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 operations. In 2011, environmental monitoring information was collected by DOE contractors (LPP, FBP, BWCS, and UDS), USEC Inc., and USEC Government Services. Because USEC Government Services responsibilities were returned to DOE in 2011, data collected by USEC Government Services is reported by FBP (the responsible DOE contractor). This chapter includes information on air emissions and water discharges from USEC, Inc. 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 PORTS operations. This impact, called a dose, can be caused by radionuclides released to air and/or water, or radiation emanating 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, and DOE sets a 100 mrem/year limit for the dose from radionuclides from all potential pathways. A person living in the United States receives an average 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 surface water (the Scioto River), from direct radiation, and from radionuclides detected in 2011 by environmental monitoring programs for sediment, soil, vegetation, crops, deer, and drinking water. The maximum dose a member of the public could receive from radiation released by PORTS in 2011 or detected by environmental monitoring programs in 2011 is 1.3 mrem/year. This summary of the dose calculations uses a worst-case approach; that is, the summary of the dose calculations assumes that the same individual is exposed to the most extreme conditions from each pathway. Table 4.1 summarizes this dose information.

Table 4.1. Summary of potential doses to the public from PORTS in 2011

Source of dose	Dose (mrem/year)[a]
Airborne radionuclides	0.032
Radionuclides released to the Scioto River	0.012
Direct radiation from cylinder storage yards	0.81
Radionuclides detected by environmental monitoring programs (sediment, soil, vegetation, crops, deer, and drinking water)	0.42
Total	1.3

[a]100 mrem/year is the DOE limit.

4.2 INTRODUCTION

Environmental monitoring programs at PORTS are designed to detect the effects (if any) of PORTS operations 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 operations and to set priorities for environmental improvements.

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* (which replaced DOE Order 5400.5 during 2011), 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. 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 2011, environmental monitoring data were collected by DOE contractors (FBP, LPP, BWCS, and UDS), USEC, Inc., and USEC Government Services. Because USEC Government Services responsibilities were returned to DOE in 2011, data collected by USEC Government Services is reported by FBP (the responsible DOE contractor). This chapter provides information on the USEC, Inc. NPDES monitoring program and air emissions of radionuclides from USEC, Inc. sources. USEC, Inc. data are provided for informational purposes only; DOE cannot ensure the quality of USEC, Inc. data.

Data from the following environmental monitoring programs are included in this chapter:

- airborne discharges
- ambient air
- direct radiation
- discharges to surface water
- surface water
- sediment
- soil
- vegetation
- 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.

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. Because there are many natural sources of radiation, a person living in the United States receives an average dose of approximately 311 mrem/year from sources of natural radiation (NCRP 2009). Appendix A provides additional information on radiation and dose.

Releases of radionuclides from PORTS activities can result in a dose to a member of the public in addition to the dose received from natural sources of radiation. 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 Clean Air Act and the National Emission Standards for Hazardous Air Pollutants (NESHAP). 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* (which replaced DOE Order 450.1A, *Environmental Protection Program* during 2011), and 458.1, *Radiation Protection of the Public and the Environment* (which replaced DOE Order 5400.5 during 2011). DOE Orders 458.1 and 5400.5 set an annual dose limit of 100 mrem/year to any member of the public from all radionuclide releases from a facility. The NESHAP apply only to airborne radiological releases.

Small quantities of radionuclides were released to the environment from PORTS operations during 2011. This chapter describes the methods used to estimate the potential doses that could result from radionuclides released from PORTS operations. In addition, this chapter assesses the potential doses that could result from radionuclides historically released by PORTS and detected in 2011 by environmental monitoring programs.

4.3 RADIOLOGICAL EMISSIONS AND DOSES

Exposure to radioactive materials can occur from releases to the atmosphere, surface water, or groundwater and from exposure to direct external radiation emanating from buildings or other objects. For 2011, doses are estimated for exposure to atmospheric releases, direct radiation, and releases to surface water (the Scioto River).

Doses are also estimated for exposure to radionuclides from PORTS operations that were detected in 2011 as part of the DOE environmental monitoring programs. 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. In 2011, doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, vegetation, crops, deer, and drinking water. Exposure to radionuclides detected in groundwater at PORTS is not included because contaminated groundwater at PORTS is not a source of drinking water.

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 Dose Terminology

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.

The three natural 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 (americium-241, neptunium-237, plutonium-238, plutonium-239/240, and uranium-236) are occasionally detected at PORTS but may be included as a conservative measure in the calculations used to determine the potential dose received from PORTS operations. Technetium-99 and transuranic radionuclides (americium-241, plutonium-238, and plutonium-239/240) are present in the environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world.

A number of specialized measurement units have been defined for characterizing exposures to ionizing radiation. Because the damage associated with exposure to radiation results primarily from the exposure of tissue to ionizing radiation, the units are defined in terms of the amount of ionizing radiation absorbed by human (or animal) tissue and in terms of the biological consequences of the absorbed energy. These units include the following:

- *Absorbed dose* – the quantity of ionizing radiation energy absorbed by an organ divided by the organ's mass. Absorbed dose is measured in units of rad or gray (1 rad = 0.01 gray).

- *Dose* – the product of the absorbed dose (rad) in tissue and a quality factor. Dose is expressed in units of rem or sievert (1 rem = 0.01 sievert).

- *Effective dose* – the sum of the doses received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. In this report, the term "effective dose" is often shortened to "dose."

- *Collective dose/collective effective dose* – the sum of the doses or effective dose of all individuals in an exposed population expressed in units of person-rem or person-sievert. The collective effective dose is also frequently called the "population dose."

4.3.2 Airborne Emissions

Airborne discharges of radionuclides from PORTS are regulated under the Clean Air Act NESHAP. Releases of radionuclides are used to calculate a dose to members of the public, which is reported annually to U.S. EPA and Ohio EPA. Section 4.3.3 discusses the results of this dose calculation.

In 2011, air emission sources associated with the gaseous diffusion process were returned to DOE from USEC Government Services. FBP was responsible for these sources. These sources included continuously monitored vents in the X-326 and X-330 Process Buildings, and the X-344A Uranium Hexafluoride Sampling Building. The vents in the X-326 and X-330 were in use to support *in-situ* deposit removal activities necessary before equipment was removed as part of D&D. The X-344A vents were in use for ongoing sampling activities of uranium product. Vents in the X-333 Process Building and X-343 Feed Vaporization and Sampling Building that were continuously monitored when the gaseous diffusion plant was operating were inactive during 2011.

Other radionuclide air emission sources returned to DOE from USEC Government Services included room ventilation exhausts and/or pressure relief vents associated with the X-700 Chemical Cleaning Facility, X-710 Technical Services Building, X-705 Decontamination Facility, and the XT-847 Glove Box. These emission sources were not continuously monitored; emissions from these sources were estimated based on operating data and U.S. EPA emission factors.

DOE and LPP/FBP were responsible for five additional radiological emission sources. One source, the X-326 L-cage Glove Box, was used to repackage wastes or other materials that contain radionuclides.

The remaining four sources, the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities, treated groundwater contaminated with radionuclides. Emissions from the groundwater treatment facilities were calculated based on quarterly influent and effluent sampling at each facility and quarterly throughput. Emissions from the X-326 L-cage Glove Box were based on the mass of the materials transferred within the glove box, analytical data available for each material, and emission factors provided by U.S. EPA. Emissions from the DOE/FBP sources in 2011 were calculated to be 0.041 Ci.

