

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 2020, 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 2020 or detected by environmental monitoring programs in 2020 is 1.0 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 2020

Source of dose	Dose (mrem/year)
Airborne radionuclides (off-site individual)	0.068 ^a
Radionuclides released to the Scioto River	0.0016
External radiation near cylinder yards (northwest portion of Perimeter Rd)	0.74
Radionuclides detected by environmental monitoring programs	0.19
Total	1.0^b

^a10 mrem/year is U.S. EPA limit for airborne radionuclides in the NESHAP (40 CFR Part 61, Subpart H).

^b100 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.

The following sections provide the assumptions for the individual dose calculations: airborne radionuclides (Section 4.3.1), radionuclides released to the Scioto River (Section 4.3.5), external radiation (Section 4.3.6), and radionuclides detected by environmental monitoring programs (Section 4.3.7).

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 (2011 to 2020). 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.

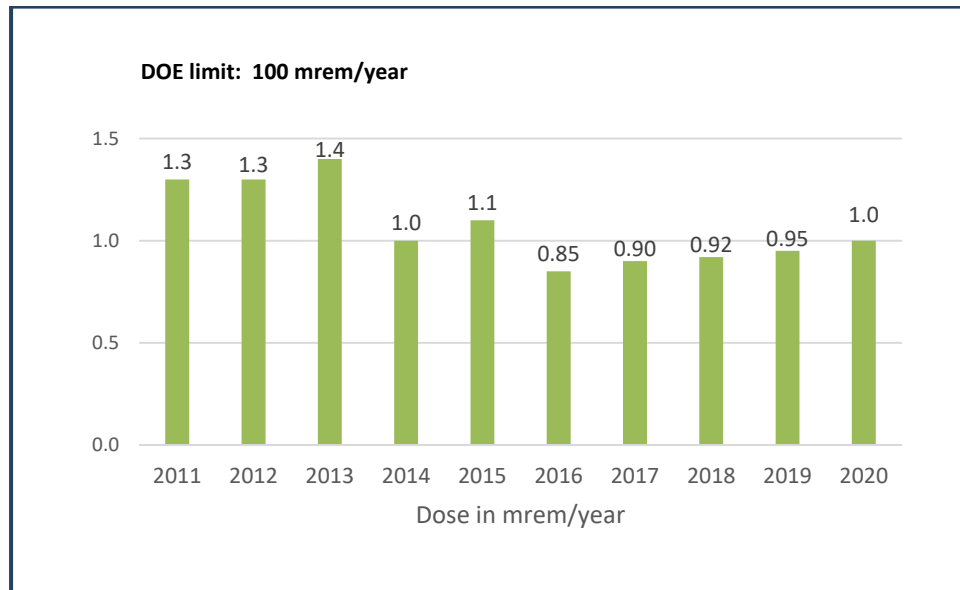


Figure 4.1. Maximum potential annual doses (all pathways) to the public, 2011 – 2020.

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 2017a). 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 2020, 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.

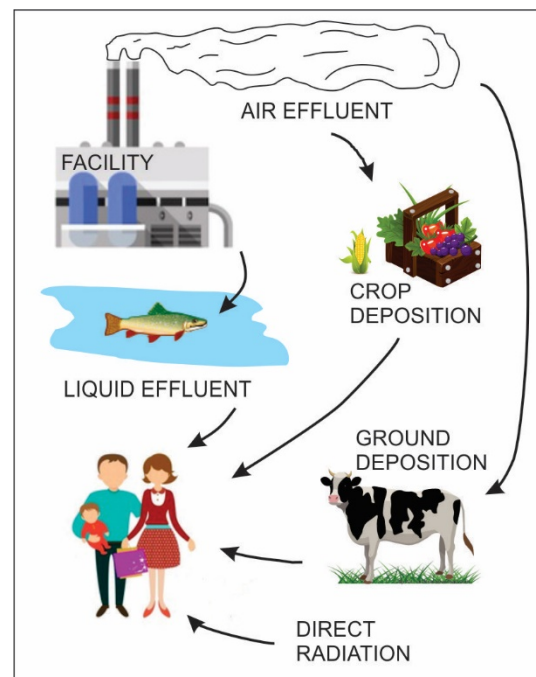


Figure 4.2. Potential radiation pathways.

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 2020. 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 2020 by environmental monitoring programs.

For 2020, 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 2020 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, milk, and eggs). 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 2020, annual doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, vegetation, and crops. Radionuclides were not detected in 2020 in samples of residential drinking water, deer, fish, milk, and eggs.

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 2020, 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 2020 were calculated to be 0.0358 Ci (3.58E-02 Ci).

MCS was responsible for air emission sources associated with the DUF₆ Conversion Facility. The DUF₆ Conversion Facility did not operate from April through December 2020 due to the COVID-19 pandemic. Emissions from the DUF₆ Conversion Facility were based on continuous monitoring of the conversion building stack. Total emissions from the MCS airborne sources in 2020 were calculated to be 0.0000163 Ci (1.63E-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 2020.

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 2020 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 4.1, 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. In reality, the majority of the foodstuffs consumed locally are purchased at supermarkets that receive foodstuffs from all over the world. 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 2020 was 0.068 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 2020, the population dose from PORTS emissions was 0.35 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 18 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). Thorium isotopes (thorium-228, thorium-230, and thorium-232) were added to the ambient air monitoring program in 2020 because these radionuclides are present in the gaseous diffusion process buildings and could be released during D&D. These thorium isotopes are also naturally present in the environment.

