

As a result of the RCRA inspection performed by Ohio EPA on June 25-26, 2019, FBP received a Notice of Violation due to failure to clean up oil that had been released to the environment in the X-530 Switchyard. During the inspection, Ohio EPA observed visible oil stains beneath one of the transformers.

To resolve the violation, FBP completed the following actions:

- removed and properly disposed the first nine inches of contaminated material called ballast (similar to gravel) from beneath the transformer,
- installed drip collection systems on transformers to collect inadvertent leaks and prevent future releases to the environment, and
- developed and implemented an inspection program to monitor for oil leaks in the switchyard and drip collection systems.

A complete cleanup of the X-530 Switchyard will be completed in the future as part of D&D of PORTS. No further actions were required.

FBP received a Notice of Violation from Ohio EPA in June 2019 related to the three issues pertaining to the NPDES permit. The issues and the responses from FBP are summarized below:

- **Exceedances of permit limitations for total suspended solids at multiple NPDES outfalls.** FBP reviewed the causes for the exceedances at each outfall. Maintenance to potentially mitigate future exceedances was identified and scheduled. Changes to operating procedures to mitigate discharges of suspended solids and additional control of upstream activities that could contribute to discharge of suspended solids were implemented. Excessive rainfall in the beginning of 2019 was also a contributing factor to the exceedances.
- **Violation of general permit conditions at the X-611B Lime Sludge Lagoon (FBP NPDES Outfall 005) that resulted in visible lime sludge deposits in Little Beaver Creek.** FBP implemented changes to the operating procedures for discharges from the X-611B Lime Sludge Lagoon to further control the discharge of suspended solids, which include lime sludge, from the lagoon. FBP is committed to reducing the lime sludge in the discharge to the extent possible given the operating requirements at the Lime Sludge Lagoon.
- **Failure to notify Ohio EPA of the significant change in the discharge from the X-611B Lime Sludge Lagoon after lime sludge deposits were discovered in Little Beaver Creek.** The lime sludge deposits were discovered on May 28, 2019 and reported to Ohio EPA on May 30, 2019 after a preliminary investigation of the field conditions, the cause of the residue, and the extent of the residue. FBP agreed to work to improve communications with the Ohio EPA Southeast District Office and to provide direct notification to the Southeast District Office of any conditions that may impact the quality of water being discharged in accordance with the NPDES permit.

FBP received two Notices of Violation from Ohio EPA in 2019 related to the operation of PORTS drinking water system. Both Notices of Violation were due to an exceedance of the secondary drinking water standard for manganese: 0.05 mg/L. Secondary drinking water standards are non-health-based guidelines for managing the aesthetic quality of drinking water. The reported exceedance began in March and ended in April resulting in two Notices of Violation. The exceedance was not due to issues with water quality, but was caused by an inaccurate field measurement instrument. The instrument was replaced and manganese concentrations measured by the new instrument were confirmed by the PORTS on-site laboratory and an independent off-site analytical laboratory. All manganese concentrations were less than the secondary drinking water standard (0.05 mg/L). No further actions were required.

2.5 UNPLANNED RELEASES

No unplanned releases from DOE activities at PORTS occurred in 2019.

2.6 SUMMARY OF PERMITS

Appendix A lists the permits held by DOE and/or DOE contractors in 2019.

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3. ENVIRONMENTAL PROGRAM INFORMATION

3.1 SUMMARY

Ohio EPA concurred with the records of decision for the process buildings and waste disposition in 2015. The record of decision for the process buildings and other facilities selected controlled removal of stored waste and materials, demolition of the buildings or structures, and characterization of materials for disposal or disposition (DOE 2015b). The record of decision for waste disposition selected a combination of on-site and off-site disposal (DOE 2015c), which includes construction of an OSWDF. The following activities continued throughout 2019: 1) removal of materials from the process buildings, 2) on-site staging or off-site reuse, recycling, or disposal of D&D materials in compliance with the records of decision, and 3) construction activities for the OSWDF.

Soil and groundwater is being investigated and remediated, if necessary, as part of the Environmental Restoration Program at PORTS. Ohio EPA approved the *Deferred Units RCRA Facility Investigation/Corrective Measures Study Work Plan for Solid Waste Management Units* in 2015 (DOE 2015a). This work plan was developed to investigate “deferred units” at PORTS. Deferred units are designated areas located in, or adjacent to, the gaseous diffusion production and operation areas. Remedial activities in these areas would have interrupted ongoing operations, or ongoing operations could have resulted in recontamination of the areas. Soil and groundwater sampling in the work plan started in 2015 and was completed in 2016. The *Deferred Units RCRA Facility Investigation/Corrective Measures Study Report* (DOE 2017a) was submitted to Ohio EPA in 2017. Ohio EPA reviewed the report and submitted comments to DOE in December 2018. DOE worked to address these comments, which included additional sampling and installation of additional monitoring wells, throughout 2019.

In 2019, FBP shipped approximately 2051 tons of waste or other materials to off-site facilities for treatment, disposal, recycling, or reuse. Activities undertaken by the Environmental Sustainability and Public Awareness programs are also discussed in this chapter.

Chapter 2, Section 2.3.6, provides information on implementation of the DOE EMS at PORTS.

3.2 D&D PROGRAM

On April 13, 2010, Ohio EPA issued the D&D DFF&O, which is an enforceable agreement between Ohio EPA and DOE that governs the process for D&D of the gaseous diffusion process buildings and associated facilities that are no longer in use at PORTS. The D&D DFF&O was revised in 2011 and 2012 to add structures that were inadvertently omitted from the original orders. The D&D DFF&O, which applies to the D&D of buildings down to and including the building slab and disposal of wastes generated by D&D, uses the CERCLA framework for determining appropriate removal and remedial actions. Documents are submitted to Ohio EPA for either concurrence or approval. Chapter 2, Section 2.3.1.1, provides additional information about the D&D DFF&O.

Public open houses in neighboring communities are held to keep the public informed and to receive their questions and comments. The PORTS Site Specific Advisory Board, comprised of local citizens, provides recommendations to DOE based on the concerns of the communities surrounding PORTS. Section 3.6 provides additional information on the PORTS Public Awareness Program.

3.2.1 Process Buildings and Other Facilities

D&D of the process buildings and other facilities at PORTS is proceeding in accordance with the record of decision for process buildings concurred with by Ohio EPA in 2015 (DOE 2015b). The record of decision includes:

- Demolition of the buildings or structures;

- Characterization and demolition of underground man-made features;
- Treatment as needed to meet transportation and disposal requirements (either on-site or off-site disposal);
- Packaging of generated waste for final disposal (either on-site or off-site disposal); and
- Transportation and disposal of the waste in accordance with the waste disposition record of decision (either on-site or off-site disposal).

The Process Buildings Deactivation Remedial Design/Remedial Action Work Plan (RD/RA Work Plan) (DOE 2016b) was developed by DOE and concurred with by Ohio EPA in 2016. Another RD/RA Work Plan, the Comprehensive Deactivation, Demolition, and Disposition RD/RA Work Plan for the Process Buildings and Complex Facilities (DOE 2018a), was prepared by DOE and concurred with by Ohio EPA in 2018 which included deactivation, demolition, and waste disposition activities. These two RD/RA Work Plans provide the information to demonstrate that deactivation activities to prepare the three main process buildings along with their associated support structures and also the other complex facilities for demolition meet the requirements of the D&D DFF&O, the Process Buildings and Waste Disposition records of decision, and other applicable requirements. Activities underway in 2019 included disassembly and removal of equipment, removal of wastes including asbestos, PCBs, and RCRA hazardous waste, and deactivation of utilities and other systems. Materials that did not meet criteria for on-site disposal at the OSWDF were shipped off site for disposal in accordance with applicable regulations.

3.2.2 Site-wide Waste Disposition

The record of decision for site-wide waste disposition was concurred with by Ohio EPA in 2015 (DOE 2015c). The record of decision selected a combination of on-site and off-site disposal, including construction of an OSWDF.

Figure 3.1 shows the location of the planned OSWDF in the northeast portion of PORTS. Site construction activities, which began in 2015, initially included tree clearing, grading, and installation of fencing, roadways, utilities, office trailers, erosion controls, sedimentation ponds, and other areas. Activities in 2019 were performed in accordance with the Comprehensive OSWDF RD/RA Work Plan (DOE 2018b). Installation of the primary liner for the first landfill cell was completed in 2019. Work continued on installation of the leachate transmission piping and valve houses as well as other support areas.

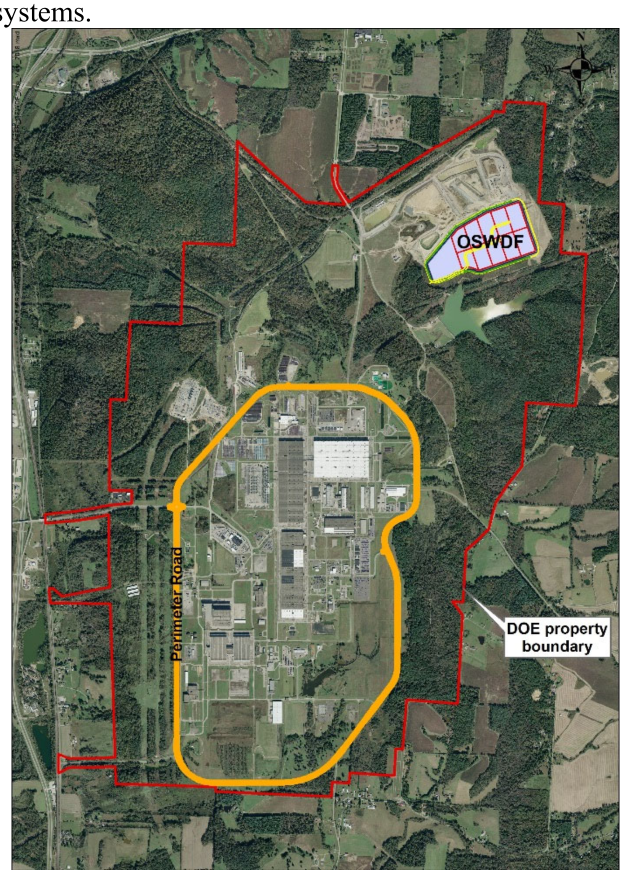

Figure 3.1. Location of the OSWDF at PORTS.

The OSWDF Final (100%) Design Package, which consisted of 11 separate documents, was submitted to Ohio EPA in November 2018. Ohio EPA reviewed and concurred with all of the documents in the Design Package in 2019 and 2020.

3.3 ENVIRONMENTAL RESTORATION PROGRAM

DOE established the Environmental Restoration Program in 1989 to identify, control, and remediate environmental contamination at PORTS. Environmental restoration has been conducted in accordance with the RCRA corrective action process, under a Consent Decree with the State of Ohio, issued on August 29, 1989 and a U.S. EPA Administrative Order by Consent, issued on September 29, 1989 (amended in 1994 and 1997 and terminated on February 13, 2017). With implementation of D&D, removal of facilities and structures down to and including the building slab is controlled by the D&D process (see Section 3.2). Investigation and remediation of environmental contamination is completed under the RCRA corrective action process and in accordance with the Consent Decree with the State of Ohio.

In general, the RCRA corrective action process consists of the following:

1) an assessment to identify releases of hazardous waste and hazardous constituents and determine the need for further investigation (the RCRA facility assessment),

2) an investigation to determine the nature and extent of any contamination (the RCRA facility investigation), and

3) a study to identify and evaluate remedial alternatives to address contamination (the corrective measures study).

Following the approval of the final corrective measures study, Ohio EPA selects the remedial alternatives that will undergo further review to determine the final remedial actions (the statement of basis, formerly called the preferred plan). Upon completion of the public review and comment period, Ohio EPA selects the final remedial actions. Ohio EPA issues a decision document to select the final remedial actions and the remedial actions are implemented by DOE. Final remedial actions are reviewed by Ohio EPA on a schedule agreed upon by Ohio EPA and DOE (approximately every five years) to ensure that the remedial actions are performing as intended by the decision document and are protective of human health and the environment.

The initial assessment and investigation of PORTS under the RCRA corrective action process was completed in the 1990s. Because PORTS is a large facility, it was divided into quadrants (Quadrant I, II, III, and IV) to facilitate the cleanup process (see Chapter 6, Figure 6.1). Remedial actions have been implemented in each of the PORTS quadrants.

Some RCRA corrective action investigations were deferred to the start of D&D activities at PORTS and are now underway. When the RCRA corrective action process began at PORTS during the 1990s, deferred units were designated areas located in, or adjacent to, the gaseous diffusion production and operation areas. Remedial activities in these areas would have interrupted ongoing operations, or ongoing operations could have resulted in recontamination of the areas. Ohio EPA deferred investigation/remedial action of soil and groundwater associated with these units until D&D of PORTS (or until the area no longer met the requirements for deferred unit status). Ongoing environmental monitoring and on-site worker health and safety programs monitor the contaminants in these areas prior to D&D.

The *Deferred Units RCRA Facility Investigation/Corrective Measures Study Work Plan* was approved by Ohio EPA in 2015 (DOE 2015a). Soil and groundwater sampling in the work plan started in 2015 and was completed in 2016. The *Deferred Units RCRA Facility Investigation/Corrective Measures Study Report* (DOE 2017a) was submitted to Ohio EPA in September 2017. Ohio EPA submitted comments to DOE in December 2018. DOE worked to address these comments, which included additional sampling and installation of additional monitoring wells, throughout 2019.

The following sections describe the remedial actions underway in each quadrant as well as ongoing activities at any formerly deferred units. Table 3.1 lists remedial activities for the groundwater monitoring areas at PORTS, which include remedial actions required by decision documents and other actions.

3.3.1 Quadrant I

The *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was approved by Ohio EPA in 2000 (DOE 2000). Ohio EPA issued the Decision Document for Quadrant I in 2001, which provided the required remedial actions for the X-749/X-120 groundwater plume and the Quadrant I Groundwater Investigative (5-Unit) Area (the Five-Unit Groundwater Investigative Area and X-231A/X-231B Oil Biodegradation Plots) (Ohio EPA 2001).

Remedial actions required for the X-749B Peter Kiewit Landfill (PK Landfill) were provided in separate Decision Documents issued by Ohio EPA in 1996 (Ohio EPA 1996a) and U.S. EPA in 1997 (U.S. EPA 1997). The following sections discuss the remedial actions required for the X-749/X-120 groundwater plume, PK Landfill, and the Quadrant I Groundwater Investigative (5-Unit) Area. Chapter 6 provides 2019 groundwater monitoring results for the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, (Section 6.4.1.3 and Figure 6.2), PK Landfill (Section 6.4.2.1 and Figure 6.2) and Quadrant I Groundwater Investigative (5-Unit) Area (Section 6.4.3.1 and Figure 6.3).

3.3.1.1 X-749/X-120 groundwater plume

The remedial actions identified for X-749/X-120 groundwater plume (see Chapter 6, Figure 6.2) include phytoremediation of the groundwater plume, installation of a barrier wall around the eastern and southern portion of the X-749 Landfill, and continued operation of the groundwater collection trenches installed at the PK Landfill and X-749 Landfill. In addition, groundwater extraction wells were installed in 2007, 2008, and 2010 to control migration of the plume and remediate areas of higher trichloroethene (TCE) concentrations within the plume.

Phytoremediation is a process that uses plants to remove, degrade, or contain contaminants in soil and/or groundwater. Phytoremediation at the X-749/X-120 groundwater plume was installed in two phases during 2002 and 2003. The barrier wall around the eastern and southern portion of the X-749 Landfill was completed in 2002.

The *First Five-Year Review for the X-749/X-120 Groundwater Plume*, submitted to Ohio EPA in 2011, found that the remedial actions implemented for the X-749/X-120 groundwater plume (both the remedial actions required by the Decision Document and the extraction wells installed in 2007 and 2008) were achieving remedial action objectives by preventing migration of contaminants from the X-749 Landfill and controlling migration of the X-749/X-120 groundwater plume (DOE 2011c). However, Ohio EPA and DOE agreed that the phytoremediation system was not as successful as anticipated in reducing concentrations of TCE in groundwater. The extraction wells that began operating in 2007-2008 in the groundwater collection trench on the southwest side of the X-749 Landfill and the X-749 South Barrier Wall Area, as well as the barrier wall on the south and east sides of the landfill (completed in 2002), appeared to be primarily responsible for the reductions in TCE concentrations within the X-749/ X-120 groundwater plume. Maintenance of the phytoremediation system was discontinued with the approval of Ohio EPA in 2011.

Table 3.1. Remedial actions at PORTS in groundwater monitoring areas

Quadrant/monitoring area	Remedial action/year completed
Quadrant I X-749/X-120 groundwater plume	X-749 multimedia cap – 1992 X-749 barrier wall (north and northwest sides of landfill) – 1992 X-749 subsurface drains and sumps – 1992 South barrier wall – 1994 X-120 horizontal well – 1996 X-625 Groundwater Treatment Facility – 1996 X-749 barrier wall (east and south sides of landfill) – 2002 Phytoremediation (22 acres) – 2002 & 2003 Injection of hydrogen release compounds – 2004 X-749 South Barrier Wall Area extraction wells – 2007 Two additional extraction wells in the groundwater collection trench on the southwest side of the X-749 Landfill – 2008 X-749/X-120 groundwater plume extraction wells – 2010
Quadrant I Peter Kiewit (PK) Landfill (X-749B)	Relocation of Big Run Creek – 1994 Groundwater collection system – 1994 Groundwater collection system expansion – 1997 PK Landfill Subtitle D cap – 1998
Quadrant I Quadrant I Groundwater Investigative (5-Unit) Area	Groundwater extraction wells (3) – 1991 X-622 Groundwater Treatment Facility – 1991 (upgraded in 2001) Interim soil cover at X-231B – 1995 X-231A/X-231B multimedia caps – 2000 Groundwater extraction wells (11) – 2002 Groundwater extraction well (1) – 2009 Removal of contaminated soil at former X-770 Building – 2010
Quadrant I X-749A Classified Materials Disposal Facility	Cap – 1994
Quadrant II Quadrant II Groundwater Investigative (7-Unit) Area	Operation of X-700 and X-705 building sumps – 1989 X-622T Groundwater Treatment Facility – 1992 Removal of X-720 Neutralization Pit – 1998 Removal of X-701C Neutralization Pit – 2001 Removal of contaminated soil near X-720 Neutralization Pit – 2001 X-627 Groundwater Treatment Facility – 2004 (replaced the X-622T facility) Enhanced anaerobic bioremediation – 2011
Quadrant II X-701B Former Holding Pond	X-237 Groundwater Collection System – 1991 X-624 Groundwater Treatment Facility – 1991 (upgraded 2006) Extraction wells (3) – 1993 (removed 2009-2011) X-623 Groundwater Treatment Facility – 1993 X-701B sump – 1995 Groundwater remediation by oxidant injection – 2008 Groundwater and soil remediation by oxidant mixing – 2011

Table 3.1. Remedial actions at PORTS in groundwater monitoring areas (continued)

Quadrant/monitoring area	Remedial action/year completed
Quadrant III X-740 Former Waste Oil Handling Facility Area	Phytoremediation – 1999 Oxidant injections – 2008 Enhanced anaerobic bioremediation – 2011
Quadrant IV X-611A Former Lime Sludge Lagoons	Soil cover – 1996 Prairie vegetation planted – 1997
Quadrant IV X-735 Landfills	Cap on northern portion – 1994 Cap on southern portion – 1998
Quadrant IV X-734 Landfills	Cap on X-734B Landfill (Phase I) – 1999 Cap on X-734 and X-734A Landfills (Phase II) – 2000
Quadrant IV X-533 Former Switchyard Complex	Contaminated soil removal – 2010

The most recent five-year review for the X-749/X-120 groundwater plume found that the remedial actions were working effectively to meet the remedial action objectives for the X-749/X-120 groundwater plume (DOE 2016c). The next review of the remedial actions implemented for the X-749/X-120 groundwater plume will be submitted to Ohio EPA in 2021.

A potential source area to the X-749/X-120 groundwater plume was identified recently north of the X-749 Landfill. This area has been investigated as part of the *Deferred Units RCRA Facility Investigation/ Corrective Measures Study Work Plan for Solid Waste Management Units* (DOE 2015a).

Chapter 6, Section 6.4.1.3 and Figure 6.2, provide additional information about the 2019 groundwater monitoring results for the X-749/X-120 groundwater plume.

3.3.1.2 PK Landfill

The remedial actions required by the PK Landfill Decision Documents consisted of the continued operation of the eastern groundwater collection system installed in 1994 and construction of an engineered cap that meets the RCRA Subtitle D and related requirements (Ohio EPA 1996a and U.S. EPA 1997). In addition, the southeastern groundwater collection system was constructed in 1997 to contain surface seeps, groundwater from the southern slope of the PK Landfill, and the groundwater plume migrating toward Big Run Creek from the X-749 Landfill.

The most recent five-year review for the PK Landfill found that the corrective actions implemented at the PK Landfill (the groundwater collection systems, landfill cap, and institutional controls) were continuing to achieve corrective action objectives by eliminating exposure pathways and reducing the potential for contaminant transport (DOE 2018d). Concentrations of many of the contaminants detected in the PK Landfill wells, sumps, and manholes have decreased. The next review of the remedial actions implemented at the PK Landfill will be submitted to Ohio EPA in 2023.

Chapter 6, Section 6.4.2.1 and Figure 6.2, provide 2019 groundwater monitoring results for the PK Landfill area.

3.3.1.3 Quadrant I Groundwater Investigative (5-Unit) Area

Remedial actions identified for the Quadrant I Groundwater Investigative (5-Unit) Area (Chapter 6, Figure 6.3) are: 1) installation of multimedia caps over the X-231A and X-231B Oil Biodegradation Plots; and 2) installation of 11 additional groundwater extraction wells to extract contaminated groundwater for treatment in the X-622 Groundwater Treatment Facility (Ohio EPA 2001). The caps were constructed in 2000 and operation of the groundwater extraction wells began in 2002. In 2009, an additional extraction well was installed south of the X-326 Process Building to control and remediate a newly identified source of TCE beneath the building. Table 3.1 lists the remedial actions completed for the Quadrant I Groundwater Investigative (5-Unit) Area.

The most recent five-year review of both the groundwater extraction system for the Quadrant I Groundwater Investigative (5-Unit) Area and the multi-layered caps for the X-231A and X-231B Oil Biodegradation Plots found that the remedial actions implemented for the X-231A and X-231B Oil Biodegradation Plots and the Five-Unit Groundwater Investigative Area (the multimedia caps and groundwater extraction system) were continuing to eliminate potential exposure pathways to contaminants, control migration of the groundwater plume, and remove volatile organic compounds (VOCs) from groundwater (DOE 2018e). The next review of the remedial actions implemented at the Quadrant I Groundwater Investigative (5-Unit) Area and X-231A/B Oil Biodegradation Plots will be submitted to Ohio EPA in 2023.

Chapter 6, Section 6.4.3.1 and Figure 6.3, provide information on the groundwater monitoring completed in the Quadrant I Groundwater Investigative (5-Unit) Area during 2019.

3.3.2 Quadrant II

The *Quadrant II Cleanup Alternative Study/Corrective Measures Study* was approved by Ohio EPA in 2001 (DOE 2001). After approval of the document, however, Ohio EPA requested an amendment to the approved study to address additional remedial alternatives for the X-701B area. Amendments were submitted in 2001 and 2002. In 2003, Ohio EPA informed DOE that a separate Decision Document would be prepared for the X-701B area, and the X-701B Decision Document was issued in 2003 (Ohio EPA 2003).

Chapter 6 provides 2019 groundwater monitoring results for the following areas in Quadrant II that require groundwater monitoring: Quadrant II Groundwater Investigative (7-Unit) Area (Section 6.4.5.1 and Figure 6.4), X-701B Former Holding Pond (Section 6.4.6.1 and Figure 6.5), and X-633 Former Recirculating Cooling Water Complex (Section 6.4.7.1 and Figure 6.6).

3.3.2.1 Quadrant II Groundwater Investigative (7-Unit) Area

A number of deferred units are in the groundwater plume in the Quadrant II Groundwater Investigative (7-Unit) Area (Chapter 6, Figure 6.4). A special investigation conducted in 2009, which sampled soil and groundwater, identified areas of higher TCE concentrations that appeared to be associated with continuing sources of groundwater contamination in the southeastern portion of the plume. In 2010, Ohio EPA approved an interim remedial measure (IRM) for this area called enhanced anaerobic bioremediation. Enhanced anaerobic bioremediation utilizes injections of fermentable carbon compounds such as sodium lactate (a common ingredient in soaps and face creams) to provide additional food for naturally-occurring microorganisms in soil that degrade TCE to harmless substances. The project began in 2010 and was completed in 2013.

The *Final Report for the 7-Unit Interim Remedial Measure* was submitted to Ohio EPA in 2014 (DOE 2014a). Overall, the results indicated that appropriate conditions could be established at the site to degrade TCE despite the high TCE concentrations in soil and groundwater. Enhanced anaerobic bioremediation successfully reduced TCE to *cis*-1,2-dichloroethene, and with bioaugmentation, some of the *cis*-1,2-dichloroethene was converted to ethane. The report concluded that after the six injection events plus a bioaugmentation event (injection of additional microorganisms that degrade VOCs), overall there was not a measureable reduction in the average concentration of TCE in groundwater, most likely due to the potential presence of dense non-aqueous phase liquid TCE in the area, and the decision was made to conclude the IRM.

DOE and Ohio EPA have agreed that selection of a remedial action for the Quadrant II Groundwater Investigative (7-Unit) Area will be incorporated into the deferred units preferred plan and decision document.

Chapter 6, Section 6.4.5.1 and Figure 6.4, provide information about the groundwater monitoring completed at the Quadrant II Groundwater Investigative (7-Unit) Area during 2019.

3.3.2.2 X-701B Former Holding Pond

Remedial actions required by the Decision Document for X-701B, issued in 2003, include groundwater remediation by injection of a chemical oxidant (Ohio EPA 2003). The oxidant injections required by the Decision Document took place between 2006 and 2008. Following the end of the injections in 2008, an independent review of the X-701B project was completed by DOE Headquarters to evaluate remediation results and provide recommendations for a path forward.

The review of the X-701B oxidant injections determined that the method used to inject oxidant into the contaminated area was not able to address contaminants in the deepest portion of the contaminated soil. If contaminants remained in this portion of the soil, they would continue to be released into the groundwater plume. Therefore, DOE proposed an IRM to excavate soil in the western portion of the X-701B plume area and directly mix oxidant into the contaminated soil. The IRM began in December 2009 and was completed in January 2011. Chapter 6, Section 6.4.6.1 and Figure 6.5, provide information about the groundwater monitoring completed at the X-701B Former Holding Pond during 2019.

3.3.2.3 X-633 Former Recirculating Cooling Water Complex

The X-633 Recirculating Cooling Water Complex was demolished in 2010. A RCRA investigation of soil and groundwater in the area was implemented in 2011. Areas of soil potentially contaminated with metals were identified, but the higher concentrations of metals may have been present in these areas (15 to 20 ft below ground surface) due to naturally-occurring variations in the geology of the area.

Chromium and TCE were detected in groundwater at concentrations above the preliminary remediation goals during the 2011 RCRA investigation for the X-633 area. DOE agreed to sample eight wells around the area annually to continue evaluation of chromium and TCE in groundwater at this area. The *2019 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides the data for this monitoring (DOE 2020).

3.3.3 Quadrant III

The *Quadrant III Cleanup Alternative Study/Corrective Measures Study* was approved by Ohio EPA in 1998 (DOE 1998a). The Decision Document for Quadrant III, issued in 1999, required phytoremediation of the groundwater plume near the X-740 Waste Oil Handling Facility (Ohio EPA 1999a).

Over 700 hybrid poplar trees were planted on a 2.6-acre area above the X-740 groundwater plume (Chapter 6, Figure 6.8) in 1999. Evaluation reports for this remedial action were completed in 2003 and 2007. The reports concluded that the phytoremediation system had not performed as expected to remove TCE from groundwater in this area (DOE 2003 and DOE 2007b).

In response to Ohio EPA concerns about the performance of the phytoremediation system, DOE implemented additional remedial activities for the X-740 area. Three rounds of oxidant injections were completed in 2008 to remove TCE from the groundwater. Although the oxidant briefly reduced TCE concentrations detected in some of the wells, TCE concentrations in groundwater returned to typical levels in 2009.

In 2010, Ohio EPA approved a pilot study of enhanced anaerobic bioremediation for the X-740 area. Section 3.3.2.1 provides additional information about enhanced anaerobic bioremediation. Emulsified oil, a slow-acting fermentable carbon compound, was injected into the selected portions of the X-740 groundwater plume during December 2010 and January 2011. TCE has decreased in wells within the area of the groundwater plume that was treated during the pilot study (see Chapter 6, Section 6.4.9.1 and Figure 6.8).

The *Final Report for the X-740 Pilot Study* (DOE 2016a) was approved by Ohio EPA in 2016. A summary of the results of the pilot study is included in the *Deferred Units RCRA Facility Investigation/Corrective Measures Study Report* (DOE 2017a).

Chapter 6 provides 2019 groundwater monitoring results for the following areas in Quadrant III that require groundwater monitoring: X-616 Former Chromium Sludge Surface Impoundments (Section 6.4.8.1 and Figure 6.7) and X-740 Former Waste Oil Handling Facility (Section 6.4.9.1 and Figure 6.8).

3.3.4 Quadrant IV

The *Quadrant IV Cleanup Alternative Study/Corrective Measures Study* was approved by Ohio EPA in 1998 (DOE 1998b). DOE received the Decision Document for Quadrant IV in 2000 (Ohio EPA 2000). No new remedial actions were required in Quadrant IV (remedial actions had already taken place at the X-344D Hydrogen Fluoride Neutralization Pit, X-735 Landfills, X-611A Former Lime Sludge Lagoons, and X-734 Landfills).

Chapter 6 provides 2019 groundwater monitoring results for the following areas in Quadrant IV that require groundwater monitoring: X-611A Former Lime Sludge Lagoons (Section 6.4.10.1 and Figure 6.9), X-735 Landfills (Section 6.4.11.1 and Figure 6.10), X-734 Landfills (Section 6.4.12.1 and Figure 6.11), X-533 Former Switchyard Complex (Section 6.4.13.1 and Figure 6.6), and X-344C Former Hydrogen Fluoride Storage Building (Section 6.4.14.1 and Figure 6.12).

3.3.4.1 X-611A Former Lime Sludge Lagoons

Ohio EPA and U.S. EPA issued a Decision Document for the X-611A area (Chapter 6, Figure 6.9) in 1996, which required a soil cover over the former lagoons and establishment of a prairie habitat (Ohio EPA 1996b). The soil cover and planting of the prairie were completed in 1997. The most recent five-year review found that the soil cover and prairie habitat were meeting the remedial action objectives for this unit by eliminating exposure pathways to the contaminants in the sludge at this area (DOE 2018c). The next review of the remedial actions implemented at the X-611A area will be submitted to Ohio EPA in 2023.

3.3.4.2 X-734 Landfills

Ohio EPA issued a Decision Document for the X-734 Landfills (Chapter 6, Figure 6.11) in 1999 (Ohio EPA 1999b). Remedial actions required by the Decision Document included construction of a multimedia cap over the northern portion of the landfills and a soil cap over the southern portion of the area. These caps were installed in 1999 and 2000.

The most recent five-year review found that the landfill caps have achieved remedial action objectives by isolating contaminants in soil and sediment from potential receptors (DOE 2018f). The caps were also preventing contaminants from migrating from soil to groundwater and from groundwater to surface water. The next review of the remedial actions implemented at the X-734 Landfills will be submitted to Ohio EPA in 2023.

3.3.4.3 X-630 Former Recirculating Cooling Water Complex

The X-630 Recirculating Cooling Water Complex, located in Quadrant IV within Perimeter Road and west of the X-533 Switchyard Complex, was removed during 2011 as part of D&D. A RCRA investigation of soil and groundwater at the X-630 Recirculating Cooling Water Complex was implemented in 2011.

Areas of soil potentially contaminated with metals were identified, but the higher concentrations of metals may have been present in these areas (15 to 20 ft below ground surface) due to naturally-occurring variations in the geology of the area.

Chromium and TCE were detected in groundwater at concentrations above the preliminary remediation goals during the 2011 RCRA investigation for the X-630 area. DOE agreed to sample four wells around the area annually to continue evaluation of chromium and TCE in groundwater at this area. The *2019 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides the data for this monitoring (DOE 2020).

3.4 WASTE MANAGEMENT PROGRAM

The DOE Waste Management Program directs the safe storage, treatment, and disposal of waste generated by past and present operations and from current D&D and Environmental Restoration projects at PORTS. Waste managed under the program is divided into the following seven categories, which are defined below:

- *LLW* – radioactive waste not classified as high level or transuranic waste.
- *Hazardous (RCRA) waste* – waste listed under RCRA or waste that exhibits one or more of the four RCRA hazardous characteristics: ignitability, corrosivity, reactivity, and toxicity. Universal waste, which includes common items such as batteries and light bulbs, is a subset of RCRA waste that is subject to reduced requirements for storage, transportation, and disposal or recycling.
- *PCB wastes* – waste containing PCBs, a class of synthetic organic chemicals. Disposal of PCB-contaminated materials is regulated under TSCA.
- *RCRA/low-level radioactive mixed waste* – waste containing both hazardous and radioactive components. The waste is subject to RCRA, which governs the hazardous components, and to the Atomic Energy Act that governs the radioactive components.
- *PCB/low-level radioactive mixed waste* – waste containing both PCB and radioactive components. The waste is subject to TSCA regulations that govern PCB components, and to the Atomic Energy Act that governs radioactive components.
- *PCB/RCRA/low-level radioactive mixed waste* – waste containing PCB and radioactive components that is also a RCRA hazardous waste. The waste is subject to RCRA regulations, TSCA regulations that govern PCBs, and to the Atomic Energy Act that governs radioactive components.

- *Solid waste* – "Solid wastes," as defined by Ohio EPA, can be solids, liquids, sludges, or other materials. These wastes can include waste from construction or demolition activity, industrial waste, sanitary waste, and office waste (subject to definitions from Ohio EPA). Waste contaminated with asbestos may also be included in this category if it is not included in any of the categories listed above (PCB, RCRA, and/or LLW).

Waste management requirements are varied and are sometimes complex because of the variety of waste streams generated by DOE activities at PORTS. DOE Orders, Ohio EPA regulations, and U.S. EPA regulations must be satisfied to demonstrate compliance with waste management activities. Additional policies have been implemented for management of radioactive, hazardous, and mixed wastes. These policies include the following:

- minimizing waste generation;

- characterizing and certifying wastes before they are stored, processed, treated, or disposed;

- pursuing volume reduction (such as blending and bulking) as well as on-site storage in preparation for safe and compliant final treatment and/or disposal; and

- recycling.

DOE is placing increased emphasis on the evaluation of materials generated by D&D for reuse or recycling. An agreement between DOE and the Southern Ohio Diversification Initiative (SODI) allows DOE to transfer excess equipment, clean scrap materials and other assets to SODI. SODI first attempts to reuse the excess equipment and property within the local community. Pursuant to the agreement, if SODI is unable to place the property for reuse in the local community, SODI may sell the property. When SODI sells the property, the proceeds are used to support economic development in the southern Ohio region. In 2019, SODI received approximately 416 tons of materials from PORTS, primarily recyclable metals, recyclable oil, and reusable equipment.

In 2019, FBP shipped approximately 2051 tons of materials to off-site facilities for treatment, disposal, recycling, or reuse (see Table 3.2).

The following materials were sent off-site by FBP for recycling in 2019:

- aluminum cans: 4000 lbs
- aerosol cans: 432 lbs
- batteries: 40,775 lbs
- electronic materials (computer equipment, circuit boards, etc.): 18,407 lbs
- used oil: 4881 lbs
- light bulbs: 5720 lbs
- thermometers containing mercury: 37 lbs
- paper/cardboard: 56,000 lbs
- plastic bottles: 27,500 lbs
- recyclable materials to SODI (excess equipment and materials, recyclable metals, recyclable oil, etc.): 416 tons.

Table 3.2. Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2019

Waste type	Waste stream	Quantity (lbs[a])	Treatment or disposal, facility
RCRA	Aerosol cans, broken lead acid batteries, and used oil filters	2862	Environmental Quality Co.
RCRA/LLW/ PCB	Ballasts and other metals	1356	EnergySolutions Clive, UT
LLW	Used oils	6119	Diversified Scientific Solutions
LLW	Contaminated liquids, soil, and sludge	1604	EnergySolutions Clive, UT
LLW	Contaminated paper	2225	EnergySolutions Bear Creek TN
LLW	D&D waste, uranium materials, scrap metal, and other solids	2,038,213	Nevada National Security Site
RCRA/LLW	Contaminated liquids, used carbon, and other solids	5433	Diversified Scientific Solutions
RCRA/LLW	D&D waste, soil, lab wastes, and other materials	60,626	EnergySolutions Clive, UT
RCRA/LLW	Contaminated debris and other solids	121	Perma-Fix Florida
RCRA/LLW	Contaminated scrap metal from the X-326 Process Building	117	Waste Control Specialists
LLW/PCB	Oil/water mixtures contaminated with PCBs	337	Diversified Scientific Solutions
LLW/PCB	Debris and metal contaminated with PCBs	1137	EnergySolutions Clive, UT
LLW/PCB	D&D waste and other solid debris contaminated with PCBs	320,611	Nevada National Security Site
Solid waste	Construction debris, office waste, and other solid materials	670,640	Rumpke/Pike Sanitation Landfill
-	Recyclable aluminum cans, batteries, electronic materials, plastic, batteries, light bulbs, etc. (see Section 3.4)	157,752	Various (not including SODI)
-	Reusable or recyclable materials transferred to SODI (see Section 3.4)	832,677	-

[a]lbs in net weight (waste only).

3.5 ENVIRONMENTAL SUSTAINABILITY PROGRAM

DOE is committed to reducing potential environmental risks, costs, wastes, and future liability by effectively integrating environmental sustainability principles into DOE activities at PORTS in a cost effective and environmentally conscious manner. The DOE Environmental Sustainability Program is a balanced, holistic approach that links planning, budgeting, measuring, and improving PORTS overall environmental performance to specific goals and outcomes. The *Fiscal Year 2020 Site Sustainability Plan* describes the Environmental Sustainability Program and integrates the tenets of an EMS (see Chapter 2, Section 2.3.6) (DOE 2019a). The Environmental Sustainability Program includes elements of pollution prevention, waste minimization, affirmative procurement, sustainable design, and energy and water efficiency.

