U.S. Department of Energy

Portsmouth Annual Environmental Report for 1999

Prairie and Wetland Habitat at the Portsmouth Gaseous Diffusion Plant

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EQ Midwest
contributed to the preparation of this document and should not be considered an eligible contractor for its review.

This document has received the appropriate reviews for release to the public.

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curie
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
kg	kilogram
LLW	low-level radioactive waste
μg/L	microgram per liter (equivalent to part per billion)
mrem	millirem
NPDES	National Pollutant Discharge Elimination System
pCi/L	picocurie per liter
PK	Peter Kiewit
PORTS	Portsmouth Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
TLD	thermoluminescent dosimeter
USEC	United States Enrichment Corporation

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DEFINITIONS

absorption – The process by which the number and energy of particles or photons entering a body of matter are reduced by interaction with the matter.

activity – See "radioactivity."

alpha particle – A positively charged particle having the same charge and mass as that of a helium nucleus (two protons and two neutrons). Alpha particles are emitted from the nucleus of an atom during radioactive decay.

ambient air – The atmosphere around people, plants, and structures.

analyte – A constituent or parameter being analyzed.

aquifer – A geologic formation capable of yielding a significant amount of groundwater to wells or springs.

atom – Smallest particle of an element capable of entering into a chemical reaction.

background radiation – Radiation that occurs naturally in the surrounding environment.

Becquerel (Bq) – The International Standard unit that measures the amount of radiation in disintegrations per second. Radioactivity is caused when atoms disintegrate, ejecting energetic particles. One Becquerel is the radiation caused by one disintegration per second.

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

biota – The animal and plant life of a particular region considered as a total ecological entity.

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

chain-of-custody – A form that documents sample collection, transport, and analysis.

closure – Control of a closed hazardous waste management facility under Resource Conservation and Recovery Act requirements.

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

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

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

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

critical habitat – Specific areas that may require special management considerations or protection and on which physical or biological features essential to the conservation of a species are found.

curie (Ci) – A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

> **kilocurie (kCi)** – 10^3 Ci, one thousand curies; 3.7×10^{13} disintegrations per second.
> **millicurie (mCi)** – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.
> **microcurie (μCi)** – 10^{-6} Ci, one-millionth of a curie, 3.7×10^4 disintegrations per second.
> **picocurie (pCi)** – 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegration per second.

daughter – A nuclide formed by the radioactivity decay of a parent nuclide.

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

decontamination and decommissioning – The cleanup and removal of buildings, structures, or objects contaminated with hazardous substances during past production or disposal activities.

derived concentration guide – The concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation) would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and the lens of the eye. The guidelines for radionuclides in air and water are provided in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

disintegration, nuclear – A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dissolved solids – Organic or inorganic material dissolved in water. Excessive amounts of dissolved solids make water unfit to drink or to use in industrial processes.

downgradient – In the direction of groundwater flow.

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

effluent – A liquid or gaseous waste discharge to the environment.

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

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

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

external radiation – The exposure to ionizing radiation when the radiation source is located outside the body.

formation – In geologic terms, a unit of rock or a unit of material that could form a rock such as sand.

friable – The ability of a material to be pulverized, crumbled, or reduced to powder by hand pressure when dry.

gamma ray – High-energy short-wavelength electromagnetic radiation emitted from the nucleus of a charged atom. Gamma rays are identical to X-rays except for the source of the emission.

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

gray (Gy) – The International Standard unit of measurement of absorbed radiation.

groundwater – Water below the land surface in a zone where all void space between rocks, soil, etc., is filled with water.

hexavalent – A compound that has six valence electrons.

half-life, radiological – The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

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

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

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

internal radiation – Occurs when natural radionuclides enter the body by ingestion of food or water or by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion – An atom or compound that carries an electrical charge.

irradiation – Exposure to radiation.

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

> **long-lived isotope** – A radionuclide that decays at such a slow rate that a given quantity will exist for an extended period (half-life is greater than three years).
> **short-lived isotope** – A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

jurisdictional wetland – An area that is periodically or permanently inundated by surface or ground water, supports plants adapted to wetlands, and has soil typically found in wetlands, but is not associated with an active holding pond.

leachate – A liquid that results from water collecting contaminants as it trickles through wastes, agricultural pesticides, or fertilizers. Leaching may occur in farming areas, feed lots, and landfills and may result in hazardous substances entering surface water, groundwater, or soil.

manifest – A form required by RCRA that is used to document and track waste during transportation and disposal.

maximally exposed individual – A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

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

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

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

mrem – The dose equivalent that is one-thousandth of a rem.

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

non-jurisdictional wetland – An area that is periodically or permanently inundated by surface or ground water, supports plants adapted to wetlands, and has soil typically found in wetlands, and is associated with an active holding pond.

nuclide – An atom specified by atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall – The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

parent nuclide – An element from which other elements are formed through the loss of protons.

person-rem – Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

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

PCB – An industrial compound, used primarily as a lubricant, which is produced by adding chlorine to biphenyl, a colorless, crystalline compound.

preliminary remediation goal – The concentration of a constituent in environmental media (soil, groundwater, etc.) that is considered protective of human health and the environment.

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

quality control – The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

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

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

radioisotopes – Radioactive isotopes.

radionuclide – An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accomplished by the emission of photons or particles.

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

rem – The unit of dose equivalent (absorbed dose in rads multiplied by the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation – The correction or cleanup of a site contaminated with waste. See "Environmental Restoration."

reportable quantity – A release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

Resource Conservation and Recovery Act (RCRA) – Legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

roentgen – A unit of exposure from X-rays or gamma rays. One roentgen equals 2.58×10^{-4} coulombs per kg of air.

routine radioactive release – A planned or scheduled release of radioactivity to the environment.

sievert (Sv) – The International System of Units unit of dose equivalent; 1 Sv = 100 rem.

source – A point or object from which radiation or contamination emanates.

stable – Not radioactive or not easily decomposed or otherwise modified chemically.

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

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

suspended solids – Mixture of fine, nonsettling particles of any solid within a liquid or gas.

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

transuranics – Elements such as plutonium and neptunium that have atomic numbers (the number of protons in the nucleus) greater than 92. All transuranics are radioactive.

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

trivalent – A compound that has three valence electrons.

troughing system – A system designed to collect leaking PCBs in the PORTS process buildings.

turbidity – A measure of the concentration of sediment or suspended particles in solution.

upgradient – In the opposite direction of groundwater flow.

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

volatile organic compounds – Chemicals composed primarily of hydrogen, oxygen, and carbon that readily volatilize into the air. They include light alcohols, acetone, trichloroethene, dichloroethene, benzene, vinyl chloride, toluene, methylene chloride, and many other compounds.

wetland – A lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support plants typically adapted to life in wet soils.