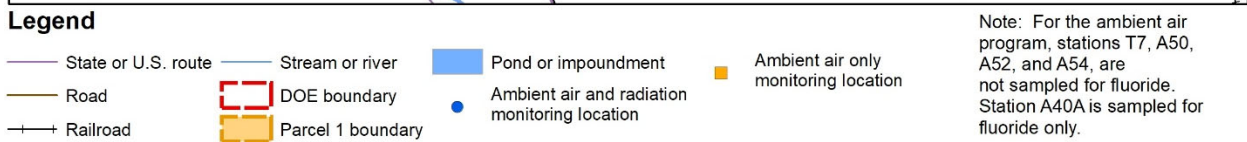
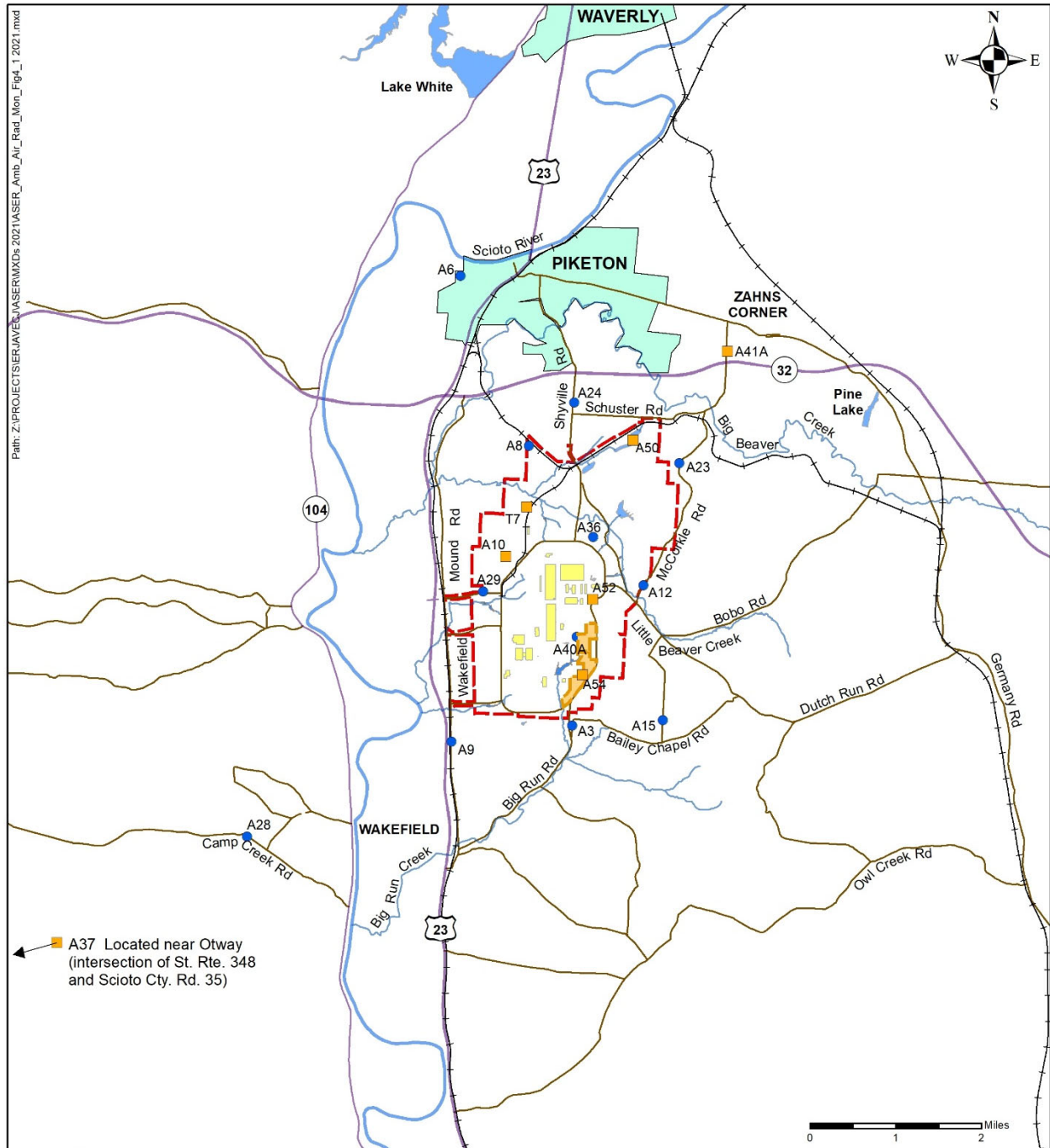


Figure 4.3. DOE ambient air and radiation monitoring locations.

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).

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/m³). The following assumptions were made to calculate the annual dose at each station: 1) the highest level of each radionuclide detected in 2020 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 0.049 mrem/year at station A29, which is on the west side of PORTS at the Ohio Valley Electric Corporation (OVEC) (see Figure 4.3). This hypothetical dose (0.049 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 2020. 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 2020 are included in this section.

4.3.4.1 FBP outfalls

In 2020, 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, groundwater infiltration, 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 002 (X-230K South Holding Pond) – The X-230K South Holding Pond receives non-contact cooling water, steam condensate, foundation drainage, storm runoff, fire-fighting training and fire suppression system water, boiler blowdown, water softener regeneration, groundwater infiltration, sanitary water for eyewash/shower station testing and flushing, and treated runoff from the former coal pile area. 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.

