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 2009, environmental monitoring information was collected by DOE contractors (LPP and UDS) and USEC. Unlike other chapters of this report that focus primarily on DOE activities at PORTS, this chapter also includes information on air emissions and water discharges from USEC.

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. The U.S. EPA sets a 10 mrem/year limit for the dose from radionuclides released to the air, and the 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 2009 by environmental monitoring programs for sediment, soil, vegetation, crops, and eggs. The maximum dose a member of the public could receive from radiation released by PORTS in 2009 (both the DOE and USEC) or detected by environmental monitoring programs in 2009 is 0.94 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 2009

Source of dose	Dose (mrem/year)[a]
Airborne radionuclides	0.024
Radionuclides released to the Scioto River	0.037
Direct radiation from depleted uranium cylinder storage yards	0.72
Radionuclides detected by environmental monitoring programs (sediment, soil, vegetation, crops, and eggs)	0.16
Total	0.94

[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 impacts 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 DOE PORTS such as limitations on discharges to air and water. DOE Orders 231.1A, *Environment Safety and Health Reporting*, and 5400.5, *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 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 total 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.

Environmental monitoring data are collected by DOE contractors and USEC. Because USEC data are important in developing a complete picture of environmental monitoring at PORTS, these data are included in this report. This chapter provides information on the USEC NPDES monitoring program and air emissions of radionuclides. USEC data are provided for informational purposes only; the DOE cannot certify the accuracy of USEC data.

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

- Airborne discharges
- Ambient air
- Radiation
- Discharges to surface water
- Surface water
- Sediment
- Soil
- Vegetation
- Biota

The 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 the U.S. EPA and the DOE. Airborne releases of radionuclides from DOE facilities are regulated by the 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.

The DOE regulates radionuclide emissions to all environmental media through DOE Orders 450.1, *Environmental Protection Program,* and 5400.5, *Radiation Protection of the Public and the Environment.* DOE Order 5400.5 sets 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 2009. 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 2009 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 2009, 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 2009 as part of the DOE PORTS 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 usually completed based on the monitoring data. In 2009, doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, vegetation, crops, and eggs. 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 5400.5 sets an absorbed dose rate limit of 1 rad per day to native aquatic organisms. This chapter discusses the dose calculations completed to demonstrate compliance with this requirement.

DOE PORTS workers and visitors 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. Section 4.3.3 discusses the results of this dose calculation.

USEC operations account for many of the sources that emit radionuclides, although the gaseous diffusion uranium enrichment process is not operational. USEC emissions currently result from reprocessing of uranium hexafluoride feedstock, equipment decontamination, and the Lead Cascade (the demonstration centrifuge for uranium enrichment). In 2009, USEC reported emissions of 0.0305 curie (a measure of radioactivity) from its radionuclide emission sources.

DOE PORTS and LPP are responsible for five radiological emission sources. One source, the X-326 L-cage Glove Box, is 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, treat groundwater contaminated with radionuclides. There were no emissions from UDS air emission sources in 2009.

Emissions from the groundwater treatment facilities were calculated based on quarterly influent and effluent sampling at each facility and quarterly throughput. There were no emissions from the X-326 L-cage Glove Box in 2009. Emissions from the DOE sources in 2009 were calculated to be 0.054 curie.

4.3.3 Dose Calculation Based on Airborne Emissions

A dose calculation for atmospheric, or airborne, radionuclides is required by the U.S. EPA under NESHAP and is provided to the U.S. EPA in an annual report. The effect of radionuclides released to the atmosphere by PORTS during 2009 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 670,000 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 the 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 foodstuffs (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 the four DOE PORTS groundwater treatment facilities as 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 DOE 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 2009 was 0.019 mrem/year. USEC also completes the dose calculations described above for the air emission sources leased to USEC (e.g., the uranium enrichment facilities and other sources). The combined dose from USEC and DOE sources is 0.024 mrem/year, 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 2009, the population dose from PORTS emissions was 0.31 person-rem/year, based on USEC calculations of 0.14 person-rem/year from USEC sources and 0.17 person-rem/year from DOE sources. The population dose based on PORTS emissions is negligible; 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 is approximately 19,430 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

The 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 the DOE and USEC 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 2009 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 is considered zero at stations with a gross dose less than the dose measured at the background station. The net dose for each station ranged from 0 at station A6 in Piketon to 0.00024 mrem/year at station A24, which is north of PORTS at Schuster Road.

The highest net dose measured at the ambient air monitoring stations (0.00024 mrem/year at station A24) is 1% of the dose calculated from the combined DOE and USEC point source emissions (0.024 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 and UDS) and USEC are responsible for NPDES outfalls at PORTS. The UDS outfall is not monitored for radionuclides; therefore, it is not discussed in this section. A description of the LPP and USEC outfalls and the discharges of radionuclides from these outfalls during 2009 are included in this section. Quarterly reports that provide radiological monitoring data for the NPDES outfalls are submitted to Ohio EPA by LPP and USEC for their respective outfalls.

4.3.5.1 LPP outfalls

LPP currently holds an NPDES permit for four outfalls through which water is discharged from the site (see Figure 4.2).