EXECUTIVE SUMMARY

SITE AND OPERATIONS OVERVIEW

The Portsmouth Gaseous Diffusion Plant (PORTS) is one of two uranium enrichment facilities operating in the United States (see Fig. 1). Responsibility for implementing environmental compliance at PORTS is split between the U.S. Department of Energy (DOE), as site owner, and the United States Enrichment Corporation (USEC), a corporation formed by the Energy Policy Act of 1992 to operate the nation's uranium enrichment business. The uranium enrichment production and operations facilities at the site are leased to USEC.

Bechtel Jacobs Company LLC assumed responsibility as the management contractor for DOE on April 1, 1998. Bechtel Jacobs Company is responsible for environmental restoration, waste management, uranium programs, and operation of nonleased facilities at PORTS. With the exception of Chap. 4, Environmental Monitoring, and Chap. 5, Dose, this report does not cover USEC operations at PORTS. USEC data is included in these two chapters to provide a more complete picture of the programs in place at PORTS to detect and assess potential impacts to human health and the environment resulting from PORTS activities.

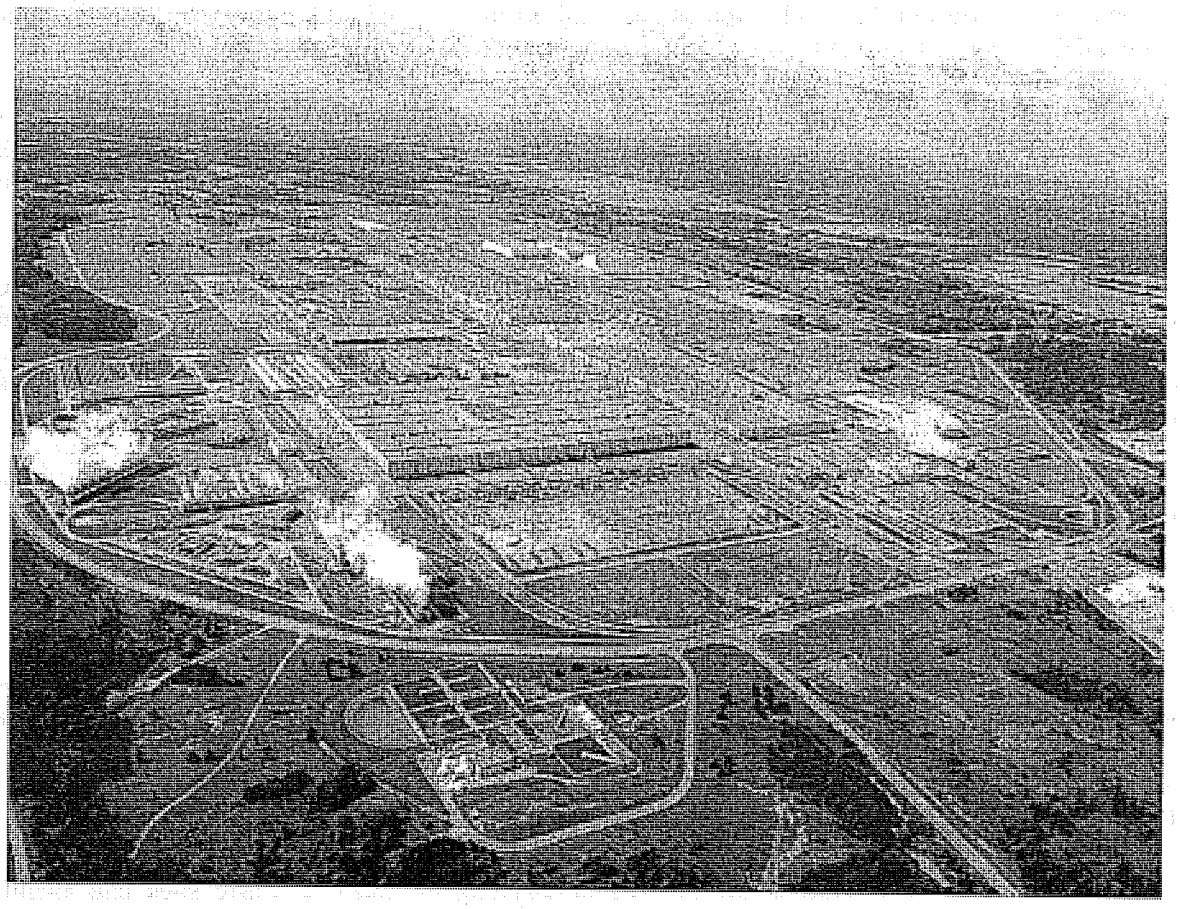

Fig. 1. The Portsmouth Gaseous Diffusion Plant.

PORTS is located on 5.8 square miles in Pike County, Ohio. The county has approximately 24,250 residents.

ENVIRONMENTAL COMPLIANCE

Several federal, state, and local agencies are responsible for enforcing environmental regulations at PORTS. DOE/PORTS conducts a self-assessment program that addresses environmental concerns and involves regulatory agencies to verify appropriate actions are being taken to maintain compliance. DOE/PORTS has been issued a National Pollutant Discharge Elimination System (NPDES) permit for discharge of water to surface streams, several air emission permits, and a Resource Conservation and Recovery Act (RCRA) permit for storage of hazardous wastes.

Environmental compliance activities in 1999 included (1) continued management of RCRA hazardous waste in accordance with the facility's permit and applicable regulations, (2) continued management of PCBs in accordance with the Toxic Substances Control Act and the PORTS Federal Facilities Compliance Agreement, (3) preparation of the annual National Emissions Standards for Hazardous Air Pollutants report for radiological emissions, (4) receipt of a new air emission permit associated with remedial activities at the X-734 landfill, (5) ongoing monitoring of NPDES outfalls, (6) submittal of information for the hazardous chemical inventory required by the Emergency Planning and Community Right-to-Know Act, and (7) submittal of the Toxic Chemical Release inventory report.

None of the NPDES permit limits were exceeded during 1999. No violations of air permits or National Emission Standards for Hazardous Air Pollutants limits occurred in 1999 at DOE/PORTS. No unplanned releases of hazardous substances that required reporting under environmental regulations occurred in 1999.

In 1999, one Notice of Violation was issued to DOE by the Ohio Environmental Protection Agency (EPA). Ohio EPA issued a Notice of Violation regarding revisions to one of PORTS RCRA Corrective Action Program documents: the *Quadrant I Cleanup Alternatives Study/Corrective Measures Study*. This dispute was resolved in 2000 and Ohio EPA considers DOE to have returned to compliance concerning the issue that caused the Notice of Violation.

No Notices of Violation were issued to DOE/PORTS in 1999 resulting from inspections by regulatory agencies.

ENVIRONMENTAL PROGRAMS

Environmental Restoration, Waste Management, and Public Information Programs are conducted at PORTS to protect and inform the local population, improve the quality of the environment, and comply with federal and state regulations.