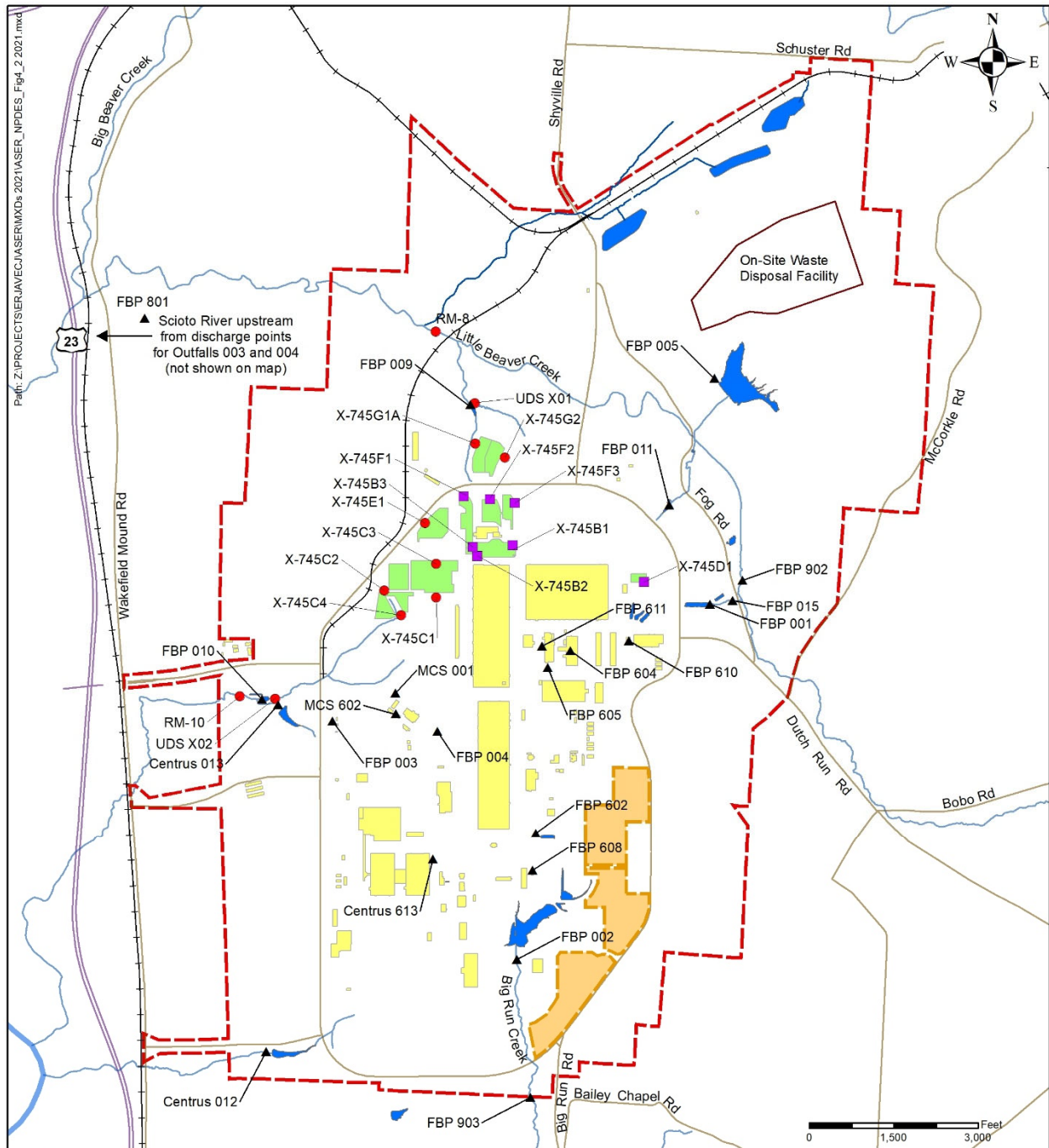


Figure 4.4. PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations.

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 Bionitrification Facility, the X-705 Decontamination Microfiltration System, X-670A cooling tower blowdown, fire-fighting training and fire suppression system waters, non-contact cooling water, steam condensate, storm water, and other 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.

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 and discharges from water treatment associated with D&D (modular treatment trains A, C, and D) 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 stormwater 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, stormwater runoff, steam condensate, fire suppression system water, groundwater infiltration, 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, stormwater runoff, steam condensate, fire-fighting training and fire suppression system water, groundwater infiltration, 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, stormwater runoff, steam condensate, fire suppression system water, groundwater infiltration, 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 Bionitrification Facility) – The X-700 Bionitrification 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 2020.

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 2020.

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 2020, uranium discharges from the FBP external outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) were estimated at 8.4 kilograms (kg). Total radioactivity (technetium-99 and isotopic uranium) released from the same outfalls was estimated at 0.058 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 (0.0016 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 2020, 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 2020.

Uranium discharges in 2020 from external Centrus NPDES outfalls (Outfalls 012 and 013) were estimated at 0.68 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 (0.0016 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 [$\mu\text{g/L}$]) 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 2017c) 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 2020 (0.0016 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 2017a). 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 2020, the average annual dose recorded by TLDs at the cylinder yards near Perimeter Road was 744 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 2017a). The total annual dose measured in 2020 at station A29, near OVEC, was 91 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 89 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 2 mrem/year difference between the average off-site background dose (89 mrem/year) and the dose at station A29 (91 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 0.24 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 0.24 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 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).

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, milk, and eggs) at off-site sampling locations. If radionuclides are not detected in the samples, a dose of 0 is assigned. 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 2020, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, vegetation, and crops. Radionuclides were not detected in 2020 in samples of residential drinking water, deer, fish, milk, and eggs.

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 2017c) 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 2020 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 2020

Source of dose	Dose (mrem/year) ^a
Sediment	0.013
Soil	0.014
Vegetation	0.00038
Crops (beans)	0.16
Total	0.19

^a100 mrem/year is the limit for all potential pathways in DOE Order 458.1.

4.3.7.1 Dose calculation for sediment

The dose calculation for sediment is based on the following detections of radionuclides in the samples collected in 2020 from monitoring locations RM-5 and RM-15, off-site sampling locations on Big Beaver Creek (see Section 4.6.5 and Figure 4.6):

	RM-5 (duplicate sample)	RM-15
• Neptunium-237:	not detected	0.038 picocurie per gram (pCi/g)
• Uranium-233/234:	1.3 pCi/g	1.1 pCi/g
• Uranium-238:	1.2 pCi/g	0.74 pCi/g.

Based on an incidental ingestion rate of 200 milligrams (mg)/day (0.007 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 2017c), 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 0.013 mrem/year. Section 4.6.5 provides additional information on the sediment monitoring program as well as a map of sediment sampling locations.