DOE is committed to minimizing and/or eliminating the amounts and types of wastes generated and to achieving reduced life cycle costs for managing and dispositioning property and wastes during all DOE projects and activities at PORTS.

Effective environmental sustainability management begins with an integrated strategy. In order to achieve the objectives and targets of the Environmental Sustainability Program, DOE has developed and implemented a well-defined strategy for setting, updating, and achieving objectives and targets in line with the EMS and in conjunction with DOE pollution prevention goals. The broad objectives are core elements of the Environmental Sustainability Program. These objectives, presented below, are both qualitative and quantitative and reduce the life cycle cost and liability of DOE programs and operations at PORTS:

- eliminating, minimizing, or recycling wastes that would otherwise require storage, treatment, disposal, and long-term monitoring and surveillance;

- eliminating or minimizing use of toxic chemicals and associated environmental releases that would otherwise require control, treatment, monitoring, and reporting;

- maximizing the use (procurement) of recycled-content materials and environmentally preferable products and services, thereby minimizing the economic and environmental impacts of managing by-products and wastes generated in the conduct of mission-related activities; and

- reducing the life-cycle cost of managing personal property at PORTS.

DOE continued energy reduction programs at PORTS that focused on accomplishing the goals of Executive Order 13834, *Efficient Federal Operations*. Executive Order 13834 provides goals for greenhouse gas emission reductions and environmental sustainability (including energy and water efficiency; waste and pollution prevention; and electronics stewardship).

In support of this Executive Order, the *Fiscal Year 2020 Site Sustainability Plan for the Portsmouth Gaseous Diffusion Plant* provides goals and progress through fiscal year 2019 for reductions in greenhouse gas emissions, water consumption, recycling/waste diversion, electronic stewardship, and other areas (DOE 2019c). The following accomplishments were listed for fiscal year 2019:

- a decrease of 76.2% in greenhouse gas emissions (primarily associated for electricity consumption) versus the fiscal year 2008 baseline emissions.

- a decrease in water consumption of 24% in fiscal year 2019 versus fiscal year 2018.

- Approximately 61.4% of nonhazardous waste was diverted from disposal at an off-site landfill (the waste was recycled).
- Approximately 38.7% of construction and demolition materials were diverted from off-site disposal (the materials were recycled).

PORTS was recognized by the Green Electronics Council in May 2019 for excellence in sustainable procurement of information technology products with a 3-Star Electronic Product Environmental Assessment Tool (EPEAT) Purchasing Award.

3.6 PUBLIC AWARENESS PROGRAM

A comprehensive community relations and public participation program is in place at PORTS. The purpose of the program is to foster a spirit of openness and credibility between PORTS officials and local citizens, elected officials, business, media, and various segments of the public. The program also provides the public with opportunities to become involved in the decisions affecting environmental issues at PORTS. Contact information for the organizations that provide PORTS information to the public is listed below.

The Environmental Information Center provides public access to documents used to make decisions on remedial actions being taken at PORTS. The Information Center is located just north of PORTS at the Ohio State University Endeavor Center (Room 207), 1862 Shyville Road, Piketon, Ohio 45661.

The PORTS Site Specific Advisory Board, comprised of citizens from the local area, provides public input and recommendations to DOE on D&D, environmental remediation, waste management, and related issues at PORTS. Regularly scheduled meetings that are open to the public are held between DOE and the PORTS Site Specific Advisory Board. Additional information about the PORTS Site Specific Advisory Board can be obtained at energy.gov/pppo/ports-ssab or by calling 740-289-5249.

The PORTS Envoy Program matches employee volunteers with community stakeholders such as families living next to DOE property, community groups, and local government organizations. The envoys communicate information about PORTS D&D and other site issues to the stakeholders and are available to answer stakeholder questions about PORTS.

PORTS Environmental Information Center **740-289-8898** **Hours: 9-12 (Mon-Tue)** **12-4 (Wed-Thu)** **or by appt** **Email: portseic@ports.pppo.gov**	**energy.gov/pppo/portsmouth-environmental-information-center**
Online Document Repository	**eic.ports.pppo.gov**
DOE Site Office **740-897-5010**	**energy.gov/pppo**
FBP Public Affairs **740-897-2964**	**fbportsmouth.com**
PORTS Environmental Data (PEGASIS)	**pegasis.ports.pppo.gov/pegasis**
PORTS Virtual Museum	**portsvirtualmuseum.org**

The PORTS version of the PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS) allows the user to obtain PORTS off-site environmental monitoring data and display it on a local map that shows the locations the data were collected. Data from 2013 through the current ASER are available in PEGASIS.

Public open houses in neighboring communities are also held to keep the public informed and to receive their comments and questions. Periodically, fact sheets about major projects are written for the public. Additionally, notices of document availability and public comment periods, as well as other communications on the program, are regularly distributed to the local newspaper, the community relations mailing list, neighbors within 2 miles of the plant, and plant employees.

Helping to grow a science, technology, engineering, and math (STEM) environment for rural Appalachian schools is a primary activity for The Ohio University Voinovich School's PORTSfuture Program. Through a grant funded from the DOE Portsmouth/Paducah Project Office, PORTSfuture has been able to reach out to over 13,000 students in the four county area in Southern Ohio around PORTS. The PORTSfuture Program engages K-12 and college students in STEM activities focused on technology, energy, environment, entrepreneurship, and water quality issues. Outreach efforts have included in-class activities and curriculum, business pitch competitions, science fairs, summer STEM enrichment programs, and after school clubs.

The PORTSfuture Program includes a project in which local high school students produce a summary of the Annual Site Environmental Report for distribution to the public. The PORTS Annual Science Alliance event brings more than 1500 high school juniors to PORTS for an interactive science fair that includes scientific demonstrations and information related to careers in STEM fields. DOE and PORTS contractors also support the annual South Central Ohio Regional Science Bowl, an academic competition for middle school and high school students. Student teams answer questions about biology, chemistry, earth sciences, math, and physics with the regional winners advancing to the National Science Bowl in Washington, D.C. The DOE PPPO web site at energy.gov/pppo and portsfuture.com provide additional information about these projects.

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4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1 SUMMARY

Environmental monitoring at PORTS measures both radiological and chemical parameters in air, water, soil, sediment, and biota (animals, vegetation, and crops). This chapter discusses the radiological component of environmental monitoring programs at PORTS; Chapter 5 discusses the non-radiological parameters for the monitoring programs.

Environmental monitoring programs are required by state and federal regulations, permits, and DOE Orders. These programs may also be developed to address public concerns about plant activities. In 2019, environmental monitoring information was collected by DOE contractors (FBP and MCS) and Centrus. This chapter includes information about water discharges from Centrus to provide a more complete summary of environmental monitoring at PORTS.

Environmental monitoring data collected at PORTS are used to assess potential impacts to human health and the environment from radionuclides released by current and historical activities at PORTS. This impact, called a dose, can be caused by radionuclides released to air and/or water, or radiation originating directly from buildings or other objects at PORTS. U.S. EPA sets a 10 mrem/year limit for the dose from radionuclides released to the air in the NESHAP (40 CFR Part 61, Subpart H). DOE sets an annual dose limit in DOE Order 458.1 as low as reasonably achievable (ALARA)[1], but no more than 100 mrem/year above background for the total public annual dose from radionuclides from all potential pathways. A person living in the United States receives an average annual dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009).

This chapter includes radiological dose calculations for the dose to the public from radionuclides released to the air and the Scioto River, from external radiation, and from radionuclides detected by environmental monitoring programs. The maximum annual dose a member of the public could receive from radiation released by PORTS in 2019 or detected by environmental monitoring programs in 2019 is 0.95 mrem/year and is considered ALARA. This summary of the dose calculations assumes that the same maximally exposed individual, or representative person, routinely drives on Perimeter Road past the cylinder yards and lives in the immediate vicinity of PORTS. The maximally exposed individual, or representative person, is assumed to be exposed to the maximum dose calculated from each pathway. Table 4.1 summarizes this dose information.

Table 4.1. Summary of potential annual doses to the public from PORTS in 2019

Source of dose	Dose (mrem/year)
Airborne radionuclides (off-site individual)	0.16[a]
Radionuclides released to the Scioto River	0.0011
External radiation near cylinder yards (northwest portion of Perimeter Rd)	0.74
Radionuclides detected by environmental monitoring programs	0.046
Total	0.95[b]

[a]10 mrem/year is U.S. EPA limit for airborne radionuclides in the NESHAP (40 CFR Part 61, Subpart H).
[b]100 mrem/year is the DOE limit for all potential pathways in DOE Order 458.1.

[1] "As low as reasonably achievable" is an approach to radiation protection to manage and control releases of radioactive material to the environment, the workforce, and members of the public so that levels are as low as reasonable, taking into account societal, environmental, technical, economic, and public policy considerations. As low as reasonably achievable is not a specific release or dose limit, but a process that has the goal of optimizing control and managing release of radioactive material to the environment and doses so they are as far below the applicable limits as reasonably achievable. This approach optimizes radiation protection.

Figure 4.1 shows the maximum potential annual dose from all exposure pathways to the public from radiation associated with PORTS for the last ten years (2010 to 2019). The figure indicates that the maximum annual dose from radiation associated with PORTS is consistently approximately 1 mrem/year. This maximum annual dose of approximately 1 mrem/year is less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1 for all radiological releases from a facility and is considered ALARA.

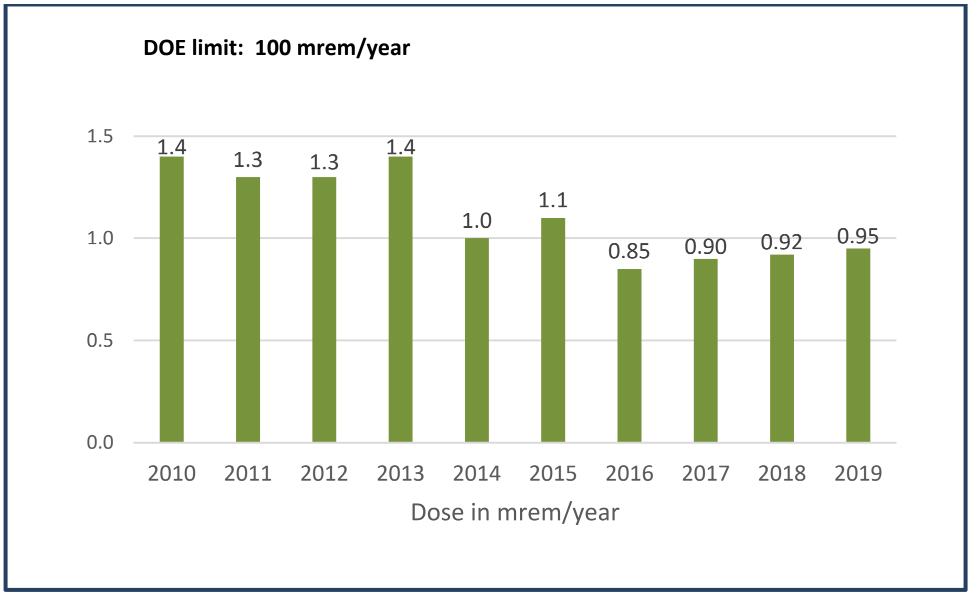

Figure 4.1. Maximum potential annual doses (all pathways) to the public, 2010 – 2019.

4.2 ENVIRONMENTAL RADIOLOGICAL PROGRAM INTRODUCTION

Environmental monitoring programs at PORTS are designed to detect the effects (if any) of activities at PORTS on human health and the environment. Multiple samples are collected throughout the year and analyzed for radionuclides that could be present from PORTS activities. The results of these monitoring programs are used to gauge the environmental impact of PORTS and to set priorities for environmental improvements.

4.2.1 Environmental Monitoring

Environmental regulations, permits, DOE Orders, and public concerns are all considered in developing environmental monitoring programs. State and federal regulations drive some of the monitoring conducted at PORTS such as limitations on discharges to air and water. DOE Orders 231.1B, *Environment, Safety and Health Reporting*, and 458.1, *Radiation Protection of the Public and the Environment,* also address environmental monitoring requirements.

The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* describes the environmental monitoring programs for DOE activities at PORTS (DOE 2017b). Specific radionuclides monitored at PORTS are selected based on the materials handled at PORTS and on historic monitoring data. For example, samples are analyzed for uranium and isotopic uranium because of the uranium enrichment process. Samples are analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) and technetium-99 because these radionuclides are produced during the fission process in nuclear reactors and were introduced to PORTS via the use of recycled uranium beginning in the late 1950s.

In 2019, environmental monitoring data were collected by DOE contractors (FBP and MCS) and Centrus. This chapter provides information on the Centrus NPDES monitoring. Centrus data are provided for informational purposes only; as Centrus operates independently of the DOE and is regulated by the NRC.

Data for the following environmental media are included in this chapter:

- airborne discharges
- ambient air
- external radiation
- discharges to surface water
- surface water
- sediment
- soil
- biota.

DOE also conducts an extensive groundwater monitoring program at PORTS. Chapter 6 provides information on the groundwater monitoring program, associated surface water monitoring, and water supply monitoring.

4.2.2 Introduction to Radiological Dose

As discussed in this chapter, dose is a measure of the potential biological damage that could be caused by exposure to and subsequent absorption of radiation to the body (in radiological terms, the effective dose). Because there are many natural sources of radiation, a person living in the United States receives an average annual dose of approximately 311 mrem/year from sources of natural radiation (NCRP 2009). Appendix B, Introduction to Radiation, provides additional information on radiation and dose.

A person can receive a radiation dose from radionuclides released to the air or water. Additionally, people can receive a radiation dose from external radiation (radiation originating from buildings or other objects such as the cylinders that store uranium in the cylinder storage yards at PORTS). Radiation exposure pathways describe how radiation exposures can reach and affect people. People can simply inhale radioactive material in the air or ingest it in water. Or, radioactive material in the air could fall on a pasture. The grass could then be eaten by cows, and the radioactive material on the grass would be present in the cow's milk. People drinking the milk would thus be exposed to this radiation. The same events could occur with radioactive material in water. Fish living in the water would be exposed; people eating the fish would then be exposed to the radioactive material in the fish. Figure 4.2 shows some of the potential radiation pathways.

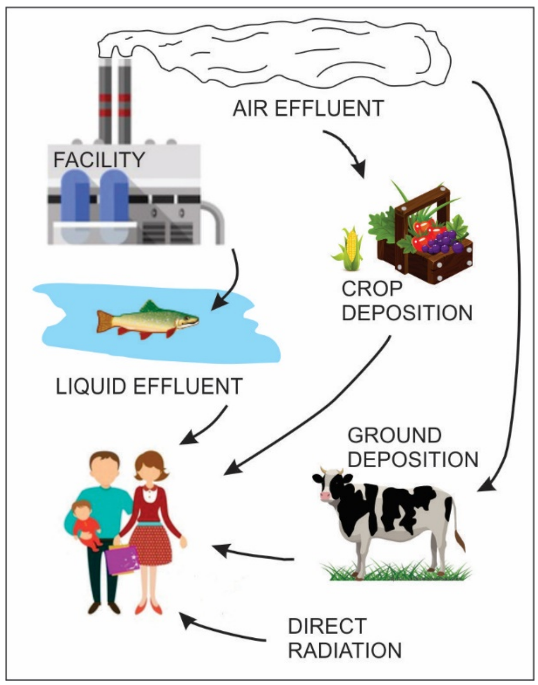

Figure. 4.2. Potential radiation pathways.

Most consequences associated with radionuclides released to the environment are caused by interactions between human tissue and various types of radiation emitted by the radionuclides. These interactions involve the transfer of energy from radiation to tissue, potentially resulting in tissue damage. Radiation may come from radionuclides outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (by inhalation, ingestion, and, in a few cases, absorption through the skin). Exposures to radiation from radionuclides outside the body are called external exposures, and 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 external 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 from an x-ray machine that a person might find in a doctor's office is an example of external exposure because the source of radiation is outside the body. An example of an internal exposure is nuclear medicine, which is the use of small amounts of radioactive materials called radiotracers that are typically injected into the bloodstream, inhaled, or swallowed for a medical procedure.

The three naturally-occurring uranium isotopes (uranium-234, uranium-235, and uranium-238) and technetium-99 are the most commonly detected radionuclides in environmental media samples collected around PORTS. Other radioactive isotopes called transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) are occasionally detected at PORTS. Technetium-99 and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) are present in the world-wide environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world (Argonne National Laboratory 2007). The transuranic radionuclides may be detected in the environment near PORTS because they are found in fallout or because they could have come from PORTS. Transuranic radionuclides from fallout or from PORTS operations, if detected, are present at extremely low levels.

4.3 RADIOLOGICAL EMISSIONS AND DOSES

Releases of radionuclides from PORTS activities can result in a dose to a member of the public in addition to the 311 mrem/year dose received from natural sources of radiation (NCRP 2009). PORTS activities that release radionuclides are regulated by U.S. EPA and DOE. Airborne releases of radionuclides from DOE facilities are regulated by U.S. EPA under the NESHAP (40 CFR Part 61, Subpart H). These regulations set an annual dose limit of 10 mrem/year to any member of the public as a result of airborne radiological releases.

DOE regulates radionuclide emissions to all environmental media through DOE Orders 436.1, *Departmental Sustainability,* and 458.1, *Radiation Protection of the Public and the Environment.* DOE Order 458.1 sets a total public annual dose limit as low as reasonably achievable, but no more than 100 mrem/year above background to any member of the public from all radionuclide releases from a facility. The annual dose limit in NESHAP (10 mrem/year) applies only to airborne radiological releases.

To aid in comparing sampling results for air and water to the 100 mrem/year dose limit, DOE has converted the 100 mrem/year limit into a derived concentration standard (DOE 2011b). The derived concentration standard is the concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (ingestion of water or inhalation of air) would result in a dose of 100 mrem/year.

Small quantities of radionuclides were released to the environment from PORTS during 2019. This chapter describes the methods used to estimate the potential doses that could result from radionuclides released from PORTS. In addition, this chapter assesses the potential doses that could result from radionuclides historically released by PORTS and detected in 2019 by environmental monitoring programs.

For 2019, annual doses are estimated for exposure to atmospheric releases, external radiation, and releases to the Scioto River. Annual doses are also estimated for exposure to radionuclides from PORTS that were detected in 2019 as part of the DOE environmental monitoring programs for sediment, soil, residential drinking water (well water – excluding naturally-occurring detections of uranium isotopes) and selected biota (vegetation, deer, fish, crops, and dairy products). Analytical data from the environmental monitoring programs are assessed to determine whether radionuclides were detected at locations accessible to the public. If radionuclides were detected at locations accessible to the public, a dose assessment is completed based on the monitoring data. Exposure to radionuclides detected in groundwater at PORTS is not included because contaminated groundwater at PORTS is not a source of drinking water.

In 2019, annual doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, and vegetation. Radionuclides were not detected in 2019 in samples of residential drinking water, deer, fish, crops, and dairy products.

In addition, DOE Order 458.1 sets absorbed dose rate limits for aquatic animals, riparian animals, terrestrial plants, and terrestrial animals. This chapter discusses the dose calculations completed to demonstrate compliance with these limits.

DOE staff, DOE contractors, and visitors to DOE areas who may be exposed to radiation are also monitored. These results are also provided in this chapter.

4.3.1 Airborne Emissions

Airborne discharges of radionuclides from PORTS are regulated under the NESHAP (40 CFR Part 61, Subpart H). Releases of radionuclides are used to calculate an annual dose to members of the public, which is reported annually to U.S. EPA and Ohio EPA. Section 4.3.2 discusses the results of this dose calculation.

In 2019, FBP was responsible for air emission sources associated with the former gaseous diffusion plant operations, including continuously monitored vents in the X-330 and X-333 Process Buildings and the X-344A Uranium Hexafluoride Sampling Building. The vents in the X-330 and X-333 Process Buildings were in use to support D&D activities. The X-344A vents were in use for ongoing sampling of uranium product. Vents in the X-326 Process Building have been permanently shut down as part of D&D activities.

Other radionuclide air emission sources included room ventilation exhausts and/or pressure relief vents associated with the X-710 Technical Services Building, X-705 Decontamination Facility, and the XT-847 Glove Box (inactive). These emission sources were not continuously monitored; emissions from these sources (when in use) were estimated based on operating data and U.S. EPA emission factors. The X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities treated groundwater contaminated with radionuclides or other site water (in accordance with the FBP NPDES permit). Emissions from the groundwater treatment facilities were calculated based on quarterly influent and effluent sampling at each facility and quarterly throughput. Total emissions from the FBP airborne sources in 2019 were calculated to be 0.08568 Ci (8.568E-02 Ci).

MCS was responsible for air emission sources associated with the DUF_6 Conversion Facility. Emissions from the DUF_6 Conversion Facility were based on continuous monitoring of the conversion building stack. Total emissions from the MCS airborne sources in 2019 were calculated to be 0.0000478 Ci (4.78E-05 Ci).

The Centrus demonstration cascade was the only source of radionuclide air emissions from Centrus that was subject to NESHAP reporting. The demonstration cascade was shut down in 2016; therefore, there were no emissions from Centrus in 2019.

4.3.2 Dose Calculation Based on Airborne Emissions

An annual dose calculation for atmospheric, or airborne, radionuclides is required by U.S. EPA under NESHAP and is provided to U.S. EPA in an annual report. The effect of radionuclides released to the atmosphere by PORTS during 2019 was determined by calculating the effective annual dose to the maximally exposed individual (the individual who resides at the most exposed point near the plant) and to the entire population (approximately 662,000 residents) within 50 miles of the plant. Dose calculations were made using a computer program called CAP88-PC Version 4.0, which was developed under sponsorship of U.S. EPA for use in demonstrating compliance with the radionuclide NESHAP. The program uses models to calculate levels of radionuclides in the air, on the ground, and in food (e.g., vegetables, meat, and milk) and subsequent intakes by individuals. The program also uses meteorological data collected at PORTS such as wind direction, wind speed, atmospheric stability, rainfall, and average air temperature.

Radionuclide emissions were modeled for each of the air emission sources discussed in Section 4.3.1. The dose calculations assumed that each person remained unprotected, resided at home (actually outside the house) during the entire year, and obtained food according to the rural pattern defined in the NESHAP background documents. This pattern specifies that 70% of the vegetables and produce, 44% of the meat, and 40% of the milk consumed by each person are produced in the local area (e.g., in a home garden). The remaining portion of each food is assumed to be produced within 50 miles of PORTS. These assumptions most likely result in an overestimate of the dose received by a member of the public, since it is unlikely that a person spends the entire year outside at home and consumes food from the local area as described above.

The maximum potential annual dose to an off-site individual from radiological releases from PORTS air emission sources in 2019 was 0.16 mrem/year. This annual dose is below the 10-mrem/year limit applicable to PORTS and the approximate 311-mrem/year annual dose that the average individual in the United States receives from natural sources of radiation (NCRP 2009).

The collective annual dose (or population dose) is the sum of doses to all individual members of the public within 50 miles of PORTS. In 2019, the population dose from PORTS emissions was 3 person-rem/year. As a comparison, the average population dose to all people within 50 miles of PORTS from the ingestion of naturally-occurring radionuclides in water and food was approximately 19,630 person-rem/year based on an average dose of approximately 29 mrem/year to an individual (NCRP 2009).

4.3.3 Dose Calculation Based on Ambient Air Monitoring

Ambient air monitoring measures pollutants in surrounding, outdoor air. DOE collects samples from 15 ambient air monitoring stations (see Figure 4.3) and analyzes them for the radionuclides that could be present in ambient air due to PORTS activities. These radionuclides are isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238), technetium-99, and selected transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). The ambient air monitoring stations measure radionuclides released from DOE point sources (the sources described in Section 4.3.1), fugitive air emissions (emissions that are not associated with a specific release point such as a stack), and background levels of radiation (radiation that occurs naturally in the environment and is not associated with PORTS).

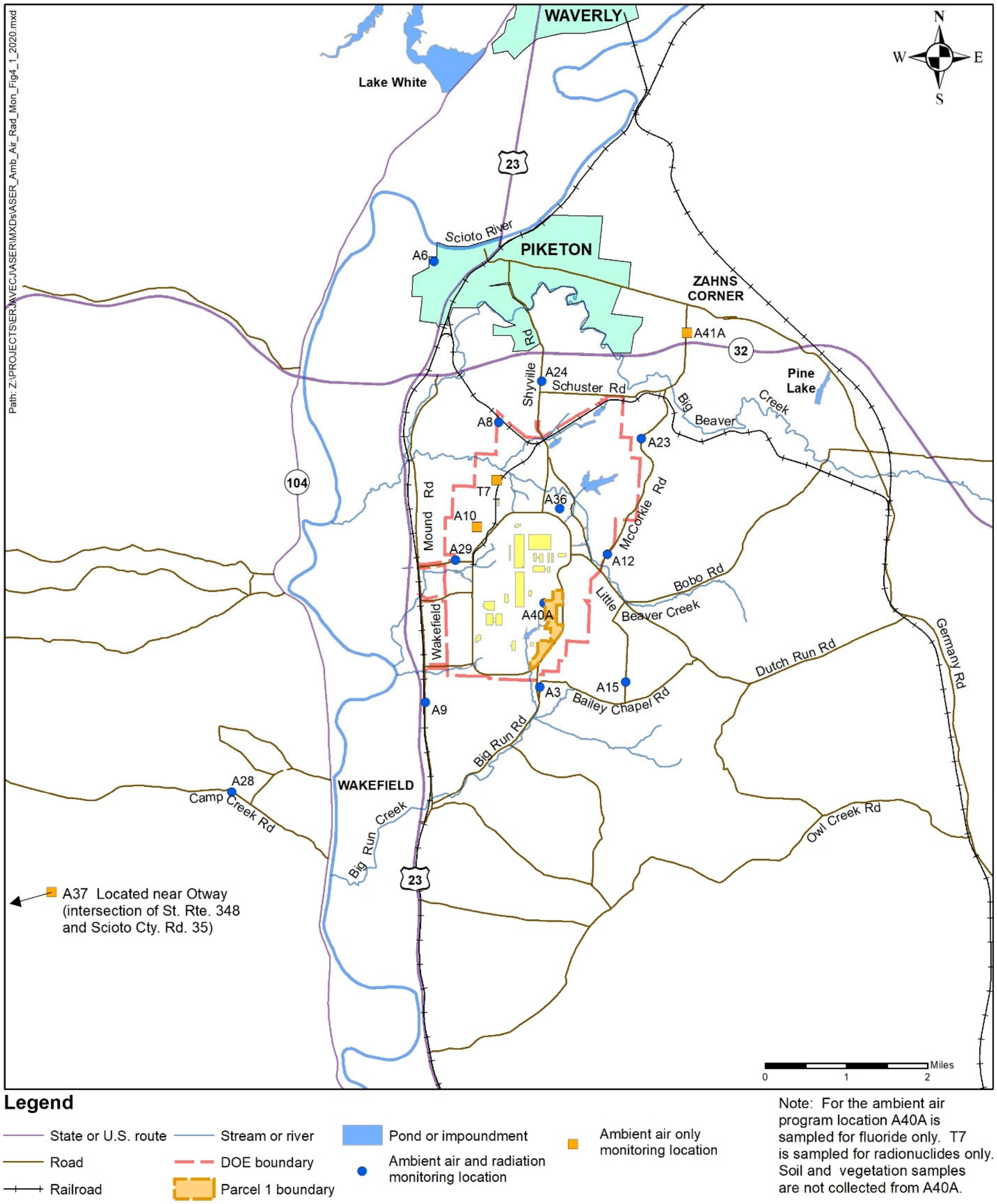

Figure 4.3. DOE ambient air and radiation monitoring locations.

The CAP88 model generates a dose conversion factor that was used to calculate an annual dose for a given level of each radionuclide in air (mrem/pCi/m^3). The following assumptions were made to calculate the annual dose at each station: 1) the highest level of each radionuclide detected in 2019 was assumed to be present for the entire year; or 2) if a radionuclide was not detected, the radionuclide was assumed to be present for the entire year at half the highest undetected result. This approach may overestimate the annual dose because it assumes an individual resides at the location of the monitoring station breathing the highest levels of radionuclides in air at that location for 24 hours/day, 365 days/year. Additionally, the annual dose associated with the background station is not subtracted from the locations near PORTS, which means that the low levels of radionuclides that are naturally-occurring or present due to worldwide fallout are not removed from the dose calculation for stations near PORTS.

The highest annual dose calculation for off-site ambient air monitoring stations near PORTS is 0.056 mrem/year at station A3, which is south of PORTS on Bailey Chapel Road (see Figure 4.3). This hypothetical dose (0.056 mrem/year) is below the 10 mrem/year limit applicable to PORTS in NESHAP (40 CFR Part 61, Subpart H).

4.3.4 Discharges of Radionuclides from NPDES Outfalls

FBP, MCS, and Centrus were responsible for NPDES outfalls at PORTS during 2019. The MCS NPDES outfall is not monitored for radionuclides; therefore, it is not discussed in this section. A description of the FBP and Centrus outfalls and the discharges of radionuclides from these outfalls during 2019 are included in this section.

4.3.4.1 FBP outfalls

In 2019, FBP was responsible for 18 monitoring locations identified in the FBP NPDES permit. Nine outfalls discharge directly to surface water, six outfalls discharge to another outfall before leaving the site, and three other locations that are not outfalls are also monitored (see Figure 4.4). A brief description of each FBP outfall or monitoring location at PORTS follows.

FBP NPDES Outfall 001 (X-230J7 East Holding Pond) – The X-230J7 East Holding Pond receives non-contact cooling water, steam condensate, foundation drainage, storm runoff, hydro-testing water from cylinders, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be diverted/contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 002 (X-230K South Holding Pond) – The X-230K South Holding Pond receives non-contact cooling water, boiler blowdown, steam condensate, foundation drainage, treated runoff from the former coal pile area, storm runoff, fire-fighting training and fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be contained, and pH can be adjusted. Water from this holding pond is discharged to Big Run Creek.

FBP NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – The X-6619 Sewage Treatment Plant treats PORTS sewage, some Pike County sewage, and process wastewater from MCS as well as water discharged from PORTS groundwater treatment facilities, the X-700 Biodenitrification Facility, the X-705 Decontamination Microfiltration System, and miscellaneous waste streams. The X-6619 Sewage Treatment Plant uses screening, aeration, clarification, and filtering followed by disinfection to treat wastewater prior to release to the Scioto River.

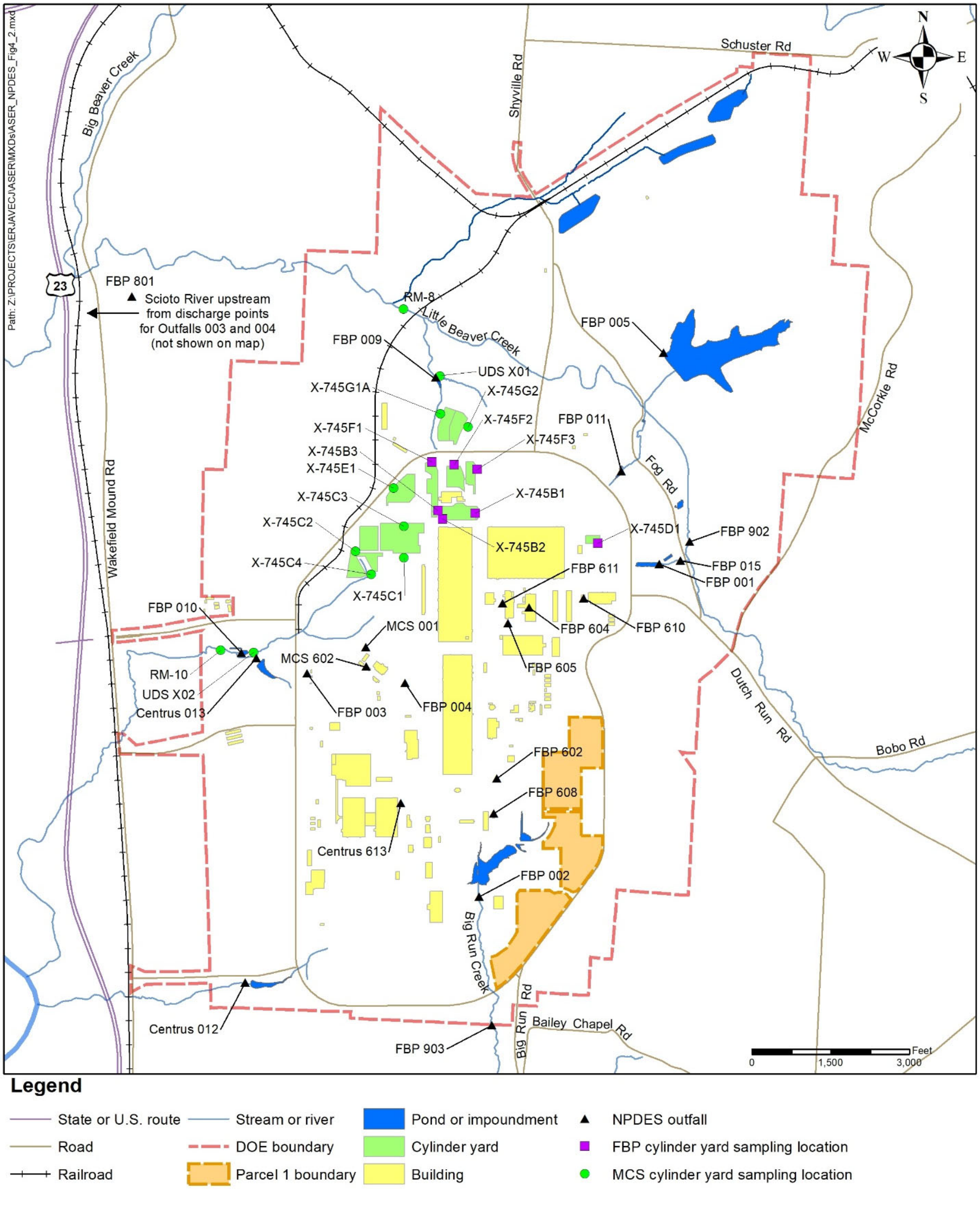

Figure 4.4. PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations.

FBP NPDES Outfall 004 (Cooling Tower Blowdown) – Outfall 004 is located within the X-680 Blowdown Sample and Treatment Building at PORTS. It monitors blowdown water from cooling towers on site prior to being discharged to the Scioto River.

FBP NPDES Outfall 005 (X-611B Lime Sludge Lagoon) – The X-611B Lime Sludge Lagoon is used to settle lime sludge used in a water-softening process. The X-611B also receives rainwater runoff. Water is discharged to Little Beaver Creek.

FBP NPDES Outfall 009 (X-230L North Holding Pond) – The X-230L North Holding Pond receives non-contact cooling water, steam condensate, storm runoff, fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 010 (X-230J5 Northwest Holding Pond) – The X-230J5 Northwest Holding Pond receives non-contact cooling water, steam condensate, storm runoff, fire-fighting training and fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be diverted/contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary commonly referred to as the Western Drainage Ditch, which flows to the Scioto River.

FBP NPDES Outfall 011 (X-230J6 Northeast Holding Pond) – The X-230J6 Northeast Holding Pond receives non-contact cooling water, steam condensate, storm runoff, fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be diverted/contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – The X-624 Groundwater Treatment Facility removes VOCs from contaminated groundwater collected in the X-237 Groundwater Collection System in the X-701B Holding Pond area. This collection system was constructed to control the migration of groundwater contaminated with VOCs toward Little Beaver Creek. Treated water is released to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – Prior to D&D of the X-600 Steam Plant Complex, the X-621 Coal Pile Runoff Treatment Facility treated storm water runoff from the coal pile at the X-600 Steam Plant Complex. The X-600 Steam Plant Complex was removed in 2013. The X-621 Treatment Facility currently operates intermittently to treat precipitation runoff from the area of the former facility. The treated water is discharged to the X-230K South Holding Pond (FBP NPDES Outfall 002).

FBP NPDES Outfall 604 (X-700 Biodenitrification Facility) – The X-700 Biodenitrification Facility receives solutions from plant operations that are high in nitrate. At the X-700, these solutions are diluted and treated biologically using bacteria prior to being discharged to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

FBP NPDES Outfall 605 (X-705 Decontamination Microfiltration System) – The X-705 Decontamination Microfiltration System treats process wastewater using microfiltration and pressure filtration technology. The treated water is discharged to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). There were no discharges from Outfall 605 in 2019.

FBP NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – The X-622 Groundwater Treatment Facility removes VOCs from contaminated groundwater originating from site remediation activities in the southern portion of the site, which is Quadrant I in the RCRA Corrective Action Program (see Chapter 3, Section 3.3.1). Treated water is discharged to the sanitary sewer and then through FBP NPDES Outfall 003.

FBP NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – The X-623 Groundwater Treatment Facility formerly treated contaminated groundwater from extraction wells in the X-701B groundwater plume. The groundwater extraction wells were removed between 2009 and 2011. Currently, the facility removes VOCs from miscellaneous water associated with site activities (in accordance with the FBP NPDES permit). Treated water is discharged to the sanitary sewer and then through FBP NPDES Outfall 003.

FBP NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – The X-627 Groundwater Treatment Facility removes VOCs from groundwater collecting in sumps located in the basements of the X-700 and X-705 buildings, which are part of Quadrant II. Treated water is discharged to the sanitary sewer and then through FBP NPDES Outfall 003.

FBP is also responsible for three additional monitoring points that are not discharge points as described in the previous paragraphs. FBP NPDES Station Number 801 is a surface water background monitoring location on the Scioto River upstream from FBP NPDES Outfalls 003 and 004 that is used for biotoxicity studies. FBP NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from FBP NPDES Outfall 001, and FBP NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from FBP NPDES Outfall 002. Water temperature is the only parameter measured at FBP NPDES Station Numbers 902 and 903.

FBP NPDES Outfalls 001, 002, 003, 004, 005, 009, 010, 011, 015, 608, 610, and 611 were monitored for radiological discharges by collecting water samples and analyzing the samples for uranium, uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238), technetium-99, and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240).

No transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were detected in samples collected from the external FBP outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) during 2019.

Discharges of radionuclides to surface water were calculated using monthly monitoring data from the NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium and technetium-99 discharged through the outfalls. In 2019, uranium discharges from the FBP external outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) were estimated at 12.4 kilograms (kg). Total radioactivity (technetium-99 and isotopic uranium) released from the same outfalls was estimated at 0.093 Ci.

Discharges of radionuclides from the outfalls are used in the dose calculation for releases to surface water (Section 4.3.5). The annual dose calculated with these data (0.0011 mrem/year) is less than the 100 mrem/year limit in DOE Order 458.1 for all radiological releases from a facility.

4.3.4.2 Centrus outfalls

In 2019, Centrus was responsible for three NPDES outfalls through which water is discharged from the site (see Figure 4.4). Two outfalls discharge directly to surface water, and one discharges to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003) before leaving the site. A brief description of each Centrus NPDES outfall follows.

Centrus NPDES Outfall 012 (X-2230M Southwest Holding Pond) – The X-2230M Southwest Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the southwestern portion of PORTS. The pond provides an area where solids can settle, chlorine can dissipate, and oil can be separated from the water prior to its release to an unnamed stream that flows to the Scioto River.

Centrus NPDES Outfall 013 (X-2230N West Holding Pond) – The X-2230N West Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the western portion of PORTS. The pond provides an area where solids can settle, chlorine can dissipate, and oil can be separated from the water prior to its release to a tributary commonly referred to as the Western Drainage Ditch, which flows to the Scioto River.

Centrus NPDES Outfall 613 (X-6002 Particulate Separator) – The X-6002 Particulate Separator removes suspended solids from water used in the X-6002 Recirculating Hot Water Plant, which provides heat to a number of buildings at PORTS. The treated water is discharged to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

Centrus Outfalls 012 and 013 were monitored for radiological discharges by collecting water samples and analyzing the samples for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, and uranium. Transuranic radionuclides and technetium-99 were not detected in any of the samples collected from Centrus NPDES outfalls in 2019.

Uranium discharges in 2019 from external Centrus NPDES outfalls (Outfalls 012 and 013) were estimated at 0.73 kg. These values were calculated using quarterly discharge monitoring reports for the Centrus NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium discharged through the Centrus NPDES outfalls.

Discharges of radionuclides from Centrus Outfalls 012 and 013 are used in the dose calculation for releases to surface water (Section 4.3.5). The annual dose calculated with these data and data from external FBP outfalls (0.0011 mrem/year) is less than the 100 mrem/year limit in DOE Order 458.1 for all radiological releases from a facility.

4.3.5 Dose Calculation for Releases to Surface Water

Radionuclides are measured at the FBP and Centrus NPDES external outfalls (nine FBP outfalls and two Centrus outfalls). Water from these external outfalls is either directly discharged to the Scioto River or eventually flows into the Scioto River from Little Beaver Creek, Big Run Creek, or unnamed tributaries to these water bodies. A hypothetical annual dose to a member of the public was calculated using the measured radiological discharges and the annual flow rate of the Scioto River.

Activity (in picocuries per liter [pCi/L]) for americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, and isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238) were measured in the water discharged from the FBP outfalls. Uranium mass (in micrograms per liter [µg/L]) and activity (in pCi/L) for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and technetium-99 were measured in the water discharged from the Centrus outfalls. Radionuclides that were not detected were assumed to be present at the detection limit. Uranium measured at the Centrus outfalls was assumed to be 5.2% uranium-235, 94% uranium-238, and 0.8% uranium-234 based on the highest enrichment of uranium produced by PORTS in the years prior to shutdown of the gaseous diffusion uranium enrichment operations. The maximum individual annual dose was calculated using the above-mentioned measured radionuclide discharges from the plant outfalls and the annual flow rate of the Scioto River.

The dose calculations were derived from the procedures developed for a similar DOE facility: *LADTAP XL: An Improved Electronic Spreadsheet Version of LADTAP II* (Hamby 1991) and *LADTAP-PA: A Spreadsheet for Estimating Dose Resulting from E-Area Groundwater Contamination at the Savannah River Site* (Jannik and Dixon 2006), which updates the 1991 LADTAP XL. Specific exposure scenarios provided in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d) were also used when available. Environmental pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. This exposure scenario overestimates the dose to the public because the Scioto River is not used for drinking water downstream of PORTS (97% of the hypothetical dose from liquid effluents is from drinking water). The annual dose from radionuclides released to the Scioto River in 2019 (0.0011 mrem/year) is less than the total public annual dose limit of 100 mrem/year DOE in DOE Order 458.1.

4.3.6 Radiological Dose Calculation for External Radiation

Radiation is emitted from DUF_6 cylinders stored on site at PORTS in the cylinder storage yards located in the northwest portion of the site near Perimeter Road. External radiation is measured at five locations along Perimeter Road near the boundaries of the cylinder storage yards in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). External radiation is measured using thermoluminescent dosimeters (TLDs), which measure both external background radiation and radiation originating from the DUF_6 cylinders. Section 4.6.2 and Figure 4.5 provide more information about the external radiation monitoring program.

Data from radiation monitoring at the cylinder yards are used to assess potential exposure to a representative on-site member of the public that drives on Perimeter Road. The radiological exposure to an on-site member of the general public is estimated as the time that a person drives on Perimeter Road past the cylinder yards, which is calculated at 8.7 hours per year (1 minute per trip, 2 trips per day, 5 work-days per week, and 52 weeks per year). In 2019, the average annual dose recorded by TLDs at the cylinder yards near Perimeter Road was 743 mrem/year, based on TLD measurements for an entire year at locations #41, #868, #874, #882, and #890 (see Section 4.6.2 and Figure 4.5). Although the total annual external radiation dose near the cylinder yards is high, a person would only receive this dose if they were present at the cylinder yards for 24 hours/day, 365 days/year. Access to the cylinder yard area is controlled by PORTS security forces so that a member of the public could not be continuously exposed to this level of radiation from the cylinder yards. External radiation levels associated with the cylinder yards diminish quickly to background levels with distance from the cylinder yards as demonstrated by radiation measurements at other on-site and all off-site monitoring locations. Based on the estimated time that a person would drive on Perimeter Road near the cylinder yards, the dose to an on-site member of the public from radiation from the cylinder yards is approximately 0.74 mrem/year.

External radiation is also measured using TLDs at 19 locations that include 12 of the ambient air monitoring stations and seven additional on-site locations in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). The total annual dose measured in 2019 at station A29, near the Ohio Valley Electric Corporation (OVEC), was 98 mrem/year (see Section 4.6.2 and Figure 4.5). The total annual dose measured at eight of the off-site or background monitoring stations averaged 95 mrem/year. A dose calculation was completed for a representative off-site member of the public, such as a worker at OVEC, based on the 3 mrem/year difference between the average off-site background dose (95 mrem/year) and the dose at station A29 (98 mrem/year). Assuming that the worker was exposed to this radiation for 250 days/year, one hour outdoors and 8 hours indoors, the dose to this worker is 0.36 mrem/year.

A person living in the United States receives an average annual dose of approximately 311 mrem/year from natural sources of radiation (NCRP 2009). The higher potential estimated dose from external radiation to a member of the public (0.74 mrem/year to a delivery person on Perimeter Road versus 0.36 mrem/year to a worker near station A29) is approximately 0.2 percent of the average yearly natural radiation exposure for a person in the United States and is less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.3.7 Radiological Dose Results for DOE Workers and Visitors

The DOE Radiological Protection Organization at PORTS monitors external radiation levels in active DOE facilities at PORTS on a continual basis. This radiation monitoring assists in determining the radiation levels that workers are exposed to and in identifying changes in radiation levels. These measurements provide 1) information for worker protection, 2) a means to trend radiological exposure data for specified facilities, and 3) a means to estimate potential public exposure to radiation from DOE activities at PORTS.

The Radiation Exposure Monitoring System report is an electronic file created annually to comply with DOE Order 231.1B. This report contains exposure results for all monitored DOE employees, DOE contractors, and visitors to DOE areas at PORTS with a positive exposure during the previous calendar year. The 2019 Radiation Exposure Monitoring System report indicated that no visitors received a measurable dose (10 mrem/year or more).

More than 2400 DOE employees and DOE contractors were monitored throughout 2019. These workers received an average dose of 1.74 mrem/year. Approximately 2.9% of the monitored workers received a measurable dose (10 mrem/year total effective dose or more), primarily workers in the vicinity of the uranium hexafluoride cylinders or in the DUF_6 Conversion Facility. No administrative guidelines or regulatory dose limits were exceeded in 2019.

4.3.8 Radiological Dose Calculations for Off-site Environmental Monitoring Data

Environmental monitoring at PORTS includes collecting samples at off-site locations around PORTS and analyzing the samples for radionuclides that could be present due to PORTS. Radiological monitoring programs at PORTS include ambient air, surface water, sediment, soil, residential drinking water (well water), and biota (vegetation, deer, fish, crops, milk, and eggs).

Samples are analyzed for the following radionuclides of potential concern: uranium, uranium isotopes, technetium-99, and/or selected transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). Uranium occurs naturally in the environment; therefore, detections of uranium cannot necessarily be attributed to PORTS. Technetium-99 and transuranics could come from PORTS because they were present in recycled uranium processed by PORTS during the Cold War. Technetium-99 and transuranic radionuclides could also come from sources other than PORTS because they are generally present in the world-wide environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world (Argonne National Laboratory 2007).

DOE sets a total public annual dose limit as low as reasonably achievable, but no more than 100 mrem/year above background in DOE Order 458.1 for a potential dose to a member of the public via exposure to all radionuclide releases from a DOE facility. To ensure that PORTS meets this standard, dose calculations may be completed for environmental media.

Dose calculations for ambient air and surface water were presented in Sections 4.3.3 and 4.3.5, respectively. Dose calculations are also completed for detections of radionuclides in sediment, soil, residential drinking water (well water – excluding naturally-occurring detections of uranium isotopes), and biota (vegetation, deer, fish, crops, and dairy products) at off-site sampling locations. If radionuclides are not detected in the samples, a dose assessment is not completed. Off-site sampling locations are selected based on detections of radionuclides that could cause the highest dose to a member of the public. Detections of radionuclides in sediment and soil on the PORTS facility are not used to assess potential risk because the public does not have access to the sampled areas of the facility.

The summary of these dose calculations assumes that the same individual is exposed to the maximum dose calculated from each pathway. In 2019, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, and vegetation. Radionuclides were not detected in 2019 in samples of residential drinking water, deer, fish, crops, and dairy products.

The following sections provide brief descriptions of the dose calculations for sediment, soil, and vegetation. Methodologies used to complete each risk calculation are based on information developed and approved by U.S. EPA including the *Exposure Factors Handbook* (U.S. 2011) and *Federal Guidance Report No. 11 (FGR 11) Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Immersion, and Ingestion* (U.S. EPA 1988).

In addition, specific exposure scenarios provided in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d) were used when available. This document integrates the results of technical meetings between Ohio EPA and DOE and provides methods for completing risk analyses at PORTS to promote consistency in the risk approach.

Table 4.2 summarizes the results of each dose calculation. Potential annual doses to the public from radionuclides detected by the PORTS environmental monitoring program in 2019 are less than the 100 mrem/year limit in DOE Order 458.1 and are considered ALARA.

Table 4.2. Summary of potential annual doses to the public from radionuclides detected by DOE environmental monitoring programs in 2019

Source of dose	Dose (mrem/year)[a]
Sediment	0.022
Soil	0.023
Vegetation	0.00096
Total	0.046

[a]100 mrem/year is the limit for all potential pathways in DOE Order 458.1.

4.3.8.1 Dose calculation for sediment

The dose calculation for sediment is based on the following detections of radionuclides in the sample collected in 2019 from monitoring location RM-7, an off-site sampling location on Little Beaver Creek (see Section 4.6.5 and Figure 4.6):

- neptunium-237: 0.0263 picocurie per gram (pCi/g)
- technetium-99: 9.12 pCi/g
- uranium-233/234: 2.7 pCi/g
- uranium-235/236: 0.138 pCi/g
- uranium-238: 0.71 pCi/g.

Based on an incidental ingestion rate of 200 milligrams (mg)/day (0.0007 ounces/day) and an exposure frequency of 100 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d), and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 2011), the annual dose that could be received by an individual from sediment contaminated at these levels is 0.022 mrem/year. Section 4.6.5 provides additional information on the sediment monitoring program as well as a map of sediment sampling locations.

4.3.8.2 Dose calculation for soil

The dose calculation for soil is based on the detections of the following uranium isotopes in the soil sample collected at the ambient air monitoring station A9, southwest of PORTS on Old U.S. Route 23 (see Section 4.6.7 and Figure 4.3):

- americium-241: 0.0159 pCi/g
- plutonium-239/240: 0.0331 pCi/g
- uranium-233/234: 0.263 pCi/g
- uranium-235/236: 0.0122 pCi/g
- uranium-238: 0.292 pCi/g.

Based on an incidental ingestion rate of 200 mg/day (0.0007 ounces/day) and an exposure frequency of 350 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d), and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. 2011), the annual dose that could be received by an individual from soil contaminated at these levels is 0.023 mrem/year. Section 4.6.7 provides additional information on the soil monitoring program.

4.3.8.3 Dose calculation for vegetation

The dose calculation for vegetation is based on the following detections of radionuclides in vegetation (primarily grass) and soil at ambient air monitoring station A6 in Piketon (see Section 4.6.8.1 and Figure 4.3):

<u>Vegetation</u>
- uranium-233/234: 0.0914 pCi/g
- uranium-238: 0.0219 pCi/g

<u>Soil</u>
- plutonium-239/240: 0.0106 pCi/g
- uranium-233/234: 0.239 pCi/g
- uranium-235/236: 0.0163 pCi/g
- uranium-238: 0.346 pCi/g.

The dose calculation is based on human consumption of beef cattle that would eat grass (and soil) containing these radionuclides. Based on an ingestion rate for beef of 2 ounces/day and an exposure frequency of 100 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d) and U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 2018), the annual dose that could be received by an individual eating beef from cattle that grazed on vegetation and soil contaminated at these levels is 0.00096 mrem/year. Section 4.6.8.1 provides additional information on the vegetation monitoring program.

4.4 PROTECTION OF BIOTA

DOE Order 458.1 sets absorbed dose rate limits for aquatic animals, riparian animals (animals that live on the banks of a river or in wetlands adjacent to a body of water), terrestrial plants, and terrestrial animals. DOE Technical Standard *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019b) was used to demonstrate compliance with these limits.

4.4.1 Aquatic and Riparian Animals

Analytical data for surface water and sediment samples collected during 2019 from the east side of the PORTS reservation [surface water sampling location EDD-SW01 (see Chapter 6, Section 6.4.15 and Figure 6.13) and sediment sampling location RM-11 (see Section 4.6.5 and Figure 4.6)] were used to assess the dose limits for aquatic and riparian animals (1 rad/day to aquatic animals and 0.1 rad/day to riparian animals). These locations were selected because levels of radionuclides detected in surface water and sediment from these locations were among the highest detected in samples collected in 2019. Section 4.6.5 and Chapter 6, Section 6.4.15 provide more information about these sediment and surface water sampling programs, respectively.

The maximum levels of radionuclides (plutonium-239/240, technetium-99, and uranium isotopes) were as follows:

Radionuclide	EDD-SW01	RM-11 (regular sample)
Plutonium-239/240	not detected	0.0486 pCi/g
Technetium-99	72.7 pCi/L	15.6 pCi/g
Uranium-233/234	10.1 pCi/L	11.7 pCi/g
Uranium-235/236	0.601 pCi/L	0.551 pCi/g
Uranium-238	2.01 pCi/L	2.42 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2019b). The software provides a screening method with generic limiting concentrations of radionuclides in environmental media. If the measured maximum levels of radionuclides detected at the selected PORTS sampling locations result in an output from the software calculations of less than 1, the doses to aquatic and riparian animals are within the dose limits (1 rad/day to aquatic animals and 0.1 rad/day to riparian animals).

In 2019, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations EDD-SW01 (surface water) and RM-11 (sediment) was 0.0657, which is less than 1. Therefore, the assessment indicates that the levels of radionuclides detected in water and sediment at these locations did not result in a dose of more than 1 rad/day to aquatic animals and 0.1 rad/day to riparian animals.

4.4.2 Terrestrial Plants and Animals

Analytical data for surface water and soil samples collected during 2019 from the northern side of the PORTS reservation [surface water sampling location LBC-SW04 (see Chapter 6, Section 6.4.15 and Figure 6.13) and soil sampling location A8 (see Figure 4.3)] were used to assess the dose limits for terrestrial plants and animals. These locations were selected because levels of radionuclides detected in surface water and soil from these locations were among the highest detected in samples collected in 2019. Section 4.6.7 and Chapter 6, Section 6.4.15 provide additional information about these soil and surface water sampling programs, respectively.

No transuranic radionuclides or technetium-99 were detected in 2019 from samples collected at LBC-SW04 (surface water) and A8 (soil). The maximum levels of uranium isotopes were as follows:

Radionuclide	LBC-SW04	A8
Uranium-233/234	1.98 pCi/L	1.54 pCi/g
Uranium-235/236	0.0885 pCi/L	0.0925 pCi/g
Uranium-238	0.653 pCi/L	1.53 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2019b). The software provides a screening method with generic limiting concentrations of radionuclides in environmental media. If the measured maximum levels of radionuclides detected at the selected PORTS sampling locations result in an output from the software calculations of less than 1, the doses to terrestrial plants and animals are within the dose limits (1 rad/day to terrestrial plants and 0.1 rad/day to terrestrial animals).

In 2019, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations LBC-SW04 (surface water) and A8 (soil) was 0.00131, which is less than 1. Therefore, the assessment indicates that the levels of radionuclides detected in water and soil at these locations did not result in a dose of more than 1 rad/day to terrestrial plants and 0.1 rad/day to terrestrial animals.

4.5 UNPLANNED RADIOLOGICAL RELEASES

No unplanned releases of radionuclides took place at PORTS in 2019.

4.6 ENVIRONMENTAL RADIOLOGICAL MONITORING

This section discusses the radiological monitoring programs at PORTS: ambient air monitoring, external radiation, surface water, sediment, settleable solids, soil, vegetation, and biota (deer, fish, crops, milk, and eggs).

4.6.1 Ambient Air Monitoring

Ambient air monitoring measures pollutants in surrounding, outdoor air. The ambient air monitoring stations measure radionuclides released from 1) DOE point sources (the sources discussed in Section 4.3.1), 2) fugitive air emissions (emissions from PORTS that are not associated with a stack or pipe such as remediation sites or normal building ventilation), and 3) background levels of radionuclides (radionuclides that occur naturally, such as uranium). These radionuclides are isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238), technetium-99, and selected transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240).

In 2019, samples were collected from 15 ambient air monitoring stations located within and around PORTS (see Section 4.3.3, Figure 4.3), including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant. The analytical results from air sampling stations closer to the plant are compared to the background measurements.

Ambient concentrations of uranium and uranium isotopes at the monitoring stations in 2019 were likely impacted (i.e., elevated) by the presence of uranium isotopes in filters used in sampling. Uranium and uranium isotopes were detected in quality control samples associated with the ambient air samples and subsequently in unused filters obtained from the manufacturer that are placed at the ambient air stations to collect samples. The presence of uranium and uranium isotopes in the unused filters may have caused slightly elevated analytical results for uranium and uranium isotopes.

In 2019, the highest levels of uranium, uranium isotopes, and technetium-99 detected in air were 0.2%, or less, of the DOE derived concentration standards (DOE 2011b)[1]. Maximum activities of detected radionuclides were located at stations A36 (on site at the X-611 Water Filtration Plant) and A10 (on site

[1]The derived concentration standard is the concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (ingestion of water or inhalation of air) would result in a dose of 100 mrem. A concentration that is 100% of the derived concentration standard would equate to a dose at the DOE limit of 100 mrem/year (DOE 2011b).

near the Don Marquis Substation on the west side of PORTS). The maximum activities of detected radionuclides (in picocurie per cubic meter [pCi/m^3]) are listed below:

Radionuclide	Maximum activity (pCi/m^3)	Location	Derived concentration standard (DOE 2011b) (pCi/m^3)[a]	Percentage of derived concentration standard (DOE 2011b)
Technetium-99	0.0037	A36	920	0.0004%
Uranium-233/234	0.0017	A10	1.1	0.2%
Uranium-235/236	0.000081	A10	1.2	0.007%
Uranium-238	0.0019	A10	1.3	0.1%

[a]The derived concentration standard has been converted to pCi/m^3 from units of microcurie per milliliter provided in the *Derived Concentration Technical Standard* (DOE 2011b).

To confirm that air emissions from PORTS are within regulatory requirements and are not harmful to human health, the ambient air monitoring data were used to calculate an annual dose to a hypothetical person living at the monitoring station. The highest annual dose calculation for off-site ambient air monitoring stations near PORTS is 0.056 mrem/year at station A3, which is south of PORTS on Bailey Chapel Road (see Figure 4.3). This hypothetical annual dose (0.056 mrem/year) is below the 10 mrem/year limit applicable to PORTS in NESHAP (40 CFR Part 61, Subpart H). Section 4.3.3 provides additional information about this dose calculation.

4.6.2 External Radiation

External radiation is measured continuously with TLDs at five locations near the DUF_6 cylinder storage yards (see Figure 4.5), 19 locations that include 12 of the ambient air monitoring stations (see Section 4.3.3, Figure 4.3), and seven additional on-site locations (see Figure 4.5). TLDs are placed at the monitoring locations at the beginning of each quarter, remain at the monitoring location throughout the quarter, and are removed from the monitoring location at the end of the quarter and sent to the laboratory for processing. A new TLD replaces the removed device. Radiation is measured in millirems as a whole body dose, which is the dose that a person would receive if they were continuously present at the monitored location.

External radiation is measured by TLDs at five locations around the northwest corner of PORTS just inside Perimeter Road near the cylinder storage yards (see Figure 4.5). The average annual dose for these five locations (#41, #868, #874, #882, and #890) is 743 mrem/year. Section 4.3.6 provides a dose calculation for the representative on-site member of the public, such as a delivery person, that is allowed on the portion of Perimeter Road near the cylinder storage yards (the general public is not allowed on the portion of Perimeter Road near the cylinder storage yards). The potential estimated annual dose from the cylinder yards to a delivery person (0.74 mrem/year) is less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

In 2019, the average annual dose measured at eight off-site or background locations (A3, A6, A9, A12, A15, A23, A24, and A28) was 95 mrem/year. Two locations within PORTS measured levels of radiation approximately 50% higher or more than the average off-site radiation (95 mrem/year): location #874 (608 mrem/year) near the X-745C Cylinder Storage Yard and location #862 (132 mrem/year) south of the cylinder yards and west of the X-530A Switchyards. Four other on-site locations (X-230J2, A8, A40A, and A29) measured radiation at levels slightly higher than the average background (ranging from 1 mrem/year to 10 mrem/year above average).

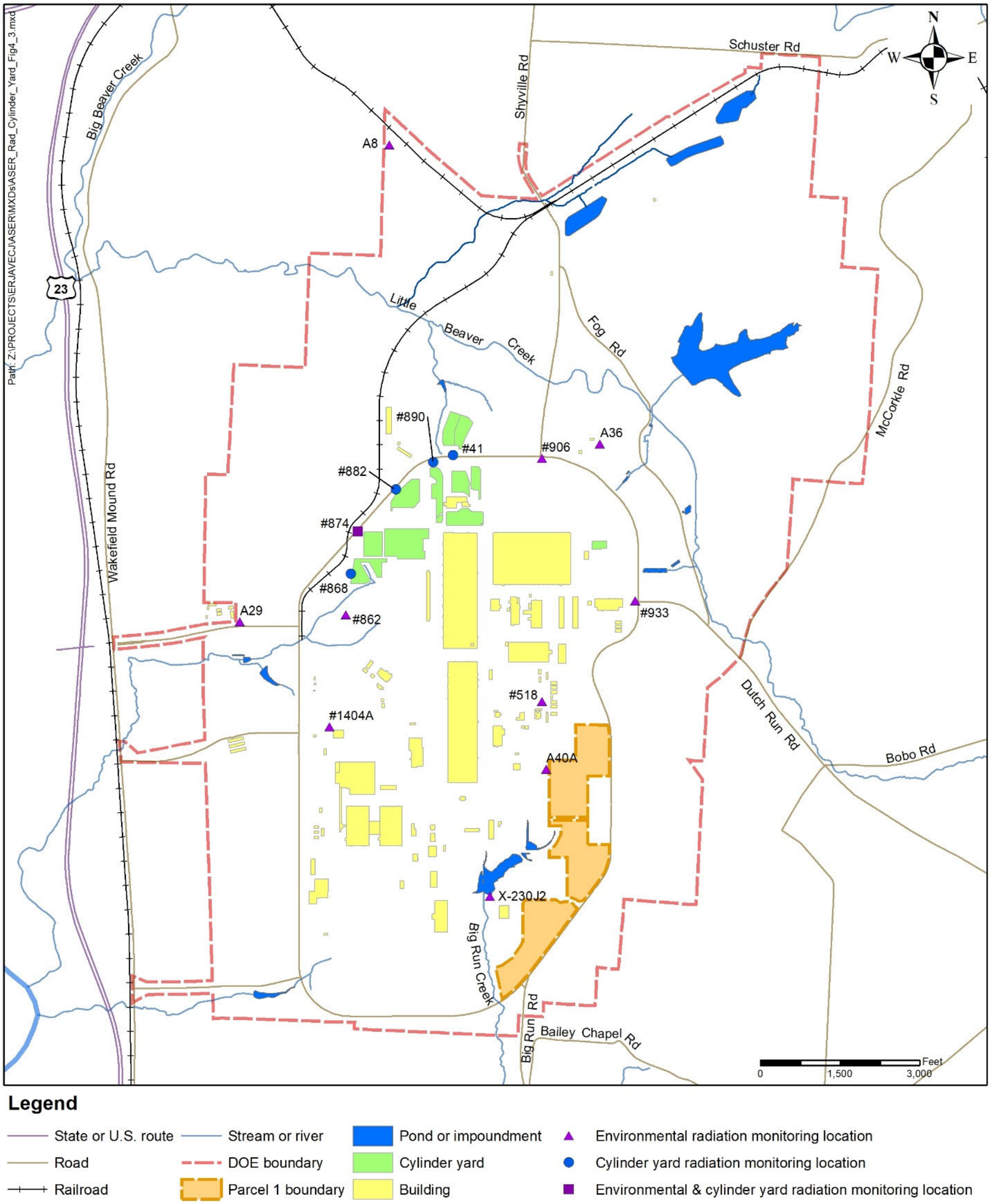

Figure 4.5. On-site radiation and cylinder yard dose monitoring locations.

The on-site locations with higher doses than the off-site average are not used by the general public, with the exception of location #874 near the cylinder yards and station A29, near OVEC. The dose calculation for the representative on-site member of the public exposed to the cylinder yards is discussed above and in Section 4.3.6. Section 4.3.6 also includes a dose calculation for the representative off-site member of the public who works at OVEC near station A29. The potential estimated annual dose to this off-site worker (0.36 mrem/year) is less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

Section 4.3.7 provides dose results for DOE workers, including workers in the cylinder yards. No administrative guidelines or regulatory dose limits were exceeded in 2019.

4.6.3 Surface Water from Cylinder Storage Yards

In 2019, FBP collected surface water samples from the X-745B, X-745D, and X-745F Cylinder Storage Yards. MCS collected surface water samples at the cylinder yards associated with the DUF_6 Conversion Facility (X-745C, X-745E, and X-745G Cylinder Storage Yards). Sections 4.6.3.1 and 4.6.3.2 provide the results of sampling completed in 2019 by FBP and MCS, respectively.

4.6.3.1 FBP cylinder storage yards

In 2019, FBP collected surface water samples from seven locations at the on-site X-745B, X-745D, and X-745F Cylinder Storage Yards. Figure 4.4 shows the sampling locations. Samples were analyzed for alpha activity, beta activity, and uranium. Samples were collected monthly if water was available.

Maximum levels of alpha activity, beta activity, and uranium were detected as follows:

Alpha activity: 1430 pCi/L (X-745B1, January 2019)
Beta activity: 1330 pCi/L (X-745B1, January 2019)
Uranium: 146 µg/L (X-745B2, January 2019).

Surface water from the cylinder storage yards flows to FBP NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the FBP outfalls. Radionuclides detected at FBP outfalls (see Section 4.3.4.1) are used in the dose calculation for releases to surface water (see Section 4.3.5). The annual dose from radionuclides released to the Scioto River in 2019 (0.0011 mrem/year) is less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.3.2 MCS cylinder storage yards

Ohio EPA requires monthly collection of surface water samples from seven locations at the on-site X-745C, X-745E, and X-745G Cylinder Storage Yards. Figure 4.4 shows the sampling locations. Samples were analyzed for alpha activity, beta activity, and uranium.

Maximum levels of alpha activity, beta activity, and uranium were detected as follows:

Alpha activity: 11.4 pCi/L (X-745C1, September 2019)
Beta activity: 16.411 pCi/L (X-745E1, June 2019)
Uranium: 10.5 µg/L (X-745C2, November 2019).

Surface water from the cylinder storage yards flows to FBP NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the FBP outfalls. Radionuclides detected at FBP outfalls (see Section 4.3.4.1) are used in the dose calculation for releases to surface water (see Section 4.3.5). The annual dose from radionuclides released to surface water (the Scioto River) in 2019 (0.0011 mrem/year) is less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.4 Local Surface Water

Local surface water samples are collected from 14 locations upstream and downstream from PORTS surface water discharges. These samples were taken from the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek (see Figure 4.6). As background measurements, samples were also collected from local streams approximately 10 miles north, south, east, and west of PORTS.

Samples were collected semiannually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b).

No transuranic radionuclides, technetium-99, or uranium-235/236 were detected in the local surface water samples collected during 2019. Maximum detections of uranium isotopes in local surface water samples are listed below:

Radionuclide	Maximum activity (pCi/L)	Location	Derived concentration standard (DOE 2011b)[a] (pCi/L)	Percentage of derived concentration standard (DOE 2011b)
Uranium-233/234	1.62	RW-7	680	0.2%
Uranium-238	0.646	RW-6	750	0.09%

[a]The derived concentration standard has been converted to pCi/L from units of microcurie per milliliter provided in the *Derived Concentration Technical Standard* (DOE 2011b).

These detected concentrations of radionuclides were 0.2%, or less, of the DOE derived concentration standards (DOE 2011b)[1]. This derived concentration standard is based upon direct use of the surface water as drinking water. This comparison is likely to overestimate the dose because surface water around PORTS is not used for drinking water.

4.6.5 Sediment

Sediment samples are collected from the same locations upstream and downstream from PORTS where local surface water samples are collected, at the NPDES outfalls on the east and west sides of PORTS, and at a location on Big Beaver Creek upstream from the confluence with Little Beaver Creek (see Figure 4.6). Samples are collected annually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b).

Neptunium-237 was detected at 0.0263 and 0.0409 pCi/g in samples collected from Little Beaver Creek (sampling locations RM-7 and RM-8). Plutonium-239/240 was detected at two on-site Little Beaver Creek sampling locations, RM-11 and RM-8, at levels ranging from 0.0243 to 0.0486 pCi/g. No other transuranics were detected in the sediment samples collected in 2019.

[1]The derived concentration standard is the concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (ingestion of water or inhalation of air) would result in a dose of 100 mrem. A concentration that is 100% of the derived concentration standard would equate to a dose at the DOE limit of 100 mrem/year (DOE 2011b).

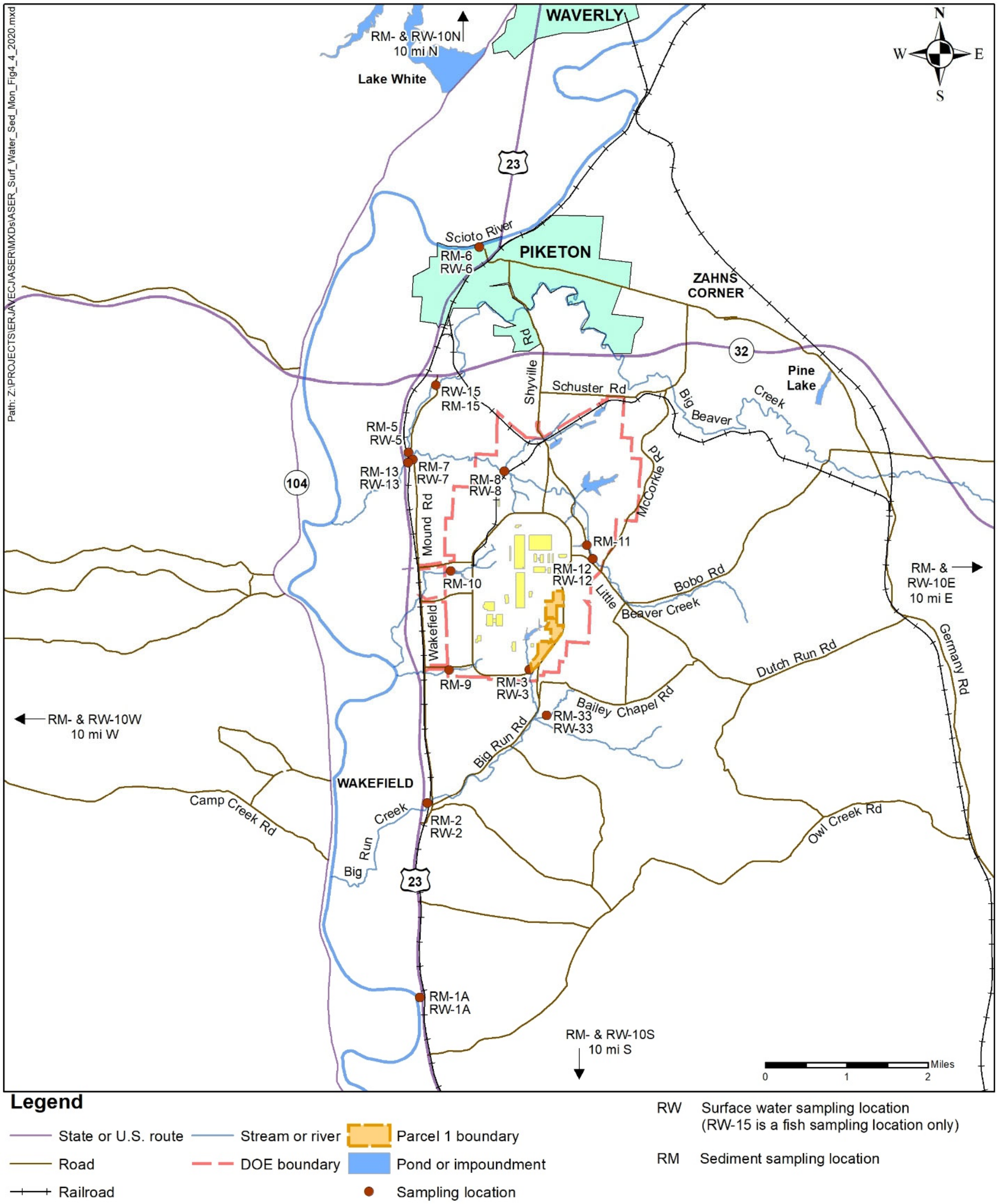

Figure 4.6. Local surface water and sediment monitoring locations.

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS surface water discharges. In 2019, technetium-99 was detected in the samples collected from the following locations:

- West Drainage Ditch at RM-10,
- Big Beaver Creek at RM-13, and
- Little Beaver Creek (RM-11, RM-7 and RM-8).

The highest detection (15.6 pCi/g) was at on-site location RM-11 (Little Beaver Creek near the X-230J7 East Holding Pond).

Uranium and uranium isotopes are naturally occurring, but may also be present due to PORTS activities. Maximum detections of uranium and uranium isotopes in sediment samples were detected at on-site sampling locations RM-11 and RM-8 (Little Beaver Creek) as follows.

Uranium: 7.82 micrograms per gram (µg/g) (RM-8)
Uranium-233/234: 12 pCi/g (RM-11)
Uranium-235/236: 0.585 pCi/g (RM-11)
Uranium-238: 2.55 pCi/g (RM-8).

Uranium and uranium isotopes detected in the 2019 samples have been detected at similar levels in previous sampling events from 2005 through 2018.

Section 4.3.8.1 provides a dose assessment based on the detections of neptunium-237 (0.0263 pCi/g), technetium-99 (9.12 pCi/g), uranium-233/234 (2.7 pCi/g), uranium-235/236 (0.138 pCi/g), and uranium-238 (0.71 pCi/g) at the off-site sediment sampling location with the detections of radionuclides that could cause the highest dose to a member of the public (RM-7 on Little Beaver Creek). The total potential annual dose to a member of the public resulting from PORTS (0.95 mrem/year), which includes this dose calculation (0.022 mrem/year), is below the total public annual dose limit of 100 mrem/year in DOE Order 458.1

4.6.6 Settleable Solids

DOE collects semiannual water samples from nine effluent locations and three background locations (see Figure 4.7) to determine the concentration of radioactive material that is present in the sediment suspended in the water sample. The data are used to determine compliance with DOE Order 458.1, *Radiation Protection of the Public and the Environment*, which states that operators of DOE facilities discharging or releasing liquids containing radionuclides from DOE activities must ensure that the discharges do not exceed an annual average (at the point of discharge) of either of the following:

- 5 pCi/g above background of settleable solids for alpha-emitting radionuclides, and
- 50 pCi/g above background for beta-gamma-emitting radionuclides.

When a low concentration of settleable solids is detected in a water sample, accurate measurement of the alpha and beta-gamma activity in the settleable solids portion of the sample is not practical due to the small sample size. A DOE memo (DOE 1995) states that settleable solids of less than 40 mg/L are in *de facto* compliance with the DOE Order 458.1 limits (5 pCi/g annual average above background for alpha activity and 50 pCi/g annual average above background for beta-gamma activity).