Environmental Restoration Program

Environmental restoration is the process of cleaning up inactive waste sites and facilities to demonstrate that risks to human health and the environment are either eliminated or reduced to safe levels. DOE established the Environmental Restoration Program to find, analyze, and correct site contamination problems as quickly and inexpensively as possible. This task may be accomplished by removing, stabilizing, or treating hazardous substances. Program expenditures in 1999 were $21 million.

The Ohio Consent Decree and the U.S. EPA Administrative Consent Order require investigation and cleanup of PORTS in accordance with the RCRA Corrective Action Program. The site is divided into four quadrants to facilitate the investigation and cleanup.

Following approval of the cleanup alternative study/corrective measures study for Quadrant III and the X-734 Landfill Area in Quadrant IV, the Ohio EPA issued decision documents to notify DOE/PORTS of the final remedial actions (corrective measures) chosen for these areas. Implementation of these final remedial actions began in 1999.

The *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was submitted to Ohio EPA on May 28, 1999. Based on comments received from both the U.S. EPA and Ohio EPA, the *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was revised and resubmitted to Ohio EPA on December 28, 1999. Development of the *Quadrant II Cleanup Alternative Study/Corrective Measures Study* continued in 1999.

Waste Management Program

The DOE/PORTS Waste Management Program directs the safe storage, treatment, and disposal of waste generated from plant operations and from environmental restoration projects.

Waste management activities must comply with DOE Orders, Ohio EPA regulations, and U.S. EPA regulations. Waste management requirements are varied and often complex because of the variety of wastes generated by DOE/PORTS activities. The types of waste managed by DOE/PORTS include:

- *Low-level radioactive waste (LLW)* – radioactive waste not classified as high level or transuranic and that does not contain any components regulated by RCRA or the Toxic Substances Control Act.

- *Hazardous (RCRA) waste* – waste that contains one or more of the wastes listed under RCRA or that exhibits one or more of the four RCRA hazardous characteristics: ignitability, corrosivity, reactivity, and toxicity.

- *RCRA/LLW mixed waste* – waste containing both hazardous and radioactive components. The waste is subject to RCRA, which governs the hazardous components, and to additional regulations that govern the radioactive components.

- *PCB wastes* – waste containing PCBs, a class of synthetic organic chemicals. Under Toxic Substances Control Act regulations, PCB manufacturing was prohibited after 1978. However, continued use of PCBs is allowed, provided that the use does not pose a risk to human health or the environment. Disposal of all PCB materials is regulated under the Toxic Substances Control Act.

- *PCB/LLW mixed waste* – waste containing both PCB and radioactive components. The waste is subject to the Toxic Substances Control Act that governs PCB components, and to additional regulations that govern radioactive components.

- *Industrial sanitary waste* – waste generated by commercial operations, such as office waste.

Supplemental policies also have been implemented for waste management including minimizing waste generation; characterizing and certifying wastes before they are stored, processed, treated, or disposed; pursuing volume reduction (such as blending and bulking) as well as on-site storage in preparation for safe and compliant final treatment and/or disposal; and recycling.

Public Awareness Program

DOE provides a public Environmental Information Center to allow access to all documents used to make decisions on remedial actions being taken at PORTS. The information center is located on the plant-site just outside the E-Vehicle portal and is open 9 a.m. to 12 p.m. Monday and Tuesday, 12 p.m. to 4 p.m. Wednesday and Thursday, or by appointment (740-289-3317). Additional information is provided by the DOE Site Office (740-897-2001) and the Bechtel Jacobs Company Public Affairs Manager (740-897-2336).

Semiannual public update meetings and public workshops on specific topics are held to keep the public informed and to receive their comments and questions. Fact sheets about major projects are produced periodically for the public, and semiannual environmental bulletins are printed and distributed to more than 4,000 recipients, including those on the community relations mailing list, neighbors residing within 2 miles of PORTS, and all plant employees and retirees.

ENVIRONMENTAL MONITORING

Environmental monitoring at PORTS includes air, water, soil, and biota (animals, vegetation, and crops) and includes measurement of both radiological and chemical parameters. Environmental monitoring programs may be required by regulations, permit requirements, and DOE Orders, but also may be developed to reduce public concerns about plant operations. In 1999, environmental monitoring information was collected by both DOE and USEC for the following programs:

- Airborne discharges,
- Ambient air,
- Direct radiation,
- Discharges to surface water,
- Surface water,
- Sediment,
- Soil,
- Vegetation, and
- Biota.

Evaluation of 1999 environmental monitoring data indicates that PORTS activities in 1999 had a minimal environmental impact, if any, inside or outside facility boundaries.

DOSE

Potential impacts on human health from radionuclides released by PORTS operations are calculated based on environmental monitoring data. 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 millirem (mrem)/year limit for dose from radionuclides released to the air and the DOE sets a 100 mrem/year limit for dose from radionuclides from all potential pathways (air, water, and direct radiation). A person living in southern Ohio receives a dose of approximately 300 mrem/year from natural sources of radiation (National Council on Radiation Protection 1987) Fig. 2 provides a comparison of the doses from various common radiation sources.

This report includes radiological dose calculations for the dose to the public from radionuclides released to the air and surface water, and from direct radiation based on environmental monitoring data

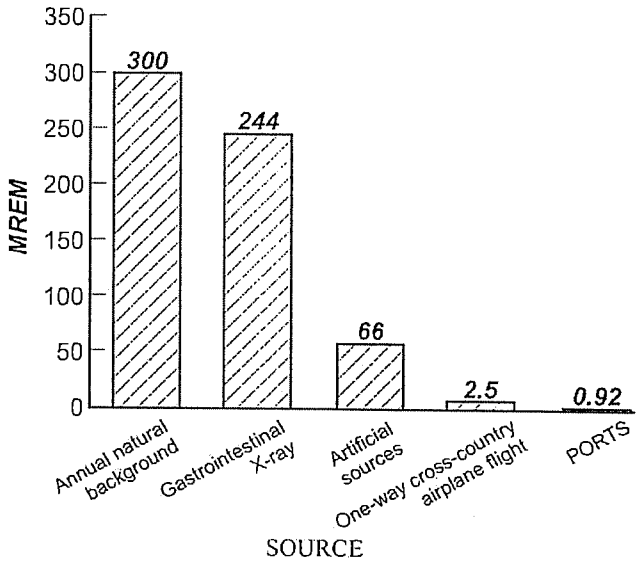

Fig. 2. Comparison of dose from various common radiation sources.

collected by both DOE and USEC. The maximum dose a member of the public could receive from radiation released by PORTS in 1999 is 0.92 mrem, based on a maximum dose of 0.28 mrem from airborne radionuclides, 0.053 mrem from radionuclides released to the Scioto River, and 0.59 mrem from direct radiation from the PORTS depleted uranium cylinder storage yards.