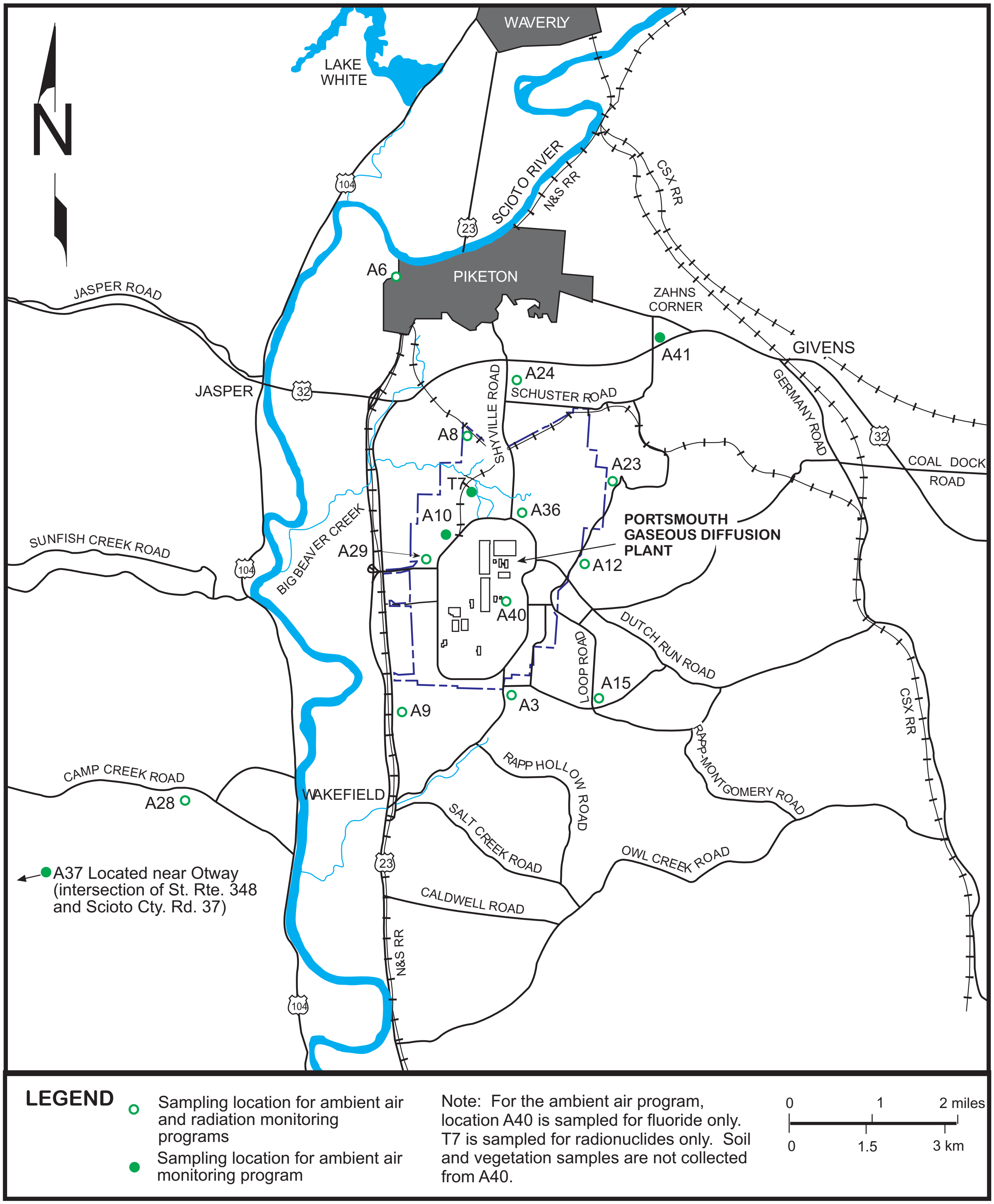

Figure 4.1. DOE ambient air and radiation monitoring locations.