4.3.7.2 Dose calculation for soil

The dose calculation for soil is based on the detections of the following uranium isotopes in the soil samples collected at off-site ambient air monitoring stations A6 (north of PORTS in Piketon), A41A (northeast of PORTS at Zahns Corner), and A28 (southwest of PORTS on Camp Creek Road) (see Section 4.6.7 and Figure 4.3):

	A6	A41A	A28
• Uranium-233/234:	0.326 pCi/g	0.387 pCi/g	0.432 pCi/g
• Uranium-235/236:	0.0227 pCi/g	not detected	0.0202 pCi/g
• Uranium-238:	0.421 pCi/g	0.369 pCi/g	0.267 pCi/g.

Based on an incidental ingestion rate of 200 mg/day (0.007 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 2017c), 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 0.014 mrem/year. Section 4.6.7 provides additional information on the soil monitoring program.

4.3.7.3 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):

Vegetation

- Uranium-238: 0.0177 pCi/g

Soil

- Uranium-233/234: 0.326 pCi/g
- Uranium-235/236: 0.0227 pCi/g
- Uranium-238: 0.421 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 2017c) 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 0.00038 mrem/year. Section 4.6.8.1 provides additional information on the vegetation monitoring program.

4.3.7.4 Dose calculation for crops

The dose calculation for crops is based on uranium-233/234 detected at 0.032 pCi/g in a sample of beans collected at off-site sampling location #9. Based on an ingestion rate for home-produced vegetables from the U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 2011) and an exposure frequency of 100 days/year [*Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017c)], the annual dose that could be received by an individual eating home-produced beans contaminated at this level is 0.16 mrem/year. Section 4.6.8.4 provides additional information on the crops 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 2019) 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 2020 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 2020. 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:

<u>Radionuclide</u>	<u>EDD-SW01</u>	<u>RM-11 (regular sample)</u>
Technetium-99	41.5 pCi/L	not detected
Uranium-233/234	8.71 pCi/L	0.68 pCi/g
Uranium-235/236	0.166 pCi/L	not detected
Uranium-238	1.58 pCi/L	0.68 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2019). 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 2020, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations EDD-SW01 (surface water) and RM-11 (sediment) was 0.0515, 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 2020 from the northern side of the PORTS reservation [surface water sampling location RW-8 (see Figure 4.6) 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 2020. Section 4.6.7 and Section 4.6.4 provide additional information about these soil and surface water sampling programs, respectively.

No transuranic radionuclides or technetium-99 were detected in 2020 from samples collected at RW-8 (surface water) and A8 (soil). The maximum levels of uranium isotopes were as follows:

<u>Radionuclide</u>	<u>RW-8</u>	<u>A8</u>
Uranium-233/234	2.97 pCi/L	0.99 pCi/g
Uranium-235/236	0.12 pCi/L	0.034 pCi/g
Uranium-238	0.745 pCi/L	0.86 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2019). 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 2020, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations RW-8 (surface water) and A8 (soil) was 0.00076, 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 2020.

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). Thorium isotopes (thorium-228, thorium-230, and thorium-232) were added to the ambient air monitoring program in 2020 because these radionuclides are present in the gaseous diffusion process buildings and could be released during D&D. These thorium isotopes are also naturally present in the environment.

In 2020, samples were collected from 18 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. Three new on-site ambient air monitoring stations that monitor radionuclides (A50, A52, and A54) were added in October 2020. The analytical results from air sampling stations closer to the plant are compared to the background measurements.

In 2020, the Ohio Department of Health (ODH) began collecting air samples at the same air monitoring locations sampled by DOE. ODH is conducting this sampling using separate sampling equipment and analytical laboratories to independently measure airborne radioactivity levels around PORTS. Use of separate sampling equipment and analytical laboratories means that analytical results for samples collected at the same location can be different. Data collected by ODH is available at https://data.ohio.gov/wps/portal/gov/data/view/doe-portsmouth-facility_-radiological-air-sampling-results. Data collected by DOE is available in PEGASIS (pegasis.ports.pppo.gov). DOE also provides a summary of DOE and ODH monitoring data in the Environmental Reports portion of PEGASIS.

Ambient concentrations of uranium and uranium isotopes at the monitoring stations in 2020 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.

No transuranic radionuclides were detected in ambient air in 2020. The highest levels of uranium isotopes, thorium isotopes, and technetium-99 detected in air were 0.05%, or less, of the DOE derived concentration standards (DOE 2011b)¹. Maximum activities of uranium isotopes were detected at station A24 (off site north of PORTS on Shyville Road). Maximum activities of technetium-99 and thorium isotopes were detected at on-site stations A36 and A29 and off-site station A23 (northeast of PORTS).

The maximum activities of detected radionuclides (in picocurie per cubic meter [pCi/m³]) are listed below:

<u>Radionuclide</u>	<u>Maximum activity (pCi/m³)</u>	<u>Location</u>	<u>Derived concentration standard (DOE 2011b) (pCi/m³)^a</u>	<u>Percentage of derived concentration standard (DOE 2011b)</u>
Technetium-99	0.00077	A36	920	0.0001%
Thorium-228	0.000043	A29	0.094	0.05%
Thorium-232	0.0000052	A23	0.16	0.003%
Uranium-233/234	0.000085	A24	1.1	0.008%
Uranium-235/236	0.0000042	A24	1.2	0.0004%
Uranium-238	0.000089	A24	1.3	0.007%

^aThe derived concentration standard has been converted to pCi/m³ 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 0.018 mrem/year at station A24, which is north of PORTS on Shyville Road (see Figure 4.3). This hypothetical annual dose (0.018 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 DUF₆ 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 744 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.

¹The 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).