GROUNDWATER PROGRAMS

Groundwater monitoring at DOE/PORTS includes RCRA hazardous waste units, solid waste disposal units, and RCRA Corrective Action Program units. In 1999, the *Integrated Groundwater Monitoring Plan* became the implementing document for groundwater monitoring at PORTS. The *Integrated Groundwater Monitoring Plan* was designed to minimize the potential for confusion interpreting requirements and to maximize resources for collecting the data. The plan establishes all groundwater monitoring requirements for PORTS and has been reviewed and approved by Ohio EPA.

Additional groundwater monitoring is completed to meet DOE Order requirements. Exit pathway monitoring assesses the effect of DOE/PORTS on regional groundwater quality and quantity. Baseline monitoring is conducted to establish background data for use in assessing the effect of DOE/PORTS operations on the groundwater. DOE Orders are also the basis for the radiological monitoring of groundwater at PORTS.

Five groundwater contamination plumes have been identified onsite at PORTS. The primary groundwater contaminant is trichloroethene. Remediation of groundwater is being addressed under Ohio EPA's RCRA Corrective Action Program. No significant changes in the groundwater plumes were noted in 1999.

The *Integrated Groundwater Monitoring Plan* also addresses monitoring of residential water supplies near PORTS to verify that site contaminants have not migrated off site. Results of this program indicate that PORTS has not affected drinking water outside the site boundaries.

QUALITY ASSURANCE AND QUALITY CONTROL

Data reliability is of the utmost importance for monitoring releases and measuring radiation in the environment. To demonstrate that the monitoring and measurement results are accurate, DOE/PORTS has implemented a quality assurance and quality control program based on guidelines from the U.S. EPA, the American Society for Testing and Materials, and other federal and state agencies. The DOE/PORTS staff administers numerous quality control activities to verify reliability of the data on a day-to-day basis.

DOE/PORTS also participates actively in quality control programs administered by agencies outside the site such as the U.S. EPA.

1. SITE AND OPERATIONS OVERVIEW

1.1 SUMMARY

The Portsmouth Gaseous Diffusion Plant (PORTS) is located on a 5.8-square-mile site in a rural area of Pike County, Ohio. U.S. Department of Energy (DOE) activities at PORTS include environmental restoration, waste management, and operation of nonleased facilities. Production facilities for the separation of uranium isotopes are leased to the United States Enrichment Corporation (USEC). USEC activities are not covered by this document, with the exception of the environmental monitoring programs discussed in Chap. 4 and radiological dose information in Chap. 5.

1.2 INTRODUCTION

PORTS is owned by DOE. Effective July 1, 1993, DOE leased the production facilities at the site to USEC, which was established by the Energy Policy Act of 1992. USEC became a publicly-held corporation in 1998. Lockheed Martin Utility Services managed and operated the leased facilities for USEC through May 17, 1999, at which time USEC assumed these responsibilities. Bechtel Jacobs Company LLC has managed the DOE programs at PORTS since April 1, 1998.

This report is intended to fulfill the substantive requirements of DOE Order 5400.1, *General Environmental Protection Program.* This DOE Order requires development of an Annual Site Environmental Report that includes information on regulatory compliance, environmental programs, radiological and non-radiological monitoring programs, groundwater programs, and quality assurance. This report is not intended to present all of the monitoring data at PORTS. Additional data collected for other site purposes, such as environmental restoration and waste management, are presented in other documents that have been prepared in accordance with applicable laws. These data are available through other mechanisms.

1.3 DESCRIPTION OF SITE LOCALE

DOE/PORTS is located in a rural area of Pike County, Ohio, on a 5.8-square-mile site (see Fig. 1.1). The site is 2 miles east of the Scioto River in a small valley running parallel to and approximately 120 feet above the Scioto River floodplain. Fig. 1.2 depicts the plant site and its immediate environs.

Pike County has approximately 24,250 residents. Scattered rural development is typical; however, the county contains numerous small villages such as Piketon, Wakefield, and Jasper that lie within a few miles of the plant. The county's largest community, Waverly, is about 10 miles north of the plant and has a population of about 4,500 residents. The nearest

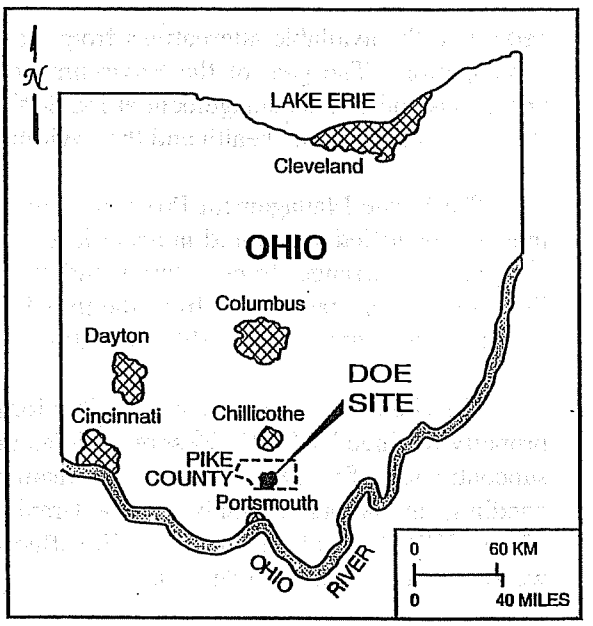

Fig. 1.1. Location of PORTS within the State of Ohio.

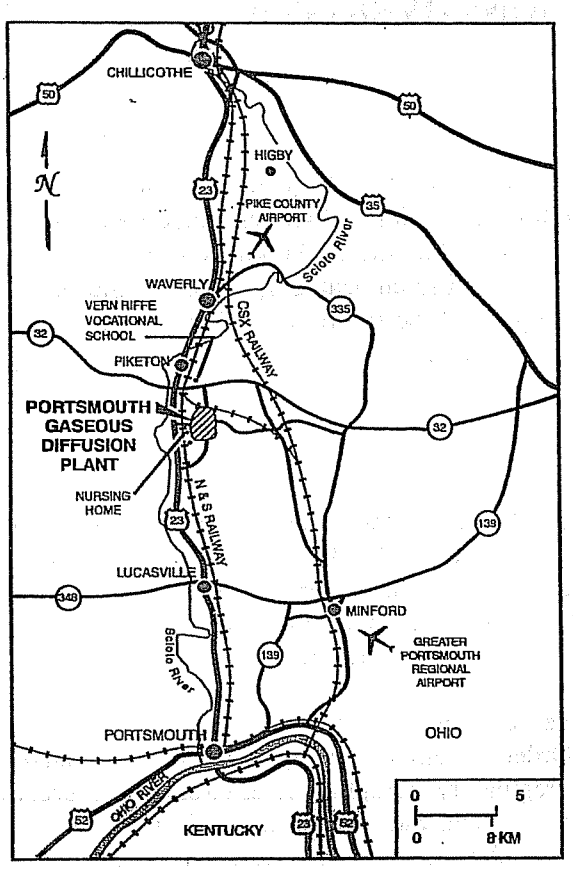

Fig. 1.2. Location of PORTS in relation to the geographic region.

residential center in this area is Piketon, which is about 5 miles north of the plant on U.S. Route 23; its population is about 1,700. Several residences are adjacent to the southern half of the eastern boundary and along Wakefield Mound Road (old U.S. 23), directly west of the plant. One nursing home, with a capacity of 36 persons, is located along Wakefield Mound Road.