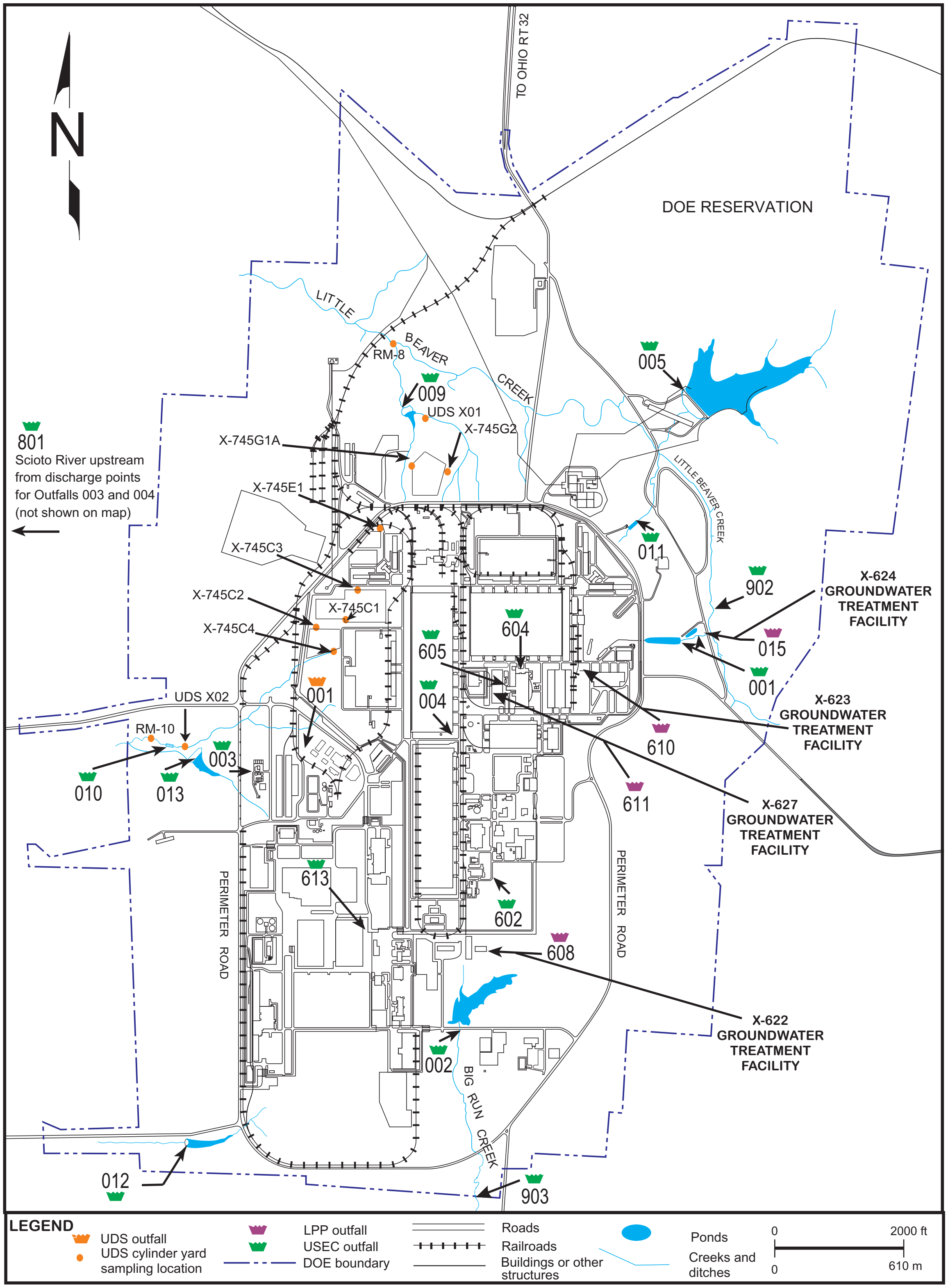

Figure 4.2. PORTS NPDES outfalls/monitoring points and UDS cylinder storage yards sampling locations.

Of the four LPP outfalls, one outfall discharges directly to Little Beaver Creek and the remaining three outfalls discharge to the USEC X-6619 Sewage Treatment Plant (USEC NPDES Outfall 003). A brief description of each LPP outfall at PORTS follows.

LPP 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.

LPP 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 USEC NPDES Outfall 003.

LPP 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 USEC NPDES Outfall 003.

LPP 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 USEC NPDES Outfall 003.

LPP monitors the NPDES outfalls for radiological discharges by collecting water samples and analyzing the samples for total 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).

Discharges of radionuclides in liquids through LPP NPDES outfalls have no significant impact on public health and the environment. Uranium discharges in 2009 from Outfall 015 (the only LPP outfall that discharges directly to surface water) were estimated at 0.014 kilogram. Total radioactivity released from Outfall 015 was 0.000018 curie of uranium isotopes.

Discharges of radionuclides were calculated using monthly monitoring data from LPP NPDES Outfall 015. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium and radiation discharged through the outfall. Discharges of radionuclides from Outfall 015 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 technetium-99 or transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were detected in samples collected from Outfall 015 during 2009.

4.3.5.2 USEC outfalls

USEC is currently responsible for 14 NPDES outfalls through which water is discharged from the site (see Figure 4.2). Ten outfalls discharge directly to surface water, and four discharge to another USEC NPDES outfall before leaving the site. A brief description of each USEC NPDES outfall follows.

USEC 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.

USEC 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.

USEC 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.

USEC 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 discharge to the Scioto River.

USEC 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.

USEC 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.

USEC 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.

USEC 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.

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 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 (USEC NPDES Outfall 002).

USEC 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 (USEC NPDES Outfall 003).

USEC 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 (USEC NPDES Outfall 003).

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 (USEC NPDES Outfall 003).

In 2009, USEC also monitored three additional monitoring points that are not discharge points as described in the previous paragraphs. USEC NPDES Station Number 801 is a background monitoring location on the Scioto River upstream from USEC NPDES Outfalls 003 and 004. USEC NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from USEC NPDES Outfall 001, and USEC NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from USEC NPDES Outfall 002.

Uranium discharges in 2009 from external USEC NPDES outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, 012, and 013) were estimated at 11.05 kilograms. Radioactivity released from the external outfalls was 0.08 curie of technetium-99. These values were calculated using quarterly discharge monitoring reports for the USEC 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 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 NPDES outfalls in 2009.

Discharges of radionuclides from external USEC outfalls 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 LPP 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 LPP and USEC NPDES external outfalls (one LPP outfall and ten USEC 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.

Total 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 LPP or USEC outfalls. As a conservative measure, radionuclides that were not detected were assumed to be present at the detection limit. Total 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: *LADTAPXL: An Improved Electronic Spreadsheet Version of LADTAP II* (Hamby 1991). 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 (90% of the hypothetical dose from liquid effluents is from drinking water). The dose from radionuclides released to the Scioto River in 2009 (0.037 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 the depleted uranium cylinders stored on site at PORTS in the X-745C, X-745E, and X-745G Depleted Uranium Hexafluoride Cylinder Storage Yards, which are located in the northwest portion of the site near Perimeter Road. Due to increased security at PORTS following September 11, 2001, the general public no longer has uncontrolled access to the portion of Perimeter Road near the cylinder yards; however, certain members of the public, such as delivery people, are allowed on this portion of the road. Therefore, 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 UDS cylinder storage yards in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (see Section 4.6.2). In 2009, the average effective dose equivalent recorded at the cylinder yards near Perimeter Road was 727 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 0.72 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 PORTS Workers and Visitors

The DOE PORTS Radiological Protection Organization monitors direct radiation levels in active DOE PORTS facilities 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 PORTS activities.