DOE and UDS/BWCS were responsible for air emission sources associated with the DUF_6 Conversion Facility. Emissions from the DUF_6 Conversion Facility were based on the annual emissions provided in the permit application for the facility and the number of days the facility operated in 2011. Emissions from the DOE/BWCS sources in 2011 were calculated to be 0.0000042 Ci.

Emissions from all DOE sources in 2011 were calculated to be 0.041 Ci. USEC, Inc. reported emissions of 0.0000122 Ci from operation of the Lead Cascade.

4.3.3 Dose Calculation Based on Airborne Emissions

A 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 2011 was characterized by calculating the effective dose to the maximally exposed person (the individual who resides at the most exposed point near the plant) and to the entire population (approximately 677,000 residents) within 50 miles of the plant. Dose calculations were made using a computer program called CAP88-PC Version 3.0, 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 4.3.2. 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 dose to an off-site individual from radiological releases from DOE air emission sources at PORTS in 2011 was 0.032 mrem/year. The combined dose from USEC, Inc. (the Lead Cascade) and DOE sources is also 0.032 mrem/year. The dose from the USEC, Inc. sources is negligible compared to DOE sources and much less than the dose from USEC, Inc. and USEC Government Services sources in 2010 because the numerous sources in the former gaseous diffusion plant were returned to DOE from USEC Government Services in 2011. This dose is well below the 10-mrem/year limit applicable to PORTS and the approximate 311-mrem/year dose that the average individual in the United States receives from natural sources of radiation (NCRP 2009).

The collective dose (or population dose) is the sum of the individual doses to the entire population within 50 miles of PORTS. In 2011, the population dose from PORTS emissions was 0.35 person-rem/year, (0.35 person-rem/year from DOE sources and 0.000038 person-rem/year from USEC, Inc.). The population dose based on PORTS emissions was insignificant; for example, 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).

4.3.4 Dose Calculation Based on Ambient Air Monitoring

DOE collects samples from 15 ambient air monitoring stations (see Figure 4.1) 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, uranium-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 and USEC, Inc. point sources (the sources described in Section 4.3.2), 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 operations).

The CAP88 model generates a dose conversion factor that was used to calculate a dose for a given level of each radionuclide in air. The following assumptions were made to calculate the dose at each station: 1) the highest level of each radionuclide detected in 2011 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.

The dose associated with each radionuclide at each ambient air monitoring station was added to obtain the gross dose for each station. The net dose for each station was obtained by subtracting the dose measured at the background station (A37). The net dose for each station ranged from 0 at stations with a lower dose than the background station to 0.0012 mrem/year at station A9, which is near the southwestern corner of the PORTS property boundary.

The highest net dose measured at the ambient air monitoring stations (0.0012 mrem/year at station A9) is 4% of the dose calculated from the combined DOE and USEC, Inc. point source emissions (0.032 mrem/year). This dose is significantly less than the 10 mrem/year NESHAP limit for airborne radiological releases and 100 mrem/year DOE limit for all radiological releases from a facility.

4.3.5 Discharges of Radionuclides from NPDES Outfalls

DOE contractors (LPP/FBP and UDS/BWCS) and USEC Government Services were responsible for NPDES outfalls at PORTS during 2011. Outfalls that were the responsibility of LPP or UDS were transferred to FBP or BWCS on March 29, 2011, when FBP and BWCS took over responsibility for their respective contracts. The majority of the outfalls and monitoring locations that were the responsibility of USEC Government Services (associated with the former gaseous diffusion process buildings and areas) were transferred to the FBP NPDES permit on September 1, 2011. The outfalls and monitoring locations transferred from USEC Government Services to FBP are Outfalls 001, 002, 003, 004, 005, 009, 010, 011, 602, 604, and 605; and Monitoring Locations 801, 902, and 903. Three outfalls associated with the ACP remained the responsibility of USEC, Inc.

The BWCS NPDES outfall is not monitored for radionuclides; therefore, it is not discussed in this section. A description of the FBP and USEC, Inc. outfalls and the discharges of radionuclides from these outfalls during 2011 are included in this section. Quarterly reports that provide radiological monitoring data for the NPDES outfalls are submitted to Ohio EPA by FBP and USEC, Inc. for their respective outfalls.

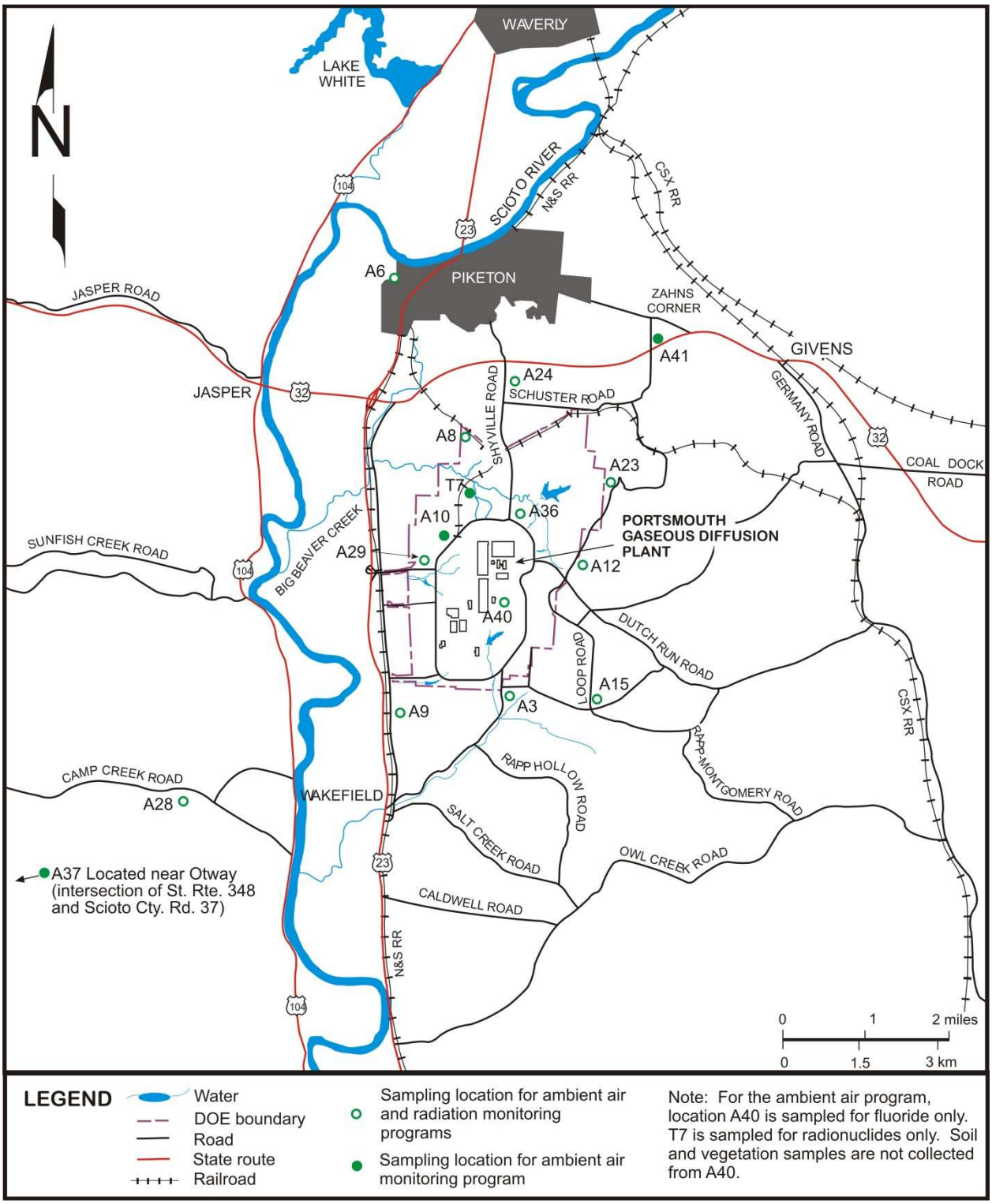

Figure 4.1. DOE ambient air and radiation monitoring locations.