Additional population centers within 50 miles of the plant are Portsmouth (population 22,249), 27 miles south; Chillicothe (population 21,923), 27 miles north; and Jackson (population 6,144), 18 miles east. The total population within 50 miles of the plant is approximately 600,000 persons (1990 U.S. Census).

1.4 DESCRIPTION OF SITE OPERATIONS

DOE, through its managing contractor Bechtel Jacobs Company, operates the Environmental Restoration, Waste Management, and Uranium Programs at the plant, as well as other nonleased DOE property. The Environmental Restoration Program performs remedial investigations to define the nature and extent of contamination, evaluate the risk to public health and the environment, and determine the available alternatives from feasibility studies of potential remedial actions for sites under investigation. The goal of the Environmental Restoration Program is to verify that releases from past operations and waste management at DOE/PORTS are thoroughly investigated and that remedial action is taken to protect human health and the environment.

The Waste Management Program is responsible for managing wastes generated at the site. Wastes must be identified and stored in accordance with all environmental regulations. The Waste Management Program also arranges transportation and off-site disposal of wastes. The goal of the Waste Management Program is to manage waste from the time it is generated to its ultimate treatment, recycling, or disposal in accordance with all applicable regulations.

The Uranium Program is responsible for the cost-effective management of PORTS facilities and real property retained by DOE. Responsibilities include managing contracts between DOE/PORTS and other subcontractors for such services as maintenance, utilities, chemical operations, uranium material handling, and laboratory analysis. The Uranium Program also oversees the management and coordination of the PORTS Depleted Uranium Hexafluoride and Lithium Management and Storage Programs and warehousing of uranium materials.

2. ENVIRONMENTAL COMPLIANCE

2.1 SUMMARY

DOE/PORTS is required to operate in accordance with environmental regulations established by federal and state laws, executive orders, DOE Orders, and compliance agreements. This chapter summarizes DOE/PORTS compliance status with regard to these various authorities.

2.2 INTRODUCTION

Responsibility for implementing environmental compliance at PORTS is divided between DOE (as the site owner) and USEC. USEC is responsible for compliance activities directly associated with the operations that are leased from DOE, including air emission permits for uranium enrichment facilities and water discharge permits for several holding ponds and water treatment facilities. USEC is also responsible for the management of wastes generated by current enrichment operations. DOE retains responsibility for "legacy" wastes, which contain constituents such as asbestos and PCBs that were used in DOE operations and became prohibited from use by law prior to the lease agreement. DOE is also responsible for the Environmental Restoration Program, Waste Management Program, and operation of all nonleased facilities.

DOE/PORTS has been issued a National Pollutant Discharge Elimination System (NPDES) permit for discharge of water to surface streams, several air emission permits, and a Resource Conservation and Recovery Act (RCRA) Part B permit for the storage of hazardous wastes. Appendix B lists the active DOE/PORTS environmental permits for 1999.

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

DOE/PORTS conducts self-assessments to identify environmental issues and consults the regulatory agencies to identify the appropriate actions necessary to achieve and maintain compliance.

2.3 COMPLIANCE PROGRAMS

2.3.1 Ohio Consent Decree and U.S. EPA Administrative Consent Order

A Consent Decree with the State of Ohio, issued on August 29, 1989, and an Administrative Consent Order with the U.S. EPA, issued on September 29, 1989 (amended in 1994 and 1997), require the investigation and cleanup of surface water and air releases, groundwater contamination plumes, and solid waste management units. PORTS was divided into four quadrants based on groundwater flow patterns to facilitate the expedient cleanup of contaminated sites in accordance with RCRA corrective action and closure requirements. The Environmental Restoration Program at PORTS addresses requirements of the Ohio Consent Decree and U.S. EPA Administrative Consent Order. Chap. 3 provides additional information on the Environmental Restoration Program.

2.3.2 Resource Conservation and Recovery Act

RCRA regulates the generation, accumulation, storage, transportation, and disposal of wastes. Wastes are designated as hazardous by the EPA because of various chemical properties, including ignitibility, corrosivity, reactivity, and toxicity.

2.3.2.1 Hazardous waste

DOE/PORTS is permitted by Ohio EPA to store hazardous waste in the X-7725 and X-326 facilities. The permit, often called a Part B Permit, was issued to DOE/PORTS in 1995. The permit includes requirements for identification of hazardous wastes, inspections of storage areas and emergency equipment, emergency procedures, training requirements, and other information required by Ohio EPA. The Part B Permit requires DOE/PORTS to submit a quarterly report to Ohio EPA detailing any permit violations that occurred during the previous quarter. No violations occurred during 1999.

On March 25 and March 29, 1999, Ohio EPA conducted an inspection of the RCRA storage facilities and operating record for compliance with RCRA requirements. No Notices of Violation were received from Ohio EPA as a result of this inspection.

RCRA also requires closure of areas formerly used to store hazardous waste. Of the 23 areas at PORTS that were formerly used to store hazardous waste, 18 have been closed in accordance with Ohio EPA requirements. In 1999, the five remaining areas that require closure were designated as "integrated units" by Ohio EPA in a legal agreement called the Director's Final Findings and Orders. This legal agreement, signed in March 1999, allows PORTS to close the integrated units (X-231B Southwest Oil Biodegradation Plot, X-744Y Storage Yard, X-701B Holding Pond, X-701C Neutralization Pit, and the X-230J7 Holding Ponds) as part of the RCRA Corrective Action Program at PORTS. Each of these areas is associated with an area of groundwater contamination and is discussed further in Chap. 6.

RCRA may also require groundwater monitoring at hazardous waste units. As part of the implementation of the 1999 Director's Final Finding and Orders discussed above, groundwater monitoring requirements at PORTS have been integrated into one document, the *Integrated Groundwater Monitoring Plan*. Hazardous waste units included in the *Integrated Groundwater Monitoring Plan* are the X-231B Southwest Oil Biodegradation Plot, X-616 Chromium Sludge Surface Impoundments, X-701B Holding Pond, X-701C Neutralization Pit, X-735 RCRA Landfill (northern portion), and X-749 Contaminated Materials Storage Yard (northern portion). Chap. 6 discusses the groundwater monitoring requirements for these units.