The Radiation Exposure Information Reporting System report is an electronic file created annually to comply with DOE Order 231.1A. This report contains exposure results for all monitored individuals at DOE PORTS, including visitors, with a positive exposure during the previous calendar year. The 2009 Radiation Exposure Information Reporting System report indicated that no visitors received a measurable dose (defined as 10 mrem or more).

Eleven hundred eighty-one DOE PORTS workers (LPP, TPMC, and UDS) were monitored during 2009. The monitored workers received an average dose of 1.3 mrem/person. No administrative guidelines or regulatory dose limits were exceeded in 2009.

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 transuranics 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.

The 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 detections of radionuclides in environmental media (residential drinking water [well water], sediment, and soil) and biota (vegetation, deer, fish, crops, and dairy products) at off-site sampling locations. Detections of radionuclides on the PORTS facility are not used to assess risk because the public does not have access to 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 2009, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, vegetation, crops, and eggs. Radionuclides were not detected in deer, fish, and milk samples collected during 2009. 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 the U.S. EPA including the *Exposure Factors Handbook* (U.S. EPA 1997) and *Internal Dose Conversion Factors for Calculation of Dose to the Public* (DOE 1988). 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 2009 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 PORTS environmental monitoring programs in 2009

Source of dose	Dose (mrem/year)[a]
Sediment	0.052
Soil	0.078
Vegetation	0.014
Crops	0.0014
Eggs	0.019
Total	0.16

[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 sediment sample collected in 2009 from monitoring location RM-7, an off-site sampling location on Little Beaver Creek downstream from PORTS: americium-241 (0.02173 pCi/g), neptunium-237 (0.08866 pCi/g), plutonium-238 (0.01444 pCi/g), plutonium-239/240 (0.06676 pCi/g), technetium-99 (57.4 pCi/g), uranium-233/234 (2.01 pCi/g), uranium-235 (0.07306 pCi/g), and uranium-238 (0.5539 pCi/g). Based on exposure factors from 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 0.052 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 1.05 pCi/g of uranium-233/234, 0.05005 pCi/g of uranium-235, and 1.089 pCi/g of uranium-238 in soil at the ambient air sampling station in Piketon (A6). Based on exposure factors from 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 0.078 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 detections of 0.4415 pCi/g of uranium-233/234, 0.02318 pCi/g of uranium-235, and 0.4581 pCi/g of uranium-238 in vegetation and 0.8317 pCi/g of uranium-233/234, 0.04178 pCi/g of uranium-235, and 0.9464 pCi/g of uranium-238 in soil at sampling location A24, which is north of PORTS at Schuster Road. The dose calculation of 0.014 mrem/year is based on human consumption of beef cattle that would eat grass contaminated at this level and exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997). 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 uranium-233/234 at 0.02682 pCi/g in a melon collected from off-site location #4. Based on exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by a person consuming melon contaminated at this level throughout the year is 0.0014 mrem/year. Section 4.6.9.3 provides additional information on the monitoring program for crops.

4.3.9.5 Dose calculation for eggs

The dose calculation for eggs is based on the detection of uranium-233/234 at an average level of 0.008485 pCi/g in the regular and duplicate egg samples collected from a location in Wakefield. Uranium-233/234 was detected at 0.009984 pCi/g in the regular sample and 0.006986 pCi/g in the duplicate sample; the average level of uranium-233/234 detected in the eggs is 0.008485 pCi/g. Based on exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by a person consuming eggs contaminated at this level throughout the year is 0.019 mrem/year. Section 4.6.9.4 provides additional information on the dairy (milk and eggs) monitoring program.

4.4 PROTECTION OF BIOTA

DOE Order 5400.5 sets an absorbed dose rate of 1 rad/day to native aquatic organisms. The DOE Technical Standard *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) was used to demonstrate compliance with this limit.

Analytical data for radionuclides detected in sediment and surface water collected at approximately the same location are used to assess compliance with the 1 rad/day limit for aquatic organisms. Data used in the evaluation are sampling data collected at sampling location RW/RM-7, which are off-site surface water and sediment sampling locations just before Little Beaver Creek flows into Big Beaver Creek. Sections 4.6.4 and 4.6.5 provide more information about the local surface water and sediment 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 2009 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 this location do not result in a dose of more than 1 rad/day to aquatic organisms.

Although there are no formal DOE limits for the dose rate to terrestrial biota, it is recommended that DOE sites meet international limits for terrestrial biota that are 1 rad/day for terrestrial plants and 0.1 rad/day for terrestrial animals. Analytical data for surface water and soil collected from the northern side of the PORTS reservation (surface water sampling location RW-8 and soil sampling location A8) were used to assess the dose recommendations for terrestrial plants and animals. These locations were selected because levels of uranium isotopes detected in surface water and soil from these locations were among the highest detected in samples collected in 2009. Sections 4.6.4 and 4.6.7 provide additional information for the local surface water and soil sampling programs, respectively.

Data for the highest levels of radionuclides detected at these locations in 2009 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 this location 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 DOE PORTS in 2009.