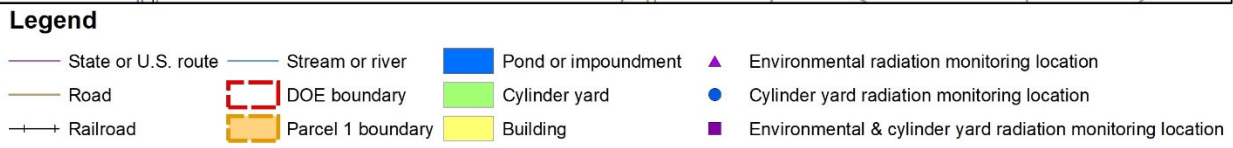
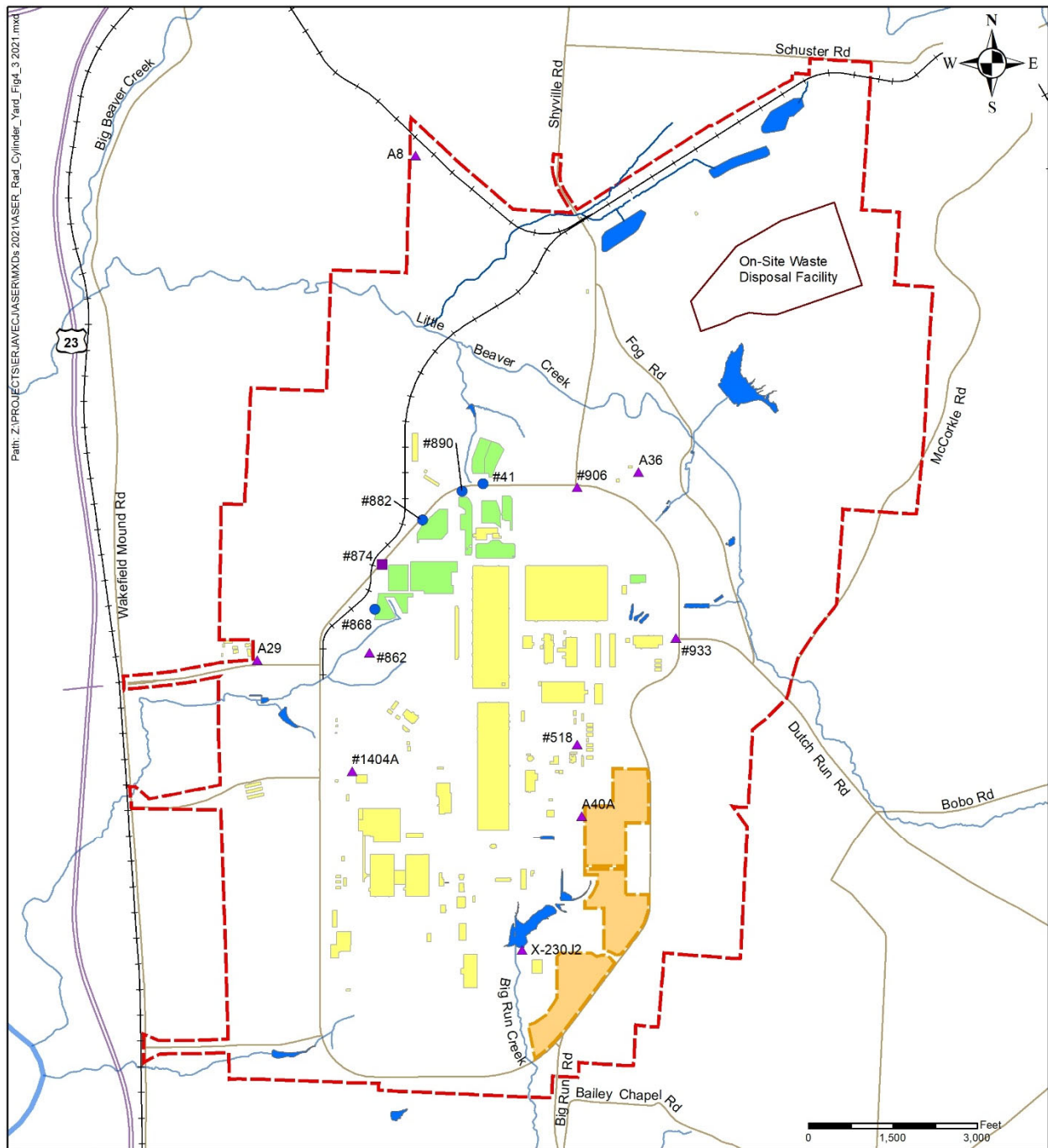


Figure 4.5. On-site radiation and cylinder yard dose monitoring locations.

In 2020, the average annual dose measured at eight off-site or background locations (A3, A6, A9, A12, A15, A23, A24, and A28) was 89 mrem/year. Two locations within PORTS measured levels of radiation approximately 50% higher or more than the average off-site radiation (89 mrem/year): location #874 (629 mrem/year) near the X-745C Cylinder Storage Yard and location #862 (120 mrem/year) south of the cylinder yards and west of the X-530A Switchyards. Three other on-site locations (X-230J2, A8, and A29) measured radiation at levels slightly higher than the average background (ranging from 2 mrem/year to 11 mrem/year above average).

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 (0.24 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 2020.

4.6.3 Surface Water from Cylinder Storage Yards

In 2020, 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 DUF₆ 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 2020 by FBP and MCS, respectively.

4.6.3.1 FBP cylinder storage yards

In 2020, 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: 182 pCi/L (X-745B2, July 2020)

Beta activity: 138 pCi/L (X-745B3, July 2020)

Uranium: 115 µg/L (X-745B2, December 2020).

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 2020 (0.0016 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: 9.08 pCi/L (X-745C1, October 2020)

Beta activity: 9.71 pCi/L (X-745E1, April 2020)

Uranium: 7.11 µg/L (X-745C2, August 2020).

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 2020 (0.0016 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 2017a).

No transuranic radionuclides were detected in the local surface water samples collected during 2020. Maximum detections of technetium-99 and uranium isotopes in local surface water samples are listed below:

<u>Radionuclide</u>	<u>Maximum activity (pCi/L)</u>	<u>Location</u>	<u>Derived concentration standard (DOE 2011b)^a (pCi/L)</u>	<u>Percentage of derived concentration standard (DOE 2011b)</u>
Technetium-99	106	RW-13	44,000	0.24%
Uranium-233/234	2.97	RW-8	680	0.44%
Uranium-235/236	0.12	RW-8	720	0.02%
Uranium-238	0.745	RW-8	750	0.10%

^aThe 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 0.44%, 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.