2.3.2.2 Solid waste

Closure of the X-734 Landfill Area began in 1999. This area, which was used for disposal of solid wastes such as construction debris, trash, and garbage, was closed in the 1980s in accordance with regulations at the time. As part of the PORTS RCRA Corrective Action Program, however, contamination consisting primarily of volatile organic compounds was identified in this area. Therefore, a landfill cap is being constructed over the area. Chap. 3 provides additional information about the X-734 Landfill Area closure.

Groundwater monitoring may be required at closed solid waste facilities. Groundwater monitoring requirements for the closed X-735 Industrial Solid Waste Landfill and X-749A Classified Materials Disposal Facility are included in the *Integrated Groundwater Monitoring Plan*. Chap. 6 discusses the groundwater monitoring programs for these units.

2.3.3 Federal Facility Compliance Act

DOE/PQRTS currently stores waste that is a mixture of RCRA hazardous waste and low-level radioactive waste. RCRA hazardous waste is subject to Land Disposal Restrictions, which do not allow the storage of hazardous waste for longer than one year. The Federal Facility Compliance Act, enacted by Congress in October 1992, allows for the storage of hazardous and low-level radioactive waste for longer than one year because treatment for this type of waste is not readily available. The Act also requires federal facilities to develop and submit site treatment plans for treatment of mixed wastes. On October 4, 1995, Ohio EPA issued Director's Final Findings and Orders to implement the Federal Facility Compliance Act. This Act allows the storage of mixed waste beyond one year and gave approval of the DOE/PORTS Proposed Site Treatment Plan. An annual report is required by these Director's Final Findings and Orders. This annual report, *Proposed Site Treatment Plan for the Mixed Wastes at the Portsmouth Gaseous Diffusion Plant,* containing calendar year 1999 information, was submitted to Ohio EPA in March 2000.

2.3.4 Comprehensive Environmental Response, Compensation, and Liability Act

DOE/PORTS is not on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List of sites requiring cleanup, but is regulated under the provisions of CERCLA by the U.S. EPA Administrative Consent Order. U.S. EPA and Ohio EPA have chosen to oversee environmental remediation activities at DOE/PORTS under the RCRA Corrective Action Program.

Section 103 of CERCLA requires that the National Response Center be notified if hazardous substances are released to the environment in amounts greater than or equal to the reportable quantity. Reportable quantities are listed in the Act and vary depending on the type of hazardous substance released. During 1999, DOE/PORTS had no reportable quantity releases of hazardous substances subject to Section 103 notification requirements.

2.3.5 Toxic Substances Control Act

The Toxic Substances Control Act regulates the use, storage, and disposal of PCBs. The electrical power system at PORTS, which is leased by USEC, uses oil-blast circuit breaker transformers and large high-voltage capacitors, both containing PCB oil, to supply electricity to the enrichment cascade. USEC leases 147 oil-blast circuit breaker transformers and 11,101 large high-voltage capacitors from DOE.

In February 1992, a Federal Facilities Compliance Agreement between DOE and U.S. EPA addressing PCB issues became effective and resolved several compliance issues. These issues included the use of PCBs in systems that are not totally enclosed, storage of wastes containing both PCBs and radionuclides in accordance with nuclear criticality safety requirements, and storage of wastes containing both PCBs and radionuclides for longer than one year. The agreement required installation of troughs under motor exhaust duct gaskets located in production facilities to collect PCB oil leaks. When leaks or spills of PCBs occur, they are managed in accordance with the Federal Facilities Compliance Agreement. As of the end of 1999, DOE/PORTS was in compliance with the requirements and milestones of this Federal Facilities Compliance Agreement.

DOE/PORTS operates a number of storage areas for PCB wastes. The storage areas meet all applicable requirements of the federal regulations and the DOE Federal Facilities Compliance Agreement. All PORTS solid PCB wastes are in long-term storage because of the lack of commercial disposal facilities authorized to dispose of wastes containing both PCBs and radionuclides.

An annual report of progress made toward milestones specified in the Federal Facilities Compliance Agreement is compiled and submitted to the U.S. EPA. In addition, DOE and U.S. EPA representatives meet to resolve any unanticipated issues or uncertainties regarding the terms of the agreement.

Other sections of the Toxic Substances Control Act have little or no impact on DOE/PORTS. Although friable asbestos, which deteriorates into airborne fibers, is regulated under the Act, the specific regulations applicable to PORTS are duplications of other state and federal regulations such as the National Emission Standards for Hazardous Air Pollutants. DOE/PORTS also responds to U.S. EPA requests for health and safety data, but such responses indicate that DOE/PORTS neither imports chemicals nor manufactures, processes, or distributes chemical substances for commercial purposes.

2.3.6 Clean Air Act

DOE/PORTS had five permitted and nine registered air emission sources at the end of 1999 (see Appendix B). One new air permit was obtained in 1999. Ohio EPA issued a permit in October 1999 for closure of the X-734 Landfill Area. The project required an air permit for emissions of particulates, or dust, from unpaved roadways and soil storage piles. Construction activities began in November 1999 and were completed in 2000.

2.3.6.1 Clean Air Act, Title VI, Stratospheric Ozone Protection

As part of the Stratospheric Ozone Protection Plan, DOE has instituted a record-keeping system consisting of forms and labels to comply with the Title VI record-keeping and labeling requirements. These requirements affect all areas that use ozone-depleting substances in units or devices. The appliance service record and retrofit or retirement plan forms apply to units with a capacity of more than 50 pounds. The refrigeration equipment disposal log and associated appliance disposal label are used by all units regardless of capacity. More than 140 air conditioning/refrigeration units and 34 motor vehicle air-conditioning units under DOE control have been identified. Maintenance and service of these units are conducted under contract with USEC. The contractor technicians who service the equipment have been trained in accordance with U.S. EPA requirements.

2.3.6.2 National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants require PORTS to submit an annual estimate of radiological emissions from DOE/PORTS sources. Two DOE/PORTS sources emit radionuclides: the X-326 L-cage Glove Box and the X-744G Glove Box. A glove box is an enclosure with built-in sleeves and gloves that is used by a person to repackage or transfer hazardous material without directly exposing the person to the material. Gaseous radiological emissions from the glove boxes are calculated by using standard engineering procedures. Radiological air emissions from the two glove boxes in 1999 were 0.000064 curie.

2.3.7 Clean Water Act

The DOE/PORTS NPDES permit, issued in 1995 and modified in 1996 and 1997, encompasses six monitored outfalls. Three of the outfalls are classified as point-source discharges to waters of the state, and the other three outfalls are internal outfalls classified as effluents. Water from these three internal outfalls is treated in the USEC Sewage Treatment Plant before reaching waters of the state. Chap. 4 provides additional information on the DOE/PORTS NPDES outfalls. Ohio EPA conducted the annual inspection of all DOE/PORTS outfalls on March 17, 1999. No problems were noted during the inspection.