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 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 2009, 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.

No transuranic radionuclides were detected in the samples collected from the ambient air stations in 2009. Technetium-99 was detected at stations A23 (the northeastern plant boundary), and A24 (north of the plant on Schuster Road). The maximum activity of technetium-99 in ambient air was 0.0031 picocurie per cubic meter (pCi/m^3) at station A24, which is well below the DOE derived concentration guide of 2000 pCi/m^3.

Uranium-233/234 and uranium-238 were detected in all of the samples. The highest average activity of uranium-233/234 (0.00083 pCi/m^3) was detected at station A29 (on site at the Ohio Valley Electric Corporation). The highest average activity of uranium-238 (0.00073 pCi/m^3) was detected at station A28 (southwest of the plant on Camp Creek Road). These average activities are well below the DOE derived concentration guides for uranium-233/234 (0.09 pCi/m^3) and uranium-238 (0.1 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 (0.00024 mrem/year) was at station A24, which is north of the plant on Schuster Road. 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 the 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.

Three locations detected elevated levels of radiation in 2009: location #874, which monitors the X-745C Depleted Uranium 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 61 to 95 mrem and averaged 79 mrem. The cumulative whole body doses at locations #874, #862, and #933 were 687 mrem, 124 mrem, and 173 mrem, respectively. The control and trip blanks associated with all of the results for this monitoring program, which measure background radiation, averaged 80 mrem.

In addition, radiation is measured at five locations around the northwest corner of PORTS just inside Perimeter Road near the UDS depleted uranium 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 249 mrem and 211 mrem, respectively. Locations #874 and #882 recorded cumulative annual whole body doses of 688 mrem and 937 mrem, respectively, and location #868 recorded a cumulative annual whole body dose of 1549 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 2009.

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 UDS cylinder storage yards. The potential estimated dose from the cylinder yards to a member of the public (0.72 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 UDS Cylinder Storage Yards

The Ohio EPA requires monthly collection of surface water samples from four locations: X-745C1 at the X-745C Depleted Uranium Hexafluoride Cylinder Storage Yards, X-745E1 at the X-745E Depleted Uranium Hexafluoride Cylinder Storage Yard, and X-745G1A and X-745G2 at the X-745G Depleted Uranium Hexafluoride Cylinder Storage Yard. The 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 2009 were analyzed for alpha activity, beta activity, and total uranium.

Uranium was detected at a maximum concentration of 15.9 µg/L in the sample collected during March 2009 at sampling location X-745C1. Detections of alpha activity and beta activity during 2009 were less than 20 pCi/L (alpha activity) and 25 pCi/L (beta activity). Surface water from the cylinder storage yards flows to USEC NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the USEC outfalls. Radionuclides detected at USEC outfalls (see Section 4.3.5.2) 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 2009 (0.037 mrem) is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