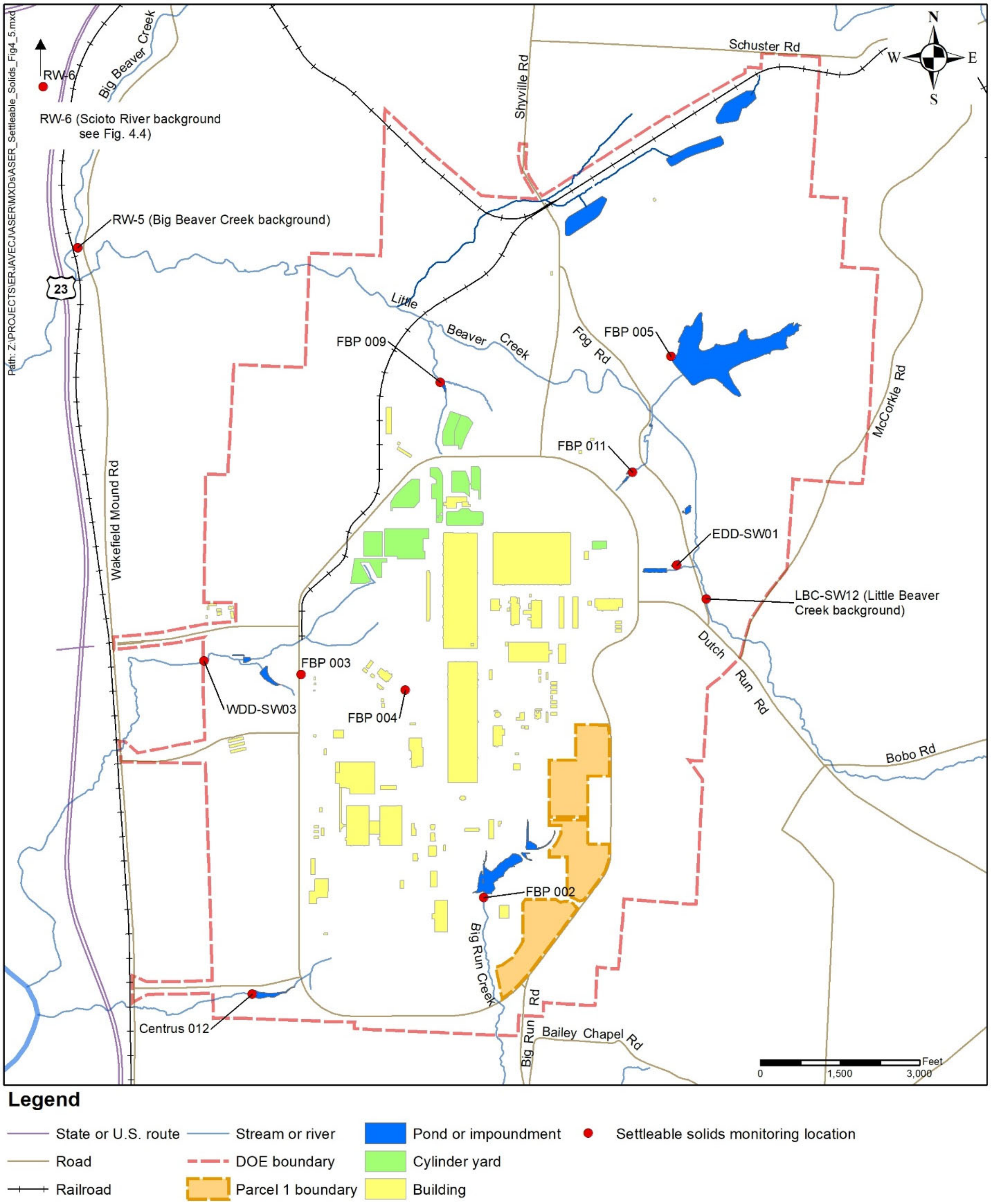

Figure 4.7. DOE settleable solids monitoring locations.

In December 2019, settleable solids were detected at 52 mg/L in the sample collected from FBP NPDES Outfall 009 at the X-230L North Holding Pond. Alpha activity was detected in the settleable solids portion of the sample at 8.86 pCi/g. Settleable solids were not detected in the June 2019 sample collected from Outfall 009. Therefore, the annual average for alpha activity at Outfall 009 is 4.43 pCi/g, which is less than the limit of 5 pCi/g.

Beta activity and beta-gamma activity were not detected in the settleable solids portion of the December 2019 sample collected at Outfall 009. Settleable solids were not detected at concentrations above 40 mg/L at any of the other monitoring locations; therefore, monitoring results for the settleable solids monitoring program are in compliance with DOE Order 458.1.

4.6.7 Soil

Soil samples are collected annually from ambient air monitoring locations (see Figure 4.3) and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b).

Plutonium-239/240 was detected in soil at eight of the 15 ambient air monitoring stations. The highest off-site detection of plutonium-239/240 was 0.0331 pCi/g at station A9 (southwest of the plant on Old U.S. Route 23). Americium-241 was also detected at station A9 at 0.0159 pCi/g. These detections are less than the soil screening levels for americium-241 (2.31 pCi/g) and plutonium-239/240 (3.78 pCi/g) in residential soil calculated using the exposure assumptions in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d). These soil screening levels were calculated using a one in a million cancer risk. No other transuranic radionuclides were detected at the soil sampling locations in 2019.

Technetium-99 was not detected in any of the soil samples collected during 2019. Uranium, uranium-233/234, uranium-235/236, and/or uranium-238 were detected at each of the sampling locations. Uranium and uranium isotopes are usually detected at similar levels at the off-site soil sampling locations, including the background location (A37), which suggests that the uranium detected in these samples is due to naturally-occurring uranium.

Section 4.3.8.2 provides a dose assessment based on the detections of americium-241 (0.0159 pCi/g), plutonium-239/240 (0.0331 pCi/g), uranium-233/234 (0.263 pCi/g), uranium-235/236 (0.0122 pCi/g), and uranium-238 (0.292 pCi/g) in soil at the off-site ambient air station with the detections of radionuclides that could cause the highest dose to a member of the public (station A9, southwest of PORTS on Old U.S. Route 23). The total potential annual dose to a member of the public resulting from PORTS (0.95 mrem/year), which includes this dose calculation (0.023 mrem/year), is below the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.8 Biological Monitoring

The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b) requires biological monitoring to assess the uptake of radionuclides into selected local biota (vegetation, deer, fish, crops, milk, and eggs).

4.6.8.1 Vegetation

To assess the uptake of radionuclides into plant material, vegetation samples (primarily grass) are collected in the same areas where soil samples are collected at the ambient air monitoring stations (see Figure 4.3). Samples are collected annually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238).

Uranium, uranium-233/234, and/or uranium-238 were detected in the vegetation samples collected at background sampling location A37 in Otway, as well as off-site sampling locations A6 (north of PORTS in Piketon), A9 (southwest of PORTS on old US Route 23), and A28 (southwest of PORTS on Camp Creek Road). Uranium and uranium isotopes were also detected in vegetation at three on-site sampling locations. Uranium and uranium isotopes are detected occasionally in vegetation samples, and have been detected at similar levels in previous sampling. Section 4.3.8.3 provides a dose assessment for a member of the public based on consumption of beef cattle that would eat grass contaminated with radionuclides at station A6 in Piketon. The total potential annual dose to a member of the public resulting from PORTS (0.95 mrem/year), which includes this dose calculation (0.00096 mrem/year), is below the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.8.2 Deer

Samples of liver, kidney, and muscle from deer killed on site in motor vehicle collisions are collected annually, if available. Samples are analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). Deer samples were collected in August (two deer) and September of 2019. No radionuclides were detected in the deer samples collected during 2019.

4.6.8.3 Fish

Fish samples are collected annually (if available) from locations on Little Beaver Creek (RW-8), Big Beaver Creek (RW-13 and RW-15), and the Scioto River (RW-1A and RW-6) as shown on Figure 4.6. In 2019, fish were caught at Little Beaver Creek and Big Beaver Creek locations. No fish were caught from the Scioto River. The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No radionuclides were detected in the fish samples collected during 2019.

4.6.8.4 Crops

In 2019, crop samples, including corn, tomatoes, and peppers, were collected from four off-site locations near PORTS. The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No radionuclides were detected in the crop samples collected during 2019.

4.6.8.5 Milk and eggs

Samples were collected in 2019 of milk and eggs produced near PORTS. The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No radionuclides were detected in the milk and egg samples collected during 2019.

4.7 RELEASE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

DOE Order 458.1 establishes limits for unconditional release of personal and real property from DOE facilities. Real property is defined as land and anything permanently affixed to the land such as buildings, fences, and those things attached to the buildings, such as light fixtures, plumbing, and heating fixtures, or other such items, that would be personal property if not attached. Personal property is defined as property of any kind, except for real property.

Sections 4.7.1 and 4.7.2 provide information about property released from FBP and MCS, respectively.

4.7.1 FBP Property Releases

FBP uses pre-approved authorized limits established by DOE Orders to evaluate and release materials defined as personal property. In 2019, FBP authorized approximately 1295 release requests for materials/items of personal property, which includes vehicles, equipment, waste/recyclables (such as batteries, light bulbs, used oil, and construction debris), and other materials.

DOE has approved authorized limits for real property release at PORTS. These authorized limits are as low as reasonably achievable and allow DOE to transfer land intended for industrial use. Table 4.3 provides the approved authorized limits.

Table 4.3. Approved authorized limits for real property transfer at PORTS

Nuclide	Outdoor Worker (pCi/g)[a]
Americium-241	54
Neptunium-237+D[b]	2
Plutonium-238	164
Plutonium-239	143
Plutonium-240	144
Technetium-99	885
Uranium-234	329
Uranium-235	3
Uranium-238+D[b]	16

[a]Source: Authorized limits letter (Bradburne May 2, 2018).
[b]"+D" indicates consideration of short-lived decay products of a principal radionuclide down to, but not including, the next principal radionuclide or the final nonradioactive nuclide in the chain.

DOE did not transfer any real property at PORTS in 2019.

4.7.2 MCS Property Releases

In 2019, MCS continued off-site shipment of aqueous hydrogen fluoride produced by the DUF_6 Conversion Facility, which converts DUF_6 into uranium oxide and aqueous hydrogen fluoride. Each shipment meets the release limit of less than 3 picocuries/milliliter (0.003 pCi/L) of total uranium activity. Approximately 752,719 gallons of aqueous hydrogen fluoride were shipped off site in 2019.

5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

5.1 SUMMARY

Non-radiological environmental monitoring at PORTS includes air, water, sediment, and fish. Monitoring of non-radiological parameters is required by state and federal regulations and/or permits, but is also performed to reduce public concerns about plant operations.

Non-radiological data collected in 2019 are similar to data collected in previous years.

5.2 ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INTRODUCTION

Environmental monitoring programs at PORTS usually monitor both radiological and non-radiological constituents that could be released to the environment as a result of PORTS activities. The radiological components of each monitoring program were discussed in the previous chapter. The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b) specifies non-radiological monitoring requirements for ambient air, surface water, sediment, and fish. Non-radiological data are not collected for all sampling locations or all monitoring programs.

Environmental permits issued by Ohio EPA to FBP, MCS, or Centrus specify discharge limitations, monitoring requirements, and/or reporting requirements for air emissions and water discharges. Centrus data for NPDES water discharges are included in this section to provide a more complete picture of environmental monitoring at PORTS. Centrus data for water discharges are provided for informational purposes only; as Centrus operates independently of the DOE and is regulated by the NRC.

Data for the following environmental media are included in this chapter:

- air
- surface water
- sediment
- biota (fish).

DOE also conducts an extensive groundwater monitoring program at PORTS that includes both radiological and non-radiological constituents. Chapter 6 provides information on the groundwater monitoring program, associated surface water monitoring, and water supply monitoring.

5.3 AIR

Permitted air emission sources at PORTS emit non-radiological air pollutants. In addition, the ambient air monitoring program measures fluoride at monitoring stations within PORTS boundaries and in the surrounding area. Chapter 4, Figure 4.3 is a map of the PORTS ambient air monitoring locations.

5.3.1 Airborne Discharges

FBP is responsible for numerous air emission sources associated with the former gaseous diffusion production facilities and support facilities. These sources, which included the boilers at the X-600 Steam Plant Complex (prior to demolition in 2013), emitted more than 100 tons per year of non-radiological air pollutants specified by Ohio EPA, which caused FBP air emission sources to become a major source of air pollutants as defined in 40 CFR Part 70.

FBP is required to submit an annual report called the Ohio EPA Fee Emissions Report to report emissions of selected non-radiological air pollutants. FBP reported the following emissions of non-radiological air pollutants for 2019: 11.24 tons of particulate matter and 1.18 tons of organic compounds. Emissions for 2019 are associated with the X-627 Groundwater Treatment Facility and plant roads/parking areas.

The DUF_6 Conversion Facility emits only a small quantity of non-radiological air pollutants. Because of these small emissions, Ohio EPA requires a Fee Emissions Report only once every two years (in odd-numbered years). MCS reported less than 10 tons/year of specified non-radiological air pollutants in 2019 (the report requires reporting in increments of emissions: zero, less than 10 tons, 10-50 tons, more than 50 tons, and more than 100 tons).

U.S. EPA also requires annual reporting of greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide). In 2019, FBP reported emissions of 13,470.4 metric tons of carbon dioxide, 0.26 metric ton of methane, and 0.026 metric ton of nitrous oxide. These emissions are from burning natural gas at the X-690 Boilers, which provide steam to portions of the plant.

Another potential air pollutant present at PORTS is asbestos released by D&D of plant facilities. Asbestos emissions are controlled by a system of work practices. The amount of asbestos removed and disposed is reported to Ohio EPA. In 2019, 1.1 tons of asbestos-containing materials (net weight) were shipped from PORTS.

5.3.2 Ambient Air Monitoring

In addition to the radionuclides discussed in Chapter 4, DOE ambient air monitoring stations also measure fluoride. Fluoride detected at the ambient air monitoring stations could be present due to background concentrations (fluoride occurs naturally in the environment), activities associated with the former gaseous diffusion process, and operation of the DUF_6 Conversion Facility.

In 2019, samples for fluoride were collected weekly from 15 ambient air monitoring stations in and around PORTS (see Chapter 4, Figure 4.3), including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant.

In 2019, fluoride was not detected in 50 percent of the samples collected for the ambient air monitoring program. The average ambient concentration of fluoride measured in samples collected at background station A37 was 0.0066 microgram per cubic meter ($\mu g/m^3$), which was calculated using the assumption that the concentration of fluoride in air was zero for samples in which fluoride was not detected. This assumption ensures that the average concentration of fluoride in ambient air at the background location is not overestimated. Concentrations of fluoride measured in samples collected at the background station ranged from zero (below the analytical detection limit) to 0.020 $\mu g/m^3$.

For the locations around PORTS, if fluoride was not detected in a sample, the ambient concentration of fluoride was calculated assuming fluoride was present at the detection limit (instead of using zero as discussed for the background location). This assumption ensures that the average concentration of fluoride in air around PORTS is not underestimated because the fluoride was actually present at a concentration less than could be detected. Average ambient concentrations of fluoride measured at the stations around PORTS ranged from 0.010 $\mu g/m^3$ at station A15 (east-southeast of PORTS on Loop Road) to 0.019 $\mu g/m^3$ at station A10 (on-site at the Don Marquis substation). These concentrations are similar to the concentrations detected in 2018 (the highest average ambient concentration in 2018 was 0.021 $\mu g/m^3$ at stations A12 and A3). Concentrations of fluoride measured in samples collected at the off-site stations near PORTS ranged from below analytical detection limits to an ambient concentration of 0.16 $\mu g/m^3$ at station A24 (north of PORTS on Shyville Road). The maximum concentration of fluoride in ambient air in 2019 (0.16 $\mu g/m^3$) is higher than the maximum concentration detected in 2018 (0.046 $\mu g/m^3$at station A3 — south of PORTS on Bailey Chapel Road). Concentrations of fluoride in ambient air around PORTS are within ambient background concentrations measured in the United States (Agency for Toxic Substances and Disease Registry 2003). There is no standard for fluoride in ambient air.

5.4 WATER

Surface water and groundwater are monitored at PORTS. Groundwater monitoring is discussed in Chapter 6, along with surface water monitoring conducted as part of the groundwater monitoring program. Non-radiological surface water monitoring primarily consists of sampling water discharges associated with the FBP, MCS, and Centrus NPDES-permitted outfalls. PCBs are monitored in on-site surface water downstream from the cylinder storage yards.

5.4.1 Water Discharges (NPDES Outfalls)

In 2019, DOE contractors (FBP and MCS) were responsible for 20 NPDES discharge points (outfalls) or sampling points at PORTS. Centrus was responsible for three outfalls. This section describes non-radiological discharges from these outfalls during 2019.

5.4.1.1 FBP NPDES outfalls

In 2019, FBP was responsible for 18 outfalls or sampling points. Nine outfalls discharge directly to surface water, and six outfalls discharge to another outfall before leaving the site. FBP also monitors three additional sampling points that are not discharge locations. Chapter 4, Section 4.3.4.1, provides a brief description of each FBP outfall or sampling point and provides a site diagram showing each FBP NPDES outfall/sampling point (see Chapter 4, Figure 4.4).

Ohio EPA selects the chemical parameters that must be monitored at each outfall based on the chemical characteristics of the water that flows into the outfall and sets discharge limitations for some of these parameters. For example, some of the FBP outfalls discharge water from the groundwater treatment facilities; therefore, the outfalls are monitored for selected VOCs (*trans*-1,2-dichloroethene and/or TCE) because the groundwater treatment facilities treat water contaminated with VOCs. Chemicals and water quality parameters monitored at each FBP outfall in 2019 are as follows:

- FBP NPDES Outfall 001 (X-230J7 East Holding Pond) – cadmium, chlorine, copper, total filterable residue (dissolved solids), fluoride, mercury, oil and grease, pH, silver, total suspended solids, and zinc.

- FBP NPDES Outfall 002 (X-230K South Holding Pond) – cadmium, fluoride, mercury, ammonia-nitrogen, oil and grease, pH, selenium, silver, total suspended solids, and thallium.

- FBP NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – acute toxicity, ammonia-nitrogen, carbonaceous biochemical oxygen demand, copper, E. coli (May-October only), mercury, nitrite + nitrate, oil and grease, pH, silver, thallium, total suspended solids, and zinc.

- FBP NPDES Outfall 004 (Cooling Tower Blowdown) – acute toxicity, chlorine, copper, total filterable residue (dissolved solids), mercury, oil and grease, pH, total suspended solids, and zinc.

- FBP NPDES Outfall 005 (X-611B Lime Sludge Lagoon) – lead, mercury, pH, selenium, and total suspended solids.

- FBP NPDES Outfall 009 (X-230L North Holding Pond) – bis(2-ethylhexyl)phthalate, copper, fluoride, mercury, oil and grease, pH, silver, total suspended solids, and zinc.

- FBP NPDES Outfall 010 (X-230J5 Northwest Holding Pond) – lead, mercury, oil and grease, pH, selenium, total suspended solids, and zinc.

- FBP NPDES Outfall 011 (X-230J6 Northeast Holding Pond) – cadmium, chlorine, copper, fluoride, oil and grease, pH, selenium, total suspended solids, thallium, and zinc.

- FBP NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – arsenic, barium, total PCBs, pH, silver, and TCE.
- FBP NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – iron, manganese, pH, and total suspended solids.
- FBP NPDES Outfall 604 (X-700 Biodenitrification Facility) – copper, iron, nickel, nitrate-nitrogen, pH, and zinc.
- FBP NPDES Outfall 605 (X-705 Decontamination Microfiltration System) – ammonia-nitrogen, chromium, hexavalent chromium, copper, Kjeldahl nitrogen, nickel, nitrate-nitrogen, nitrite-nitrogen, oil and grease, pH, sulfate, total suspended solids, TCE, and zinc.
- FBP NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – TCE, pH, and *trans*-1,2-dichloroethene.
- FBP NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – TCE, pH, and *trans*-1,2-dichloroethene.
- FBP NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – pH and TCE.

The FBP NPDES Permit also identifies additional monitoring points that are not discharge points as described in the previous paragraphs. FBP NPDES Station Number 801 is a surface water background monitoring location on the Scioto River upstream from FBP NPDES Outfalls 003 and 004. Samples are collected from this monitoring point to measure toxicity to minnows and another aquatic organism, *Ceriodaphnia*.

FBP NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from FBP NPDES Outfall 001. FBP NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from FBP NPDES Outfall 002. Water temperature is the only parameter measured at each of these monitoring points.

The monitoring data detailed in the previous paragraphs are submitted to Ohio EPA in a monthly discharge monitoring report. In 2019, discharge limitations at the FBP NPDES monitoring locations were exceeded on 30 occasions (see Table 5.1).

Various discharge limits for total suspended solids were exceeded at five outfalls a total of 27 times in 2019 (see Table 5.1). These exceedances were generally caused by a combination of excessive rainfall and operational issues at the outfall. Operational issues that contributed to the exceedances were corrected immediately. In many cases, a single high daily measurement resulted in more than one permit exceedance. Permit limitations can be set for the maximum daily limit, maximum daily loading limit, maximum average monthly limit, and/or maximum average monthly loading limit (each of these limits are not set for every parameter at every outfall). The maximum daily limit and maximum average monthly limit are concentration limits in mass per volume: for example milligram per liter. Samples collected at the outfall are measured in these units, generally milligrams or micrograms per liter. The loading limits (daily and monthly) are limits set for total mass per day (or month). These limits are calculated using the measured concentration of the sample multiplied by the total daily amount of water released through the outfall.

Table 5.1 FBP NPDES exceedances in 2019

Outfall	Parameter	Limit	Number of Exceedances	Date and Result[a]
002	Total suspended solids	20 mg/L (monthly average)	1	February: 25 mg/L
003	Total suspended solids	18 mg/L (maximum daily)	1	February 27: 29 mg/L
		27.3 kg/day (maximum daily loading)	2	February 6: 36.59 kg/day February 27: 35.78 kg/day
		12 mg/L (monthly average)	1	February: 17 mg/L
		18.2 kg/day (monthly average loading)	1	February: 28.43 mg/L
005	Total suspended solids	15 mg/L (maximum daily)	9	March 27: 36 mg/L May 7: 16 mg/L May 14: 30 mg/L June 14: 47.4 mg/L July 25: 29 mg/L October 15: 35 mg/L November 11: 22 mg/L November 14: 25.2mg/L December 22: 17.6 mg/L
		10 mg/L (monthly average)	6	March: 16 mg/L May: 20 mg/L June: 24 mg/L October: 12.65 mg/L November: 16 mg/L December: 13.7 mg/L
009	Total suspended solids	45 mg/L (maximum daily)	2	February 27: 120 mg/L March 13: 138 mg/L
		30 mg/L (monthly average)	2	February: 120 mg/L March: 50 mg/L
010	Total suspended solids	45 mg/L (maximum daily)	1	July 16: 46 mg/L
		30 mg/L (monthly average)	1	July: 46 mg/L
611	TCE	10 µg/L (maximum daily)	2	December 9: 14.1 µg/L December 16: 14.1 µg/L
		10 µg/L (monthly average)	1	December: 14.1 µg/L

[a]Units: kilogram per day (kg/day). microgram per liter (µg/L). milligram per liter (mg/L).

Discharge limitations for TCE at Outfall 611 (the X-627 Groundwater Treatment Facility) were exceeded in December 2019. Two samples collected on December 9 and 16 exceeded the daily discharge limitation, which also resulted in an exceedance of the monthly average discharge limitation (see Table 5.1). The air stripping unit at the treatment facility, which removes TCE from the water, was cleaned and compliance was restored. Water from this outfall is treated further at the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003) prior to discharge from PORTS. No further actions were required.

In 2019, the overall FBP NPDES compliance rate with the NPDES permit was 98%.

5.4.1.2 MCS NPDES outfalls

MCS is responsible for the NPDES permit for the discharge of process wastewaters from the DUF_6 Conversion Facility. The MCS NPDES permit provides monitoring requirements for two outfalls: MCS Outfall 001 and MCS Outfall 602. Chapter 4, Figure 4.4 shows the location of the MCS NPDES outfalls. Monitoring requirements for MCS Outfall 001 are only effective when process wastewater is being discharged through the outfall. No process waste water was discharged through Outfall 001 in 2019; therefore, no monitoring was required.

MCS Outfall 602 monitors the discharge of MCS process wastewater to the sanitary sewer, which flows to the X-6619 Sewage Treatment Plant that discharges through FBP NPDES Outfall 003. Process wastewater discharged from MCS Outfall 602 was monitored for pH and total flow.

The monitoring data collected in accordance with the MCS permit are submitted to Ohio EPA in a monthly discharge monitoring report. No exceedances of permit limitations at MCS Outfall 602 occurred during 2019; therefore, the overall MCS compliance rate with the NPDES permit was 100%.

5.4.1.3 Centrus NPDES outfalls

Centrus is responsible for three NPDES outfalls through which water is discharged from the site (see Chapter 4, Figure 4.4). Two outfalls discharge directly to surface water, and one outfall discharges to FBP NPDES Outfall 003 before leaving the site. Chapter 4, Section 4.3.4.2, provides a brief description of each Centrus NPDES outfall. Chemicals and water quality parameters monitored at each Centrus outfall are as follows:

- Centrus NPDES Outfall 012 (X-2230M Southwest Holding Pond) – cadmium, chlorine, copper, iron, mercury, oil and grease, pH, selenium, silver, suspended solids, total PCBs, thallium, and TCE.
- Centrus NPDES Outfall 013 (X-2230N West Holding Pond) – antimony, arsenic, barium, cadmium, chlorine, copper, mercury, oil and grease, pH, suspended solids, thallium, total PCBs, and zinc.
- Centrus NPDES Outfall 613 (X-6002A Recirculating Hot Water Plant particle separator) – chlorine and suspended solids.

The monitoring data are submitted to Ohio EPA in a monthly discharge monitoring report. No exceedances of permit limitations at Centrus Outfalls 012, 013, and 613 occurred during 2019; therefore, the overall Centrus compliance rate with the NPDES permit was 100%.

5.4.2 Surface Water Monitoring Associated with MCS Cylinder Storage Yards

Surface water samples (filtered and unfiltered) are collected quarterly from four locations in the drainage basins downstream from the MCS X-745C, X-745E, and X-745G Cylinder Storage Yards (UDS X01, RM-8, UDS X02, and RM-10 – see Chapter 4, Figure 4.4). These locations are on site at PORTS and not accessible to the public. Samples are analyzed for PCBs.

PCBs were detected at 0.34 µg/L in the unfiltered surface water sample collected in the second quarter at UDS X01, but were not detected in the sample collected at RM-8, which is downstream from UDS X01. PCBs were not detected in any of the other surface water samples (filtered or unfiltered) collected during 2019. Section 5.5.2 presents the results for sediment samples collected as part of this program.

5.5 SEDIMENT

In 2019, sediment monitoring at PORTS included local streams and the Scioto River upstream and downstream from PORTS and drainage basins downstream from the MCS cylinder storage yards.

5.5.1 Local Sediment Monitoring

Sediment samples are collected annually at the same locations upstream and downstream from PORTS where local surface water samples are collected, at the NPDES outfalls on the east and west sides of PORTS, and at a location on Big Beaver Creek upstream from the confluence with Little Beaver Creek (see Chapter 4, Figure 4.6). In 2019, samples were analyzed for 20 metals and PCBs, in addition to the radiological parameters discussed in Chapter 4.

PCBs were detected at three on-site and one off-site sampling locations. Samples collected on site from Little Beaver Creek (RM-8 and RM-11) and West Drainage Ditch (RM-10) contained PCBs at concentrations ranging from 71.6 to 380 micrograms per kilogram (µg/kg) or parts per billion (ppb). PCBs were also detected at the off-site sampling location on Little Beaver Creek (RM-7) at 33.1 µg/kg. The concentration of PCBs detected in the off-site sample from Little Beaver Creek (33.1 µg/kg) is less than the risk-based regional screening level for PCB-1254/1260 developed by U.S. EPA and utilized by Ohio EPA: 240 µg/kg (U.S. EPA 2020).

The results of metals sampling conducted in 2019 indicate that no appreciable differences are evident in the concentrations of metals present in sediment samples taken upstream from PORTS and downstream from PORTS. Metals occur naturally in the environment. Accordingly, the metals detected in the samples most likely did not result from activities at PORTS.

5.5.2 Sediment Monitoring Associated with MCS Cylinder Storage Yards

Sediment samples are collected quarterly from four locations in the drainage basins downstream from the MCS X-745C, X-745E, and X-745G Cylinder Storage Yards (UDS X01, RM-8, UDS X02, and RM-10) and analyzed for PCBs. These locations are on site at PORTS and not accessible to the public (see Chapter 4, Figure 4.4).

In 2019, PCBs were detected in at least one of the sediment samples collected at each location. The maximum concentration of PCBs (230 µg/kg) was detected in the second quarter sample collected at sampling location RM-8. The concentrations of PCBs detected in 2019 are below the 1 ppm (1000 µg/kg) reference value set forth in the U.S. EPA Region 5 *TSCA Approval for Storage for Disposal of PCB Bulk Product (Mixed) Waste,* which applies to the storage of DUF_6 cylinders at PORTS that may have paint on the exterior of the cylinders that contains more than 50 ppm PCBs. None of the samples contained PCBs above the risk-based regional screening level for PCB-1254/1260 developed by U.S. EPA and utilized by Ohio EPA: 240 µg/kg (ppb) (U.S. EPA 2020).

Section 5.4.2 presents the results for surface water samples collected as part of this program.

5.6 BIOLOGICAL MONITORING - FISH

Fish samples are collected annually (if available) from the following locations:

- Little Beaver Creek (RW-8): on site at PORTS
- Big Beaver Creek (RW-15): off site upstream from the confluence with Little Beaver Creek
- Big Beaver Creek (RW-13): off site downstream from the confluence with Little Beaver Creek
- Scioto River (RW-1A): off site downstream from PORTS water discharges
- Scioto River (RW-6): off site upstream from PORTS water discharges (Piketon).

In 2019, fish, all bass, were caught in Big Beaver Creek and Little Beaver Creek. No fish were caught in the Scioto River. Chapter 4, Figure 4.6, shows the surface water monitoring locations where the fish were caught.

Fish samples were analyzed for PCBs, in addition to the radiological parameters discussed in Chapter 4. Fish samples collected for this program included only the fish fillet, that is, only the portion of the fish that would be eaten by a person. Both regular and duplicate samples were collected from the fish caught at RW-15.

Table 5.2 summarizes the results of the PCB sampling in fish for 2019 and compares the results to suggested consumption limits from the State of Ohio.

Table 5.2. PCB results in fish and Ohio advisory consumption limits

	Ohio advisory consumption limits for PCBs in fish[a]		
	Unrestricted Less than 50 µg/kg	1 meal/week 50-220 µg/kg	1 meal/month 220-1000 µg/kg
PORTS 2019 fish samples	RW-13 PCBs: not detected RW-15 (regular sample) PCBs: 41.7 µg/kg	RW-8 PCBs:130 µg/kg	RW-15 (duplicate sample) PCBs: 412 µg/kg

[a]Source: *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program* (Ohio EPA 2010).

PCBs were detected at 41.7 µg/kg in the regular sample collected at RW-15 and at 412 µg/kg in the duplicate sample. These samples consisted of several fish, which indicates that concentrations of contaminants in fish can vary even among similar fish.

The Ohio Sport Fish Consumption Advisory, available from the Ohio Department of Health, advises the public on consumption limits for sport fish caught from all water bodies in Ohio and should be consulted before eating any fish caught in Ohio waters (Ohio Department of Health 2020). The advisory recommends a limit of one meal per month for white bass (12 inches and over), common carp, and channel or flathead catfish caught in the Scioto River in Pike and Scioto Counties due to mercury and/or PCB contamination. The Ohio Department of Health advises that everyone limit consumption of sport fish caught from all waterbodies in Ohio to one meal per week, unless there is a more or less restrictive advisory.

6. GROUNDWATER PROGRAMS

6.1 SUMMARY

Groundwater monitoring at PORTS is required by a combination of state and federal regulations, legal agreements with Ohio EPA, and DOE Orders. More than 400 monitoring wells are used to track the flow of groundwater and to identify and measure groundwater contaminants. Groundwater programs also include on-site surface water monitoring and water supply monitoring.

Groundwater plumes that consist of VOCs, primarily TCE, are found at five of the PORTS monitoring areas: X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, Quadrant I Groundwater Investigative (5-Unit) Area, Quadrant II Groundwater Investigative (7-Unit) Area, X-701B Former Holding Pond, and X-740 Former Waste Oil Handling Facility. In general, concentrations of most contaminants detected within these plumes were stable or decreasing during 2019. However, a few contaminants increased in 2019 as discussed below and in the remaining sections of this chapter.

The groundwater plume at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility is near the southern boundary of PORTS. In 2018 and 2019, concentrations of VOCs increased in several of the wells that monitor the X-749 South Barrier Wall area (the southern portion of the plume near the property boundary), including one off-site well. The concentrations of VOCs in these wells returned to typical levels by the fourth quarter of 2019. TCE was detected in the first quarter sample collected from off-site well WP-03G at 0.17 µg/L. Prior to the detections in 2018, VOCs had not been detected in well WP-03G since 2012 (DOE 2013), although these VOCs were routinely detected in the well before 2012 (DOE 2011a, DOE 2012). No other VOCs were detected in 2019 in any of the off-site monitoring wells. TCE has not been detected in groundwater beyond the DOE property boundary at concentrations that exceed the Ohio EPA drinking water standard of 5 µg/L.

Several factors may have contributed to these increases including high rainfall and reduced pumping rates in the groundwater extraction wells in the X-749 South Barrier Wall area. The X-749 groundwater extraction wells operated at reduced pumping rates from the end of January through the end of May in 2018 when repairs were completed on a pipeline that transfers groundwater from the X-749 extraction wells to the X-622 Groundwater Treatment Facility. The increased precipitation in 2018 and reduced pumping rates caused higher than typical water levels in the X-749 South Barrier Wall area monitoring wells. Extraction wells in the X-749 South Barrier Wall Area were cleaned in 2019 to optimize groundwater extraction.

The *2019 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides further details on the groundwater plumes at PORTS, specific monitoring well identifications, and analytical results for monitoring wells (DOE 2020). This document and other documents referenced in this chapter are available in the PORTS Environmental Information Center.

6.2 GROUNDWATER PROGRAMS INTRODUCTION

This chapter provides an overview of groundwater monitoring at PORTS and the results of the groundwater monitoring program for 2019. The following sections provide an overview of the PORTS groundwater monitoring program followed by a review of the history and 2019 monitoring data for each area. Chapter 3, Section 3.3, provides additional information about the remedial actions implemented at a number of the areas discussed in this chapter to reduce or eliminate groundwater contamination.

This chapter also includes information on the groundwater treatment facilities at PORTS. These facilities receive contaminated groundwater from the groundwater monitoring areas and treat the water prior to discharge through the permitted FBP NPDES outfalls.

6.3 OVERVIEW OF GROUNDWATER MONITORING AT PORTS

This section provides an overview of the regulatory basis for groundwater monitoring at PORTS, groundwater use and geology, and monitoring activities and issues. Section 6.3.4 provides information on federal and state emerging contaminants of concern.

6.3.1 Regulatory Programs

Groundwater monitoring at PORTS was initiated in the 1980s. Groundwater monitoring has been conducted in response to state and/or federal regulations, regulatory documents prepared by DOE, agreements between DOE and Ohio EPA or U.S. EPA, and DOE Orders.

Because of the numerous regulatory programs applicable to groundwater monitoring at PORTS, an *Integrated Groundwater Monitoring Plan* was developed to address all groundwater monitoring requirements for PORTS. The initial plan was approved by Ohio EPA and implemented at PORTS starting in April 1999. The *Integrated Groundwater Monitoring Plan* is periodically revised by DOE and approved by Ohio EPA. An annual groundwater report is submitted to Ohio EPA in accordance with the *Integrated Groundwater Monitoring Plan*.

Groundwater monitoring in 2019 was completed in accordance with the *Integrated Groundwater Monitoring Plan* dated August 2017 (DOE 2017c). The August 2017 *Integrated Groundwater Monitoring Plan* incorporated minor revisions to the monitoring program that were previously approved by Ohio EPA. These revisions included a reduction in sampling parameters and frequency at the X-740 Former Waste Oil Handling Facility and deletion of one well from the monitoring program for the X-735 Landfills because the well required removal due to construction activities for the OSWDF.

Groundwater monitoring is also conducted to meet DOE Order requirements. Exit pathway monitoring assesses the effect of PORTS on off-site groundwater quality. DOE Orders are the basis for radiological monitoring of groundwater at PORTS.

6.3.2 Groundwater Use and Geology

Two water-bearing zones are present beneath the industrialized portion of PORTS: the Gallia and Berea formations. The Gallia is the uppermost water-bearing zone and contains most of the groundwater contamination at PORTS. The Berea is deeper than the Gallia and is usually separated from the Gallia by the Sunbury shale, which acts as a barrier to impede groundwater flow between the Gallia and Berea formations. Additional information about site hydrogeology is available in the PORTS Environmental Information Center.

Groundwater directly beneath PORTS is not used as a domestic, municipal, or industrial water supply, and contaminants in the groundwater beneath PORTS do not affect the quality of the water in the Scioto River Valley buried aquifer. PORTS is the largest industrial user of water in the vicinity and obtains water from water supply well fields north and west of PORTS in the Scioto River Valley buried aquifer. DOE has filed a deed notification at the Pike County Auditor's Office that restricts the use of groundwater beneath the PORTS site.

6.3.3 Monitoring Activities

Groundwater monitoring at PORTS includes several activities. Samples of water are collected from groundwater monitoring wells and analyzed to obtain information about contaminants and naturally-occurring compounds in the groundwater. Monitoring wells are also used to obtain other information about groundwater. When the level of water, or groundwater elevation, is measured in a number of wells over a short period of time, the groundwater elevations, combined with information about the subsurface soil, can be used to estimate the rate and direction of groundwater flow. The rate and direction of groundwater flow can be used to predict the movement of contaminants in the groundwater and to develop ways to control or remediate groundwater contamination.

6.3.4 Emerging Contaminants

Federal and state regulators are interested in emerging contaminants of concern that may be present at DOE sites. These emerging contaminants are chemicals that have been detected in drinking water supplies around the United States, but their risk to human health and the environment may not be fully understood.