The DOE/PORTS NPDES permit expired on March 31, 1999. DOE submitted a permit renewal application to Ohio EPA in 1998 in accordance with Ohio EPA requirements. The old permit will remain in effect until Ohio EPA issues a new permit. This old permit was in effect throughout 1999.

Compliance rates (by individual parameter) at all DOE outfalls were 100%. The overall DOE compliance rate for 1999 was also 100%. The compliance rate is calculated by dividing the number of measurements that did not exceed the applicable permit limits by the total number of measurements made. None of the NPDES permit limits were exceeded during 1999.

2.3.8 Underground Storage Tank Regulations

The Underground Storage Tank Program is managed in accordance with the Ohio State Fire Marshal's Bureau of Underground Storage Tank Regulations. DOE/PORTS renewed the registration of eight tanks in June 1999. DOE leases all of these underground storage tanks to USEC.

2.3.9 Emergency Planning and Community Right-To-Know Act

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

Section 304 of the Emergency Planning and Community Right-To-Know Act requires reporting of off-site reportable quantity releases to state and local authorities. During 1999, DOE/PORTS had no reportable quantity releases.

The Hazardous Chemical Inventory Report, which includes the identity, location, storage information, and hazards of the chemicals that exceeded threshold planning quantities, is submitted annually to state and local authorities. Eleven materials stored by DOE/PORTS exceeded the threshold planning quantities for the entire site (including USEC) in 1999: aluminum trioxide, diesel fuel, ethylene glycol, lithium hydroxide, PCBs, sodium fluoride, sulfuric acid, triuranium octaoxide, uranium hexafluoride, uranium tetrafluoride, and uranium (ingots and fuel rods).

The Toxic Chemical Release Inventory is sent annually to U.S. EPA and Ohio EPA. This report details releases to the environment of specified chemicals when they are manufactured, processed, or otherwise used by the entire site (including USEC) in amounts that exceed threshold quantities specified by U.S. EPA. In 1999, DOE/PORTS was required to report the offsite transfer of 4 lbs. methanol to a permitted treatment/disposal facility.

2.3.10 National Environmental Policy Act

The National Environmental Policy Act requires evaluation of the environmental impacts of activities at federal facilities and of activities funded with federal dollars. Reviews are required for all projects to determine the potential for environmental impacts to the following:

- property (e.g., sites, buildings, structures, and objects) of historical, archaeological, or architectural significance, as officially designated by federal, state, or local governments, including properties eligible for listing on the *National Register of Historic Places*;

- potential habitat (including critical habitat) of federally listed endangered, threatened, proposed, or candidate species or of state-listed endangered and threatened species;

- floodplains and wetlands;
- natural areas such as federally and state-designed wilderness areas, national parks, national natural landmarks, wild and scenic rivers, coastal zones, state and federal wildlife refuges, and marine sanctuaries;
- prime agricultural lands; and
- special sources of water (such as sole-source aquifers, wellhead protection areas, and other water sources that are vital to a region).

Reviews also consider impacts to air, surface water, groundwater, biota, socioeconomics, environmental justice, and worker safety and health.

DOE/PORTS has a formal program dedicated to compliance pursuant to DOE Order 451.1, *National Environmental Policy Act Compliance Program*. Restoration actions, waste management, enrichment facilities maintenance, and other activities are evaluated to determine the appropriate level of documentation. Documents are evaluated and approved internally. Environmental impact statements, however, must be produced by an independent organization. Routine operation and maintenance activities are also evaluated to assess potential environmental impacts. Most activities at PORTS qualified for a categorical exclusion as defined in the regulations. These activities were judged to be routine and had no significant individual or cumulative environmental impacts.

In 1999, 14 record reports and 7 categorical exclusions were generated for DOE/PORTS project activities. These projects were part of the Waste Management, Environmental Restoration, and Uranium Programs. Examples of projects addressed by the reports or exclusions include X-616 Chromium Sludge Disposal, X-740 Phytoremediation, New Uranium Hexafluoride Cylinder Storage Yard, and Roof Repair of X-7725 Facility Area 4.

2.3.11 Federal Insecticide, Fungicide, and Rodenticide Act

Plant personnel apply general-use pesticides according to product labeling, and all product warnings and cautions are strictly obeyed. When application of a restricted-use pesticide is required, a certified contractor is employed. No restricted-use pesticides were applied at DOE/PORTS in 1999.

2.4 OTHER ENVIRONMENTAL ACTS AND FEDERAL REGULATIONS

2.4.1 Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened wildlife and plants, and the habitat on which such species depend. When appropriate, formal consultations are made with the U.S. Fish and Wildlife Service and the Ohio Department of Natural Resources. A sitewide threatened and endangered species habitat survey and an Indiana bat (*Byosis sodalis*) survey were completed in August 1996. No Indiana bats were found at PORTS. Few potential critical habitats were identified, and a report of the survey activities and results was provided to the Ohio Department of Natural Resources as required by the Federal Fish and Wildlife permit obtained to conduct the survey. No additional activities were completed in 1999.

2.4.2 National Historic Preservation Act

The National Historic Preservation Act of 1966 is the primary law governing the protection of cultural resources (archaeological and historical properties). Cultural resource reviews are conducted on a case-by-case basis, and consultations with the Ohio State Historic Preservation Officer are made as required by Section 106 of the Act. A draft programmatic agreement among DOE, the Ohio State Historic Preservation Officer, and the Advisory Council on Historic Preservation concerning the management of historical and cultural properties at DOE/PORTS was submitted to the State Historic Preservation Officer for review and comment in 1997.

Phase I of the historical/archaeological survey was completed in September 1996. Fieldwork for Phase II of the project was completed in May 1997. Artifacts from the 1940s and 1950s were uncovered as well as remains from former dwellings that were present prior to construction of PORTS. Results from the survey will be coordinated with the State of Ohio Historic Preservation Office, and a Cultural Resources Management Plan will be developed.

2.4.3 Archaeological and Historic Preservation Act and Archaeological Resources Protection Act

The Archaeological and Historic Preservation Act and the Archaeological Resources Protection Act require the Secretary of the Department of Interior to report to Congress on various federal archaeological activities. The Archaeological Resources Protection Act requires federal land managers to provide archaeology program information to the Secretary of the Interior for this report. *The Department of the Interior Questionnaire on Fiscal Year 1996 Federal Archaeological Activities at the Portsmouth Gaseous Diffusion Plant* was completed and submitted to DOE Headquarters and forwarded to the Department of Interior in 1997 to satisfy this requirement.

2.4.4 Farmland Protection Policy Act

The Farmland Protection Policy Act of 1981 requires federal agencies to consider the effects of their proposed actions on prime farmland. Prime farmland is generally defined as land that has the best combination of physical and chemical characteristics for producing crops of statewide or local importance. When required, prime farmland surveys are conducted, and consultations with the U.S. Department of Agriculture's Natural Resources Conservation Service are made. No prime farmland surveys have been conducted at DOE/PORTS.