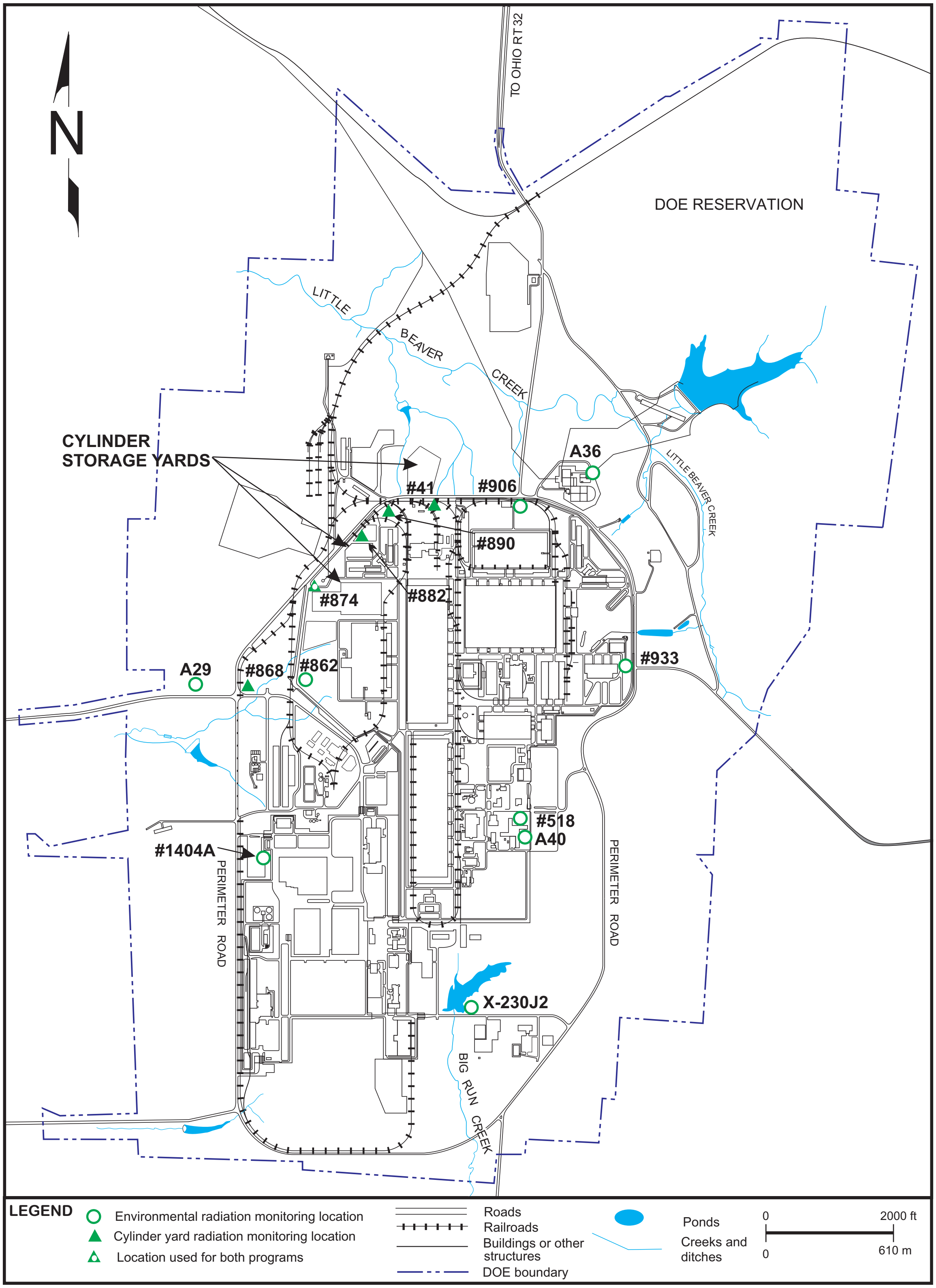

Figure 4.3. On-site radiation and cylinder yard dose monitoring locations.

4.6.4 Local Surface Water

In 2009, 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.

Samples were collected semiannually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total 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*.

No transuranics or technetium-99 were detected in any of the surface water samples collected in 2009. Maximum detections of uranium and uranium isotopes in local surface water samples were detected at location RW-8 (Little Beaver Creek). Uranium was detected at 6.21 µg/L, uranium-233/234 was detected at 2.691 pCi/L, uranium-235 was detected at 0.1132 pCi/L, and uranium-238 was detected at 2.075 pCi/L. Uranium-236 was not detected in any of the local surface water samples collected in 2009. Detections of uranium and uranium isotopes in local surface water samples in 2009 remain well below the DOE derived concentration guide for the respective uranium isotope in drinking water (500 pCi/L for uranium-233/234 and 600 pCi/L for uranium-235 and 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, total 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), RM-11 (on site near USEC NPDES Outfalls 010 and 013), and RM-8 (Little Beaver Creek). Uranium was detected at 2.882 µg/g (RM-10W), uranium-233/234 was detected at 3.554 pCi/g (RM-11), uranium-235 was detected at 0.1436 pCi/g (RM-11), uranium-236 was detected at 0.008971 pCi/g (RM-8), and uranium-238 was detected at 0.963 pCi/g (RM-10W). Uranium and uranium isotopes detected in the 2009 samples have been detected at similar levels in previous sampling events from 1999 through 2008.

Transuranic radionuclides were detected at very low activities in two sediment sampling locations upstream from PORTS (RM-5 – upstream on Big Beaver Creek and RM-33 – upstream on Big Run Creek), one background location (RM-10S – 10 miles south of PORTS), and five locations downstream from PORTS (locations on Little Beaver Creek, Big Beaver Creek, and the Scioto River). The highest detections for each transuranic radionuclide were at one of the downstream sampling locations on Little Beaver Creek (RM-7). Americium-241 was detected at 0.02173 pCi/g, neptunium-237 was detected at 0.08866 pCi/g, plutonium-238 was detected at 0.01444 pCi/g, and plutonium-239/240 was detected at 0.06676 pCi/g. These detections are much less than the U.S. EPA preliminary remediation goal for each radionuclide in residential soil: americium-241 – 1.87 pCi/g, neptunium-237 – 1 pCi/g, plutonium-238 – 2.97 pCi/g, and plutonium-239/240 – 2.59 pCi/g.