¹The 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).

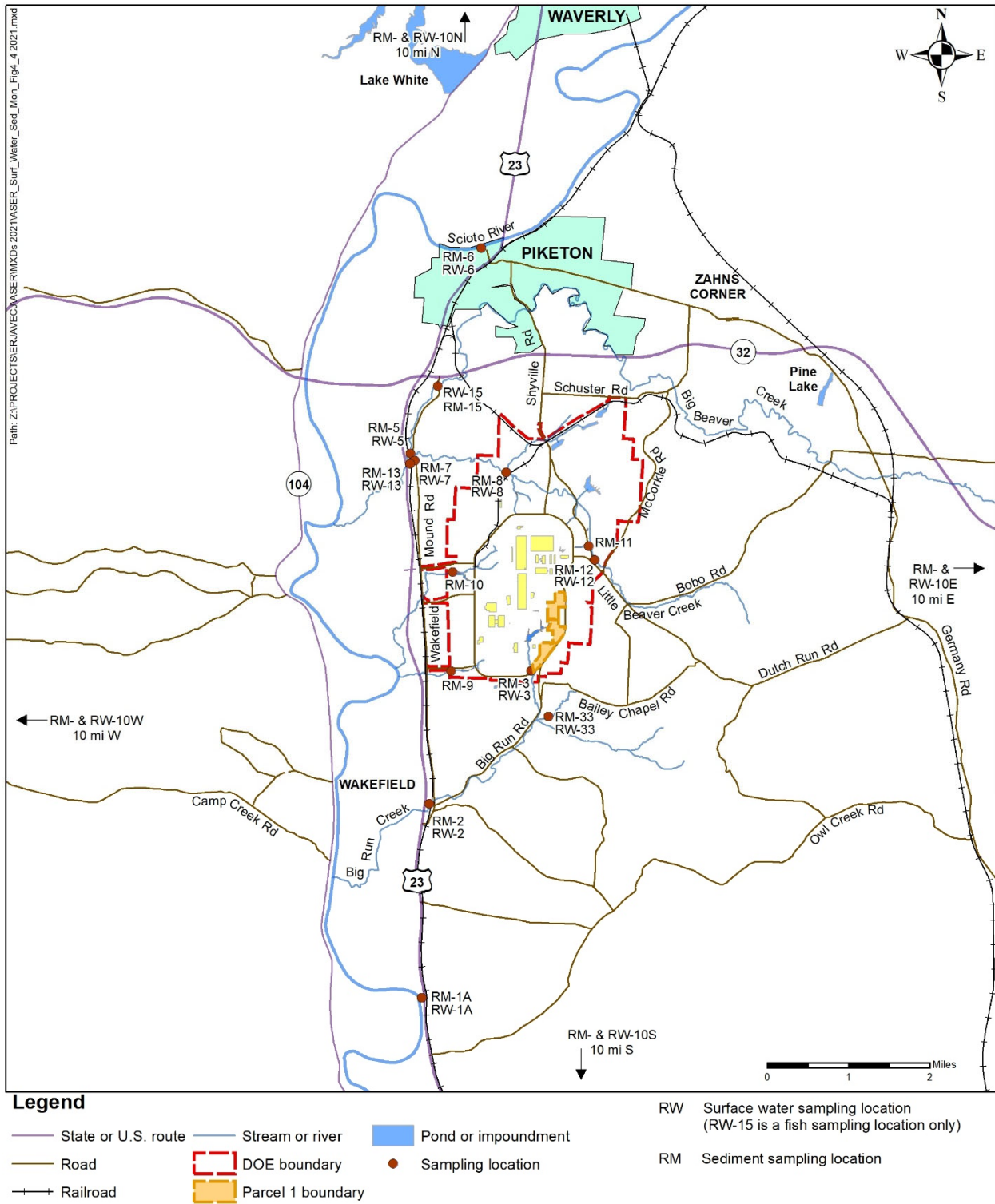


Figure 4.6. Local surface water and sediment monitoring locations.

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 2017a).

Neptunium-237 was detected at 0.038 pCi/g in the sample collected from the off-site upstream sampling location on Big Beaver Creek (RM-15). No other transuranics were detected in the sediment samples collected in 2020.

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS surface water discharges; however, technetium-99 was not detected in any of the sediment samples collected in 2020.

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 on Big Run Creek or the West Drainage Ditch (locations RM-3 and RM-10, respectively) as follows:

Uranium: 4.51 micrograms per gram ($\mu\text{g/g}$) (RM-3)
Uranium-233/234: 2.4 pCi/g (RM-3)
Uranium-235/236: not detected
Uranium-238: 1.5 pCi/g (RM-3 and RM-10).