4.3.5.1 FBP outfalls

At the end of 2011, 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 4.2). 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, and oil can be diverted and contained. Water from this holding pond is discharged to a ditch 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, treated coal pile runoff, 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 as well as water discharged from DOE 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 chlorination to treat wastewater prior to release to the Scioto River.

FBP NPDES Outfall 004 (Cooling Tower Blowdown) – Outfall 004 is located at the junction of Pike Avenue and 15th Avenue at PORTS. It monitors blowdown water from various 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. Currently the lagoon only discharges during periods of excess rainfall.

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, and oil can be contained. Water from this holding pond is discharged to an unnamed stream 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, and oil can be diverted and contained. Water from this holding pond is discharged to the West Ditch, which flows to the Scioto River.

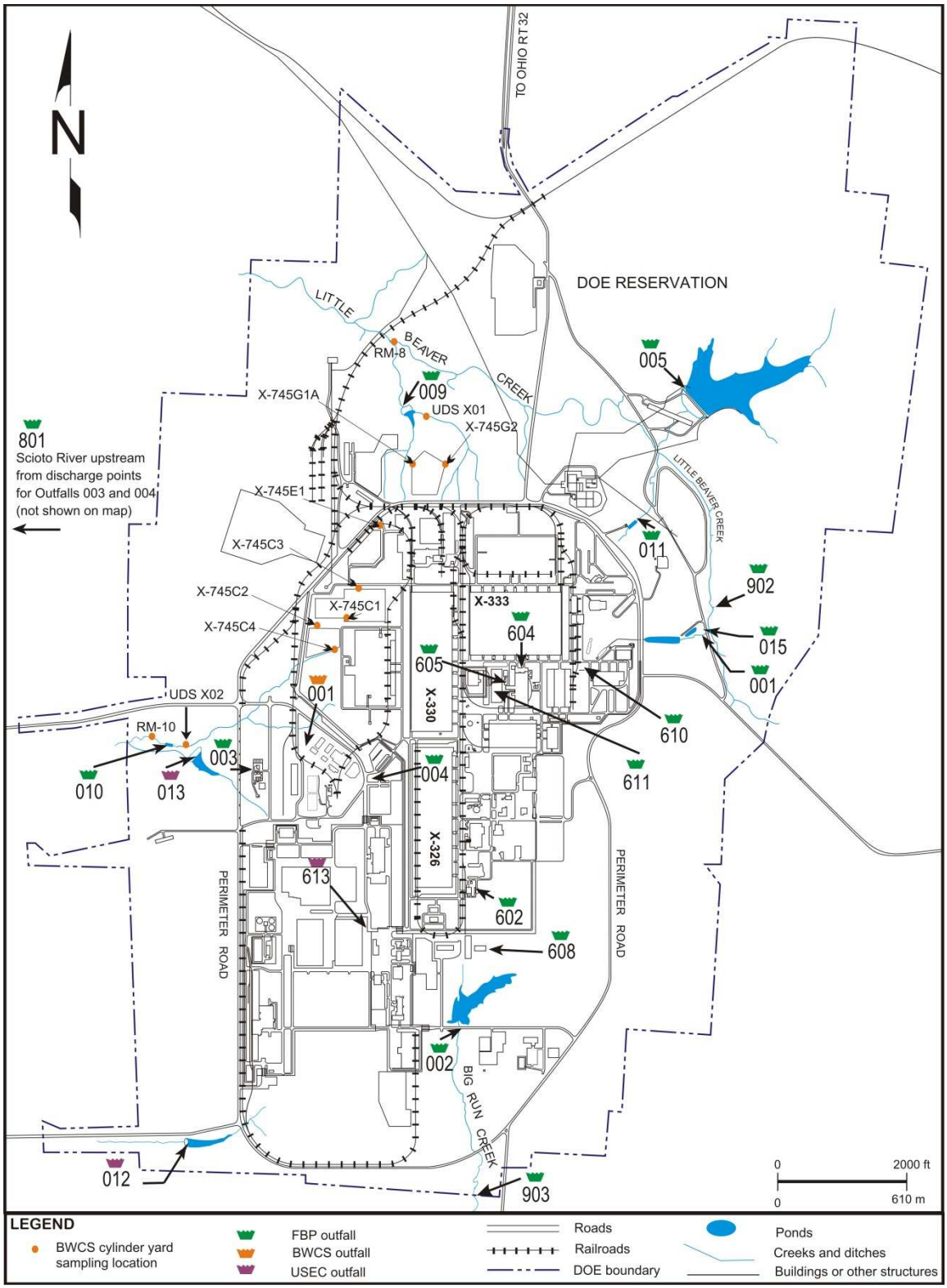

Figure 4.2. PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations.

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, and oil can be diverted and contained. Water from this holding pond is discharged to an unnamed stream that flows to Little Beaver Creek.

FBP NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – The X-624 Groundwater Treatment Facility removes volatile organic compounds 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 volatile organic compounds toward Little Beaver Creek. Treated water is released to a ditch that flows to Little Beaver Creek.

FBP NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – The X-621 Coal Pile Runoff Treatment Facility treats storm water runoff from the coal pile at the X-600 Steam Plant. 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).

FBP NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – The X-622 Groundwater Treatment Facility removes volatile organic compounds 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 3.2.1). 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 removes volatile organic compounds from contaminated groundwater originating from site remediation activities in the X-701B Holding Pond area in Quadrant II and from miscellaneous well development and purge waters. 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 volatile organic compounds 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 background monitoring location on the Scioto River upstream from FBP NPDES Outfalls 003 and 004. 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.

FBP NPDES Outfalls 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, uranium-236, and uranium-238), technetium-99, and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). The external outfalls transferred from USEC Government Services to FBP (Outfalls 001, 002, 003, 004, 005, 009, 010, and 011) were monitored for technetium-99, uranium, and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), due to different monitoring requirements under USEC Government Services.

Discharges of radionuclides in liquids through FBP NPDES outfalls have no significant impact on public health and the environment. In 2011, uranium discharges from the FBP external outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) were estimated at 8.7 kilograms. Technetium-99 discharges from the same outfalls were estimated at 0.06 Ci.

Discharges of radionuclides were calculated using monthly or weekly 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. Discharges of radionuclides from the outfalls are used in the dose calculation for releases to surface water (Section 4.3.6). The dose calculated with these data is significantly less than the 100 mrem/year limit for all radiological releases from a facility.

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 2011.

4.3.5.2 USEC, Inc. outfalls

At the end of 2011, USEC, Inc. was responsible for three NPDES outfalls through which water is discharged from the site (see Figure 4.2). 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 USEC, Inc. NPDES outfall follows.

USEC 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 southern 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.

USEC 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 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 the West Ditch, which flows to the Scioto River.

USEC 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).

Uranium discharges in 2011 from external USEC, Inc. NPDES outfalls (Outfalls 012 and 013) were estimated at 0.55 kilogram. Technetium-99 discharges from Outfalls 012 and 013 were estimated at 0.001 Ci. These values were calculated using quarterly discharge monitoring reports for the USEC, Inc. NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the

calculations to determine the quantities of uranium and radiation (technetium-99) discharged through the USEC, Inc. NPDES outfalls.

Transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were not detected in any of the samples collected from USEC, Inc. NPDES outfalls in 2011.

Discharges of radionuclides from USEC, Inc. Outfalls 012 and 013 are used in the dose calculation for releases to surface water (Section 4.3.6). The dose calculated with these data and data from external FBP outfalls is significantly less than the 100 mrem/year limit for all radiological releases from a facility.

4.3.6 Dose Calculation for Releases to Surface Water

Radionuclides are measured at the FBP and USEC, Inc. NPDES external outfalls (nine FBP outfalls and two USEC, Inc. 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 dose to a member of the public was calculated using the measured radiological discharges and the annual flow rate of the Scioto River.

Uranium mass (in micrograms per liter [µg/L]) and activity (in picocuries per liter [pCi/L]) for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and technetium-99 were measured in the water discharged from the FBP or USEC, Inc. outfalls. As a conservative measure, radionuclides that were not detected were assumed to be present at the detection limit. Uranium 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 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* were also used when available. Environmental pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. This exposure scenario is very conservative 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 dose from radionuclides released to the Scioto River in 2011 (0.012 mrem) is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

4.3.7 Radiological Dose Calculation for Direct Radiation

Radiation is emitted from uranium hexafluoride cylinders stored on site at PORTS in the cylinder storage yards located in the northwest portion of the site near Perimeter Road. Data from direct radiation monitoring at the cylinder yards are used to assess potential exposure to the members of the public that drive on Perimeter Road.

Environmental 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* (see Section 4.6.2). In 2011, the average dose recorded at the cylinder yards near Perimeter Road was 818 mrem/year, based on exposure to ionizing radiation for an entire year. The radiological exposure to members of the general public is estimated as the time that a person drives on Perimeter Road past the cylinder yards, which is conservatively estimated at 8.7 hours per year (1 minute per trip, 2 trips per day, 5 work-days per week, and 52 weeks per year).

Based on these assumptions, exposure to a member of the public from radiation from the cylinder yards is approximately 0.81 mrem/year. The average annual dose to a person in the United States from all radiation sources (natural and manmade) is approximately 620 mrem (NCRP 2009). The potential estimated dose from the cylinder yards to a member of the public is approximately 0.1 percent of the average yearly radiation exposure for a person in the United States and is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

4.3.8 Radiological Dose Results for DOE Workers and Visitors

The DOE Radiological Protection Organization at PORTS monitors direct 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 Information Reporting 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 2011 Radiation Exposure Information Reporting System report indicated that no visitors received a measurable dose (defined as 10 mrem or more).

More than 1200 DOE employees and DOE contractors were monitored throughout 2011. Beginning in the fourth quarter of 2011, workers formerly associated with USEC Government Services transitioned to FBP or other DOE contractors and were added to the DOE monitoring program. The 2402 total workers monitored in 2011 received an average dose of 0.9 mrem (including former USEC Government Services workers). Only 38 DOE contractors, primarily cylinder yard workers, received a measurable dose (defined as 10 mrem total effective dose or more). These workers received a measurable dose that averaged 52 mrem. No administrative guidelines or regulatory dose limits were exceeded in 2011.

4.3.9 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 operations. Samples are analyzed for 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 operations. Technetium-99 and transuranics could come from PORTS operations 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 environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world.

DOE sets a limit of 100 mrem/year 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 (residential drinking water [well water], sediment, and soil) and biota (vegetation, deer, fish, crops, and dairy products) at off-site sampling locations with 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 risk because the public does not have access to the sampled areas of the facility. The summary of these dose calculations uses a worst-case approach; that is, the summary of the dose calculations assumes that the same individual is exposed to the most extreme conditions from each pathway.

In 2011, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, vegetation, crops, deer, and residential drinking water. Chapter 6, Section 6.4.13, provides additional information concerning detections of radionuclides in residential drinking water.

The following sections provide brief descriptions of the dose calculations for each monitoring program. 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. EPA 1997) 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* were used when available. This document integrates the results of technical meetings between U.S. EPA, 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 doses to the public from radionuclides detected by the PORTS environmental monitoring program in 2011 are significantly less than the DOE limit of 100 mrem/year.

Table 4.2. Summary of potential doses to the public from radionuclides detected by DOE environmental monitoring programs in 2011

Source of dose	Dose (mrem/year)[a]
Sediment	0.012
Soil	0.036
Vegetation	0.002
Crops	0.009
Deer	0.19
Drinking water	0.169
Total	0.42

[a]100 mrem/year is the DOE limit.

4.3.9.1 Dose calculation for sediment

The dose calculation for sediment is based on the following detections of radionuclides in the duplicate sample collected in 2011 from monitoring location RM-13, an off-site sampling location on Big Beaver Creek downstream from PORTS:

- neptunium-237: 0.0151 (picocuries per gram [pCi/g]),
- technetium-99: 4.34 pCi/g,
- uranium-233/234: 1.41 pCi/g,
- uranium-235: 0.0612 pCi/g,
- uranium-236: 0.0118 pCi/g, and
- uranium-238: 0.815 pCi/g.

Based on an ingestion rate of 200 milligrams (mg)/day (0.0007 ounces/day) and an exposure frequency of 85 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant*, and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by an individual from

sediment contaminated at these levels is 0.012 mrem/year. Section 4.6.5 provides additional information on the sediment monitoring program as well as a map of sediment sampling locations.

4.3.9.2 Dose calculation for soil

The dose calculation for soil is based on the detections of 0.0105 pCi/g of plutonium 239/240, 0.822 pCi/g of uranium-233/234, 0.0394 pCi/g of uranium-235, and 0.891 pCi/g of uranium-238 in soil at the ambient air monitoring station at Zahns Corner 2.6 miles northeast of PORTS (A41).

Based on an 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,* and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by an individual from soil contaminated at these levels is 0.036 mrem/year. Section 4.6.7 provides additional information on the soil monitoring program.

4.3.9.3 Dose calculation for vegetation

The dose calculation for vegetation is based on the following detections of radionuclides in soil and vegetation at ambient air monitoring station A41 (Zahns Corner):

Vegetation
- uranium-233/234: 0.00785 pCi/g, and

Soil
- plutonium-239/240: 0.0105 pCi/g,
- uranium-233/234: 0.822 pCi/g,
- uranium-235: 0.0394 pCi/g, and
- uranium-238: 0.891 pCi/g.

The dose calculation of 0.002 mrem/year is based on human consumption of beef cattle that would eat grass (and soil) contaminated at this level. Based on an ingestion rate for beef of 2 ounces/day and an exposure frequency of 365 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* and U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by an individual eating beef from cattle that grazed on vegetation and soil contaminated at these levels is 0.002 mrem/year. Section 4.6.8 provides additional information on the vegetation monitoring program.

4.3.9.4 Dose calculation for crops

The dose calculation for crops is based on the detection of americium-241 at 0.0125 pCi/g in sample of crops consisting of grapes, tomatoes, corn, soy beans, and peppers collected from off-site location #5. Based on an ingestion rate for home-grown vegetables of 1.2 pounds/day and an exposure frequency of 365 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* and U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by a person consuming crops contaminated at this level throughout the year is 0.009 mrem/year. Section 4.6.9.3 provides additional information on the monitoring program for crops.