PORTS collects samples at selected groundwater monitoring wells for some of these contaminants: 1,4-dioxane, 1,2,3-trichloropropane, 2,4-dinitrotoluene, and N-nitrosodimethylamine. In the most recent sampling conducted in 2019, none of these contaminants were detected except 1,4-dioxane. 1,4-Dioxane is routinely detected in the PORTS TCE groundwater plumes. Concentrations of 1,4-dioxane detected in groundwater in 2019 ranged from 2 to 37 µg/L. 1,4-Dioxane is a common component of chlorinated solvents like 1,1,1-trichloroethane and TCE, which were historically used at PORTS.

6.4 GROUNDWATER MONITORING AREAS

The *Integrated Groundwater Monitoring Plan* requires groundwater monitoring of the following areas within the quadrants of the site designated by the RCRA Corrective Action Program (DOE 2017c). These areas (see Figure 6.1) are:

- Quadrant I
  - X-749 Contaminated Materials Disposal Facility /X-120 Former Training Facility,
  - PK Landfill,
  - Quadrant I Groundwater Investigative (5-Unit) Area,
  - X-749A Classified Materials Disposal Facility,
- Quadrant II
  - Quadrant II Groundwater Investigative (7-Unit) Area,
  - X-701B Former Holding Pond,
  - X-633 Former Recirculating Cooling Water Complex,
- Quadrant III
  - X-616 Former Chromium Sludge Surface Impoundments,
  - X-740 Former Waste Oil Handling Facility,
- Quadrant IV
  - X-611A Former Lime Sludge Lagoons,
  - X-735 Landfills,
  - X-734 Landfills,
  - X-533 Former Switchyard Complex, and
  - X-344C Former Hydrogen Fluoride Storage Building.

The *Integrated Groundwater Monitoring Plan* also contains requirements for 1) surface water monitoring in creeks and drainage ditches at PORTS that receive groundwater discharge; and 2) water supply monitoring (DOE 2017c).

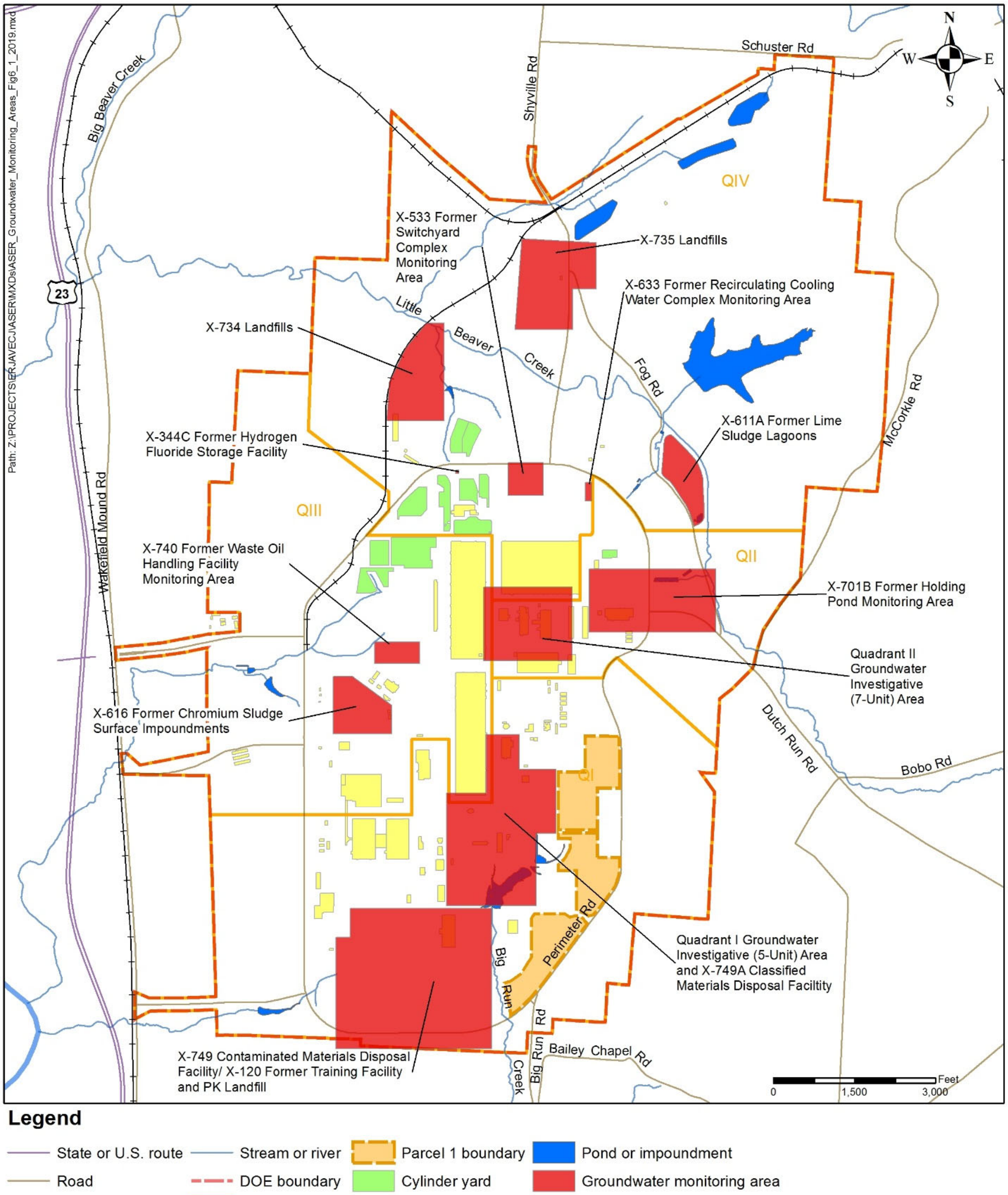

Figure 6.1. Groundwater monitoring areas at PORTS.

In general, samples are collected from wells (or surface water locations) at each area listed above and are analyzed for metals, VOCs, and/or radionuclides. Table 6.1 lists the analytical requirements for each groundwater monitoring area and other monitoring programs described in this chapter. Constituents detected in the groundwater are then compared to standards called preliminary remediation goals to assess the potential for each constituent to affect human health and the environment. Preliminary remediation goals are initial clean-up goals developed early in the decision-making process that are 1) protective of human health and the environment, and 2) comply with applicable or relevant and appropriate requirements. Preliminary remediation goals are intended to satisfy regulatory cleanup requirements. For groundwater at PORTS, preliminary remediation goals are the Ohio EPA drinking water standards (maximum contaminant levels).

Five areas of groundwater contamination, commonly called groundwater plumes, have been identified at PORTS. Groundwater contamination consists of VOCs (primarily TCE) and radionuclides such as technetium-99. The areas that contain groundwater plumes are X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, Quadrant I Groundwater Investigative (5-Unit) Area, Quadrant II Groundwater Investigative (7-Unit) Area, X-701B Former Holding Pond, and X-740 Former Waste Oil Handling Facility. Other areas are monitored to evaluate groundwater contaminated with metals, to ensure past uses of the area (such as a landfill) have not caused groundwater contamination, or to monitor remediation that has taken place in the area.

The following sections describe the history of each groundwater monitoring area and groundwater monitoring results for each area in 2019.

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS in 2019

Monitoring Area or Program	Analytes		
X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U total metals:	Be, Cd, Cr, Mn, Ni
PK Landfill[b]	VOCs	total metals:	Be, Cd, Cr, Mn, Ni
Quadrant I Groundwater Investigative (5-Unit) Area[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U total metals:	Be, Cd, Cr, Mn, Ni
X-749A Classified Materials Disposal Facility	VOCs–2 technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U alkalinity chloride sulfate chemical oxygen demand total dissolved solids	total metals nitrate/nitrite ammonia	Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn
Quadrant II Groundwater Investigative (7-Unit) Area[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U total metals:	Be, Cd, Cr, Mn, Ni

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS in 2019 (continued)

Monitoring Area or Program	Analytes	
X-701B Former Holding Pond[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$ technetium-99 U, $^{233/234}U$, $^{235/236}U$, ^{238}U	alkalinity chloride sulfate total dissolved solids total metals: Be, Cd, Cr, Mn, Ni
X-633 Former Recirculating Cooling Water Complex	total metals: Cr	
X-616 Former Chromium Sludge Surface Impoundments	VOCs	total metals: Be, Cd, Cr, Mn, Ni
X-740 Former Waste Oil Handling Facility[a]	VOCs	
X-611A Former Lime Sludge Lagoons	total metals: Be, Cr	
X-735 Landfills	VOCs–2 technetium-99 U, $^{233/234}U$, $^{235/236}U$, ^{238}U alkalinity chloride sulfate chemical oxygen demand total dissolved solids	total metals: Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Hg, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn nitrate/nitrite ammonia
X-734 Landfills	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$ technetium-99 U, $^{233/234}U$, $^{235/236}U$, ^{238}U alkalinity chloride	total metals: Be, Cd, Cr, Mn, Ni, Na ammonia chemical oxygen demand nitrate/nitrite sulfate total dissolved solids
X-533 Former Switchyard Complex	total metals: Cd, Ni	
X-344C Former Hydrogen Fluoride Storage Building	VOCs	
Surface Water	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$	technetium-99 U, $^{233/234}U$, $^{235/236}U$, ^{238}U
Water Supply	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$	technetium-99 U, $^{233/234}U$, $^{235/236}U$, ^{238}U alpha activity

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS in 2019 (continued)

Monitoring Area or Program	Analytes	
Exit Pathway	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U

[a]Selected well(s) in this area are sampled once every two years for a comprehensive list of more than 200 potential contaminants (40 CFR Part 264 Appendix IX – Appendix to Ohio Administrative Code Rule 3745-54-98).
[b]Not all wells in this area are analyzed for all listed analytes.

Notes:
VOCs: Acetone, benzene, bromodichloromethane, bromoform, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, dibromochloromethane, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, bromomethane, chloromethane, methylene chloride, 2-butanone (methyl ethyl ketone), 4-methyl-2-pentanone (methyl isobutyl ketone), 1,1,2,2-tetrachloroethane, tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, TCE, trichlorofluoromethane (CFC-11), vinyl chloride, xylenes (m,p-xylenes).

VOCs–2: VOCs listed above plus: acrylonitrile, bromochloromethane, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, trans-1,4-dichloro-2-butene, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 2-hexanone (methyl butyl ketone), dibromomethane, iodomethane, styrene, 1,1,1,2-tetrachloroethane, 1,2,3-trichloropropane, and vinyl acetate.

Appendix C lists the symbols for metals and transuranic radionuclides.

6.4.1 X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility

In the southernmost portion of PORTS in Quadrant I, groundwater concerns focus on three contaminant sources: X-749 Contaminated Materials Disposal Facility (also called the X-749 Landfill), X-120 Former Training Facility, and PK Landfill. A contaminant plume consisting of VOCs, primarily TCE, is associated with the X-749 Contaminated Materials Disposal Facility and X-120 Former Training Facility. The PK Landfill, located immediately northeast of the X-749 Landfill, is not a contaminant source to the X-749/X-120 groundwater plume.

6.4.1.1 X-749 Contaminated Materials Disposal Facility

The X-749 Contaminated Materials Disposal Facility is a landfill located in the south-central section of the facility in Quadrant I. The landfill covers approximately 11.5 acres and was built in an area of highest elevation within the southern half of PORTS. The landfill operated from 1955 to 1990, during which time buried wastes were generally contained in metal drums or other containers compatible with the waste.

The northern portion of the X-749 Landfill contains waste contaminated with industrial solvents, waste oils from plant compressors and pumps, sludges classified as hazardous, and low-level radioactive materials. The southern portion of the X-749 Landfill contains non-hazardous, low-level radioactive scrap materials.

The initial closure of the X-749 Landfill in 1992 included installation of 1) a multimedia cap; 2) a barrier wall along the north side and northwest corner of X-749 Landfill; and 3) subsurface groundwater drains on the northern half of the east side and the southwest corner of the landfill, including one sump within each of the groundwater drains. The barrier wall and subsurface drains extended down to bedrock. An additional barrier wall on the south and east sides of the X-749 Landfill was constructed in 2002. The groundwater drain and sump on the east side of the landfill were removed for construction of this barrier wall. Groundwater from the remaining subsurface drain is treated at the X-622 Groundwater Treatment Facility and discharged through FBP NPDES Outfall 608, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

The leading edge of the contaminated groundwater plume originating from the X-749 Landfill is near the southern boundary of PORTS. In 1994, a subsurface barrier wall was completed across a portion of this southern boundary of PORTS. The X-749 South Barrier Wall was designed to inhibit migration of the plume off plant property prior to the implementation of a final remedial measure; however, VOCs moved beyond the wall. In 2007, four groundwater extraction wells were installed in the X-749 South Barrier Wall Area, and in 2008, two extraction wells were installed in the groundwater collection system on the southwest side of the landfill. These extraction wells are controlling migration of the plume off plant property and reducing concentrations of TCE in groundwater. Two additional groundwater extraction wells were installed in 2010 to further control migration of the X-749/X-120 groundwater plume and remediate areas of higher TCE concentrations within the plume. A third extraction well was installed in the X-120 area of the plume (see Section 6.4.1.2). Chapter 3, Section 3.3.1.1, provides additional information about the remedial actions implemented to address the X-749/X-120 groundwater plume.

Ninety-eight wells and one sump/extraction well were sampled during 2019 to monitor the X-749/X-120 area. Table 6.1 lists the analytical parameters for the wells and sump in this area.

6.4.1.2 X-120 Former Training Facility

The X-120 Former Training Facility (originally called the Goodyear Training Facility and also called the X-120 Old Training Facility), which is west and north of the X-749 Contaminated Materials Disposal Facility, covered an area of approximately 11.5 acres west of the present-day XT-847 building. The X-120 Former Training Facility included a machine shop, metal shop, paint shop, and several warehouses used during the construction of PORTS in the 1950s.

Groundwater in the vicinity of this facility is contaminated with VOCs, primarily TCE. In 1996, a horizontal well was installed along the approximate axis of the X-120 plume. Contaminated groundwater flowed from this well to the X-625 Groundwater Treatment Facility. In 2003, operation of the X-625 Groundwater Treatment Facility and horizontal well ceased with the approval of Ohio EPA due to the limited amount of groundwater collected by the well. A groundwater extraction well was installed in 2010 in the area west of the X-120 Former Training Facility to remediate the higher concentrations of TCE in groundwater in this area. Chapter 3, Section 3.3.1.1, provides additional information about the remedial actions implemented to address the X-749/X-120 groundwater plume.

Ninety-eight wells and one sump/extraction well were sampled during 2019 to monitor the X-749/X-120 area. Table 6.1 lists the analytical parameters for the wells and sump in this area.

6.4.1.3 Monitoring results for the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility in 2019

The most extensive and most concentrated constituents associated with the X-749/X-120 plume are VOCs, particularly TCE (see Figure 6.2). As shown in the adjacent summary, the number of wells with TCE over 5 µg/L has been stable over the last five years. The average and median concentrations of TCE in wells within the X-749/X-120 plume are decreasing, which indicates that the overall extent of the plume is relatively stable, but concentrations of TCE within the plume are decreasing.

X-749/X-120: TCE	2015	2019
Number of wells sampled	99	99
Number of wells over 5 µg/L	48	49
Average TCE (µg/L)	350	186
Median TCE (µg/L)	66	47

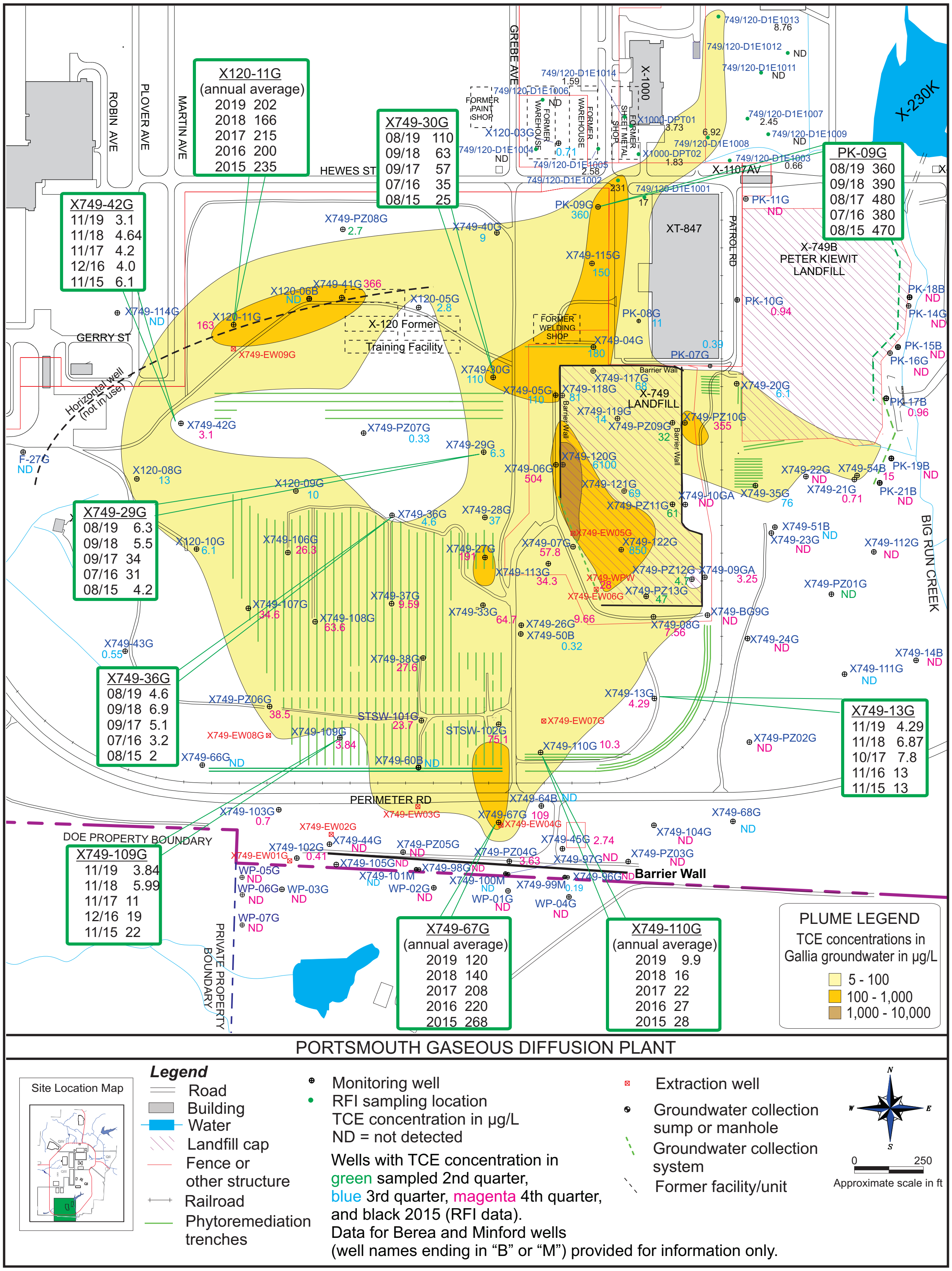

Figure 6.2. TCE-contaminated Gallia groundwater plume at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility– 2019.

In the fourth quarter of 2019, concentrations of TCE were at typical levels for the wells that monitor the X-749 South Barrier Wall area (the southern portion of the plume). TCE was detected in the first quarter sample collected from off-site well WP-03G at 0.17 µg/L; however, TCE was not detected in the second, third, or fourth quarter samples. In 2018, VOCs including TCE were detected in the third and fourth quarter samples from well WP-03G. Prior to the detections in 2018, VOCs had not been detected in well WP-03G since 2012 (DOE 2013), although these VOCs were routinely detected in the well before 2012 (DOE 2011a, DOE 2012). No other VOCs were detected in 2019 in any of the off-site monitoring wells.

In on-site monitoring wells in the X-749 South Barrier Wall area, TCE was detected above the preliminary remediation goal (5 µg/L) in samples collected from wells X749-45G and X749-PZ04G in the first, second, and third quarters of 2019. TCE decreased in these wells to less than 5 µg/L by the fourth quarter of 2019.

Several factors may have contributed to the higher concentrations of TCE in some of the wells in 2018 and 2019 including high rainfall and reduced pumping rates in the groundwater extraction wells in the X-749 South Barrier Wall area. The X-749 groundwater extraction wells operated at reduced pumping rates from the end of January through the end of May in 2018 when repairs were completed on a pipeline that transfers groundwater from the X-749 extraction wells to the X-622 Groundwater Treatment Facility. The increased precipitation in 2018 and reduced pumping rates caused higher than typical water levels in the X-749 South Barrier Wall area monitoring wells. The extraction wells in the X-749 South Barrier Wall Area were cleaned in 2019 to optimize groundwater extraction.

Groundwater in the area north of the X-749 Landfill was investigated in 2015 as part of the Deferred Units RCRA Facility Investigation. The results of this investigation have expanded the X-749/X-120 Gallia groundwater plume in the northern portion of the monitoring area. Analytical data for this investigation are provided in the *Deferred Units Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Report* (DOE 2017a).

Concentrations of TCE changed in the X-749/X-120 groundwater plume in 2019 as described below:

- In the northern portion of the X-749/X-120 groundwater plume, the area of the plume with concentrations of TCE higher than 100 µg/L expanded to wells X749-30G and X749-05G (both 110 µg/L). The northern perimeter of the plume expanded to include well X749-40G (9 µg/L). The concentration of TCE in well X749-40G has increased from 2.6 µg/L in 2018 and less than 0.5 µg/L in 2014-2017 (DOE 2020). The concentration of TCE in well X749-PZ08G also increased to 2.7 µg/L from 1.3 µg/L in 2017 and 2015 (DOE 2020).

- The southern portion of the plume became smaller in 2019 based on detections of TCE in wells X749-13G (southeast plume perimeter) and X749-109G (southwest plume perimeter). Concentrations of TCE in both these wells were less than 5 µg/L in the fourth quarter of 2019 (see Figure 6.2).

- The area of TCE that is above 100 µg/L in the southern portion of the plume has become smaller based on decreasing concentrations of TCE in well STSW-102G. The only well in the southern portion of the plume with concentrations of TCE above 100 µg/L is well X749-67G. Concentrations of TCE are decreasing in well X749-67G (see Figure 6.2).

Extraction well X749-EW09G was installed in 2010 to remediate higher concentrations of TCE associated with the former X-120 facility in the northern portion of the X-749/X-120 groundwater plume. Well X120-11G, which is immediately north of X749-EW09G, monitors the highest concentrations of TCE in this area. The average concentration of TCE detected in 2019 in well X120-11G (200 µg/L) is higher than 2018 (166 µg/L) but the same or less than average concentrations in 2015-2017 (200-235 µg/L) (see Figure 6.2).

Extraction well X749-EW08G is intended to control migration of the southwestern portion of the X-749/X-120 groundwater plume. TCE was not detected in the downgradient well X749-66G in 2019.

Groundwater extraction well X749-EW07G was installed in 2010 to remediate areas of higher TCE concentrations south of the X-749 Landfill. Wells X749-67G and X749-110G monitor the performance of extraction well X749-EW07G. The average concentration of TCE detected in 2019 in well X749-67G (120 µg/L) has decreased from the average annual concentrations detected in 2015-2018 (see Figure 6.2). The average concentration of TCE detected in 2019 in well X749-110G (9.9 µg/L) has decreased from the average annual concentrations detected in 2015-2018 (see Figure 6.2). These results indicate that extraction well X749-EW07G is functioning as intended to reduce concentrations of TCE south of the X-749 Landfill.

Samples from selected groundwater monitoring wells in the X-749/X-120 groundwater plume were analyzed for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and/or uranium-238). If detected, radionuclides were present in groundwater at levels below Ohio EPA drinking water standards (900 pCi/L for technetium-99 based on a 4 mrem/year dose from beta emitters and 30 µg/L for uranium).

6.4.2 PK Landfill

The PK Landfill is located west of Big Run Creek just south of the X-230K Holding Pond in Quadrant I and northeast of the X-749 Landfill. PK Landfill, which began operations in 1952, was used as a salvage yard, burn pit, and trash area during the construction of PORTS. After the initial construction, the disposal site was operated as a sanitary landfill until 1968, when soil was graded over the site and the area was seeded with native grasses.

During site investigations, intermittent seeps were observed originating from the PK Landfill into Big Run Creek. In 1994, a portion of Big Run Creek was relocated approximately 50 feet to the east. A groundwater collection system was installed in the old creek channel to capture the seeps from the landfill. A second collection system was constructed in 1997 on the southeastern landfill boundary to contain the groundwater plume migrating toward Big Run Creek from the southern portion of the PK Landfill. Although the PK Landfill is adjacent to the X-749 Landfill and X-749/X-120 groundwater plume, it is not a source of contaminants detected in the X-749/X-120 groundwater plume. A cap was constructed over the landfill in 1998. Chapter 3, Section 3.3.1.2, provides additional information about the remedial actions implemented at PK Landfill.

In 2019, nine wells, two sumps, and two manholes were sampled to monitor the PK Landfill area. Table 6.1 lists the analytical parameters for the wells, sumps, and manholes in this area.

6.4.2.1 Monitoring results for the PK Landfill in 2019

The PK Landfill is not part of the X-749/X-120 groundwater plume, although some of the wells associated with the PK Landfill are contaminated with low levels of VOCs, including TCE (see Figure 6.2). Most of the detections of VOCs in the PK Landfill monitoring wells are below preliminary remediation goals. In 2019, vinyl chloride was detected in samples collected from wells PK-17B and PK-21B at concentrations ranging from 12.2 to 21 µg/L, which exceed the preliminary remediation goal of 2 µg/L. Vinyl chloride is typically detected in these wells at concentrations above the preliminary remediation goal. No other VOCs were detected in the PK Landfill monitoring wells at concentrations that exceeded the preliminary remediation goals.

6.4.3. Quadrant I Groundwater Investigative (5-Unit) Area

The Quadrant I Groundwater Investigative (5-Unit) Area consists of a groundwater plume resulting from a number of potential sources of groundwater contamination in the northern portion of Quadrant I: the X-231A and X-231B Oil Biodegradation Plots, X-600 Former Steam Plant Complex, X-600A Former Coal Pile Yard, X-621 Coal Pile Runoff Treatment Facility, X-710 Technical Services Building, the X-760 Former Pilot Investigation Building, and the X-770 Former Mechanical Testing Facility. The X-231B Southwest Oil Biodegradation Plot was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*.

Three groundwater extraction wells were installed in 1991 as part of an IRM for the X-231B Southwest Oil Biodegradation Plot. Eleven additional groundwater extraction wells were installed in 2001-2002 as part of the remedial actions required by the Quadrant I Decision Document. These wells began operation in 2002. An additional extraction well south of the X-326 Process Building began operating in 2009. The extracted groundwater is treated at the X-622 Groundwater Treatment Facility and discharged through FBP NPDES Outfall 608, which flows into the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). Multimedia landfill caps were installed over the X-231B area and a similar area, X-231A, in 2000 to minimize water infiltration and control the spread of contamination. Chapter 3, Section 3.3.1.3, provides additional information about the remedial actions implemented in the Quadrant I Groundwater Investigative (5-Unit) Area.

Thirty-four wells were sampled in 2019 as part of the monitoring program for the Quadrant I Groundwater Investigative (5-Unit) Area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.3.1 Monitoring results for the Quadrant I Groundwater Investigative (5-Unit) Area in 2019

A contaminated groundwater plume consisting primarily of TCE is associated with the Quadrant I Groundwater Investigative (5-Unit) Area (see Figure 6.3). Other VOCs are also present in the plume. As shown in the adjacent summary, the number of wells with TCE over 5 µg/L has been relatively stable over the last five years. The average concentration of TCE has increased because the TCE in the most contaminated well in the plume has increased. However, TCE is stable or decreasing in most wells within the plume, as shown by the decrease in the median concentration of TCE within the plume. The overall extent of the plume is relatively stable, and concentrations of TCE are stable or decreasing in most wells that monitor the plume.

5-Unit: TCE	2015	2019
Number of wells sampled	34	34
Number of wells over 5 µg/L	20	22
Average TCE (µg/L)	1950	2570
Median TCE (µg/L)	165	100

Concentrations of TCE are changing in four wells that monitor the northern portion of the 5-Unit Area plume near the former X-760 and X-770 Buildings and the X-710 Technical Services Building. TCE is decreasing in wells X760-03G and X760-07G. TCE in well X760-03G decreased to 72 µg/L, which the first detection of TCE that is less than 100 µg/L (see Figure 6.3). However, TCE continues to increase in well X231B-36G, which monitors the northern portion of the plume on the south side of the X-710 Technical Services Building. TCE was detected at 850 µg /L in 2019, which has increased from 690 µg/L in 2018. TCE is also increasing in well X770-17GA on the east side of the former X-770 Building.

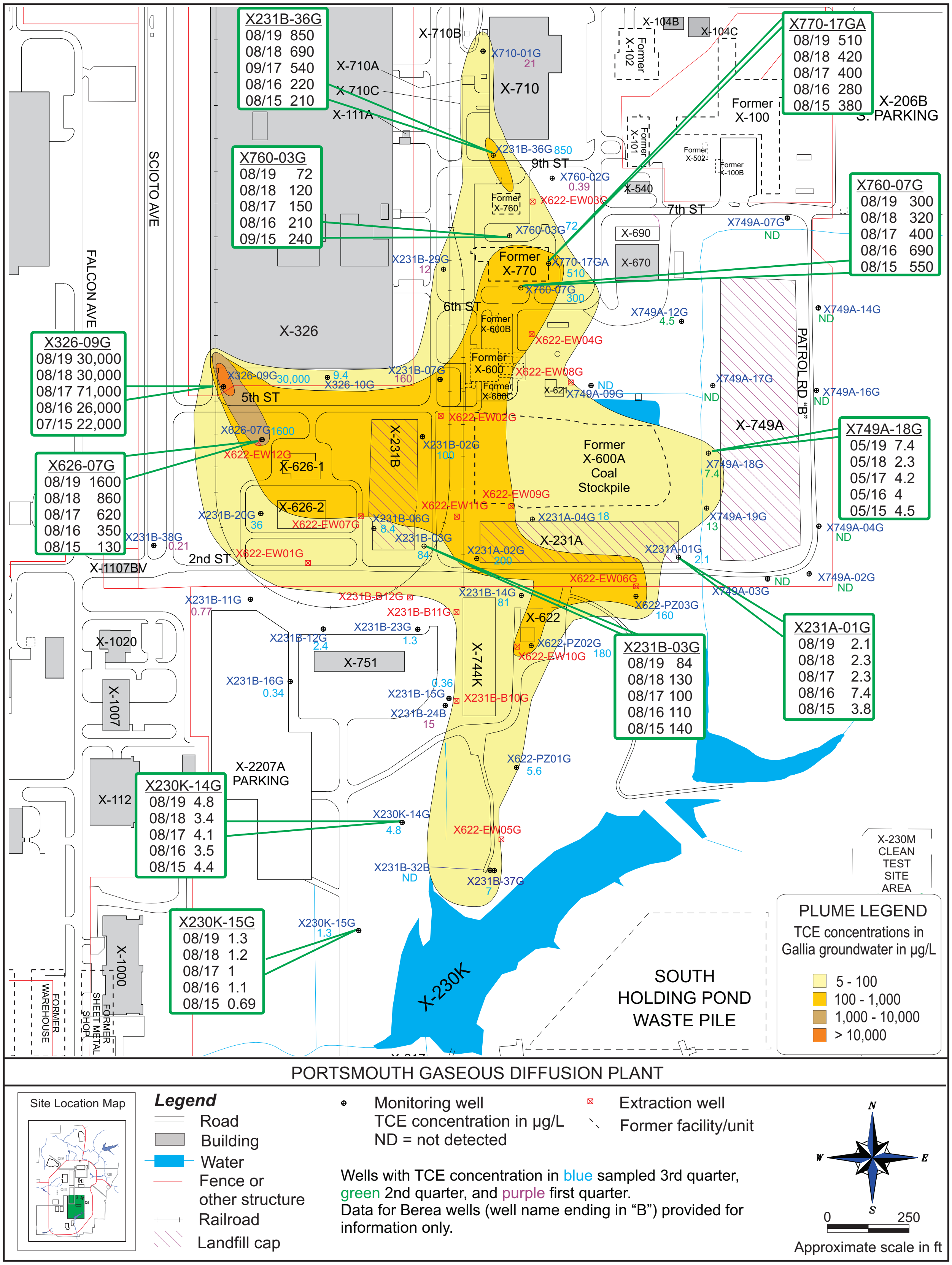

Figure 6.3. TCE-contaminated Gallia groundwater plume at the Quadrant I Groundwater Investigative (5-Unit) Area – 2019.

In the western portion of the plume, TCE is increasing in well X626-07G, which is located near extraction well X622-EW12G. This increase may indicate that the extraction well is drawing groundwater contaminated with higher levels of TCE near the southwest corner of the X-326 Process Building into the area monitored by well X626-07G.

Samples from selected wells that monitor the Quadrant I Groundwater Investigative (5-Unit) Area were analyzed for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and/or uranium-238). If detected, radionuclides were present at levels below Ohio EPA drinking water standards (900 pCi/L for technetium-99 based on a 4 mrem/year dose from beta emitters, and 30 µg/L for uranium).

6.4.4 X-749A Classified Materials Disposal Facility

The 6-acre X-749A Classified Materials Disposal Facility (also called the X-749A Landfill) is a landfill that operated from 1953 through 1988 for the disposal of wastes classified under the Atomic Energy Act (see Figure 6.3). Potential contaminants include PCBs, asbestos, radionuclides, and industrial waste. Closure of the landfill, completed in 1994, included the construction of a multilayer cap and the installation of a drainage system to collect surface water runoff. The drainage system discharges via the X-230K South Holding Pond (FBP NPDES Outfall 002). Although the X-749A Classified Materials Disposal Facility is located at the eastern edge of the Quadrant I Groundwater Investigative (5-Unit) Area groundwater plume, the X-749A Landfill is not the source of the VOCs detected in some of the X-749A monitoring wells at the eastern edge of the Quadrant I Groundwater Investigative (5-Unit) Area groundwater plume.

Ten wells associated with the landfill were sampled in 2019. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.4.1 Monitoring results for the X-749A Classified Materials Disposal Facility in 2019

Under the detection monitoring program for the X-749A Landfill, concentrations of alkalinity, ammonia, calcium, chloride, iron, nitrate/nitrite, sodium, and sulfate in downgradient Gallia wells were evaluated using two statistical procedures to monitor potential impacts to groundwater and trends in concentrations of these parameters. Ohio EPA is notified when the statistical control limit for any of the indicator parameters using the first statistical procedure is exceeded at any of the downgradient Gallia wells in two consecutive semiannual sampling events. The second statistical procedure monitors long-term trends in concentrations of the indicator parameters and does not require Ohio EPA notification. None of the control limits requiring Ohio EPA notification were exceeded in the X-749A wells in 2019.

Samples from each of the wells were also analyzed for technetium-99, uranium, and isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238). Technetium-99 was detected at 8.03 pCi/L in the sample collected from well X749A-16G, which is less than the Ohio EPA drinking water standard for technetium-99 (900 pCi/L, based on a 4 mrem/year dose from beta emitters). Uranium and uranium isotopes, if detected, were present at low levels typical for the wells in this area and below the drinking water standard (30 µg/L for uranium).

6.4.5 Quadrant II Groundwater Investigative (7-Unit) Area

The Quadrant II Groundwater Investigative (7-Unit) Area consists of an area of groundwater contamination with several potential sources. One of these sources, the X-701C Neutralization Pit, was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*. The X-701C Neutralization Pit was an open-topped neutralization pit that received process effluents and basement sump wastewater such as acid and alkali solutions and rinse water contaminated with TCE and other VOCs from metal-cleaning operations. The X-701C Neutralization Pit was located within a TCE plume centered around the X-700 and X-705 buildings. The pit was removed in 2001. In 2010, Ohio EPA approved an IRM to remediate contaminant source areas within the southeastern portion of the groundwater plume, which was completed in 2013. Chapter 3, Section 3.3.2.1 provides additional information about the Quadrant II Groundwater Investigative (7-Unit) Area.

The natural groundwater flow direction in this area is to the east toward Little Beaver Creek. The groundwater flow pattern has been changed in this area by use of sump pumps in the basements of the X-700 and X-705 buildings. Thus, the groundwater plume in this area does not spread but instead flows toward the sumps where it is collected and then treated at the X-627 Groundwater Treatment Facility. This facility discharges through FBP NPDES Outfall 611, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). Twenty-four wells are part of the routine monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.5.1 Monitoring results for the Quadrant II Groundwater Investigative (7-Unit) Area in 2019

A contaminated groundwater plume consisting primarily of TCE is associated with the Quadrant II Groundwater Investigative (7-Unit) Area (see Figure 6.4). As shown in the adjacent summary, the number of wells with TCE over 5 µg/L has been stable over the last five years. The average and median concentrations of TCE in wells within the 7-Unit plume have decreased slightly, which indicates that the overall extent of the plume is stable, and concentrations of TCE within the plume are stable or decreasing slightly.

7-Unit: TCE	2015	2019
Number of wells sampled	24	24
Number of wells over 5 µg/L	19	19
Average TCE (µg/L)	79,300	78,600
Median TCE (µg/L)	391	375

On the southern perimeter of the plume, TCE continues to increase in well X701-45G. TCE is also increasing in well X701-27G, which monitors the eastern plume perimeter (see Figure 6.4).

Groundwater in the western and northwestern portion of the monitoring area, beneath and adjacent to the X-333 and X-330 Process Buildings, was investigated in 2015 as part of the Deferred Units RCRA Facility Investigation. The results from the sampling locations that were part of this investigation have expanded the Gallia groundwater plume in the western and northwestern portion of the monitoring area.

Samples from selected wells that monitor the Quadrant II Groundwater Investigative (7-Unit) Area were analyzed for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and/or uranium-238). If detected, radionuclides were present at levels below Ohio EPA drinking water standards (900 pCi/L for technetium-99 based on a 4 mrem/year dose from beta emitters, and 30 µg/L for uranium).