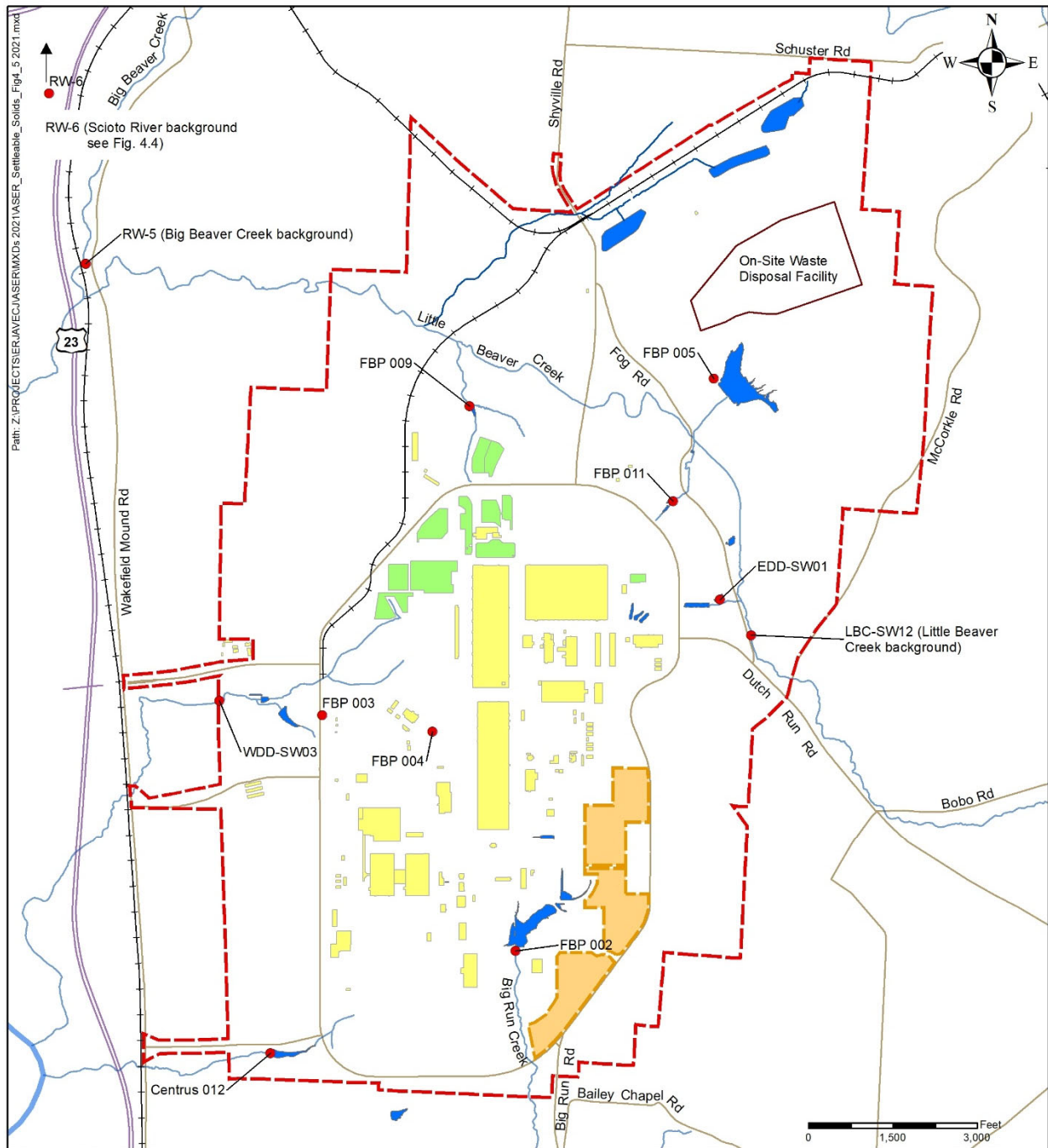
Uranium and uranium isotopes detected in the 2020 samples have been detected at similar levels in previous sampling events from 2005 through 2019.

Section 4.3.7.1 provides a dose assessment at the off-site sediment sampling locations with the detections of radionuclides that could cause the highest dose to a member of the public: RM-5 and RM-15 on Big Beaver Creek. The total potential annual dose to a member of the public resulting from PORTS (1.0 mrem/year), which includes this dose calculation (0.013 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.



Legend

- State or U.S. route
- Road
- Railroad
- Stream or river
- DOE boundary
- Parcel 1 boundary
- Pond or impoundment
- Cylinder yard
- Building
- Settleable solids monitoring location

Figure 4.7. DOE settleable solids monitoring locations.

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 milligrams per liter (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).

In August 2020, settleable solids were detected above 40 mg/L in the sample collected from a background location: RW-5 in Big Beaver Creek. Alpha activity was detected at 56.9 pCi/g in the settleable solids portion of the sample. This result is not due to radionuclides released from PORTS because the sampling location is upstream from PORTS discharges to Big Beaver Creek. The result shows that naturally-occurring radiation is present in the environment. Beta-gamma activity was not detected. DOE discharge limits do not apply to background locations. Settleable solids were not detected in the December 2020 sample collected from background location RW-5.

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 15 ambient air monitoring locations (see Figure 4.8). 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) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017a).

No transuranic radionuclides or technetium-99 were detected at the soil sampling locations in 2020. 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.