4.3.9.5 Dose calculation for deer

The dose calculation for deer is based on the detection of uranium-233/234 at 0.01786 pCi/g in a deer muscle sample collected in January 2011 from a deer killed in a vehicle collision on site at PORTS. Based on a consumption rate for venison of 101 grams/day (0.2 pounds) for 365 days/year, as specified in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant,* the dose that could be received by a person consuming venison contaminated at

this level throughout the year is 0.19 mrem/year. Section 4.6.9.1 provides additional information on the deer monitoring program.

4.3.9.6 Dose calculation for residential drinking water

The dose calculation for residential drinking water is based on the detection of americium-241 at 0.0665 pCi/L in the first quarter sample collected from a residential drinking water supply north of PORTS on State Route 124. Based on a consumption rate of 700 liters of water/year (185 gallons), as specified in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant*, the dose that could be received by a person consuming water contaminated at this level throughout the year is 0.169 mrem/year. Chapter 6, Section 6.4.14 provides additional information on the water supply monitoring program.

4.4 PROTECTION OF BIOTA

DOE Order 458.1, which replaced DOE Order 5400.5 during 2011, 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 2002) was used to demonstrate compliance with these limits.

Analytical data for surface water and sediment collected from the northern side of the PORTS reservation (surface water sampling location NHP-SW01 and sediment sampling location RM-8) were used to assess the dose limits for aquatic and 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 2011. Section 4.6.5 and Chapter 6, Section 6.4.13 provide more information about these sediment and surface water sampling programs, respectively.

The maximum values of transuranic radionuclides, technetium-99, and uranium isotopes detected in sediment or surface water samples collected from these locations in 2011 were entered into the RESRAD-BIOTA program that is designed to implement the DOE Technical Standard (DOE 2002). The assessment indicates that the levels of radionuclides detected in water and sediment at these locations do not result in a dose of more than 1 rad/day to aquatic animals and 0.1 rad/day to riparian animals.

Analytical data for surface water and soil collected from the northern side of the PORTS reservation (surface water sampling location NHP-SW01 and soil sampling location A8) 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 2011. Section 4.6.7 and Chapter 6, Section 6.4.13 provide additional information about these soil and surface water sampling programs, respectively.

Data for the highest levels of radionuclides detected at these locations in 2011 were entered into the RESRAD-BIOTA program that is designed to implement the DOE Technical Standard (DOE 2002). The assessment indicates that the levels of radionuclides detected in water and soil at these locations do 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 2011.

4.6 ENVIRONMENTAL RADIOLOGICAL MONITORING

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

4.6.1 Ambient Air Monitoring

The ambient air monitoring stations measure radionuclides released from 1) DOE and USEC, Inc. point sources (the sources discussed in Section 4.3.2), 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, uranium-236, and uranium-238), technetium-99, and selected transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240).

In 2011, samples were collected from 15 ambient air monitoring stations located within and around PORTS (see Section 4.3.4, Figure 4.1), 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.

Americium-241, plutonium-238, and plutonium-239/240 were detected in a few of the samples collected from the ambient air stations in 2011. The maximum activity of americium-241 detected in air was 0.000011 picocurie per cubic meter (pCi/m^3) at station T7. The maximum activities of plutonium-238 (station A15) and plutonium-239/240 (station T7) were 0.0000094 pCi/m^3 and 0.00013 pCi/m^3, respectively. These detections are well below the derived concentration standards for each radionuclide: 0.097 pCi/m^3 (americium-241), 0.088 pCi/m^3 (plutonium-238), and 0.081 pCi/m^3 (plutonium-239/240).

Technetium-99 was detected at each of the 15 ambient air stations. The maximum activity of technetium-99 in ambient air was 0.028 pCi/m^3 at station A9 (southwest of the plant on Old U.S. Route 23), which is well below the DOE derived concentration standard of 920 pCi/m^3.

Uranium-233/234 and uranium-238 were detected in all of the samples. The maximum activity of uranium-233/234 in ambient air (0.00071 pCi/m^3) was detected at station A10 (on the northeastern plant boundary). The maximum activity of uranium-238 in ambient air (0.00027 pCi/m^3) was detected at station A41 (northeast of the plant at Zahns Corner). These activities are well below the DOE derived concentration standards for uranium-233/234 (1.1 pCi/m^3) and uranium-238 (1.3 pCi/m^3).

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 a dose to a hypothetical person living at the monitoring station. The highest net dose calculation for the off-site ambient air stations (0.0012 mrem/year) was at station A9, which is southwest of the plant on Old U.S. Route 23. This hypothetical dose is well below the 10 mrem/year limit applicable to PORTS. Section 4.3.4 provides additional information about this dose calculation.

4.6.2 Environmental Radiation

Radiation is measured continuously by DOE at 19 locations that include most of the ambient air monitoring locations (see Section 4.3.4, Figure 4.1) and other on-site locations (see Figure 4.3). Measuring devices 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 measuring device 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.