6.4.6 X-701B Former Holding Pond

In the eastern portion of Quadrant II, groundwater concerns focus on three areas: the X-701B Former Holding Pond, the X-230J7 Holding Pond, and the X-744Y Waste Storage Yard.

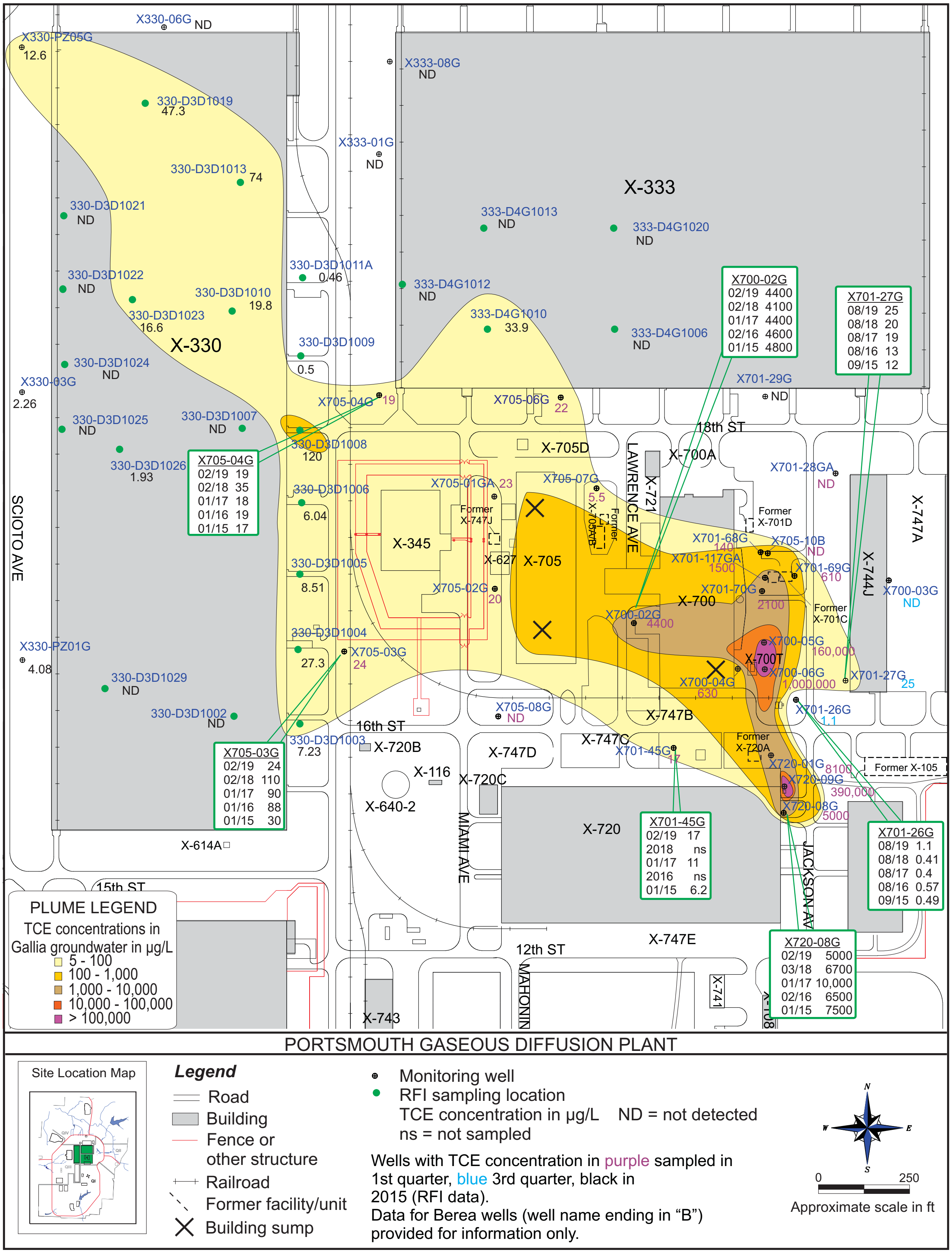

Figure 6.4. TCE-contaminated Gallia groundwater plume at the Quadrant II Groundwater Investigative (7-Unit) Area – 2019.

The X-701B Former Holding Pond was used from the beginning of plant operations in 1954 until 1988. The pond was designed for neutralization and settlement of acid waste from several sources. TCE and other VOCs were also discharged to the pond. Two surface impoundments (sludge retention basins) were located west of the holding pond. The X-230J7 Holding Pond received wastewater from the X-701B Former Holding Pond. The X-744Y Waste Storage Yard is south of the X-701B Former Holding Pond. The yard was approximately 15 acres and surrounded the X-744G Bulk Storage Building. RCRA hazardous waste was managed in this area.

A contaminated groundwater plume extends from the X-701B Former Holding Pond towards Little Beaver Creek. Three groundwater extraction wells were installed in 1993 southeast of the X-701B Former Holding Pond and a sump was installed in 1995 in the bottom of the pond as part of the RCRA closure of the unit. These wells and sump were designed to intercept contaminated groundwater originating from the holding pond area before it could join the existing groundwater contaminant plume. The extraction wells and sump were removed between 2009 and 2011 because of the X-701B IRM (see Chapter 3, Section 3.3.2.2).

Two groundwater interceptor trenches (French drains) are used to intercept TCE-contaminated groundwater in the eastern portion of the monitoring area. These interceptor trenches, called the X-237 Groundwater Collection System, control TCE migration into Little Beaver Creek. The 660-foot-long primary trench has two sumps in the backfill and a 440-foot-long secondary trench intersects the primary trench. The extracted groundwater is treated at the X-624 Groundwater Treatment Facility and discharges through FBP NPDES Outfall 015, which flows to Little Beaver Creek.

Groundwater remediation in the X-701B Former Holding Pond Area was initiated in 2006 (see Chapter 3, Section 3.3.2.2). Oxidant was injected into the subsurface in the western portion of the area from 2006 through 2008 to remediate VOCs in soil and groundwater. The X-701B IRM was initiated in December 2009 and completed in 2011 to further address contaminants remaining in soil and groundwater following the oxidant injections. Contaminated soil in the X-701B IRM area was removed and mixed with oxidant, with additional oxidant mixed into soil remaining at the bottom of the excavation.

Sixty-three wells that monitor the X-701B Former Holding Pond area were sampled in 2019. Table 6.1 lists the analytical parameters for the wells that are part of the *Integrated Groundwater Monitoring Plan* (DOE 2017c).

6.4.6.1 Monitoring results for the X-701B Former Holding Pond in 2019

A contaminated groundwater plume consisting of TCE and other VOCs is located in the X-701B Former Holding Pond area (see Figure 6.5). As shown in the adjacent summary, the average and median concentrations of TCE in wells within the X-701B plume have decreased in the last five years. The number of wells with concentrations over 5 µg/L has increased due to expansion of the plume in wells on the north and south sides of the plume.

X-701B: TCE	2015	2019
Number of wells sampled	62	63
Number of wells over 5 µg/L	44	47
Average TCE (µg/L)	32,500	19,400
Median TCE (µg/L)	7900	2800

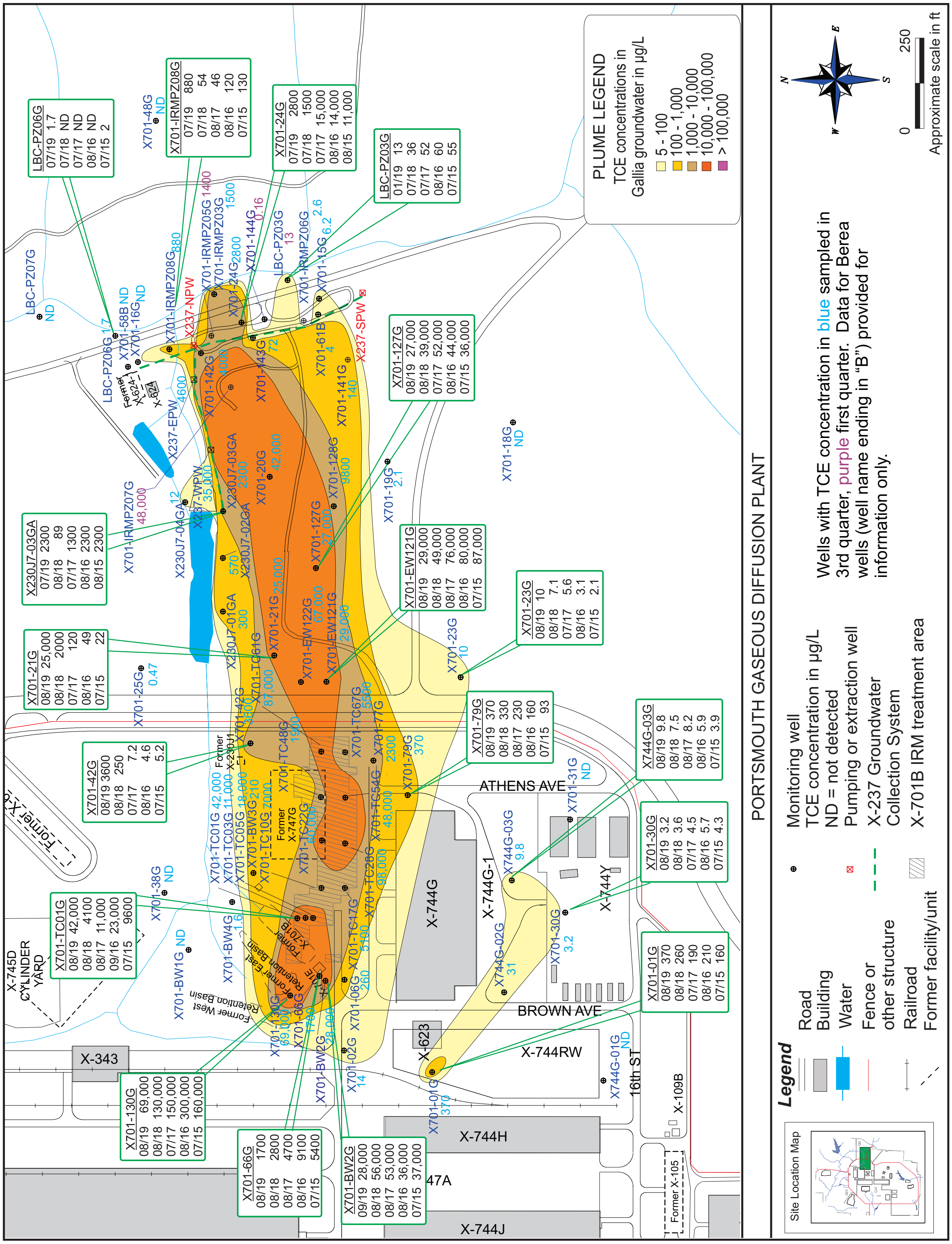

Figure 6.5. TCE-contaminated Gallia groundwater plume at the X-701B Former Holding Pond – 2019.

The concentration of TCE detected in well X701-42G on the north edge of plume increased to 3600 µg/L in 2019. TCE was detected at 250 µg/L in 2018 and less than 10 µg/L in 2015-2017 (see Figure 6.5). TCE is also increasing in two wells in the southern portion of the plume: X701-23G and X701-79G. TCE has increased in X701-23G from 2.1 µg/L in 2015 to 10 µg/L in 2019. TCE has increased in X701-79G from 93 µg/L in 2015 to 370 µg/L in 2019 (see Figure 6.5).

TCE has increased in well X701-21G (a mid-plume well) from less than 50 µg/L in 2015-2016 to 25,000 µg/L in the third quarter of 2019. Based on the increasing concentrations of TCE in wells X701-42G, X230J7-04GA, and X701-21G, higher concentrations of TCE are shifting to the north in the X-701B groundwater plume. The increasing concentrations of TCE in some of the X-701B monitoring wells are being considered as part of the evaluation of the detections of VOCs in the East Drainage Ditch and Little Beaver Creek (see Section 6.4.15.1) and the X-237 Groundwater Collection System, which is continuing in 2020.

Three wells in the western portion of the X-701B plume had concentrations of TCE greater than 100,000 µg/L in 2018: X701-130G, X701-TC28G, and X701-TC61G. In the third quarter of 2019, concentrations of TCE in each of these wells decreased to less than 100,000 µg/L. TCE is decreasing in many of the wells that monitor the western portion of the X-701B plume (the area west of Perimeter Road).

Samples from 49 wells that monitor the X-701B Holding Pond were analyzed for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and/or uranium-238). Technetium-99 or uranium were detected above Ohio EPA drinking water standards (900 pCi/L for technetium-99 based on a 4 mrem/year dose from beta emitters, and 30 µg/L for uranium) in three wells near the former X-701B Pond and east retention basin and in wells installed within the IRM area. Concentrations of radionuclides present in groundwater in the X-701B area can be affected by the oxidant used in the X-701B IRM and the oxidant injections conducted in 2006 through 2008 that were part of the X-701B groundwater remedy. The oxidant, which affects the oxidation/reduction potential and pH of the soil and/or groundwater, temporarily causes metals in soil to be mobilized into the groundwater. It is expected that the metals will move downgradient with groundwater flow for a short distance and then be re-adsorbed into the soil matrix as the geochemistry of the soil and groundwater returns to ambient conditions.

Samples from five wells that monitor the area near the X-744G Bulk Storage Building and X-744Y Storage Yard were analyzed for cadmium and nickel, which were detected above preliminary remediation goals in three of the five wells (X701-01G, X744G-01G, and X744G-02G). These results are typical for the X-744 area wells. Nickel was also detected at concentrations above the preliminary remediation goal in samples collected from wells X701-20G and X701-127G, which monitor the center of the plume downgradient from the IRM treatment area and the area in which oxidant was injected from 2006 through 2008. This area is likely affected by the oxidant used in the X-701B IRM and the oxidant injections conducted in 2006 through 2008.

6.4.7 X-633 Former Recirculating Cooling Water Complex

The X-633 Former Recirculating Cooling Water Complex in Quadrant II consisted of a recirculating water pumphouse and four cooling towers with associated basins. Chromium-based corrosion inhibitors were added to the cooling water until the early 1990s, when the system was converted to a phosphate-based inhibitor. D&D of the facilities was completed in 2010. Chapter 3, Section 3.3.2.3 provides additional information about the RCRA investigation of soils and groundwater in this area.

The X-633 Former Recirculating Cooling Water Complex was identified as an area of concern for potential metals contamination in 1996 based on historical analytical data for groundwater wells in this area. Samples from wells in this area were collected in 1998 and 1999 to assess the area for metals contamination. Based on detections of chromium above the preliminary remediation goal, this area was added to the PORTS groundwater monitoring program. Two wells are sampled semiannually for chromium as part of the monitoring program for this area.

6.4.7.1 Monitoring results for the X-633 Former Recirculating Cooling Water Complex in 2019
Chromium was detected in both of the X-633 monitoring wells in 2019. Samples collected from well X633-07G contained chromium at concentrations above the preliminary remediation goal of 100 µg/L: 590 µg/L (second quarter) and 530 µg/L (fourth quarter). Samples collected from well X633-PZ04G also contained chromium but at concentrations below the preliminary remediation goal. These results are typical for these wells. Figure 6.6 shows the chromium concentrations detected in the X-633 Former Recirculating Cooling Water Complex wells.

6.4.8 X-616 Former Chromium Sludge Surface Impoundments
The X-616 Former Chromium Sludge Surface Impoundments in Quadrant III were two unlined surface impoundments used from 1976 to 1985 for storage of sludge generated by the treatment of water from the PORTS process cooling system. A corrosion inhibitor containing chromium was used in the cooling water system. Sludge containing chromium was produced by the water treatment system and was pumped into and stored in the X-616 impoundments. The sludge was removed from the impoundments and remediated as an interim action in 1990 and 1991. The unit was certified closed in 1993. Sixteen wells are sampled as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.8.1 Monitoring results for the X-616 Former Chromium Sludge Surface Impoundments in 2019
Chromium is of special concern at X-616 because of the previous use of the area. In 2019, chromium was detected above the preliminary remediation goal of 100 µg/L in one well that monitors the X-616 area: well X616-05G (on the northeastern boundary of the area). Chromium is typically detected above the preliminary remediation goal in this well. Nickel was detected above the preliminary remediation goal (100 µg/L for Gallia wells) in two wells (X616-05G and X616-25G). Nickel is typically detected above the preliminary remediation goal in these two wells. Figure 6.7 shows the concentrations of chromium and nickel in wells at the X-616 Former Chromium Sludge Surface Impoundments.

TCE was detected above the preliminary remediation goal of 5 µg/L in three wells west of the former surface impoundments: wells X616-09G, X616-13G, and X616-20B. TCE has been detected above 5 µg/L in wells X616-09G and X616-20B since 2004 or earlier. Concentrations of TCE increased to above 5 µg/L in well X616-13G in 2013. Figure 6.7 shows the concentrations of TCE detected in the X-616 wells in 2019.

6.4.9 X-740 Former Waste Oil Handling Facility
The X-740 Former Waste Oil Handling Facility, which was demolished in 2006, was located on the western half of PORTS south of the X-530A Switchyard in Quadrant III. The X-740 facility, which operated from 1983 until 1991, was used as an inventory and staging facility for waste oil and waste solvents that were generated from various plant operational and maintenance activities. A sump within the building was used between 1986 and 1990 to collect residual waste oil and waste solvents from containers crushed in a hydraulic drum crusher at the facility. The facility and sump were initially identified as hazardous waste management units in 1991. The X-740 Former Waste Oil Handling Facility (both the facility and sump identified as hazardous waste management units) underwent closure, and closure certification was approved by Ohio EPA in 1998.

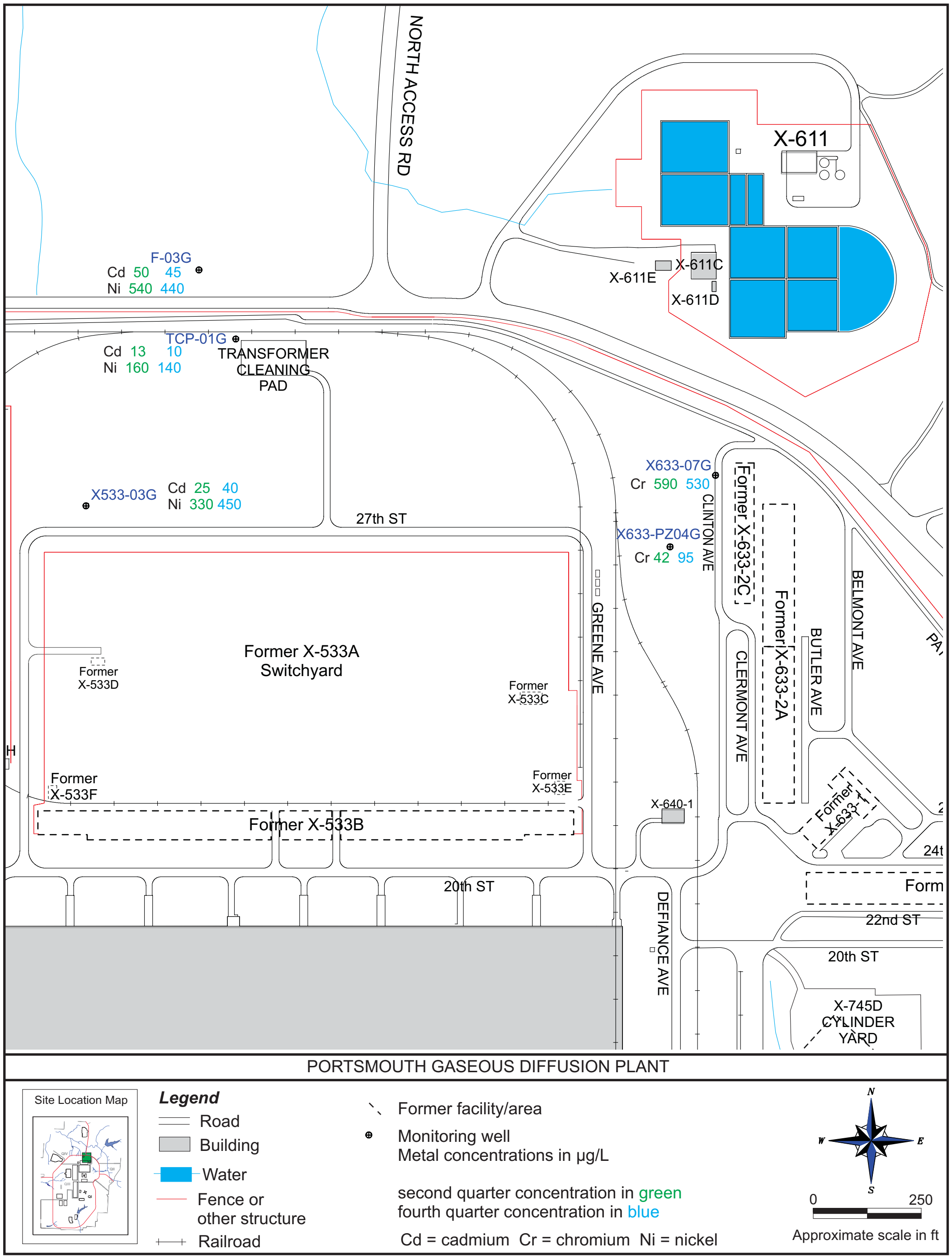

Figure 6.6. Metal concentrations in groundwater at the X-633 Former Recirculating Cooling Water Complex and X-533 Former Switchyard Complex – 2019.

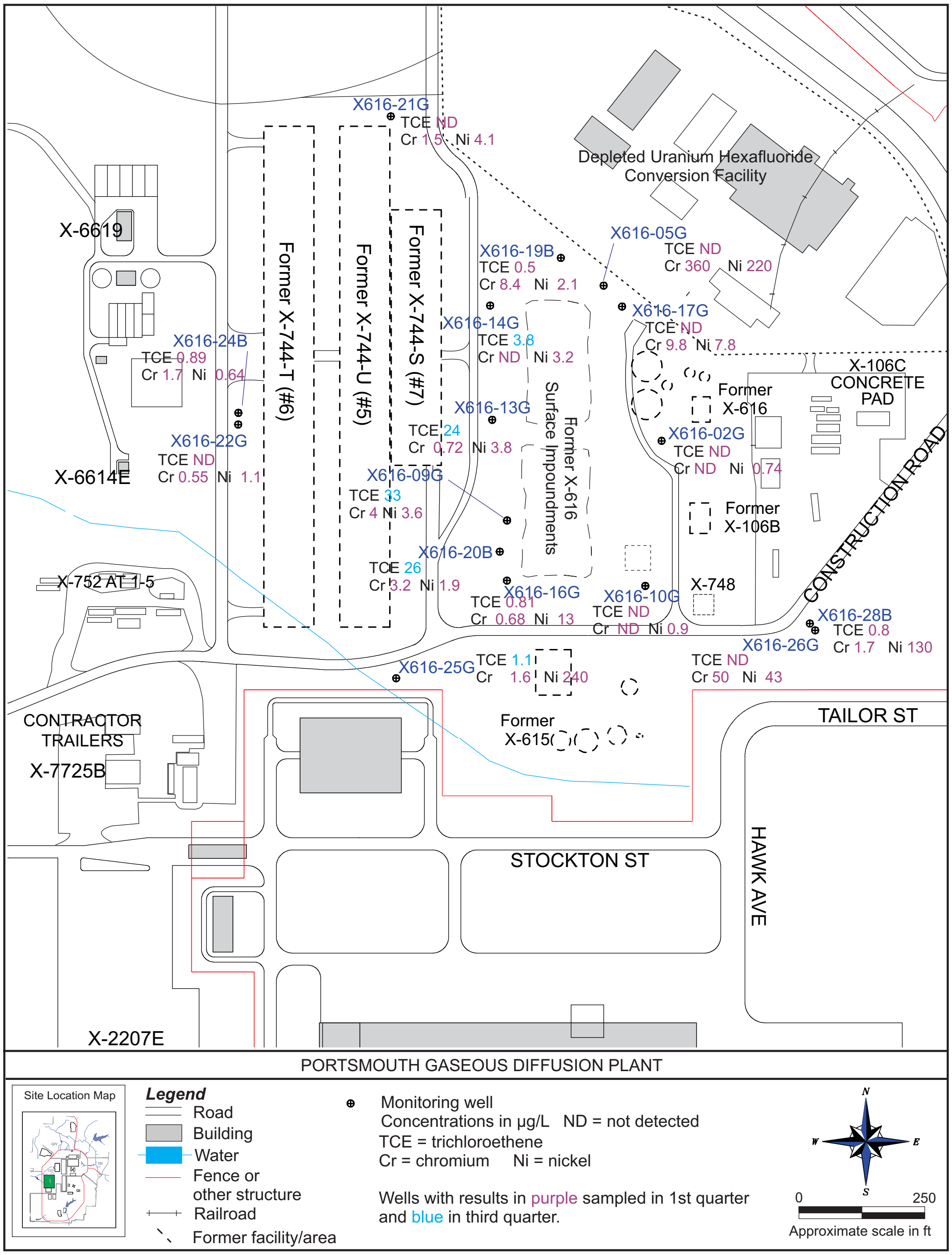

Figure 6.7. TCE and metal concentrations in groundwater at the X-616 Former Chromium Sludge Surface Impoundments – 2019.

In 1999, poplar trees were planted in a 2.6-acre phytoremediation area above the groundwater plume near the X-740 Former Waste Oil Handling Facility. Because phytoremediation did not work as anticipated to reduce the concentrations of VOCs in groundwater in this area, three rounds of oxidant injections were completed during 2008. Additional alternatives for groundwater remediation in this area were evaluated in 2009, and a pilot study of enhanced anaerobic bioremediation took place from 2010 through 2015. Chapter 3, Section 3.3.3, provides additional information about the remedial activities for the X-740 area.

Twenty-three wells that monitor the X-740 Former Waste Oil Handling Facility were sampled during 2019.

6.4.9.1 Monitoring results for the X-740 Former Waste Oil Handling Facility in 2019

In general, concentrations of TCE continue to decrease in the TCE plume near the X-740 facility due to the bioremediation project that took place in this area (see Chapter 3, Section 3.3.3). As shown in the adjacent summary, the number of wells with concentrations of TCE over 5 µg/L has decreased from 15 to seven between 2015 and 2019. Because of the reduction of the number of wells within the plume, the wells remaining above 5 µg/L are the wells with higher concentrations of TCE. Therefore, the average and median concentrations of TCE have increased from 2015 to 2019. In other words, the X-740 plume has gotten smaller, but the concentration of TCE detected within the smaller plume is higher than it was in 2015 within the larger plume.

X-740: TCE	2015	2019
Number of wells sampled	23	23
Number of wells over 5 µg/L	15	7
Average TCE (µg/L)	74	81
Median TCE (µg/L)	17	40

The plume perimeter changed slightly in 2019 based on detections of TCE in the samples collected from four wells that define the north portion of the plume. TCE detected in wells X740-02G, X740-03G, X740-19G and X740-PZ17G decreased to less than the preliminary remediation goal (5 µg/L) in 2019. Figure 6.8 shows the Gallia groundwater plume and decreasing TCE concentrations in selected wells for the X-740 Former Waste Handling Facility.

6.4.10 X-611A Former Lime Sludge Lagoons

The X-611A Former Lime Sludge Lagoons in Quadrant IV were comprised of three adjacent unlined sludge retention lagoons constructed in 1954 and used for disposal of lime sludge waste from the site water treatment plant from 1954 to 1960. The lagoons covered a surface area of approximately 18 acres and were constructed in a low-lying area that included Little Beaver Creek. As a result, approximately 1500 feet of Little Beaver Creek were relocated to a channel just east of the lagoons.

As part of the RCRA Corrective Action Program, a prairie habitat has been developed in this area by placing a soil cover over the north, middle, and south lagoons. A soil berm was also constructed outside the northern boundary of the north lagoon to facilitate shallow accumulation of water in this low-lying area. Chapter 3, Section 3.3.4.1, provides more information about this remediation. Six wells are sampled semiannually as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

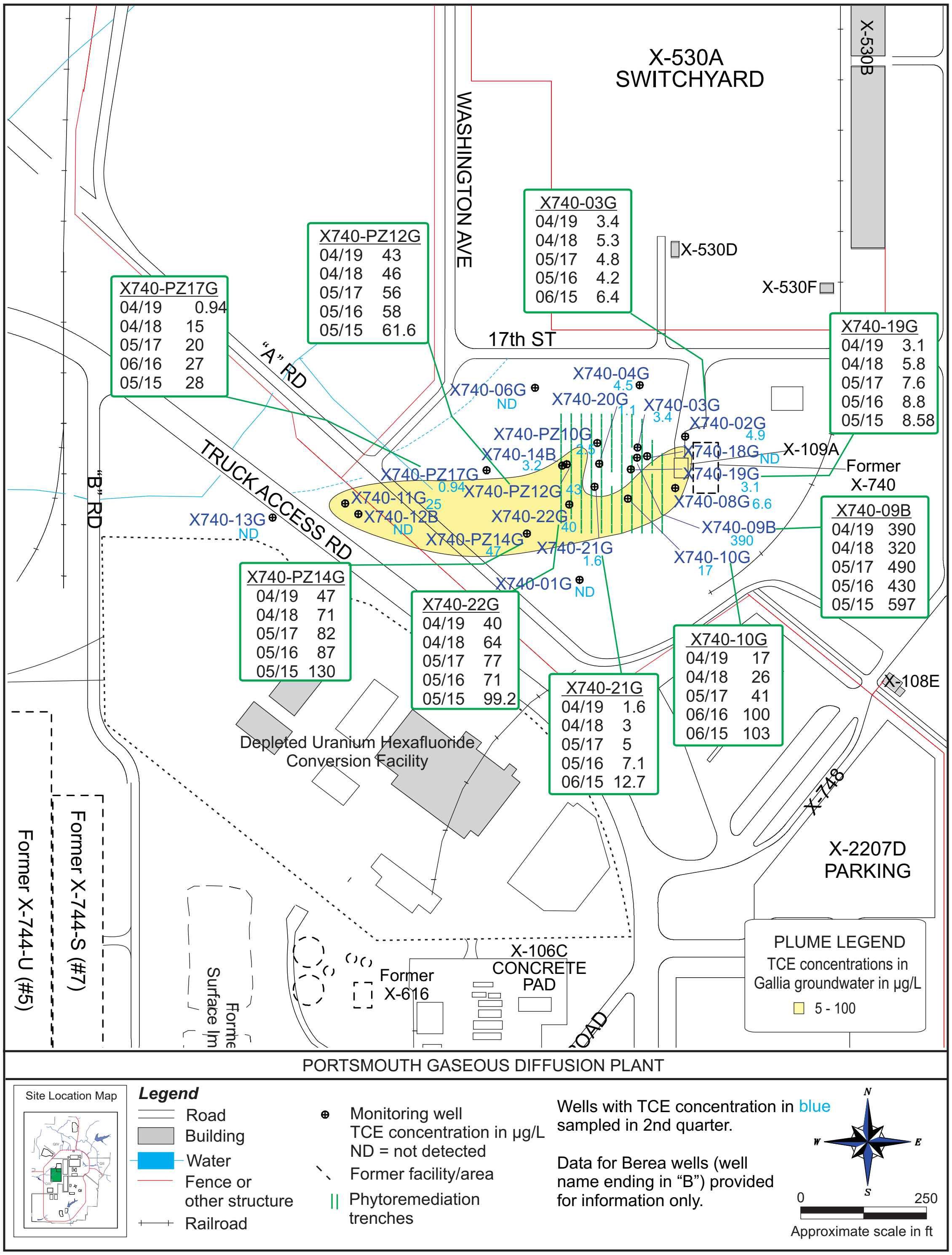

Figure 6.8. TCE-contaminated Gallia groundwater plume near the X-740 Former Waste Oil Handling Facility – 2019.

6.4.10.1 Monitoring results for the X-611A Former Lime Sludge Lagoons in 2019

The six monitoring wells at X-611A are sampled and analyzed semiannually for beryllium and chromium. In 2019, chromium was detected in the samples collected from all six wells in this area at concentrations between 0.5 and 17 µg/L, which are below the preliminary remediation goal (100 µg/L).

In 2019, beryllium was detected in three of the six wells in this area at concentrations between 0.17 and 1.3 µg/L, which are less than the preliminary remediation goals (6.5 µg/L for Gallia wells and 7 µg/L for Berea wells). Figure 6.9 shows the concentrations of beryllium and chromium detected in the X-611A wells in 2019.

6.4.11 X-735 Landfills

Several distinct waste management units are contained within the X-735 Landfills area in Quadrant IV. The main units consist of the hazardous waste landfill, referred to as the X-735 RCRA Landfill, and the X-735 Industrial Solid Waste Landfill. The X-735 Industrial Solid Waste Landfill includes the industrial solid waste cells, asbestos disposal cells, and the chromium sludge monocells A and B. The chromium sludge monocells contain a portion of the chromium sludge generated during the closure of the X-616 Chromium Sludge Surface Impoundments.

Initially, a total of 17.9 acres was approved by Ohio EPA and Pike County Department of Health for landfill disposal of conventional solid wastes. The landfill began operation in 1981. During operation of the landfill, PORTS investigations indicated that wipe rags contaminated with solvents had inadvertently been disposed in the northern portion of the landfill. The contaminated rags were considered a hazardous waste. Waste disposal in the northern area ended in 1991, and Ohio EPA determined that the area required closure as a RCRA hazardous waste landfill. Consequently, this unit of the sanitary landfill was identified as the X-735 RCRA Landfill.

A buffer zone was left unexcavated to provide space for groundwater monitoring wells and a space between the RCRA landfill unit and the remaining southern portion, the X-735 Industrial Solid Waste Landfill. Routine groundwater monitoring has been conducted at the X-735 Landfills since 1991.

The industrial solid waste portion of the X-735 Landfills included a solid waste section and an asbestos waste section. The X-735 Industrial Solid Waste Landfill, not including the chromium sludge monocells, encompasses a total area of approximately 4.1 acres. Operation of the X-735 Industrial Solid Waste Landfill ceased in 1997; this portion of the landfill was capped in 1998.

The *Integrated Groundwater Monitoring Plan* incorporates monitoring requirements for the hazardous and solid waste portions of the X-735 Landfills (DOE 2017c). In addition, the *Corrective Measures Plan for the X-735 Landfill* was approved by Ohio EPA in 2008 (DOE 2007a). This plan provides the monitoring requirements for Gallia wells that monitor the X-735 Landfill. Corrective measures monitoring was implemented because Ohio EPA determined that assessment monitoring of the landfill, completed between 2005 and 2007, identified that a small release of leachate constituents is occurring or has occurred from the X-735 Landfills. Seventeen wells were sampled in 2019 as part of the monitoring programs for this area. Table 6.1 lists the analytical parameters and Figure 6.10 shows the monitoring wells in this area.

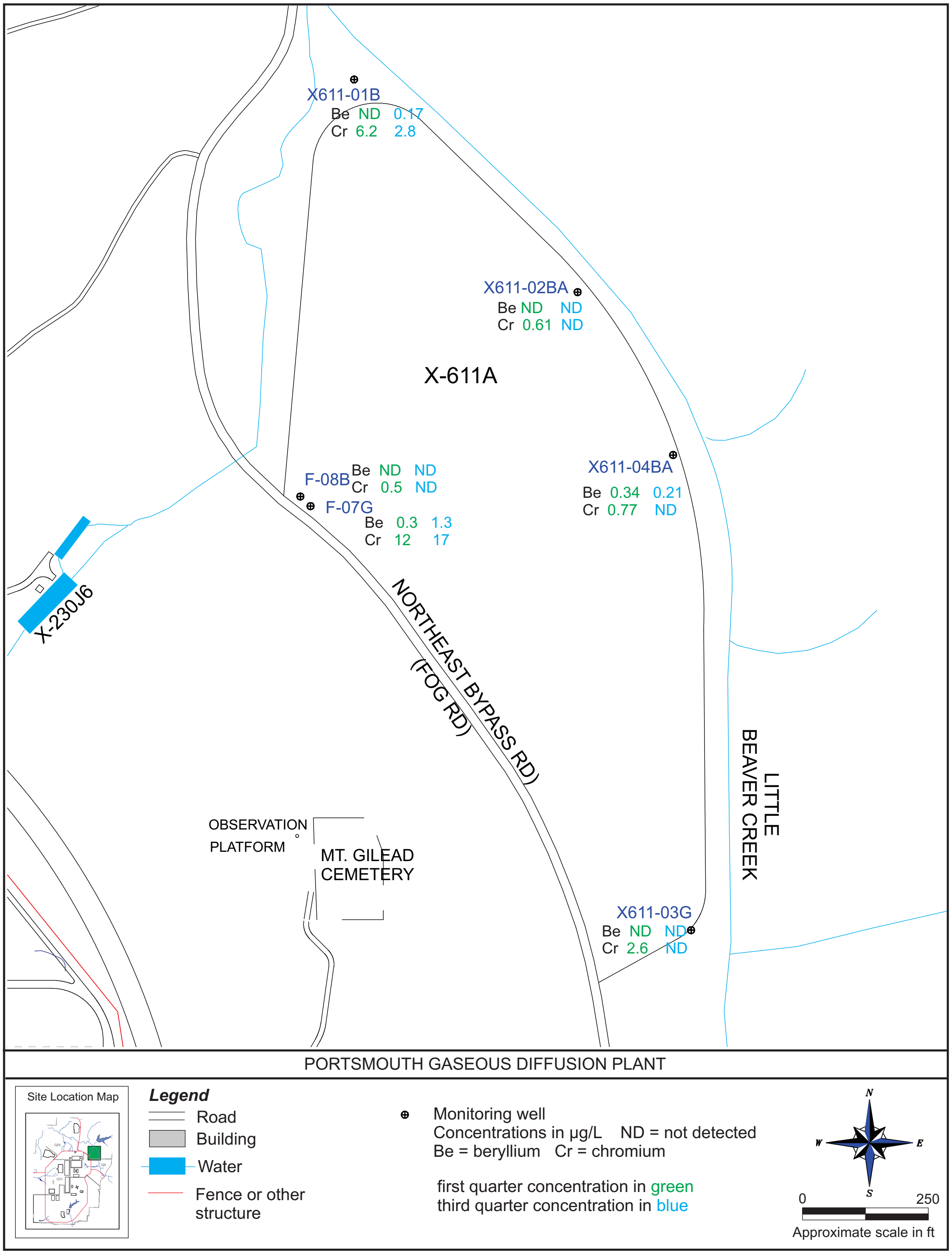

Figure 6.9. Metal concentrations in groundwater at the X-611A Former Lime Sludge Lagoons — 2019.