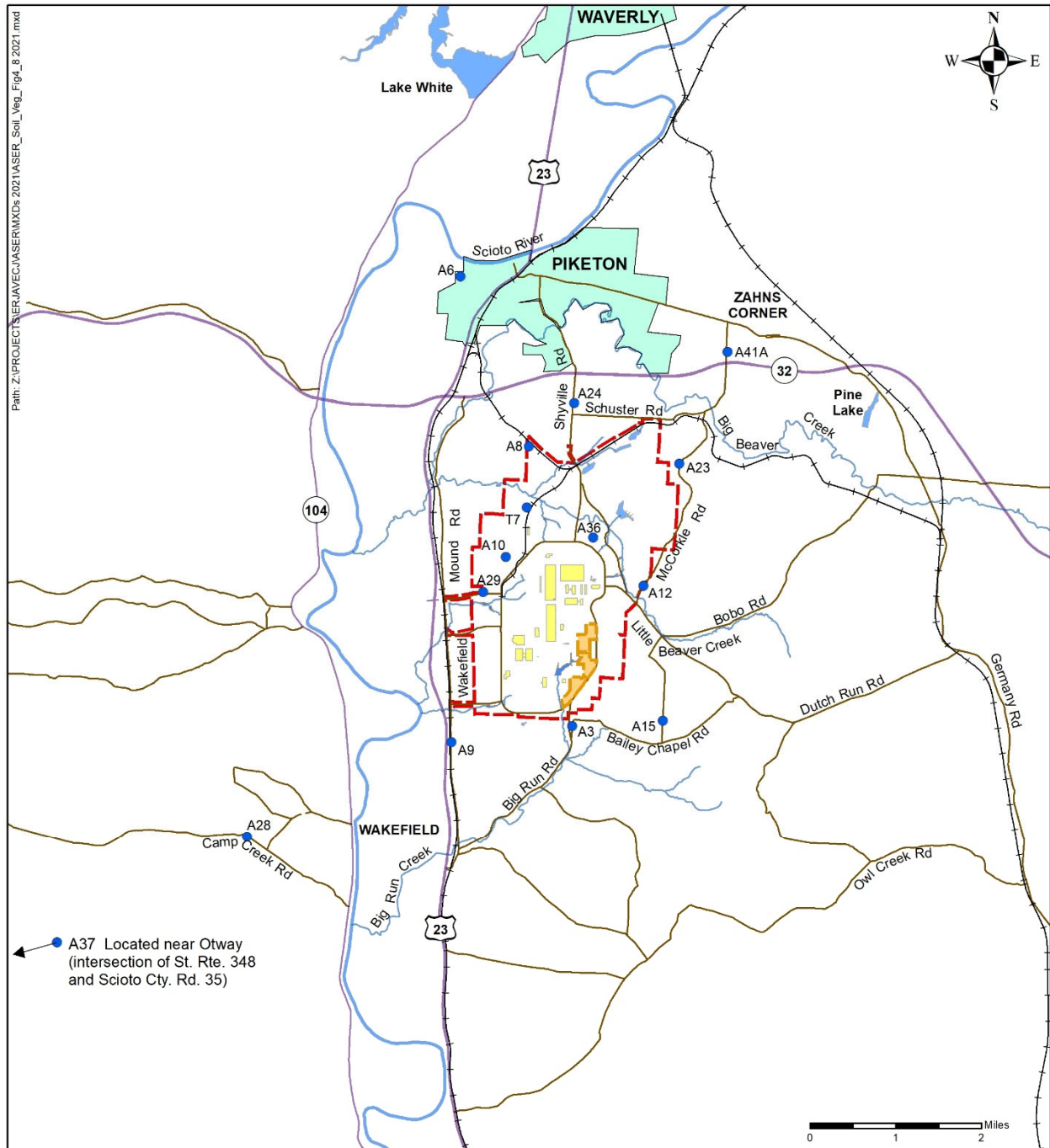
Section 4.3.7.2 provides a dose assessment based on the detections of uranium isotopes in soil at the off-site ambient air stations with the detections of radionuclides that could cause the highest dose to a member of the public: A6 (north of PORTS in Piketon), A41A (northeast of PORTS at Zahns Corner), and A28 (southwest of PORTS on Camp Creek Road). The total potential annual dose to a member of the public resulting from PORTS (1.0 mrem/year), which includes this dose calculation (0.014 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 2017a) 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 4.8). 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).



Legend

- State or U.S. route
- Road
- +— Railroad
- Stream or river
- DOE boundary
- Parcel 1 boundary
- Pond or impoundment
- Soil and vegetation monitoring location

Figure 4.8. DOE soil and vegetation monitoring locations.

Uranium, uranium-233/234, and/or uranium-238 were detected in the vegetation samples collected at on-site sampling locations A10, A29, A36, A8, and T7, as well as off-site sampling locations A6 (north of PORTS in Piketon), A9 (southwest of PORTS on old US Route 23), and A37 (the background station in Otway). Uranium and uranium isotopes are detected occasionally in vegetation samples, and have been detected at similar levels in previous sampling. Section 4.3.7.3 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 (1.0 mrem/year), which includes this dose calculation (0.00038 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 February (two deer) and November of 2020 (one deer).

Technetium-99 was detected at 0.495 pCi/g in the liver sample collected from the deer in November 2020. Technetium-99 was not detected in the muscle and kidney samples collected from this deer. A dose assessment is only completed when radionuclides are detected in deer muscle samples because people do not typically eat deer liver or kidneys. No other radionuclides were detected in the deer samples collected during 2020.

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 2020, fish were caught at each of these locations. 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 2020.

4.6.8.4 Crops

In 2020, crop samples, including corn, tomatoes, and peppers, were collected from five 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). Uranium-233/234 was detected at 0.032 pCi/g in a sample of beans collected from off-site location #9. Uranium isotopes are occasionally detected in crop samples. No other radionuclides were detected in the crop samples collected during 2020.

Section 4.3.7.4 provides a dose assessment for a member of the public based on uranium-233/234 detected at 0.032 pCi/g in home-grown beans. The total potential annual dose to a member of the public resulting from PORTS (1.0 mrem/year), which includes this dose calculation (0.16 mrem/year), is below the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.8.5 Milk and eggs

Samples were collected in 2020 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 2020.

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. Release criteria for surface contamination limits as specified in DOE Order 458.1 are used for clearance of objects with the potential for surface contamination, while specific authorized limits have been derived to control whether items with potential volumetric contamination are released.

Sections 4.7.1 and 4.7.2 provide information about property released from FBP (and PMA) 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 2020, FBP authorized approximately 1151 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

^aSource: 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 2020.

4.7.2 MCS Property Releases

In 2020, MCS authorized approximately 106 release requests for materials to be released off site. These released included vehicles, equipment, waste/recyclables (such as batteries, light bulbs, used oil, and construction debris), contractor equipment, equipment being sent out for calibration, and various other items that met the criteria for release off site.

MCS authorized approximately 226 items that met the criteria for exemption in 2020. These items included contractor equipment that received an inbound survey prior to coming on site and that were here for a short time that never entered into an area controlled for radioactive material, new and unused items that were sent to MCS by mistake, new unused items that had expired or needed to be returned to the vender for repair or calibration, and various other items that met the criteria for exemption. All of these items had a thorough evaluation prior to determination.

In 2020, MCS continued off-site shipment of aqueous hydrogen fluoride produced by the DUF₆ Conversion Facility, which converts DUF₆ 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 266,937 gallons of aqueous hydrogen fluoride were shipped off site in 2020.