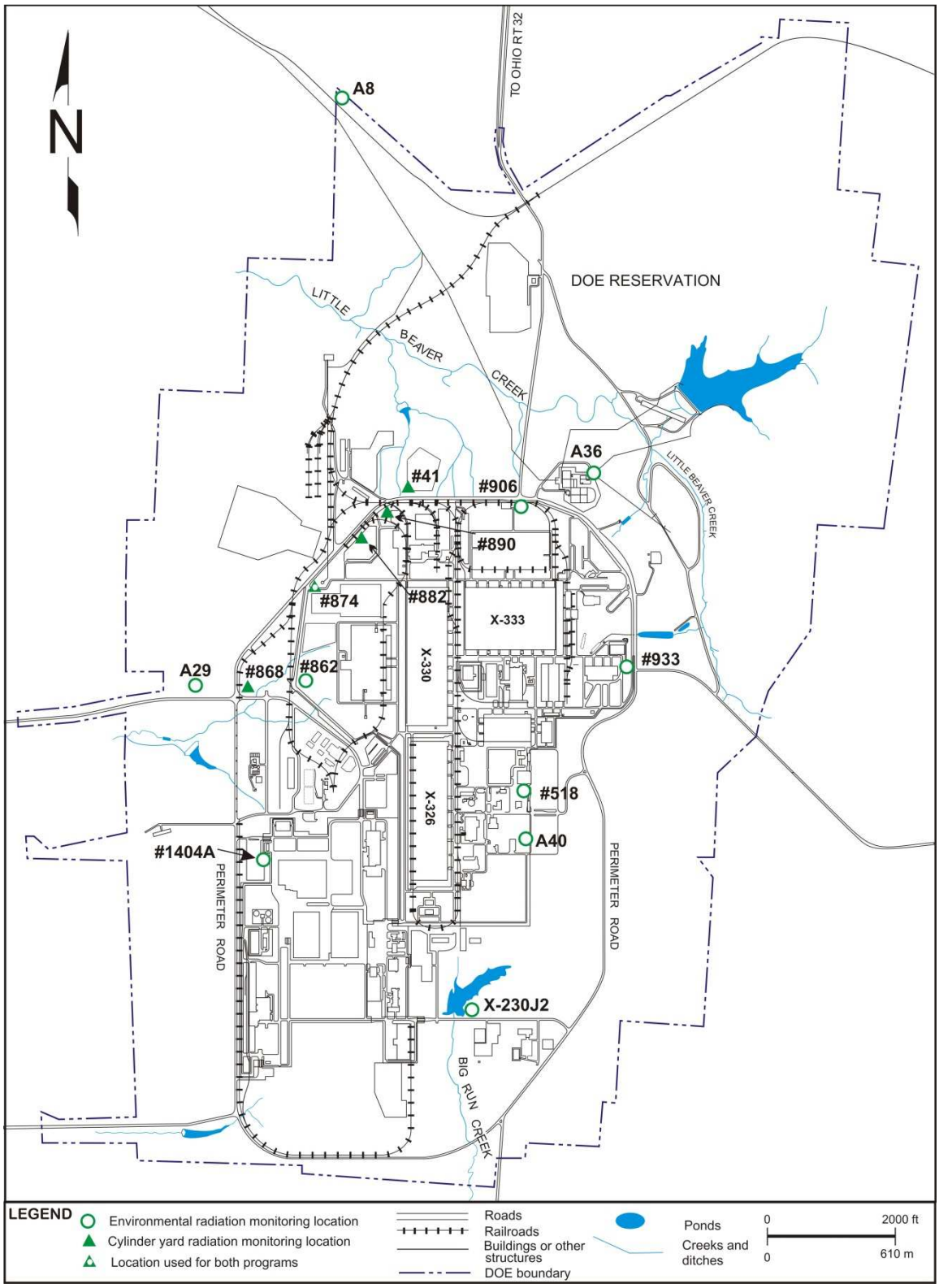

Figure 4.3. On-site radiation and cylinder yard dose monitoring locations.

Three locations detected elevated levels of radiation in 2011: location #874, which monitors the X-745C Cylinder Storage Yard; location #862, which is south of the cylinder yards and west of the X-530A Switchyards; and location #933, which is east of the X-744G building in the X-701B Holding Pond groundwater monitoring area. The cumulative whole body dose calculated for each of the other 16 locations (i.e., excluding locations #874, #862, and #933) ranged from 72 to 99 mrem and averaged 91 mrem. The cumulative whole body doses at locations #874, #862, and #933 were 765 mrem, 140 mrem, and 169 mrem, respectively. The control and trip blanks associated with all of the results for this monitoring program, which measure background radiation, averaged 73 mrem.

In addition, radiation is measured at five locations around the northwest corner of PORTS just inside Perimeter Road near the cylinder storage yards (see Figure 4.3). These locations are not accessible to the general public. The cumulative annual whole body doses at locations #41 and #890 were 280 mrem and 269 mrem, respectively. Locations #874 and #882 recorded cumulative annual whole body doses of 753 mrem and 1087 mrem, respectively, and location #868 recorded a cumulative annual whole body dose of 1702 mrem. Section 4.3.8 provides dose results for DOE workers, including workers in the cylinder yards. No administrative guidelines or regulatory dose limits were exceeded in 2011.

Section 4.3.7 provides a dose calculation for members of the public, such as delivery people, that are allowed on the portion of Perimeter Road near the cylinder storage yards. The potential estimated dose from the cylinder yards to a member of the public (0.81 mrem/year) is significantly less than DOE's 100 mrem/year dose limit to the public for radionuclides from all potential pathways.

4.6.3 Surface Water from Cylinder Storage Yards

Ohio EPA requires monthly collection of surface water samples from four locations: X-745C1 at the X-745C Cylinder Storage Yard, X-745E1 at the X-745E Cylinder Storage Yard, and X-745G1A and X-745G2 at the X-745G Cylinder Storage Yard. DOE voluntarily collects samples at three additional locations around the X-745C storage yard (X-745C2, X-745C3, and X-745C4). Figure 4.2 shows the sampling locations. Samples collected during 2011 were analyzed for alpha activity, beta activity, and uranium.

Uranium was detected at a maximum concentration of 17.2 µg/L in the sample collected during January 2011 at sampling location X-745C4. Maximum levels of alpha activity and beta activity (35.4 and 34.5 pCi/L, respectively) were detected in the sample collected from X-745C4 in July 2011. Other detections of alpha activity and beta activity during 2011 were less than 15 pCi/L. 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 4.3.5.1) are used in the dose calculation for releases to surface water (see Section 4.3.6). The dose from radionuclides released to surface water (the Scioto River) in 2011 (0.012 mrem) is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

4.6.4 Local Surface Water

In 2011, local surface water samples were collected from 14 locations upstream and downstream from PORTS. These samples were taken from the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek (see Figure 4.4). As background measurements, samples were also collected from local streams approximately 10 miles north, south, east, and west of PORTS.

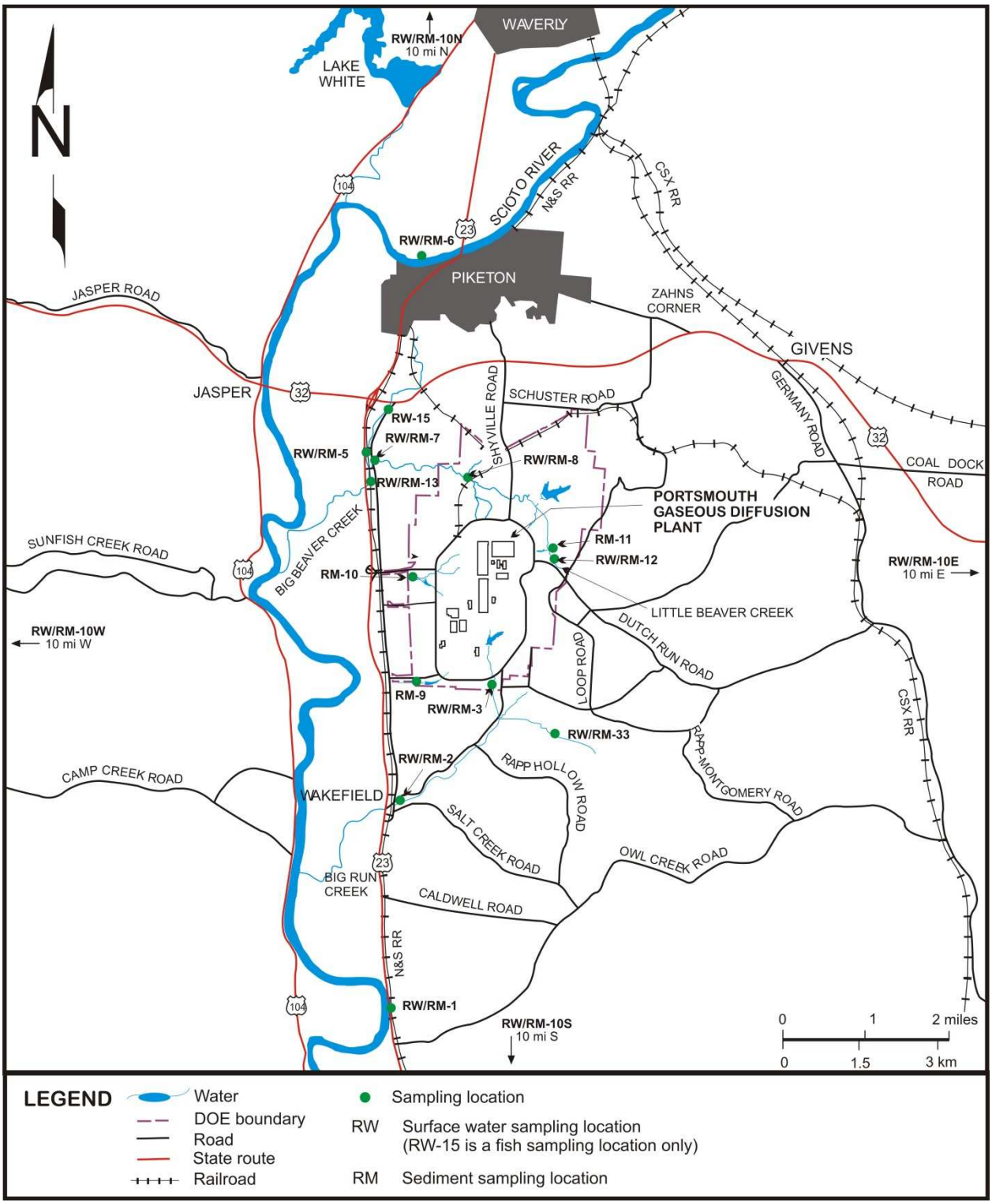

Figure 4.4. Local surface water and sediment monitoring locations.