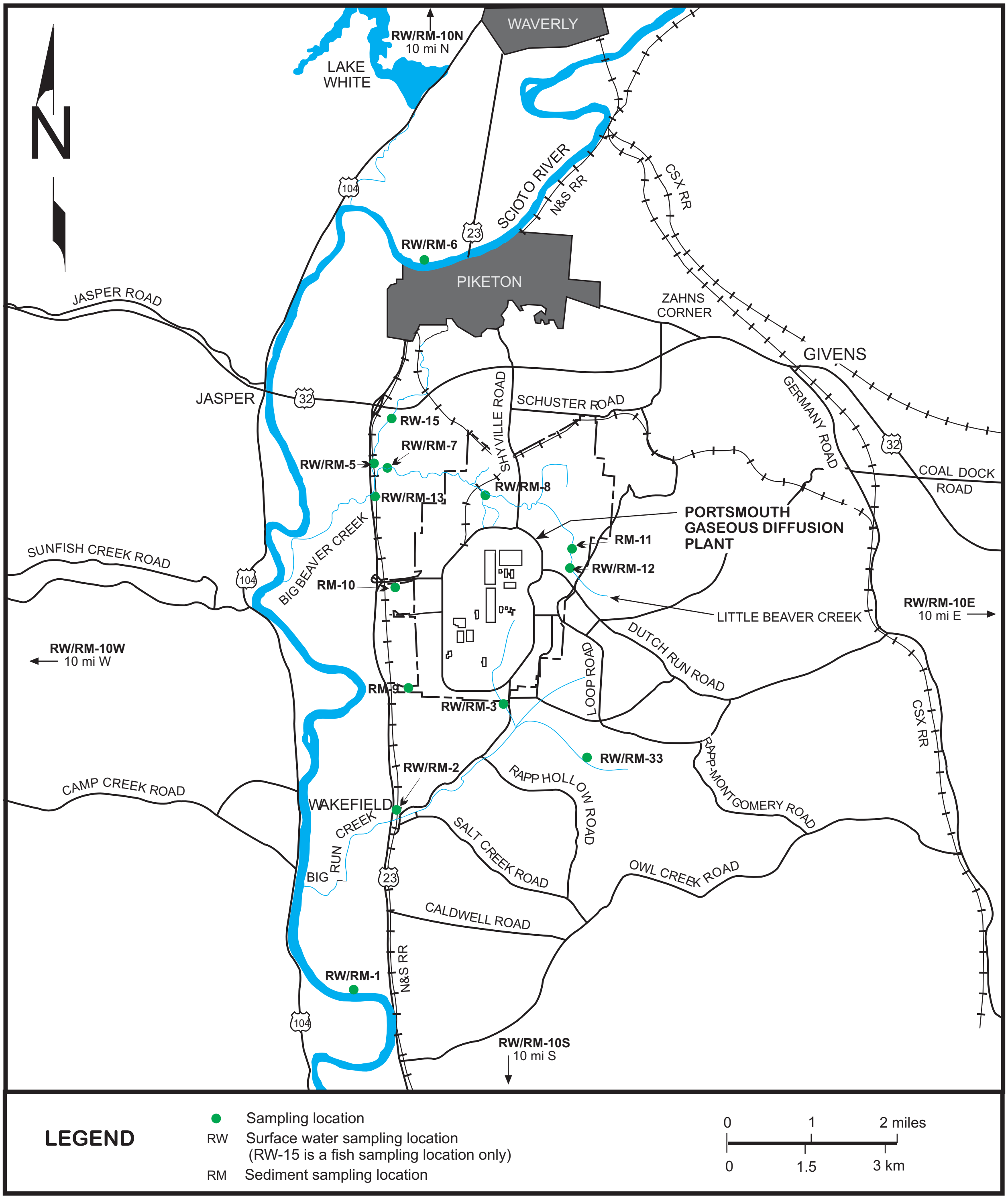

Figure 4.4. Local surface water/sediment monitoring locations.

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS. In 2009, technetium-99 was detected in the sample collected from the downstream location on Big Beaver Creek (RM-13), the downstream location on Big Run Creek (RM-3), the west drainage ditch location near USEC NPDES Outfalls 010 and 013 (RM-10), and downstream locations on Little Beaver Creek (RM-11, RM-7, and RM-8). The highest detection (57.4 pCi/g) was at location RM-7, a downstream location on Little Beaver Creek. These detections of technetium-99 are consistent with data from previous sampling events (2002 through 2008).

Section 4.3.9.1 provides a dose assessment to a member of the public based on detections of transuranics, technetium-99 and uranium isotopes at the downstream sampling location on Little Beaver Creek just before it flows into Big Beaver Creek (RM-7). This off-site sampling location had the following levels of radionuclides detected in 2009 that would cause the highest dose to a member of the public: 0.02173 pCi/g of americium-241, 0.08866 pCi/g of neptunium-237, 0.01444 pCi/g of plutonium-238, 0.06676 pCi/g of plutonium-239/240, 57.4 pCi/g of technetium-99, 2.01 pCi/g of uranium-233/234, 0.07306 pCi/g of uranium-235, and 0.5539 pCi/g of uranium-238. The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.052 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.6 Settleable Solids

The 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.*

Two samples are collected from each of the three monitoring locations. The first sample is analyzed for total suspended solids, total alpha activity, and total beta activity. The second sample is analyzed for non-settleable solids, total alpha activity, and total beta activity.

In 2009, alpha and beta activity were not detected in the samples, therefore; the DOE standards (5 pCi/g for alpha activity and 50 pCi/g for beta activity) were not exceeded at any location.

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, total 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*.