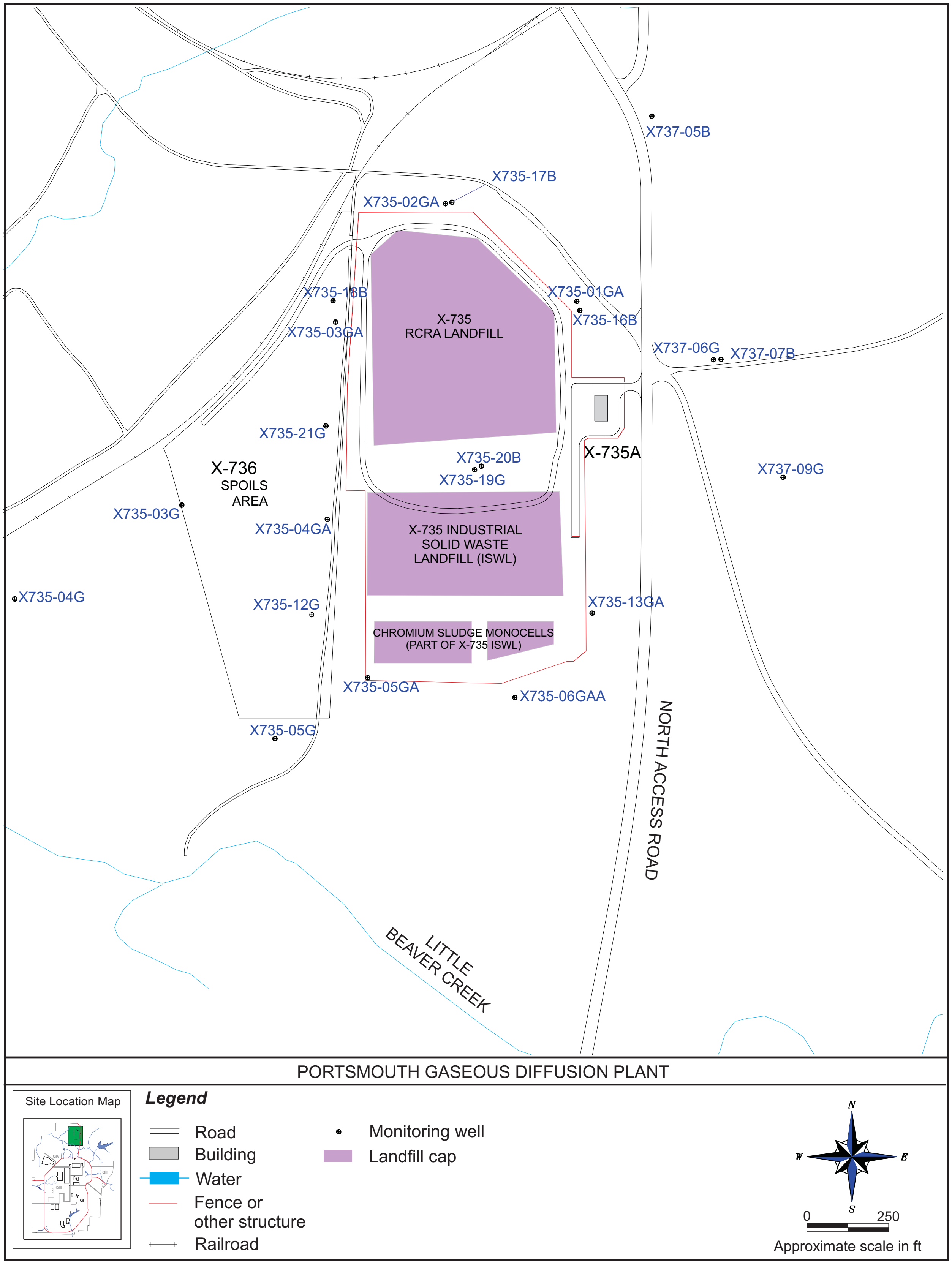

Figure 6.10. Monitoring wells at the X-735 Landfills.

6.4.11.1 Monitoring results for the X-735 Landfills in 2019
The monitoring program at the X-735 Landfills includes corrective measures monitoring for Gallia wells and detection monitoring for Berea wells. As required by the corrective measures monitoring program, concentrations of three metals (cobalt, mercury, and nickel) and five indicator parameters (alkalinity, chloride, sodium, sulfate, and total dissolved solids) detected in downgradient Gallia wells are compared to concentration limits based on drinking water standards or site background concentrations. None of these concentration limits were exceeded in 2019.

The detection monitoring program for X-735 Berea wells continued in 2019. Concentrations of alkalinity, ammonia, calcium, chloride, iron, nitrate/nitrite, potassium, sodium, and sulfate in downgradient Berea wells were evaluated to monitor potential impacts to groundwater and trends in concentrations of these parameters. No control limits used to determine a statistically significant change in the indicator parameters requiring Ohio EPA notification were exceeded in the X-735 Berea wells in 2019.

Samples from each of the wells were also analyzed for technetium-99, uranium, and isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238). Technetium-99 was not detected in any of the wells. Uranium and uranium isotopes, if detected, were present at low levels typical for the wells in this area and below the drinking water standard (30 µg/L for uranium).

6.4.12 X-734 Landfills
The X-734 Landfills in Quadrant IV consisted of three landfill units that were used until 1985. Detailed records of materials disposed in the landfills were not kept. However, wastes known to be disposed at the landfills included trash and garbage, construction spoils, wood and other waste from clearing and grubbing, and empty drums. Other materials reportedly disposed in the landfills may have included waste contaminated with metals, empty paint cans, and uranium-contaminated soil from the X-342 area.

The X-734 Landfills were closed in accordance with regulations in effect at that time, and no groundwater monitoring of the area was required. However, the RCRA Facility Investigation conducted in the early 1990s identified the presence of VOCs, metals, and radionuclides in soil and/or groundwater in the area. The X-734 Landfills were capped in 1999-2000 as part of the remedial actions required for Quadrant IV. Chapter 3, Section 3.3.4.2, provides more information about the remedial actions for this area.

Fifteen wells (see Figure 6.11) are sampled semiannually as part of the monitoring program for this area. Table 6.1 lists the monitoring parameters for the wells in this area.

6.4.12.1 Monitoring results for the X-734 Landfills in 2019
VOCs are routinely detected in a number of the wells that monitor the X-734 Landfills, but generally at concentrations below preliminary remediation goals. In 2019, no VOCs were detected at concentrations above the preliminary remediation goals in the samples collected from the X-734 monitoring wells.

Samples from the all of the X-734 monitoring wells were also analyzed for five metals (beryllium, cadmium, chromium, manganese, and nickel). None of the samples contained metals at concentrations above the respective preliminary remediation goal.

Samples collected from each well in the second quarter were also analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238). No transuranics or technetium-99 were detected in the samples. Detections of uranium and uranium isotopes were typical for these wells and below the drinking water standard (30 µg/L for uranium).

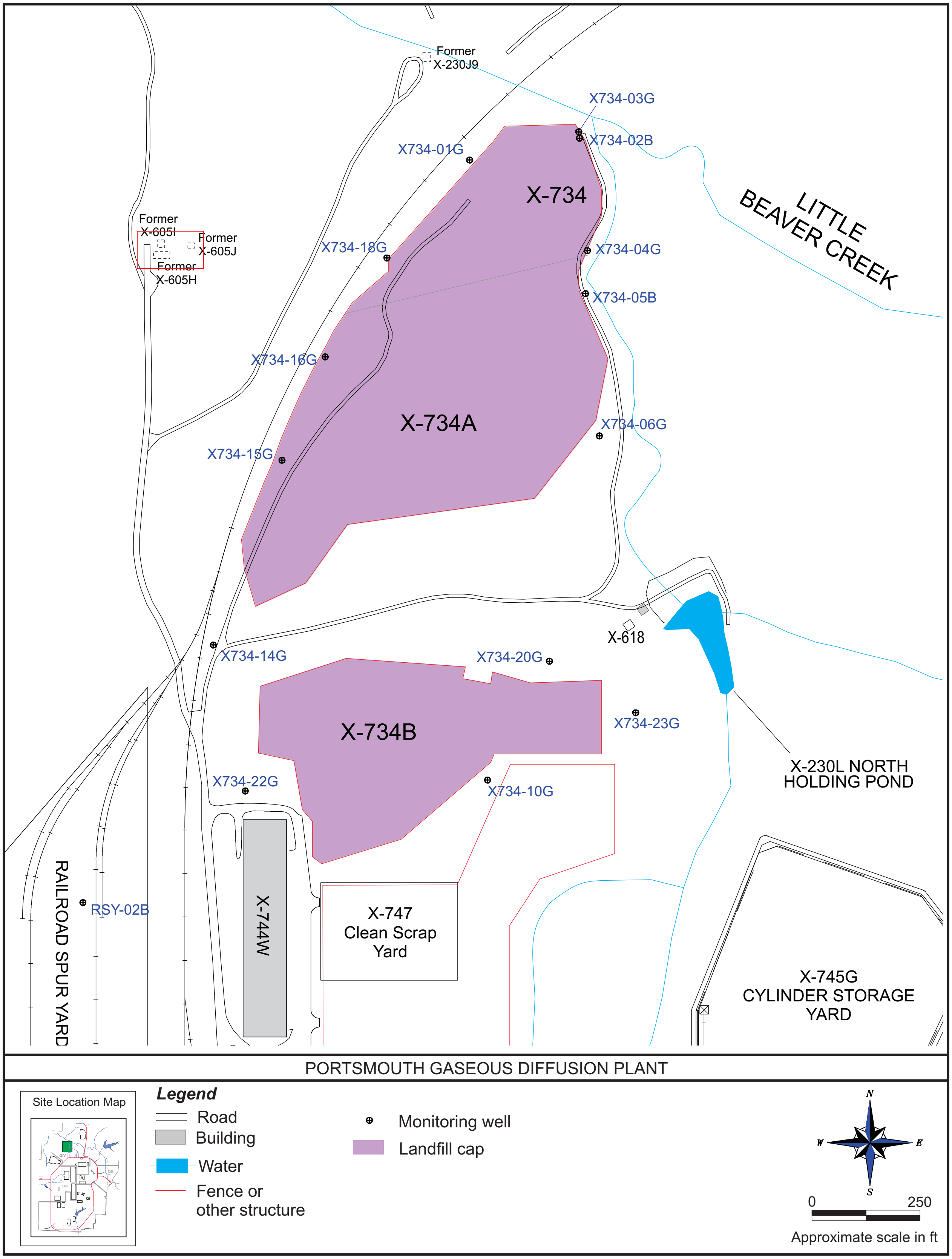

Figure 6.11. Monitoring wells at the X-734 Landfills.

6.4.13 X-533 Former Switchyard Complex

The X-533 Former Switchyard Complex in Quadrant IV consisted of a switchyard containing electrical transformers and circuit breakers, associated support buildings, and a transformer cleaning pad. The groundwater area of concern is located north of the switchyard and associated support buildings near the transformer cleaning pad. D&D of the facilities began in 2010 and was completed in 2011. Soil contaminated with PCBs or metals was removed from three areas within the complex in 2010; however, none of the soil removal areas were located near the groundwater area of concern (the north side of the area near the transformer cleaning pad).

The X-533 Former Switchyard Complex was identified as an area of concern for potential metals contamination in 1996 based on historical analytical data for groundwater wells in this area. Samples from wells in this area were collected in 1998 and 1999 to assess the area for metals contamination. The area was added to the PORTS groundwater monitoring program because the sampling identified metals that may have contaminated groundwater in this area. Three wells are sampled semiannually for cadmium and nickel.

6.4.13.1 Monitoring results for the X-533 Former Switchyard Complex in 2019

Three wells that monitor the X-533 Former Switchyard Complex (F-03G, TCP-01G, and X533-03G) were sampled in the second and fourth quarters of 2019 and analyzed for cadmium and nickel. Each of the wells contained these metals at concentrations above the preliminary remediation goals (6.5 µg/L for cadmium and 100 µg/L for nickel). Concentrations of cadmium detected in the wells ranged from 10 to 50 µg/L, and concentrations of nickel detected in the wells ranged from 140 to 540 µg/L. Figure 6.6 shows the concentrations of metals detected in the X-533 wells in 2019.

6.4.14 X-344C Former Hydrogen Fluoride Storage Building

The X-344C Former Hydrogen Fluoride Storage Building and associated hydrogen fluoride storage tanks were demolished and removed in 2006. In 2009, an investigation of soils and groundwater near the former building determined that groundwater in one monitoring well south of the former building contained two VOCs (*cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene) at concentrations below the preliminary remediation goals.

This area was added to the PORTS groundwater monitoring program in 2010. One well is sampled annually for VOCs under the monitoring program for this area (see Figure 6.12).

6.4.14.1 Monitoring results for the X-344C Former Hydrogen Fluoride Storage Building in 2019

Three VOCs, *cis*-1,2-dichloroethene, carbon disulfide, and TCE, were detected in the sample collected in the first quarter of 2019 at low concentrations less than 1.1 µg/L, which are below the preliminary remediation goals. These detections are consistent with the data collected at this well in 2014 through 2018.

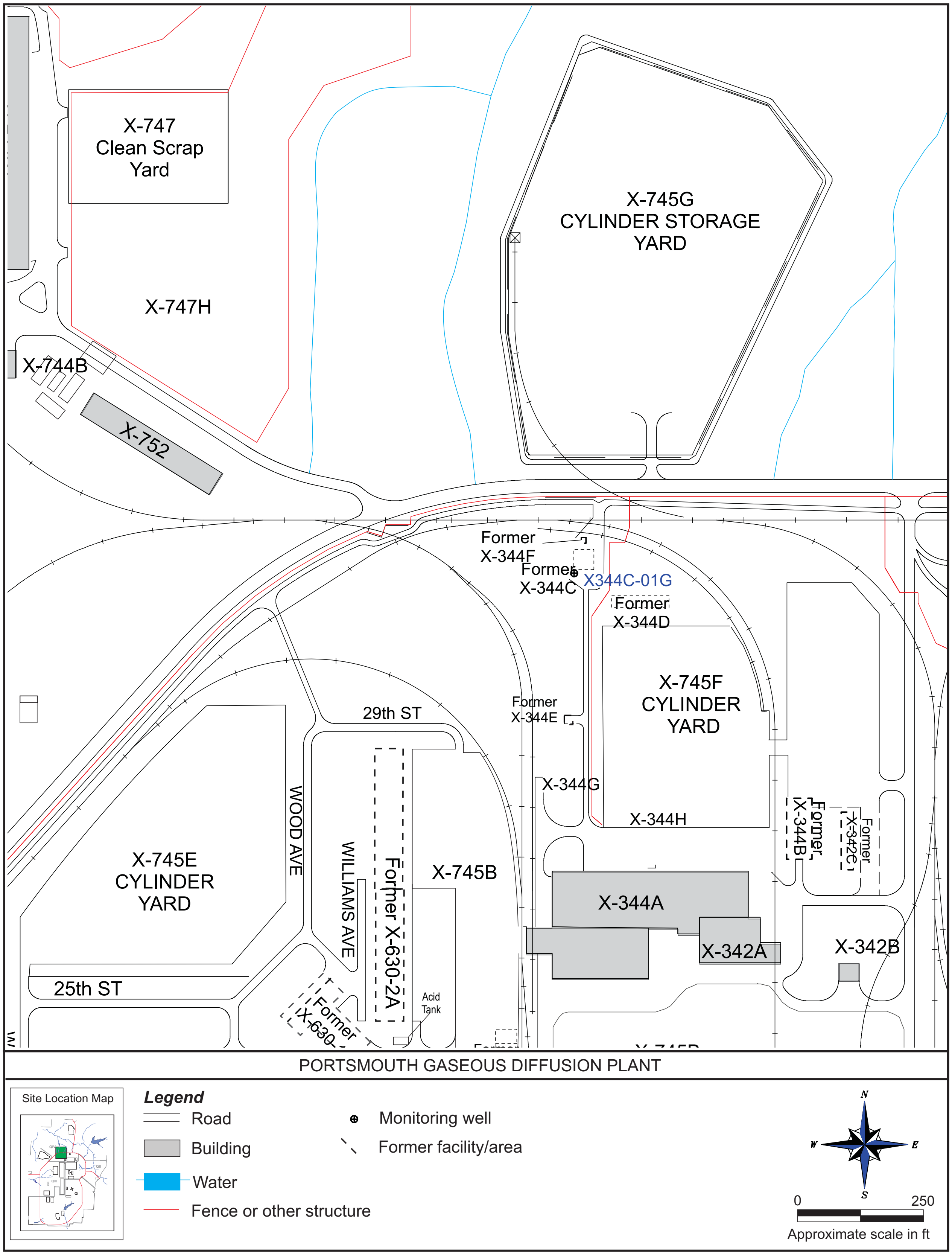

Figure 6.12. Monitoring well at the X-344C Former Hydrogen Fluoride Storage Building.

6.4.15 Surface Water Monitoring

Surface water monitoring is conducted in conjunction with groundwater assessment monitoring to determine if contaminants present in groundwater are detected in surface water samples. Surface water is collected quarterly from 14 locations (see Figure 6.13). Surface water samples are analyzed for the parameters listed in Table 6.1. The purpose for each surface water monitoring location is described as follows:

- Little Beaver Creek and East Drainage Ditch sample locations LBC-SW01, LBC-SW02, and EDD-SW01 assess possible X-701B area groundwater discharges.
- Little Beaver Creek sample locations LBC-SW02 and LBC-SW03 assess potential contamination from the X-611A Former Lime Sludge Lagoons.
- Big Run Creek sample location BRC-SW01 assesses potential groundwater discharges from the Quadrant I Groundwater Investigative (5-Unit) Area.
- Big Run Creek sample location BRC-SW05 monitors potential discharges from the X-749/PK Landfill groundwater collection system on the east side of the landfills, as well as the Quadrant I Groundwater Investigative (5-Unit) Area.
- Big Run Creek sample location BRC-SW02 (downstream from BRC-SW01 and BRC-SW05) monitors potential discharges from the Quadrant I Groundwater Investigative (5-Unit) Area, X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, and PK Landfill.
- Southwestern Drainage Ditch sample locations UND-SW01 and UND-SW02 assess potential groundwater releases to this creek and the X-2230M Southwest Holding Pond from the western portion of the X-749/X-120 groundwater plume.
- North Holding Pond sample location NHP-SW01 and Little Beaver Creek sample location LBC-SW04 assess potential groundwater discharges from the X-734 Landfill and other Quadrant IV sources.
- Western Drainage Ditch sample locations WDD-SW01, WDD-SW02, and WDD-SW03 assess potential groundwater discharges from the X-616 and X-740 areas to the Western Drainage Ditch and the X-2230N West Holding Pond.

6.4.15.1 Monitoring results for surface water in 2019

Trihalomethanes are a category of VOCs that are byproducts of water chlorination and include bromodichloromethane, bromoform, chloroform, and dibromochloromethane. These compounds are detected at most of the surface water sampling locations because the streams receive discharges that contain chlorinated water from the PORTS NPDES outfalls. These detections were below the Ohio EPA non-drinking water quality criteria for the protection of human health in the Ohio River drainage basin (bromodichloromethane – 460 µg/L; bromoform – 3600 µg/L; chloroform – 4700 µg/L; and dibromochloromethane – 340 µg/L).

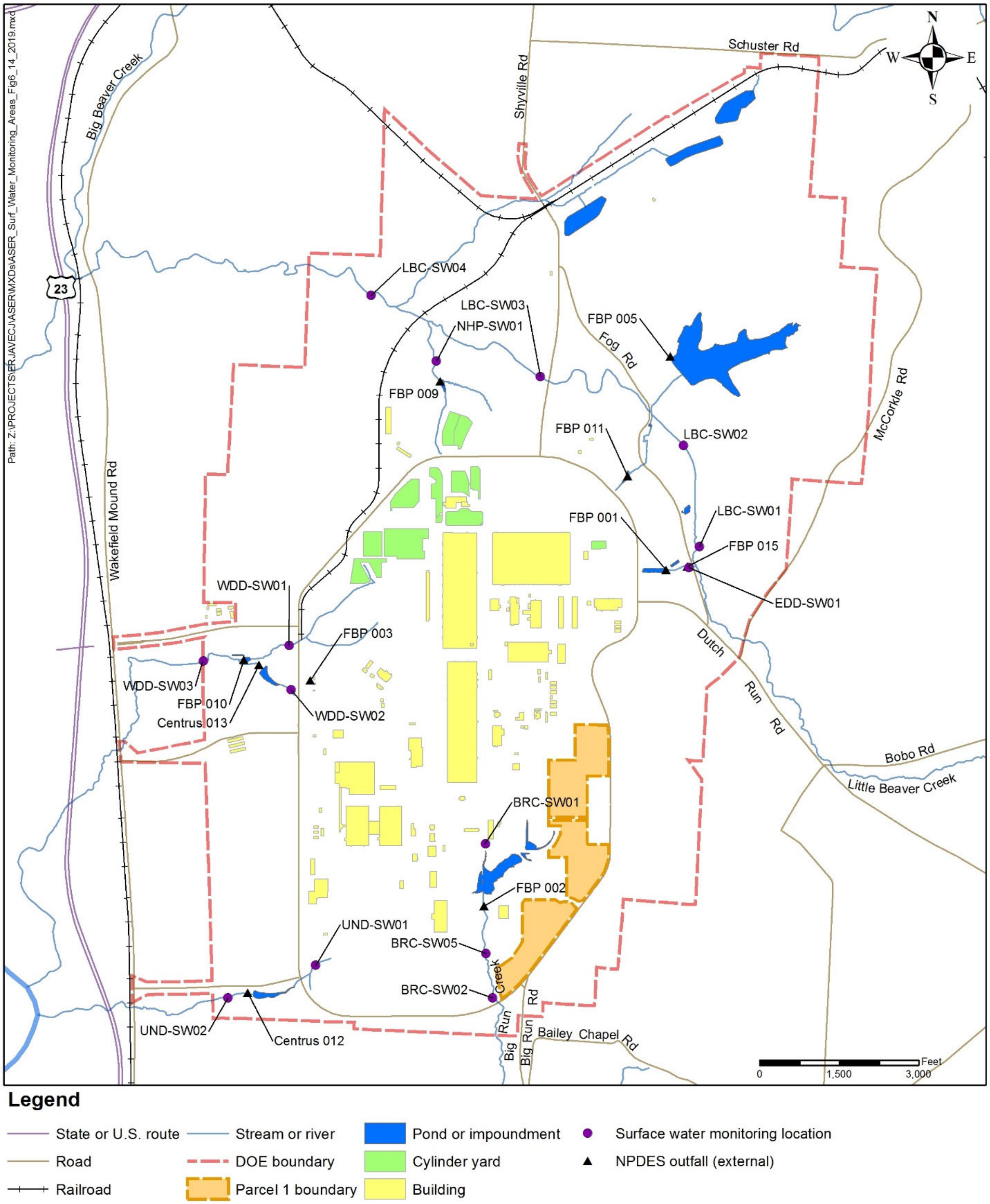

Figure 6.13. Surface water monitoring locations.

TCE and other VOCs are routinely detected in East Drainage Ditch and Little Beaver Creek. However, elevated concentrations of VOCs were detected in 2018 and continued in 2019. In the fourth quarter of 2018, elevated concentrations of TCE and other VOCs were detected in the surface water sample collected from East Drainage Ditch at EDD-SW01, which discharges to Little Beaver Creek. In the first through third quarters of 2019, concentrations of TCE decreased in samples collected from East Drainage Ditch and Little Beaver Creek, but increased again in the fourth quarter of 2019. TCE was detected in the sample collected from EDD-SW01 at 271 µg/L. Concentrations of TCE in Little Beaver Creek ranged from 17.4 µg/L to below detection limits in LBC-SW03 and LBC-SW04. Additional samples were collected in December 2019, which confirmed the elevated TCE results (DOE 2020). The detections of TCE were below the Ohio EPA non-drinking water quality criterion for TCE (810 µg/L) for the protection of human health in the Ohio River drainage basin. An evaluation of the detections of VOCs in the East Drainage Ditch and Little Beaver Creek, the X-701B Holding Pond area, and the X-237 Groundwater Collection System is continuing in 2020 in conjunction with Ohio EPA.

Since the 1990s, TCE has been detected regularly at low levels in samples collected from the Southwestern Drainage Ditch (UND-SW01, located inside Perimeter Road). In 2019, TCE was detected at 1.95 to 6.5 µg/L in each of the four samples collected from the Southwestern Drainage Ditch at UND-SW01. *Cis*-1,2-dichloroethene and 1,1-dichloroethene were also detected at estimated concentrations of 0.5 µg/L or less in samples collected at UND-SW01. VOCs were not detected in the samples collected from the Southwestern Drainage Ditch at UND-SW02. The detections of TCE were below the Ohio EPA non-drinking water quality criterion for TCE (810 µg/L) for the protection of human health in the Ohio River drainage basin.

Samples collected in the second and fourth quarters of 2019 were analyzed for selected transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). No transuranics were detected in the surface water samples collected during 2019.

Technetium-99 was detected at levels up to 72.7 pCi/L in samples collected from the East Drainage Ditch (EDD-SW01) and Little Beaver Creek (LBC-SW01 and LBC-SW02). These detections are within the historical range of technetium-99 detected in surface water at PORTS, and are 0.17% or less of derived concentration standard for technetium-99 in water (44,000 pCi/L – DOE 2011b).

The concentrations of uranium detected in the surface water samples were 1.5% or less of the DOE derived concentration standards for uranium isotopes (680 pCi/L for uranium-233/234, 720 pCi/L for uranium-235, and 750 pCi/L for uranium-238) (DOE 2011b). The detections of uranium and uranium isotopes in surface water during 2019 were within the historical range of uranium detected in surface water at PORTS.

6.4.16 Water Supply Monitoring

Routine monitoring of private residential drinking water sources is completed at PORTS in accordance with the requirements of Section VIII of the September 1989 Consent Decree between the State of Ohio and DOE and the *Integrated Groundwater Monitoring Plan* (DOE 2017c).

The purpose of the program is to determine whether PORTS has had any impact on the quality of the private residential drinking water sources. Although this program may provide an indication of contaminant transport off site, it should not be interpreted as an extension of the on-site groundwater monitoring program, which bears the responsibility for detection of contaminants and determining the rate and extent of contaminant movement. Data from this program will not be used in environmental investigations due to the lack of knowledge of how residential wells were constructed and due to the presence of various types of pumps (which may not be ideal equipment for sampling).

Four residential drinking water sources participated in the program in 2019. Two residential drinking water sources that are included in the water supply monitoring program (RES-004 and RES-005) were not able to be sampled in 2019 because the well pumps were not operable. The PORTS water supply is also sampled as part of this program. Figure 6.14 shows the drinking water sources that were part of the monitoring program in 2019. Sampling locations may be added or deleted if requested by a resident and as program requirements dictate. Typically, sampling locations are deleted when a resident obtains a public water supply. Wells are sampled semiannually with samples analyzed for the parameters listed in Table 6.1. The *2019 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides data for the water supply monitoring program (DOE 2020).

In the third quarter of 2019, TCE was detected at an estimated concentration 0.53 µg/L in the sample collected from RES-017, which is south of PORTS on Big Run Road. No other VOCs were detected in the samples at this location. Since this residential water supply was added to the monitoring program in 2009, TCE has routinely been detected in the water supply samples at concentrations up to 1 µg/L. These detections are less than the drinking water standard for TCE (5 µg/L). Big Run Creek is located between RES-017 and the affected water-bearing formation (i.e., Gallia groundwater) located in the southern portion of the plant site west of Big Run Creek. The Gallia groundwater drains into Big Run Creek.

Chlorination byproducts called trihalomethanes (bromodichloromethane, bromoform, chloroform, and dibromochloromethane), which are common residuals in treated drinking water, were detected in the first and third quarter samples collected from residential sampling location RES-015. The total concentration of these trihalomethanes was less than the Ohio EPA drinking water standard (80 µg/L for total trihalomethanes).

Each sample was analyzed for transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No transuranics or technetium-99 were detected in any of the water supply samples collected in 2019. Low levels of uranium and uranium isotopes detected in some of the wells are consistent with naturally-occurring concentrations found in groundwater in the area.

6.5 DOE ORDER MONITORING PROGRAMS

One of the DOE surveillance monitoring programs at PORTS is exit pathway monitoring. Exit pathway monitoring assesses the effect of the facility on off-site surface water and groundwater quality.

6.5.1 Exit Pathway Monitoring

Selected locations on local streams and drainage channels near the PORTS boundary are sampling points of the exit pathway monitoring program because surface water from PORTS NPDES outfalls and groundwater discharge to these surface waters. Monitoring wells near the PORTS boundary are also used in the exit pathway monitoring program. Figure 6.15 shows the sampling locations for exit pathway monitoring and Table 6.1 lists the analytical parameters.

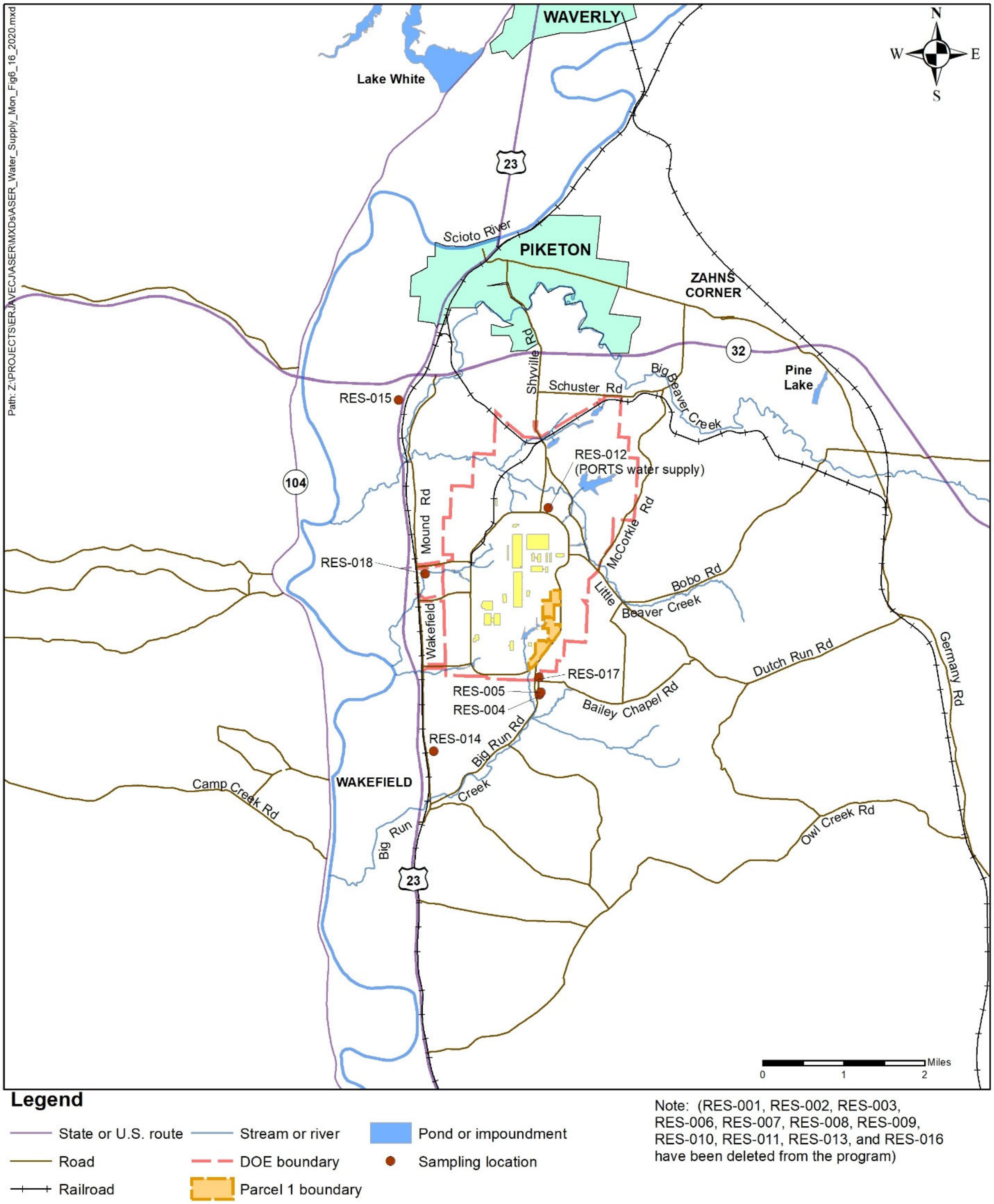

Figure 6.14. Water supply monitoring locations.

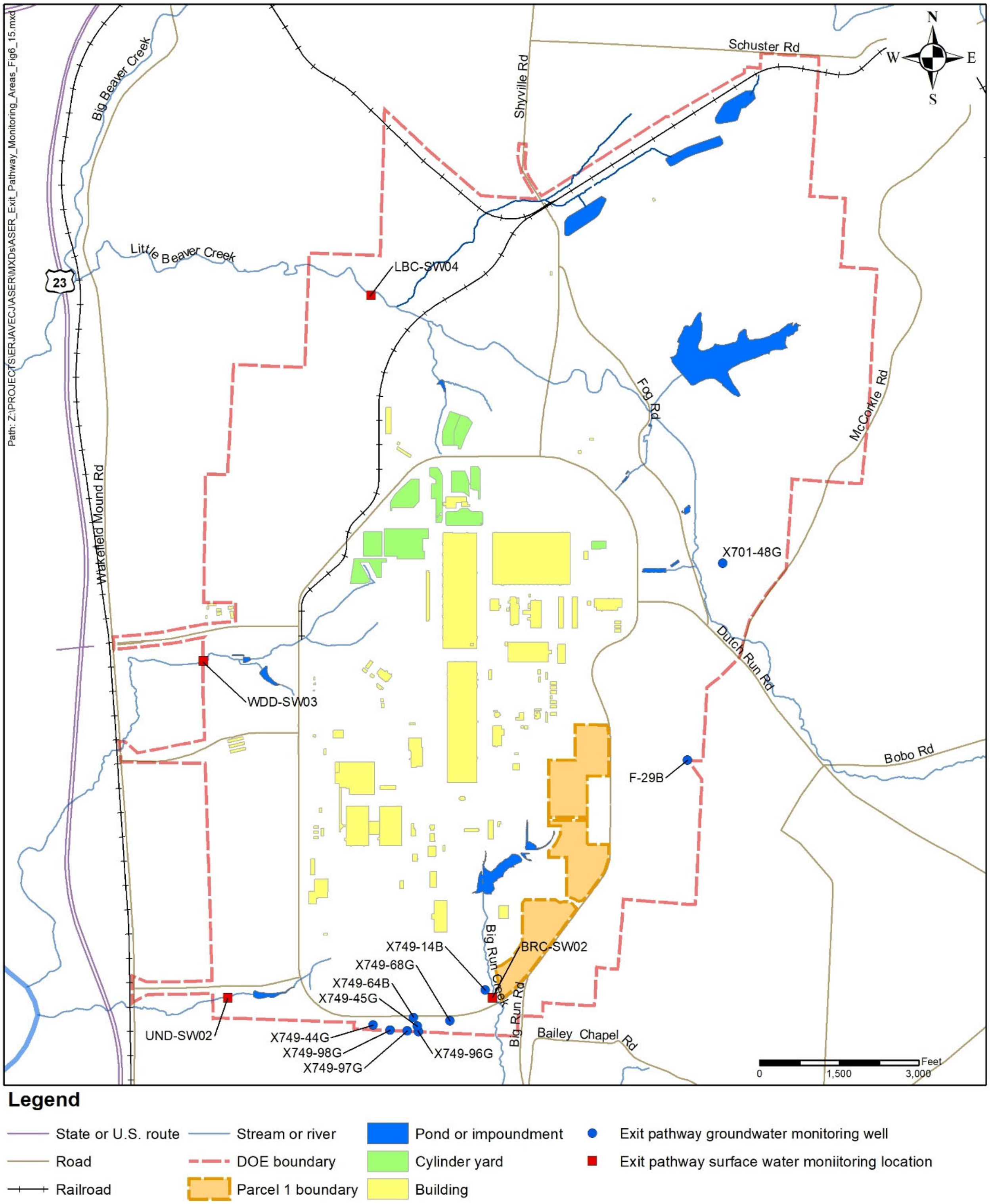

Figure 6.15. Exit pathway monitoring locations.

Surface water sampling points on Big Run Creek (BRC-SW02), Little Beaver Creek (LBC-SW04), Southwestern Drainage Ditch (UND-SW02), and Western Drainage Ditch (WDD-SW03) are part of the exit pathway monitoring program (see Figure 6.15). Trihalomethanes (bromodichloromethane, bromoform, chloroform, and dibromochloromethane), which are common residuals in chlorinated drinking water, were detected in samples collected from Little Beaver Creek at concentrations below Ohio EPA non-drinking water quality criteria for trihalomethanes for the protection of human health in the Ohio River drainage basin (see Section 6.4.15.1). TCE was detected in the first quarter sample collected from Little Beaver Creek (LBC-SW04) at a concentration of 0.68 µg/L. This detection was also below the Ohio EPA non-drinking water quality criterion for TCE (810 µg/L) for the protection of human health in the Ohio River drainage basin.

No transuranics (americium-241, neptunium-237, plutonium-238, plutonium-239/240) or technetium-99 were detected in samples collected at the surface water exit pathway monitoring locations.

VOCs were also detected in several on-site groundwater monitoring wells that are part of the exit pathway monitoring program. TCE and other VOCs were detected in several wells that monitor the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility (see Section 6.4.1.3). TCE was detected in on-site well X749-45G at concentrations ranging from 2.74 to 16 µg/L, with results above the Ohio EPA drinking water standard (5 µg/L) in the first, second, and third quarter samples collected from the well. All other detections of TCE and other VOCs in the exit pathway monitoring wells were below Ohio EPA drinking water standards.