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, uranium-236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*.

Americium-241 and/or plutonium-239/240 were detected at activities ranging from 0.0529 to 0.0756 pCi/L in samples collected from five locations: downstream locations on Big Run Creek (RW-2 and RW-3), a downstream location on Big Run Creek (RW-13), a downstream location on Little Beaver Creek (RW-7), and the upstream monitoring location on the Scioto River (RW-6). These detections are well below the DOE derived concentration standards for americium-241 and plutonium-239/240 in drinking water (170 pCi/L and 140 pCi/L, respectively).

Technetium-99 was detected at 9.05 pCi/L the second quarter sample collected from Little Beaver Creek at RW-7. Technetium-99 is occasionally detected at low levels in surface water samples collected downstream from PORTS. The detection is well below the DOE derived concentration standard for technetium-99 in drinking water (44,000 pCi/L).

Maximum detections of uranium and uranium isotopes in local surface water samples were detected at locations RW-7 or RW-8 on Little Beaver Creek. Uranium was detected at 1.84 µg/L, uranium-233/234 was detected at 2.42 pCi/L, uranium-235 was detected at 0.0937 pCi/L, and uranium-238 was detected at 0.608 pCi/L. Uranium-236 was not detected in any of the local surface water samples collected in 2011. Detections of uranium and uranium isotopes in local surface water samples in 2011 remain well below the DOE derived concentration standard for the respective uranium isotope in drinking water (680 pCi/L for uranium-233/234, 720 pCi/L for uranium-235, and 750 pCi/L for uranium-238).

4.6.5 Sediment

Sediment samples are collected from the same locations upstream and downstream from PORTS where local surface water samples are collected and at the NPDES outfalls on the east and west sides of PORTS (see Figure 4.4). 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, uranium-236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*.

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 locations RM-10W (the background sampling location west of PORTS) and RM-8 (Little Beaver Creek). Uranium was detected at 6.08 µg/g (RM-10W), uranium-233/234 was detected at 5.41 pCi/g (RM-8), uranium-235 was detected at 0.206 pCi/g (RM-8), uranium-236 was detected at 0.0536 pCi/g (RM-8), and uranium-238 was detected at 2.03 pCi/g (RM-10W). Uranium and uranium isotopes detected in the 2011 samples have been detected at similar levels in previous sampling events from 2002 through 2010.

Plutonium-239/240 and neptunium-237 were detected at very low activities ranging from 0.00548 to 0.0217 pCi/g in sediment samples collected from three locations on Little Beaver Creek (RM-11, RM-7, and RM-8) and one location on Big Beaver Creek (RM-13). These detections are much less than the U.S. EPA preliminary remediation goal for each radionuclide in residential soil: neptunium-237 (1 pCi/g), and plutonium-239/240 (2.59 pCi/g).

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS. In 2011, technetium-99 was detected in the sample collected from the upstream location on Big Beaver Creek (RM-5), the downstream location on Big Beaver Creek (RM-13), the downstream location on Big Run Creek (RM-3), and downstream locations on Little Beaver Creek (RM-11, RM-7, and RM-8). The

highest detection (9.58 pCi/g) was at location RM-8, a downstream location on Little Beaver Creek. These detections of technetium-99 are consistent with data from previous sampling events (2002 through 2010).

Section 4.3.9.1 provides a dose assessment to a member of the public based on detections of radionuclides at the downstream sampling location on Big Beaver Creek (RM-13). This off-site sampling location had the following levels of radionuclides detected in 2011 in the duplicate sample that would cause the highest dose to a member of the public: 0.0151 pCi/g of neptunium-237, 4.34 pCi/g of technetium-99, 1.44 pCi/g of uranium-233/234, 0.0612 pCi/g of uranium-235, 0.0118 pCi/g of uranium-236, and 0.815 pCi/g of uranium-238. The total potential dose to a member of the public resulting from PORTS operations (1.3 mrem/year), which includes this dose calculation (0.012 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.6 Settleable Solids

DOE collects semiannual water samples from three NPDES effluent locations (see Figure 4.5) 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 5400.5, *Radiation Protection of the Public and the Environment*, Chapter II, paragraph 3a(4). This paragraph states:

> *To prevent the buildup of radionuclide concentrations in sediments, liquid process waste streams containing radioactive material in the form of settleable solids may be released to natural waterways if the concentration of radioactive material in the solids present in the waste stream does not exceed 5 pCi (0.2 becquerel) per gram above background level, of settleable solids for alpha-emitting radionuclides or 50 pCi (2 becquerels) per gram above background level, of settleable solids for beta-gamma-emitting radionuclides.*

DOE Order 458.1, which replaced DOE Order 5400.5 during 2011, revised the requirements for this monitoring program. PORTS implemented the revised monitoring program in 2012.

Samples were collected from the three monitoring locations (X-616, X-6619, and Outfall 015) in June and December of 2011. Settleable solids were not detected in any of the samples collected in December 2011 or in the sample collected from X-616 in June 2011.

Settleable solids were detected in the samples collected in June 2011 from X-6619 (7.4 mg/L) and Outfall 015 (6.6 mg/L). When a low concentration of settleable solids is detected in a water sample, accurate measurement of the alpha and beta 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 5400.5 limits (5 pCi/g above background for alpha activity and 50 pCi/g above background for beta activity). Therefore, monitoring results for the settleable solids monitoring program are in compliance with the DOE Order.

4.6.7 Soil

Soil samples are collected annually from ambient air monitoring locations (see Figure 4.1) 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, uranium-236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*.