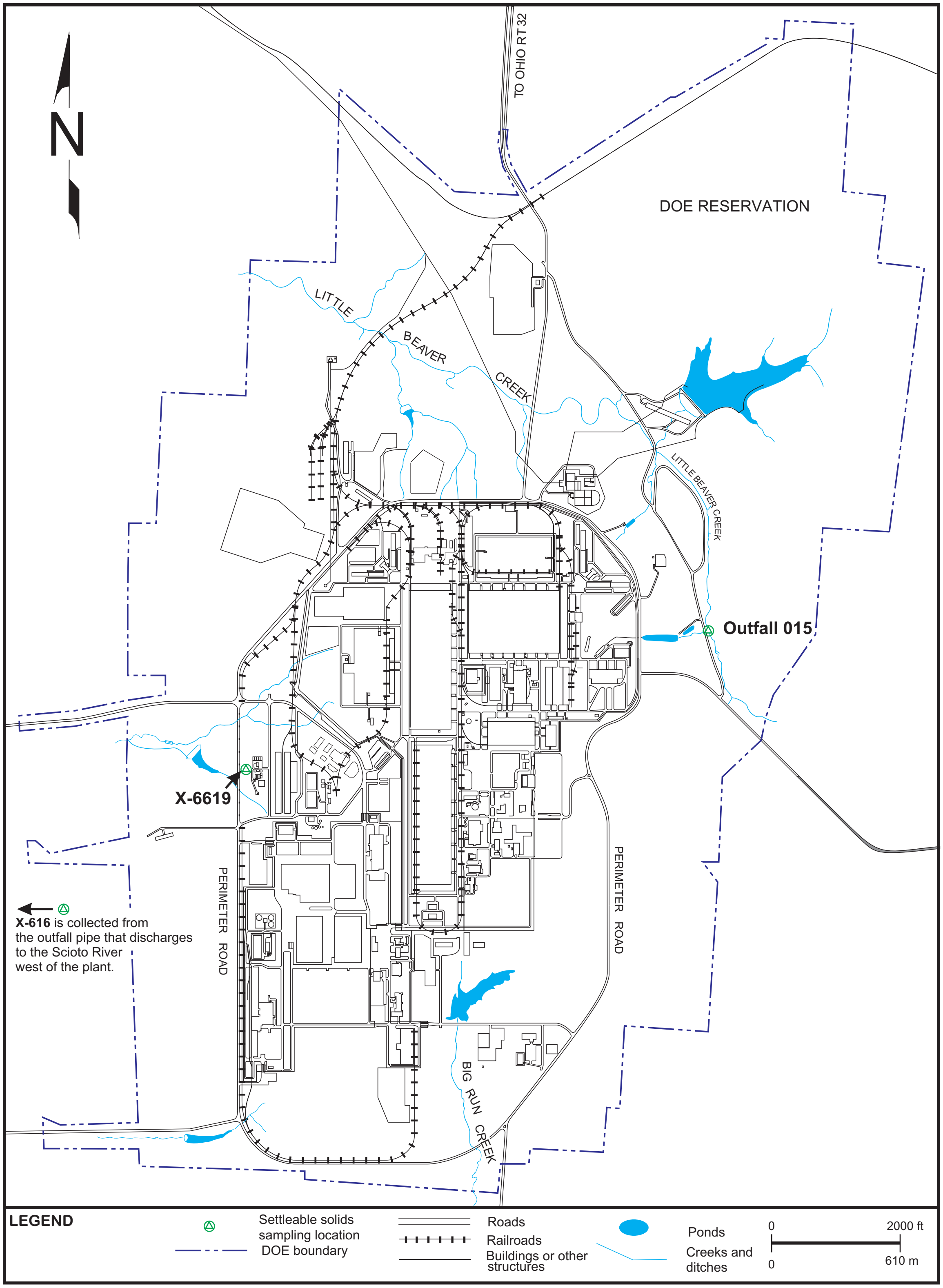

Figure 4.5. DOE settleable solids monitoring locations.

No transuranics or technetium-99 were detected in the soil samples collected during 2009. Uranium (total), uranium-233/234, uranium-235, and uranium-238 were detected at most of the sampling locations. Uranium-236 was not detected in any of the soil samples collected in 2009. Uranium and uranium isotopes were 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 uranium-233/234 (1.05 pCi/g), uranium-235 (0.05005 pCi/g), and uranium-238 (1.089 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 A6 in Piketon). The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.078 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, total 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*.

No transuranics were detected in vegetation samples collected in 2009. Technetium-99 was detected at 0.361 and 0.141 pCi/g, respectively, in the samples collected from stations A23 (the northeastern plant boundary) and A36 (on site near the X-611 Water Treatment Plant). Technetium-99 is occasionally detected at low activities less than 1 pCi/g at the ambient air monitoring stations.

Uranium, uranium-233/234, uranium-235, and/or uranium-238 were detected in the samples collected from nine of the fifteen monitoring stations, including the background monitoring station A37. Uranium and uranium isotopes are detected occasionally, and have been detected at similar levels in previous sampling (2002 through 2008). 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 that could cause the highest dose to a member of the public (station A24). The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.014 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 collisions with motor vehicles were collected in April and November of 2009. The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). No radionuclides were detected in the samples.

4.6.9.2 Fish

In 2009, fish were caught at downstream locations on the Scioto River (RW-1) and Little Beaver Creek (RW-8) as well as upstream locations on the Scioto River (RW-6) and Big Beaver Creek (RW-15). The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). No radionuclides were detected in the fish samples.

4.6.9.3 Crops

In 2009, 17 crop samples, including peppers, corn, tomatoes, cucumbers, melon, and zucchini, were collected from five residential locations near PORTS.

Each sample was analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). No transuranics or technetium-99 were detected in any of the samples. Uranium-233/234 was detected at 0.02682 pCi/g in the melon sample. No other radionuclides were detected in the samples.

Section 4.3.9.4 provides a dose assessment to a member of the public based on consumption of melon containing uranium-233/234 at 0.02682 pCi/g. The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.0014 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.9.4 Milk and eggs

Two samples (a regular and a duplicate sample) were collected in 2009 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, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). No radionuclides were detected in the milk samples collected during 2009.

Uranium-233/234 was detected at 0.009984 pCi/g in the regular egg sample and at 0.006986 pCi/g in the duplicate sample. Uranium is occasionally detected at low levels in the dairy samples. No other radionuclides were detected in the egg samples.

Section 4.3.9.5 provides a dose assessment to a member of the public based on consumption of eggs containing uranium-233/234 at an average level of 0.008485 pCi/g (the average of 0.009984 and 0.006986 pCi/g). The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.019 mrem/year), is well below the DOE standard of 100 mrem/year.

4.7 RELEASE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

In 2009, no DOE property (equipment, excess materials, etc.) was released to the public that contained radioactive material that exceeded the release limits for DOE PORTS. The release limits are established in accordance with DOE Order 5400.5 and Title 10 of the *Code of Federal Regulations,* Part 835.