Exit pathway groundwater monitoring wells were sampled for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and uranium-238) in 2019. If detected, radionuclides were present at levels below Ohio EPA drinking water standards (900 pCi/L for technetium-99 based on a 4 mrem/year dose from beta emitters, and 30 µg/L for uranium).

6.6 GROUNDWATER TREATMENT FACILITIES

In 2019, a combined total of approximately 32.7 million gallons of water were treated at the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Approximately 13.4 gallons of TCE were removed from the water. All processed water is discharged through NPDES outfalls before exiting PORTS. Facility information is summarized in Table 6.2.

Table 6.2. Summary of TCE removed by PORTS groundwater treatment facilities in 2019[a]

Facility	Gallons of water treated	Gallons of TCE removed
X-622	20,720,900	2.53
X-623	8890	< 0.0001
X-624	367,400	0.27
X-627	11,638,356	10.64

[a]Source: *2019 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* (DOE 2020)

6.6.1 X-622 Groundwater Treatment Facility

The X-622 Groundwater Treatment Facility consists of an air stripper with aqueous-phase activated carbon filtration. This facility processes groundwater from the following systems in Quadrant I (see Figures 6.2 and 6.3):

- groundwater collection system with associated sump (X749-WPW) and extraction wells X749-EW05G and X749-EW06G on the southwest boundary of the X-749 Landfill;
- groundwater extraction wells X749-EW01G, X749-EW02G, X749-EW03G, and X749-EW04G installed in 2007 in the X-749 South Barrier Wall area;
- groundwater extraction wells (X749-EW07G, X749-EW08G, and X749-EW09G) installed in 2010 in the X-749/X-120 groundwater plume;
- groundwater collection system and associated sumps (PK-PL6 and PK-PL6A) on the eastern boundary of the PK Landfill; and
- fifteen extraction wells located in the Quadrant I Groundwater Investigative (5-Unit) Area.

The facility processed approximately 20.7 million gallons of groundwater during 2019, thereby removing approximately 2.53 gallons of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 608, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 608 in 2019.

6.6.2 X-623 Groundwater Treatment Facility

The X-623 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. Prior to implementation of the X-701B IRM in 2009, the X-623 Groundwater Treatment Facility treated TCE-contaminated groundwater from a sump in the bottom of the X-701B Former Holding Pond and three groundwater extraction wells (X623-EW01G, X623-EW02G, and X623-EW03G) east of the holding pond. The sump and extraction wells were removed in 2009-2011 to facilitate implementation of the IRM.

During 2019, the X-623 Groundwater Treatment Facility operated only during January and February to treat miscellaneous water associated with site activities in accordance with the NPDES permit.

The facility treated 8890 gallons of water during 2019, thereby removing less than 0.0001 gallon of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 610, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 610 in 2019.

6.6.3 X-624 Groundwater Treatment Facility

At the X-624 Groundwater Treatment Facility, groundwater is treated via an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. This facility processes TCE-contaminated groundwater from the X-237 Groundwater Collection System on the east side of the X-701B groundwater plume. The X-237 Groundwater Collection System consists of north-south and east-west collection trenches and two sumps/pumping wells (see Figure 6.5).

The X-624 Groundwater Treatment Facility treated approximately 367,400 gallons of water in 2019, thereby removing approximately 0.27 gallon of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 015, which discharges to Little Beaver Creek. No NPDES permit limitations were exceeded at Outfall 015 in 2019.

6.6.4 X-627 Groundwater Treatment Facility

The X-627 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous phase activated carbon filtration. The X-700 and X-705 buildings are located above the Quadrant II Groundwater Investigative (7-Unit) Area plume, and contaminated water is collected in the sumps located in the basement of each building (see Figure 6.4).

Approximately 11.6 million gallons of groundwater were processed during 2019, thereby removing approximately 10.64 gallons of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 611, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

NPDES permit limitations were exceeded three times at Outfall 611 in 2019. Two samples collected on December 9 and 16 exceeded the daily discharge limit of 10 µg/L for TCE with concentrations of 14.1 µg/L in both samples, which also resulted in an exceedance of the monthly average discharge limitation (see Chapter 5, Section 5.4.1.1). No other permit limitations were exceeded in 2019 at this location.

7. QUALITY ASSURANCE

7.1 SUMMARY

Quality assurance and quality control are essential components of DOE environmental monitoring programs at PORTS. Quality is integrated into sample preservation, field data and sample collection, sample transportation, sample analysis, data management, and recordkeeping. Numerous program assessment activities in the field and within the facilities are conducted at regular intervals to demonstrate that quality is built into and maintained in all DOE programs. Analytical laboratories used by DOE contractors during 2019 participated in the DOE Consolidated Audit Program and Mixed-Analyte Performance Evaluation Program.

FBP implements and conducts its QA Program in compliance with the following standards or regulations:

- DOE Order 414.1D, *Quality Assurance*;
- American Society of Mechanical Engineers Nuclear Quality Assurance Standards NQA-1-2008 with the NQA-1a-2009 Addenda, *QA Requirements for Nuclear Facility Applications*;
- Title 10 CFR Part 830, Nuclear Safety Management.

7.2 QUALITY ASSURANCE INTRODUCTION

Quality assurance, an integral part of environmental monitoring, requires systematic control of the processes involved in sampling the environment and in analyzing the samples. To demonstrate accurate results, DOE uses the following planned and systematic controls:

- implementation of standard operating procedures for sample collection and analysis;
- training and qualification of surveyors and analysts;
- implementation of sample tracking and chain-of-custody procedures to demonstrate traceability and integrity of samples and data;
- participation in external quality control programs;
- frequent calibration and routine maintenance of measuring and test equipment;
- maintenance of internal quality control programs;
- implementation of good measurement techniques and good laboratory practices; and
- frequent assessments of field sampling, measurement activities, and laboratory processes.

Environmental sampling is conducted by DOE contractors at PORTS in accordance with state and federal regulations and DOE Orders. Sampling plans and procedures are prepared, and appropriate sampling instruments or devices are selected in accordance with practices recommended by U.S. EPA, the American Society for Testing and Materials, or other authorities. Chain-of-custody forms document sample custody from sample collection through receipt by the analytical laboratory. The samples remain in the custody of the sampling group until the samples are received at the laboratory. Samples shipped to an off-site laboratory are sealed within the shipping container to prevent tampering until they are received by the sample custodian at the off-site laboratory.

The analytical data are reviewed to determine compliance with applicable regulations and permits. The data are used to identify locations and concentrations of contaminants of concern, to evaluate the rate and extent of contamination at the site, and to help determine the need for remedial action. Adequate and complete documentation generated as a result of these efforts supports the quality standards established by DOE. Quality Assurance Project Plans were used by FBP and MCS during 2019 to ensure a consistent system for collecting, assessing, and documenting environmental data of known and documented quality.

7.3 SAMPLE COLLECTION AND HANDLING

The FBP Quality Assurance Project Plan consists of the *Sample Analysis Data Quality Assurance Project Plan* (DOE 2014b), project-specific sampling and analysis plans (SAPs), and their associated data quality objectives (DQOs). While the DQOs and SAPs are specific to discrete projects, the *Sample Analysis Data Quality Assurance Project Plan* (DOE 2014b) provides an overarching framework to ensure that standardized and consistent processes are utilized to obtain samples, perform data collection, and perform laboratory services.

Personnel involved in sampling and monitoring are properly trained through a combination of classroom, on-line, and/or on-the-job training as required by environmental, health, and safety regulations and DOE contract requirements. Procedures are developed from guidelines and regulations created by DOE or other regulatory agencies that have authority over PORTS activities.

Data generated from sampling can be greatly influenced by the methods used to collect and transport the samples. A quality assurance program provides the procedures for proper sample collection so that the samples represent the conditions that exist in the environment at the time of sampling. The DOE quality assurance program at PORTS mandates compliance with written sampling procedures, use of clean sampling devices and containers, use of approved sample preservation techniques, and collection of field quality control samples. Chain-of-custody procedures are strictly followed to maintain sample integrity. In order to maintain sample integrity, samples are delivered to the laboratory as soon as practicable after collection.

Field quality control samples that are collected and analyzed include trip blanks, field blanks, field duplicates, and equipment rinseates. Quality control samples for environmental monitoring are collected at a target rate of one per twenty environmental samples or one per analytical batch for environmental samples, as applicable to the samples being collected and the analyses required. Not all types of sampling require all of the field quality control samples. Table 7.1 summarizes the uses and definitions of the field quality control samples.

Analytical results for field quality control samples are evaluated to determine if the sampling activities have biased the environmental sample results. This evaluation typically occurs as part of data validation and/or assessment (see Section 7.5.2). An example of the successful use of quality control samples to identify bias in sampling is in the ambient air monitoring program (see Chapter 4, Section 4.6.1). Field blank samples collected for the ambient air program contain low levels of uranium and uranium isotopes. Upon further investigation, it was discovered that the filters used to collect air samples contain low levels of uranium due to the materials used to make the filters. Therefore, levels of uranium reported in ambient air may be slightly elevated.

7.4 ANALYTICAL QUALITY ASSURANCE

In 2019, samples collected for DOE environmental monitoring programs at PORTS such as NPDES monitoring, groundwater monitoring required by the *Integrated Groundwater Monitoring Plan* (DOE 2017c), and environmental monitoring required by the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b), were sent to analytical laboratories that participated in DOE programs to ensure data quality.

Table 7.1. Definitions and purpose of field quality control samples

Type of sample	Definition and purpose
Trip blank	Used to evaluate contamination from VOCs during the sampling process. The trip blank is an unopened container of laboratory-grade water that accompanies environmental samples analyzed for VOCs from sample collection through laboratory analysis.
Field blank	Used to evaluate contamination during the sampling process. The field blank is a container of laboratory-grade water that is carried into the field and opened to expose the field blank to field conditions when the environmental samples are collected. The field blank is analyzed for the same analytes as the environmental samples.
Field duplicate	Used to document the precision of the sampling process and provide information on analytical variability caused by collection methods, laboratory procedures, and sample heterogeneity (the variability within the sample media). A field duplicate, or duplicate sample, is a second environmental sample collected at the same time and from the same place as the first environmental sample. The duplicate sample is analyzed for the same analytes as the first sample.
Equipment rinseate	Used to assess contamination that could be present from reusable sampling equipment, such as a bailer used at a groundwater well to collect water. The sample is collected by rinsing the cleaned equipment with laboratory-grade water. An equipment rinseate is not required when dedicated or disposable sampling equipment is used for sample collection. The equipment rinseate sample is typically analyzed for the same analytes as the associated environmental samples.

DOE contractors at PORTS only use analytical laboratories that demonstrate compliance in the following areas through participation in independent audits and surveillance programs:

- compliance with federal waste disposal regulations,
- data quality,
- materials management,
- sample control,
- data management,
- electronic data management,
- implementation of a laboratory quality assurance plan, and
- review of external and internal performance evaluation program.

The following analytical laboratories were used by FBP, MCS, and/or Centrus in 2019 for analysis of environmental samples discussed in this report:

- GEL Laboratories, LLC
- Eurofins TestAmerica
- Southwest Research Institute
- ALS
- ETT Environmental, Inc.
- Portsmouth Analytical Laboratory
- Radiation Detection Company
- ARS Aleut Analytical, LLC

When available and appropriate for the sample matrix, U.S. EPA-approved methods are used for sample analysis. When U.S. EPA-approved methods are not available, other nationally recognized methods, such as those developed by DOE and American Society for Testing and Materials, are used. Analytical methods are identified in a statement of work for laboratory services. Analytical laboratories follow chain-of-custody procedures and document the steps in sample handling, analysis, and reporting.

PORTS is required by DOE, Ohio EPA, and/or U.S. EPA to participate in independent QC programs. The DOE Consolidated Audit Program implements annual performance qualification audits of environmental laboratories. The DOE Mixed-Analyte Performance Evaluation Program provides semiannual performance testing and evaluation of analytical laboratories. The site also participates in voluntary independent programs to improve analytical QC. These programs generate data that readily are recognized as objective measures that provide participating laboratories and government agencies a periodic review of their performance. These programs are conducted by EPA, DOE, and commercial laboratories. 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.

7.5 DATA MANAGEMENT

After analytical laboratory data are received by DOE contractors, they are verified for completeness, correctness, consistency, and compliance with written analytical specifications. Selected data are independently evaluated using a systematic process that compares the data to established quality assurance/quality control criteria. An independent data validator checks documentation produced by the analytical laboratory to verify that the laboratory has provided data that meet established criteria.

7.5.1 Data Management Systems

The data generated from sampling events are stored in the Project Environmental Measurements System (PEMS), a consolidated site data system for tracking and managing data. PEMS is used to manage field-generated data, import laboratory-generated data, input data qualifiers identified during data validation, and transfer data to the PORTS Oak Ridge Environmental Information System (OREIS) database. PORTS OREIS is used to consolidate data from PEMS for long term storage.

Environmental data from PORTS OREIS is periodically loaded into the PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS). PEGASIS allows public access to environmental monitoring data and displays it on a local map that shows the locations the data were collected. Public access to PEGASIS is available at pegasis.ports.pppo.gov/pegasis

7.5.2 Data Verification, Validation, and Assessment

Data verification is the systematic process of checking data for completeness, correctness, consistency, and compliance with written analytical specifications. The verification process compares the laboratory data package to requirements associated with the project and documents requirements that were and were not met. All data collected for environmental monitoring programs are verified.

Data validation is the process performed by a qualified individual for a data set, independent from sampling, laboratory, project management, or other decision making personnel. Data validation evaluates laboratory adherence to analytical method requirements to determine the technical reliability of the reported results. Data are qualified as acceptable, estimated, or rejected. These validation qualifiers are stored in PEMS and transferred with the data to PORTS OREIS. Typically, at least 10% of analytical data associated with the environmental sampling programs are validated.

Data assessment is conducted by trained technical personnel in conjunction with other project team members. Data are reviewed for compliance with applicable standards or limits, as applicable. Current analytical results are also compared to previous results for the sampling location. Other data analyses may be completed such as trend analyses or summary statistics (calculation of average, median, data range, etc.).

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9. GLOSSARY

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

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

alpha particle – A positively charged particle consisting of two protons and two neutrons, identical with the nucleus of a helium atom; emitted by several radioactive substances.

ambient – Of the surrounding area or the environment. Ambient air usually means outdoor air (as opposed to indoor air).

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

aquifer – A permeable layer of sand, gravel, and/or rock below the ground surface that is capable of yielding quantities of groundwater to wells and springs. A subsurface zone that yields economically important amounts of water to wells.

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.

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.

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 applicable regulations or requirements of a plan or schedule ordered or approved by a government authority.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – An act to provide 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.

contaminant – Any substance that enters a system (the environment, food, the human body, etc.) where it is not normally found. Contaminants include substances that spoil food, pollute the environment, or cause other adverse effects.

cosmic radiation – Ionizing radiation with very high energies that originates outside the earth's atmosphere. Cosmic radiation is one contributor to natural background radiation.

critical habitat – Specific geographic areas, whether occupied by a species listed under the Endangered Species Act or not, that are essential for conservation of the species and that have been formally designated by a rule published in the Federal Register.

curie (Ci) – A unit of radioactivity, defined as that quantity of any radioactive nuclide which has 3.7×10^{10} (37 billion) disintegrations per second. Several fractions of the curie are commonly used:

> **millicurie (mCi)** – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.
> **microcurie (µCi)** – 10^{-6} Ci, one-millionth of a curie, 3.7×10^{4} disintegrations per second.
> **picocurie (pCi)** – 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegration per second.

decontamination and decommissioning (D&D) – Removing equipment, demolishing buildings, disposing of wastes, and investigating potential contamination in areas of PORTS that are no longer part of current operations.

deferred unit – An area at PORTS that was in or adjacent to the gaseous diffusion production and operational areas such that remedial activities would have interrupted operations, or an area that could have become recontaminated from ongoing operations.

derived concentration standard – The concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation) would result in either a dose of 0.1 rem (100 mrem) or a dose of 5 rem to any tissue, including skin and the lens of the eye. The DOE publication *Derived Concentration Technical Standard* (DOE 2011b) provides the derived concentration standards.

dose – In this document, "dose" is used exclusively to refer to a radiological dose; the energy imparted to matter by ionizing radiation.

- **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).

- **effective dose** – A measure of the potential biological risk of health effects due to exposure to radiation measured in units of mrem (1 mrem = 0.01 mSv). 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).

Note that "dose" can also be used to refer to a chemical dose; however, chemical doses are not discussed in this document.

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 – The 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.

glove box – An enclosure with built-in sleeves and gloves used by a person to manipulate hazardous materials such as highly enriched uranium without directly exposing the person to the material.

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.

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

in situ – In its original place; field measurements taken without removing the sample from its original location; remediation performed while the contaminated media (e.g., groundwater or soil) remains below the surface or in place.

interim remedial measure (IRM) – Cleanup activities initiated after it has been determined that contamination or waste disposal practices pose an immediate threat to human health and/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 (DOE Order 458.1).

maximum contaminant level (MCL) – The maximum permissible level of a contaminant in drinking water provided by a public water system.

median – The middle value in a group of numbers. The median can be a more useful measurement of the central tendency of a group of numbers if some of the numbers in the group are significantly higher or lower than the rest of the numbers in the group.

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

millirem (mrem) – The dose that is one-thousandth of a rem.

monitoring – Process whereby the quantity and quality of factors that can affect the environment or human health are measured periodically to regulate and control potential impacts.

natural radiation – Radiation from cosmic and other naturally occurring radionuclide sources (such as radon) in the environment.

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

outfall – The point of conveyance (e.g., 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 milligram per liter (mg/L), the weight to weight ratio expressed as milligram per kilogram (mg/kg), or the weight to weight ratio of microgram per gram (µg/g).

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

preliminary remediation goal – An initial clean-up goal developed early in the decision-making process that is 1) protective of human health and the environment, and 2) complies with applicable or relevant and appropriate requirements. Preliminary remediation goals are intended to satisfy regulatory cleanup requirements. For groundwater at PORTS, preliminary remediation goals are the National Pollutant Discharge Elimination System (NPDES) drinking water standards (maximum contaminant levels).

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

quality control – The routine application of procedures within environmental monitoring 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 spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accomplished by the emission of photons or particles.

release – Any discharge to the environment. "Environment" is broadly defined as any water, land, or ambient air.

rem – The unit of dose (absorbed dose in rads multiplied by the radiation quality factor). Dose is frequently reported in units of 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 reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

Resource Conservation and Recovery Act (RCRA) – 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.

settleable solids – Material settling out of suspension in a liquid within a defined period of time.

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 U.S. 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, that 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 (uranium). All transuranics are radioactive.

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

trip blank – A quality control sample of water that accompanies sample containers from the analytical laboratory, to the field sampling location where environmental samples are collected, back to the analytical laboratory to determine whether environmental samples have been contaminated during transport, shipment, and/or site conditions.

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 hydraulically 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 (VOCs) – Organic (carbon-containing) compounds that evaporate readily at room temperature. These compounds are present in solvents, degreasers, paints, thinners, and fuels. Due to a number of factors including widespread industrial use, they are commonly found as contaminants in soil and groundwater. VOCs found at PORTS include TCE, vinyl chloride, benzene, and dichloroethenes.

weighting factor (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 (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 (bone marrow, lungs, thyroid, etc.).

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 A

ENVIRONMENTAL PERMITS

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Table A.1. DOE environmental permits and registrations at PORTS

Permit/registered source	Source no.	Issue date	Expiration date	Status
	FBP– Clean Air Act Permits			
Title V Permit	P0109662	4/28/2014	5/19/2019	Active Renewal submitted 11/13/2018
Permit to Install X-627 Groundwater Treatment Facility (06-07283)	P474, T104, T105	3/15/2005	None	Active
Permit to Install and Operate X-735 Landfill Cap and Venting System (northern portion) (P0104170)	P023	11/12/2008	None	Active
Permit to Install X-670A Cooling Tower (P0106292)	P539	07/29/2010	None	Active
Permit to Install X-333 Low Assay Withdrawal Seal Exhaust System (06-07984)	P117	01/10/2006	None	Inactive
Permit to Install Biodenitrification Vent #1 (06-07928)	P040	11/03/2005	None	Active
Permit to Install Biodenitrification Vent #2 (06-07928)	P041	11/03/2005	None	Active
Permit to Install Biodenitrification Vent #3 (06-07928)	P042	11/03/2005	None	Active
Permit to Install X-700 Radiation Calibration Lab Fume Hood (06-07928)	P045	11/03/2005	None	Active
Permit to Install X-705 Calciners (B Area) (06-07928)	P053	11/03/2005	None	Active
Permit to Install X-344 Pigtail Gulper (06-07760)	P430	05/17/2005	None	Active
Permit to Install X-705 8 inch, 12 inch, and 2.5 Ton Uranium Cylinders, Cleaned for Reuse or Disposal (06-06703)	P470	04/11/2002	None	Active
Permit to Install X-344 Toll Transfer Facility (06-06303)	P469	12/12/2000	None	Active
Permit to Install X-343 Feed Vaporization and Sampling (06-06302)	P468	12/12/2000	None	Inactive
Permit to Install 85 Horsepower Trash Pump (06-06170)	P467	05/24/2000	None	Active
Permit to Install X-847 Glove Box (06-5682)	P466	07/21/1999	None	Active
X-624 Groundwater Treatment Facility (now considered a *de minimis* source)	P019	10/28/1992	None	Active
Permit to Install X-623 Groundwater Treatment Facility (06-4613)	P018	01/08/1992	None	Active
Permit to Install X-749 Contaminated Materials Disposal Facility (06-2999)	P027	04/17/1991	None	Active
Permit to Install Gasoline Dispensing Facility (06-02906)	G001	10/31/1990	None	Active

Table A.1. DOE environmental permits and registrations at PORTS (continued)

Permit/registered source	Source no.	Issue date	Expiration date	Status
		MCS – Clean Air Act Permits		
Permit No. P0109511 to Install and Operate Process Line 1 (DUF_6 Conversion Facility)	P001	3/23/2012	3/23/2022	Active
Permit No. P0109511 to Install and Operate Process Line 2 (DUF_6 Conversion Facility)	P002	3/23/2012	3/23/2022	Active
Permit No. P0109511 to Install and Operate Process Line 3 (DUF_6 Conversion Facility)	P003	3/23/2012	3/23/2022	Active
Permit No. P0109511 to Install and Operate HVAC System (DUF_6 Conversion Facility)	P004	3/23/2012	3/23/2022	Active
		FBP – Clean Water Act/Safe Drinking Water Act Permits		
NPDES Permit	0IO00000*ND	5/1/2018 (effective date)	8/31/2020	Active
Safe Drinking Water Act – License to Operate a Public Water System	OH6632414		Renewed annually	Active
Permit to Install X-622 Groundwater Treatment Facility	06-2951	11/20/1990	None	Active
Permit to Install X-623 Groundwater Treatment Facility	06-3528	1/9/1996	None	Active
Permit to Install X-624 Groundwater Treatment Facility	06-3556	10/28/1992	None	Active
Permit to Install X-627 Groundwater Treatment Facility	06-07283	1/13/2004	None	Active
		MCS – Clean Water Act Permit		
NPDES Permit	0IS00034*CD	10/1/2019 (effective date)	9/30/2024	Active
		FBP – Hazardous Waste Permit		
RCRA Part B Permit (DOE/FBP)	Ohio Permit No. 04-66-0680	3/25/2011	3/25/2021	Active
		FBP – Registrations		
Underground Storage Tank Registration	66005107		Renewed annually	Active

APPENDIX B

INTRODUCTION TO RADIATION

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This section presents basic facts concerning radiation. The information is intended as a basis for understanding the dose associated with releases from the Portsmouth Gaseous Diffusion Plant (PORTS), not as a comprehensive discussion of radiation and its effects on the environment and biological systems. *The McGraw-Hill Dictionary of Scientific and Technical Terms* (McGraw-Hill 1989) defines radiation and radioactivity as follows:

> *radiation*—1) The emission and propagation of waves transmitting energy through space or through some medium; for example, the emission and propagation of electromagnetic, sound, or elastic waves. 2) The energy transmitted through space or some medium; when unqualified, usually refers to electromagnetic radiation. Also known as radiant energy. 3) A stream of particles, such as electrons, neutrons, protons, alpha particles, or high-energy photons, or a mixture of these (McGraw-Hill 1989).
>
> *radioactivity*—A particular type of radiation emitted by a radioactive substance, such as alpha radioactivity (McGraw-Hill 1989).

Radiation occurs naturally; it was not invented but discovered. People are constantly exposed to radiation. For example, radon in air, potassium in food and water, and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation, including atoms and isotopes; types of radiation; radiation measurement; sources of radiation; and dose information.

ATOMS AND ISOTOPES

All matter is made up of atoms. An atom is "a unit of measure consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (American Nuclear Society 1986). The number of protons in the nucleus determines an element's atomic number, or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the number of neutrons may vary among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element with a different number of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights. Figure B.1 depicts isotopes of the element hydrogen.

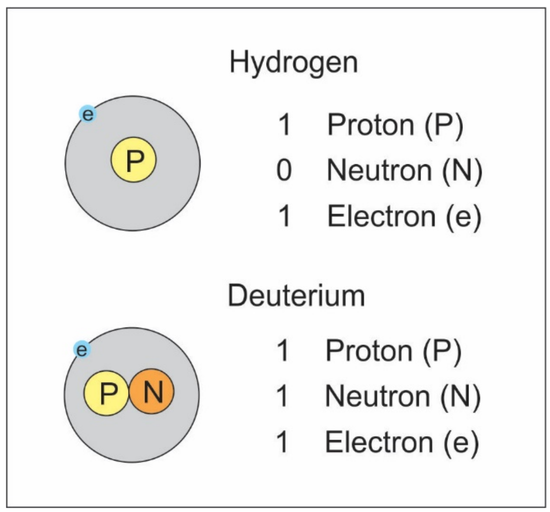

Figure B.1. Isotopes of the element hydrogen.

Another example is the element uranium, which has 92 protons; all isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons. Uranium-238 (also denoted ^{238}U) has 92 protons and 146 neutrons; uranium-235 has 92 protons and 143 neutrons; uranium-234 has 92 protons and 142 neutrons.

Some isotopes are stable, or nonradioactive; some are radioactive. A radioactive isotope, or radionuclide, gives off radioactivity because the nucleus has too many particles, too much energy, or too much mass to be stable. The nucleus of the atom disintegrates in an attempt to reach a stable or nonradioactive state. As the nucleus disintegrates, energy is released in the form of radiation. Each radionuclide has a "radioactive half-life," which is the average time that it takes for half of a specified number of atoms to decay. Half-lives can be very short (less than a second) or very long (millions of years), depending on the radionuclide. Appendix C presents the half-lives of radionuclides of interest at PORTS.

RADIATION

Although there are different types of radiation, radiation given off by radionuclides such as uranium-235 is called ionizing radiation. In this report, the term radiation is used to describe ionizing radiation.

Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage, and thus is potentially harmful to human health. Ionizing radiation can include alpha particles, beta particles, and gamma rays. Figure B.2 shows the penetrating potential of different types of ionizing radiation.

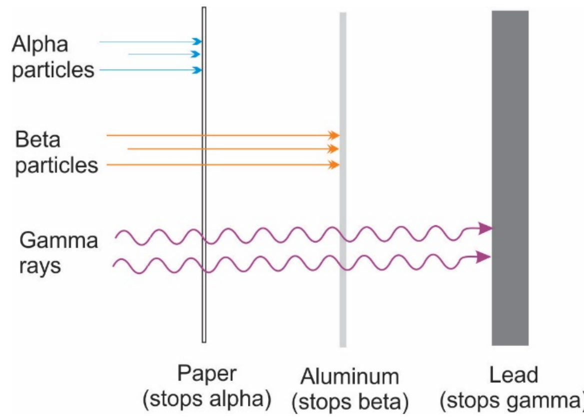

Figure B.2. Penetrating power of radiation.

MEASURING RADIATION

To determine the possible effects of radiation on the environment and the health of people, the radiation must be measured. More precisely, its potential to cause damage must be determined.

Activity

When measuring the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radionuclides. For that reason, 1 gram of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, 1 curie = 3.7E+10 (37,000,000,000) atom disintegrations per second (dps). A curie is a relatively large measure of radiation; therefore, radioactivity is often measured in this report in picocuries (pCi). A picocurie is one trillionth of a curie or 2.2 disintegrations per minute.

Absorbed Dose

The absorbed dose is the total amount of energy absorbed per unit mass (the amount of energy deposited in body tissue) as a result of exposure to radiation. Absorbed dose is expressed in a unit of measure known as a rad. In terms of human health, however, it is the effect of the absorbed energy that is important, not the actual amount. Therefore, this type of dose measurement is not used in this report.

Effective Dose

The effective dose is a measure of the potential biological damage that could be caused by exposure to and subsequent absorption of radiation to the body. Effective dose is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large dose, dose is often expressed as a millirem (mrem) or 1/1000 of a rem.

Although there are several specific types of dose measurements, for simplicity, this report discusses dose in terms of the effective dose. The effective dose is the sum of the doses received by all organs or tissues of the body after each one has been multiplied by the appropriate radiation and tissue weighting factors. It includes the dose from radiation sources internal and/or external to the body. In this report, the term "effective dose" is often shortened to "dose".

Population Dose

The sum of the effective doses to all the people in a specified community is called the population dose, or sometimes, the collective dose. If 100 people in the community each received a dose of 1 mrem, the population dose would be 100 person-mrem, or 0.1 person-rem (changing the units from mrem to rem).

Table B.1 summarizes radiation and dose terminology, definitions, and units of measure used in this report.

Table B.1. Summary of radiation and dose terminology

Term	Definition	Unit of measure (Standard system)
Activity	The amount of radiation emitted by a radioactive material.	Ci or pCi
Absorbed dose	The total amount of energy deposited in body tissue as a result of exposure to radiation.	rad
Effective dose (shortened to dose in this report)	A measure of the potential biological damage that could be caused by exposure to and subsequent absorption of radiation to the body.	rem or mrem
Population dose	The sum of the effective doses to all persons in a specified community.	Person-rem

Table B.2 provides unit of radiation measure and applicable conversions to the international measurement system.

Table B.2. Units of radiation measure

Standard System	International System	Conversion
Ci (curie)	becquerel (Bq)	1 Ci = 3.7 x 10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

SOURCES OF RADIATION

Radiation is everywhere. Most occurs naturally, but a small percentage is human-made. Naturally occurring radiation is known as background radiation.

Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Although people have little control over the amount of background radiation to which they are exposed, this exposure must be put into perspective. Background radiation remains relatively constant over time; background radiation present in the environment today is much the same as it was hundreds of years ago.

Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as cosmic, terrestrial, or internal, depending on its origin. In the United States, the average person receives an annual dose from natural background radiation of 311 mrem/year. Table B.3 summarizes various doses from both naturally-occurring and human-made radiation sources.

Exposure to radiation from atmospheric testing of atomic weapons is considered part of background radiation. However, testing of atomic weapons has been suspended in the United States and most parts of the world. China conducted the last atmospheric atomic weapons test in 1980. Fallout from atmospheric weapons testing is not currently a significant contributor to background radiation (Health Physics Society 2010).

Cosmic/space radiation. Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called cosmic or space radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level — the higher a person is in elevation, the less shielding is provided by the atmosphere.

The average annual dose received by residents of the United States from cosmic radiation is about 33 mrem/year (National Council on Radiation Protection [NCRP] 2009). The average annual dose to a person living in Honolulu, Hawaii (at sea level and near the equator) is about 20 mrem/year, while the average annual dose to a person living in Colorado Springs, Colorado (high altitude and latitude) is about 70 mrem/year (Health Physics Society 2010).

Terrestrial radiation. Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon, radon progeny, the relatively short-lived decay products of radium-226, potassium-40, thorium isotopes, and uranium isotopes are the elements responsible for most terrestrial radiation.

The average annual dose received from terrestrial gamma radiation is about 21 mrem/year in the United States (NCRP 2009). Similar to cosmic radiation, this dose varies geographically across the country with the lowest doses on the Atlantic and Gulf coastal plains and highest doses in the mountains in the western United States.

Internal radiation. Radioactive material in the environment can enter the body through different routes of exposure, for example, the air people breathe and the food they eat, or through an open wound. Natural radionuclides that can enter the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, and lead in the uranium-238 and thorium-232 decay series. In addition, the body contains isotopes of potassium (potassium-40), rubidium (rubidium-87), and carbon (carbon-14).

Inhalation of the short-lived decay products of radon are the major contributors to the annual dose equivalent for internal radionuclides, mostly radon-222). They contribute an average annual dose of about 228 mrem/year (NCRP 2009). The average annual dose from ingestion of radionuclides is about 29 mrem/year, which can be attributed to the naturally occurring potassium-40, thorium isotopes, uranium isotopes, and the uranium and thorium decay series (NCRP 2009).

Table B.3. Comparison and description of various dose levels[a]

Dose level	Description
0.85 mrem	Approximate daily dose for a person in the United States from natural background radiation, including radon
1.92 mrem	Cosmic dose to a person on a one-way airplane flight from Washington D.C. to Seattle
10 mrem	Annual exposure limit, set by the U.S. Environmental Protection Agency (U.S. EPA), for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants and uranium mines and mills
36 mrem	Average annual dose to a person who smokes one pack of cigarettes per day
36 mrem	Mammogram (two views)
46 mrem	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear power plant accident
60 mrem	X-ray (single exposure) of abdomen or hip
100 mrem	Annual dose limit to a member of the public from radiological activities, including remediation, at a DOE facility
244 mrem	Average dose from an upper gastrointestinal diagnostic X-ray series
300 mrem	Average annual dose to a person in the United States from all sources of medical radiation
311 mrem	Average annual dose to a person in the United States from all sources of natural background radiation, including radon
620 mrem	Average annual dose to a person in the United States from all sources of natural and human-made radiation (based on rounded values for individual categories)
700 mrem	Computed tomography (CT scan) – chest
1000-5000 mrem	U.S. EPA protective action guideline calling for public officials to take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range
5000 mrem	Annual dose limit for occupational exposure of radiation workers set by the Nuclear Regulatory Commission and DOE
10,000 mrem	The Biological Effects of Ionizing Radiation V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer of 0.8%, which means that of 1000 persons exposed at 10,000 mrem, eight persons would die from cancer caused by the radiation exposure (Biological Effects of Ionizing Radiation 1990)
25,000 mrem	U.S. EPA guideline maximum dose to emergency workers volunteering for non-lifesaving work

Table B.3. Comparison and description of various dose levels[a] (continued)

Dose level	Description
75,000 mrem	U.S. EPA guideline for maximum dose to emergency workers volunteering for lifesaving work
50,000-600,000 mrem	Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people would die within 60 days.

[a]Adapted from Savannah River Site Environmental Report for 1993, Summary Pamphlet, WSRC-TR-94-076, (Westinghouse Savannah River Company 1994) and NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009).

Human-made Radiation

Most people are exposed to human-made sources of radiation. Examples include consumer products, medical sources, and industrial or occupational sources. About one-half of 1% of the U.S. population performs work in which radiation in some form is present. In the United States, the average person receives an annual dose from human-made radiation of approximately 313 mrem/year, primarily from medical procedures.

Consumer products and activities. Some consumer products are sources of radiation. In some consumer products, such as smoke detectors, watches, or clocks, radiation is essential to the performance of the device. In other products or activities, such as smoking tobacco products or building materials, the radiation occurs incidentally to the product function. Commercial air travel is another consumer activity that results in exposure to radiation (from cosmic radiation).

The U.S. average annual dose received by an individual from consumer products is about 13 mrem/year (NCRP 2009). Almost 90 percent of this annual dose results from smoking cigarettes, commercial air travel, and building materials (radionuclides present in brick, masonry, cement, concrete, and other materials).

Medical sources. Radiation is an important tool of diagnostic medicine and treatment, and, in this use, is the main source of exposure to human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. Generally, medical exposures result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Radiation and radioactive materials are also used in a wide variety of pharmaceuticals and in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Nuclear medicine examinations and treatment involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body.

Medical exams and procedures account for the largest portion of the average annual dose received from human-made sources. These procedures include x-rays, computed tomography (CT) scans—a more sophisticated type of x-ray), fluoroscopy, and nuclear medicine. The increase in the use of medical imaging procedures, especially computed tomography, over the last 25 years has resulted in a marked increase in the average annual dose from medical sources received by a person in the United States: 53 mrem/year in the early 1980s to 300 mrem/year in 2006 (NCRP 2009). The actual annual doses received by individuals who complete such medical exams can be much higher than the average value because not everyone receives such exams each year.

Industrial and occupational sources. Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium enrichment plants, uranium mines, and nuclear power plants; emissions from mineral extraction facilities; and the transportation of radioactive materials. Workers in certain occupations may also be exposed to radiation due to their jobs, in addition to the average background radiation exposure. These occupations include positions in medicine, aviation, research, education, and government. Pilots and other air crew members have the highest annual average exposure to radiation as part of their jobs: 307 mrem/year (NCRP 2009). This exposure is from cosmic radiation.

Small doses received by individuals occur as a result of emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem/year to the average annual dose to an individual (NCRP 2009).

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APPENDIX C

RADIONUCLIDE AND CHEMICAL NOMENCLATURE

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Table C.1. Nomenclature for elements and chemical constituents

Constituent	Symbol
Aluminum	Al
Ammonia	NH_3
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Nitrogen	N
Nitrate ion	NO_3-
Nitrite ion	NO_2-
Phosphorus	P
Phosphate ion	PO_4^{2-}
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Sulfate ion	SO_4-
Sulfur dioxide	SO_2
Thallium	Tl
Uranium	U
Vanadium	V
Zinc	Zn

Table C.2. Nomenclature and half-life for radionuclides

Radionuclide	Symbol	Half-life (years)
Americium-241	^{241}Am	432.2
Neptunium-237	^{237}Np	2,140,000
Plutonium-238	^{238}Pu	87.7
Plutonium-239	^{239}Pu	24,100
Plutonium-240	^{240}Pu	6,564
Technetium-99	^{99}Tc	211,000
Uranium-233	^{233}U	159,000
Uranium-234	^{234}U	246,000
Uranium-235	^{235}U	704,000,000
Uranium-236	^{236}U	23,400,000
Uranium-238	^{238}U	4,470,000,000

Source: *Derived Concentration Technical Standard* (DOE 2011b), Table A.3.

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