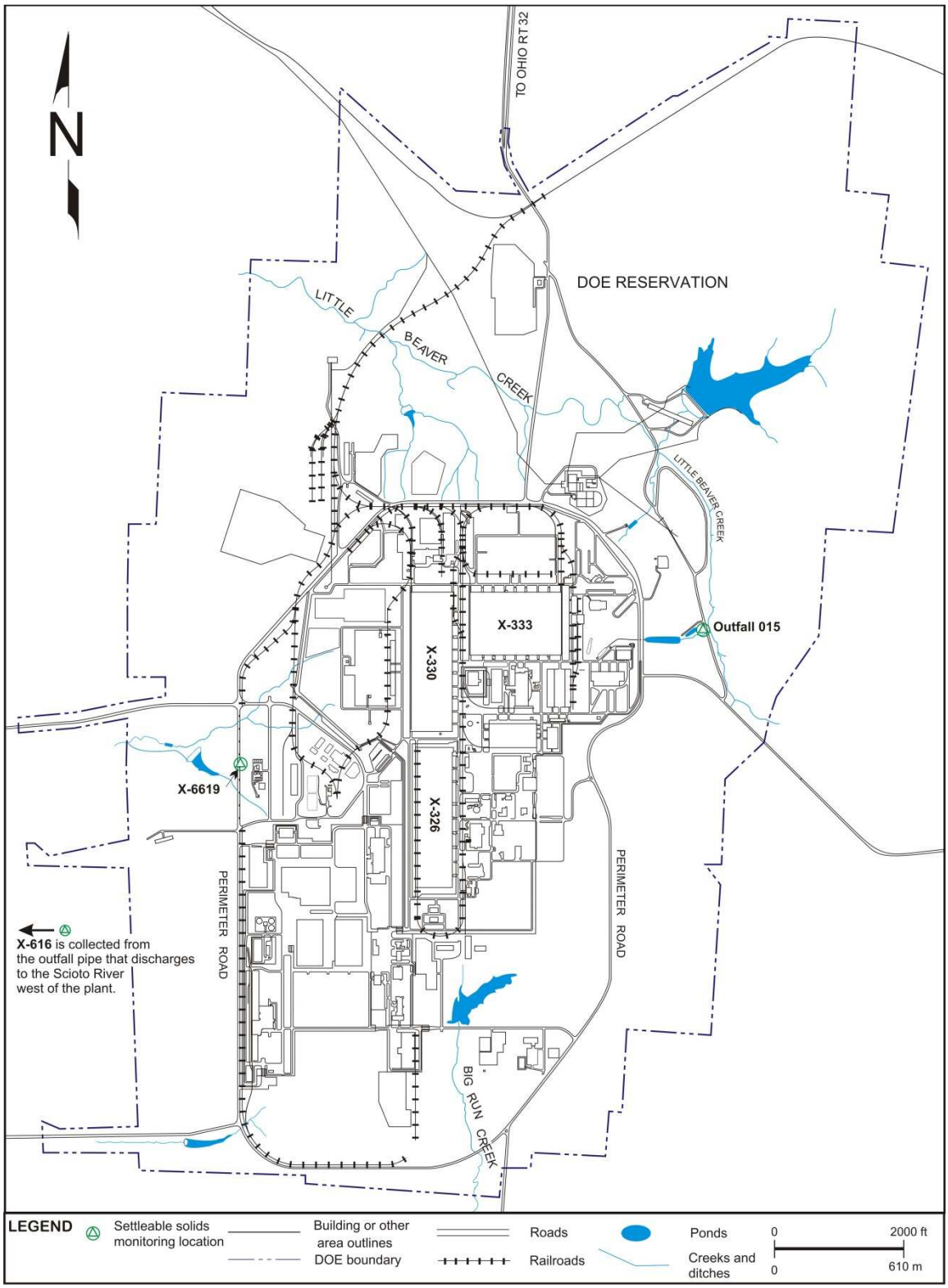

Figure 4.5. DOE settleable solids monitoring locations.

Plutonium-239/240 was detected at activities ranging from 0.0105 to 0.0144 pCi/g in the samples collected from 4 of the 15 monitoring stations. These detections are much less than the U.S. EPA preliminary remediation goal for plutonium-239/240 (2.59 pCi/g) in residential soil, and are most likely present due to atmospheric fallout from nuclear weapons testing. No other transuranics were detected in any of the soil samples collected during 2011.

Technetium-99 and uranium-236 were not detected in the soil samples collected during 2011. Uranium, uranium-233/234, uranium-235, and uranium-238 were detected at most of the sampling locations. Uranium and uranium isotopes are usually detected at similar levels at all the soil sampling locations, including the background location (A37), which suggests that the uranium detected in these samples is due to naturally-occurring uranium.

Section 4.3.9.2 provides a dose assessment based on the detections of plutonium-239/240 (0.0105 pCi/g), uranium-233/234 (0.822 pCi/g), uranium-235 (0.0394 pCi/g), and uranium-238 (0.891 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 A41 at Zahns Corner). The total potential dose to a member of the public resulting from PORTS operations (1.3 mrem/year), which includes this dose calculation (0.036 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.8 Vegetation

To assess the uptake of radionuclides into plant material, vegetation samples are collected in the same areas where soil samples are collected at the ambient air monitoring stations (see Figure 4.1). 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, uranium-236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*.

With the exception of uranium-233/234, no radionuclides were detected in vegetation samples collected in 2011. Uranium-233/234 was detected at 0.00785 pCi/g in the sample collected from station A41 (Zahns Corner). Uranium isotopes are detected occasionally in vegetation samples, and have been detected at similar levels in previous sampling (2002 through 2010). Section 4.3.9.3 provides a dose assessment for a member of the public based on consumption of beef cattle that would eat grass contaminated with radionuclides. The total potential dose to a member of the public resulting from PORTS operations (1.3 mrem/year), which includes this dose calculation (0.002 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.9 Biological Monitoring

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

4.6.9.1 Deer

Samples of liver, kidney, and muscle from deer killed on site in motor vehicle collisions were collected in January and December of 2011. 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, uranium-236, and uranium-238).

No transuranics or technetium-99 were detected in the deer samples collected during 2011. Uranium-233/234 was detected at levels ranging from 0.01521 to 0.0251 pCi/g in each of the samples collected from the deer killed in January 2011.

Section 4.3.9.5 provides a dose assessment to a member of the public based on consumption of venison containing uranium-233/234 at 0.01786 pCi/g (the level of uranium-233/234 detected in the muscle sample). The total potential dose to a member of the public resulting from PORTS operations (1.3 mrem/year), which includes this dose calculation (0.19 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.9.2 Fish

In 2011, samples from fish caught at downstream locations on the Scioto River (RW-1), Big Beaver Creek (RW-13), and Little Beaver Creek (RW-8) as well as the upstream locations on the Scioto River (RW-6) and Big Beaver Creek (RW-15) were analyzed for radionuclides. These radionuclides were transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). No radionuclides were detected in the fish samples collected during 2011.

4.6.9.3 Crops

In 2011, crop samples, including peppers, corn, tomatoes, cucumbers, and squash, were collected from five off-site locations near PORTS. Individual vegetables from each location were combined to make one sample from each location, called a composite sample. The composite sample from each location was 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, uranium-236, and uranium-238).

Americium-241 was detected at 0.0125 pCi/g in the sample collected from one of the off-site locations. Uranium (0.0289 µg/g), uranium-233/234 (0.00697 pCi/g) and uranium-238 (0.00947 pCi/g) were detected in the crop sample from a different off-site location. Section 4.3.9.4 provides a dose assessment to a member of the public based on consumption of vegetables containing radionuclides that would cause the highest dose to a member of the public (americium-241 at 0.0125 pCi/g). The total potential dose to a member of the public resulting from PORTS operations (1.3 mrem/year), which includes this dose calculation (0.009 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.9.4 Milk and eggs

Samples were collected in 2011 of milk produced by a dairy near Waverly and eggs from a farm near Lucasville. Each sample was 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, uranium-236, and uranium-238). No radionuclides were detected in the milk and egg samples collected during 2011.

4.7 RELEASE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

In 2011, no DOE property (equipment, excess materials, etc.) was released to the public that contained radioactive material that exceeded DOE release limits. The release limits are established in accordance with DOE Order 5400.5, which was replaced by DOE Order 458.1 during 2011, and Title 10 of the *Code of Federal Regulations*, Part 835.

In 2011, BWCS began shipment of hydrogen fluoride produced by the DUF_6 Conversion Facility, which converts DUF_6 into uranium oxide and hydrogen fluoride. Each shipment must meet the release limit of less than 3 picocuries/milliliter (pCi/mL) of total uranium activity. Just over 39,000 gallons of hydrogen fluoride were shipped off site during 2011. The average total uranium activity of all the shipments was 0.01 pCi/mL.