2.4.5 Title 10 Code of Federal Regulations Part 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements"

Part 1022 of Title 10 of the Code of Federal Regulations establishes policy and procedures for compliance with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands. The regulatory authority for wetlands is the United States Army Corps of Engineers. Activities (other than routine maintenance) proposed within 100-year and 500-year floodplains or in wetlands require publication of a notice of involvement in the Federal Register. For floodplains, a floodplain statement of findings summarizing the floodplain assessment is also required by DOE and must be published in the Federal Register for public comment at least 15 days prior to the start of the project. An assessment is also required for activity in a wetland prior to authorization to determine all effects of the proposed project. Many activities have been previously authorized by nationwide or regional permits and only require notification. Other activities qualify for abbreviated permit processing, whereby permission is granted via correspondence from the Corps of Engineers.

The sitewide wetland survey report was completed and submitted to the Corps of Engineers in 1996. There are 41 jurisdictional wetlands and four non-jurisdictional wetlands totaling 34.361 acres at PORTS. Activities in jurisdictional wetlands require a Clean Water Act Section 404 permit from the Corps of Engineers. No DOE activities required a Clean Water Act Section 404 permit during 1999.

2.5 DOE ORDERS

2.5.1 DOE Order 5400.1, General Environmental Protection Program

DOE Order 5400.1 establishes environmental protection program requirements, authorities, and responsibilities for DOE operations for compliance with applicable U.S. EPA, state, and local environmental regulations, Executive Orders, and internal DOE policies. The order specifically defines the mandatory environmental protection standards (including those imposed by federal and state law), establishes reporting of environmental occurrences and periodic routine reporting of significant environmental protection information, and provides requirements and guidance for environmental monitoring programs. DOE Order 5400.1 requires the development and periodic update of several environmental reports and programs. Examples of these reports include an annual site environmental report, environmental protection implementation plan, and waste minimization program plan.

DOE Order 5400.1 also requires an environmental monitoring program that defines environmental monitoring activities for PORTS. The program assesses pathways by which humans and/or the environment could be exposed to radionuclides and other chemicals released by PORTS activities. Chap. 4 discusses the results of environmental monitoring (with the exception of groundwater) at PORTS. Groundwater monitoring is discussed in Chap. 6.

2.5.2 DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5400.5 provides guidance and establishes radiation protection standards and control practices designed to protect the public and the environment from undue radiological risk from operations of DOE and DOE contractors. The order requires that off-site radiation doses do not exceed 100 mrem/year above background for all exposure pathways. Chap. 5 provides the dose calculations for compliance with this DOE Order.

2.6 ENVIRONMENTAL PROGRAM INSPECTIONS AND VISITS

During 1999, seven inspections of the DOE/PORTS programs were conducted by federal, state, or local agencies. Table 2.1 summarizes the results of these inspections.

2.6.1 Notices of Violation

One Notice of Violation was issued to DOE/PORTS during 1999. On June 16, 1999, Ohio EPA issued a Notice of Violation regarding revisions to one of PORTS RCRA Corrective Action Program documents: the *Quadrant I Cleanup Alternatives Study/Corrective Measures Study*. This dispute was resolved in 2000 and Ohio EPA considers DOE to have returned to compliance concerning the issue that caused the Notice of Violation.

No Notices of Violation were issued to DOE/PORTS in 1999 resulting from inspections by the regulatory agencies listed in Table 2.1.

Table 2.1. Environmental inspections at DOE/PORTS for 1999

Date	Agency	Type	Findings
March 10	Ohio EPA	RCRA groundwater evaluation	None
March 17	Ohio EPA	NPDES permit inspection	None
March 25 and March 29	Ohio EPA	RCRA compliance inspection	None
April 28	Ohio Dept. of Natural Resources	Safety inspection of X-611A Lime Sludge Lagoons	None
May 4	Pike County Health Dept. and Ohio EPA	Inspection of closed solid waste facilities: X-749A, X-749, and X-735 (solid waste portion)	None
July 14	U.S. Dept. of Transportation	Shipment of lithium hydroxide	None
September 20-22	U.S. EPA	Compliance with underground storage tank regulations	None

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3. ENVIRONMENTAL PROGRAMS

3.1 SUMMARY

Environmental programs at DOE/PORTS include Environmental Restoration, Waste Management, Waste Minimization, Pollution Prevention, Training, Information Exchanges, and Public Awareness.

3.2 ENVIRONMENTAL RESTORATION PROGRAM

DOE established the Environmental Restoration Program in 1989 to identify and correct site contamination areas as quickly and cost-effectively as possible. The Environmental Restoration Program was granted an initial budget of $13.8 million. The 1999 Environmental Restoration Program expenditures were $21 million.

The Environmental Restoration Program addresses inactive sites through remedial action and deals with active facilities through eventual decontamination and decommissioning. Options for correcting or mitigating the contaminated sites and facilities include removal, containment, and treatment of contaminants. Because PORTS is a large facility, it is divided into four quadrants (Quadrant I, II, III, and IV) to facilitate the cleanup process.

The Environmental Restoration Program was established to fulfill the cleanup requirements of the Ohio Consent Decree and U.S. EPA Administrative Consent Order, both issued in 1989. As required by these enforcement actions, DOE/PORTS Environmental Restoration Program activities are conducted in accordance with the RCRA corrective action process, which consists of the following:

- *Description of current conditions* – to provide knowledge of the groundwater, surface water, soil, and air.
- *RCRA facility assessment* – to identify releases of contaminants and determine the need for further investigation.
- *RCRA facility investigation* – to determine the nature and extent of any contamination.
- *Cleanup alternatives study/corrective measures study* – to evaluate and select a remediation alternative.
- *Corrective measures implementation* – to implement the selected remediation measure.
- *Interim remedial measures* – to implement quick remediation or mitigation measures prior to permanent action.

DOE/PORTS has completed the description of current conditions, RCRA facility assessment, and RCRA facility investigation. No interim remedial measures were undertaken in 1999. Cleanup alternatives study/corrective measures study activities, corrective measures implementations, and technology applications are described in the following sections.

3.2.1 Cleanup Alternatives Study/Corrective Measures Study

As required by the Consent Decree and the Administrative Consent Order, the cleanup alternatives studies/corrective measures studies identify the solid waste management units and explore the remedial alternatives within Quadrants I through IV. Following the approval of the final cleanup alternative studies/corrective measure studies, Ohio EPA selects the remedial alternatives that will undergo further review for determining the final remedial actions. Upon concurrence from the U.S. EPA and completion of the public review and comment period, the U.S. EPA and Ohio EPA select the final remedial actions for each quadrant. Ohio EPA issues a decision document to notify DOE/PORTS of the final remedial actions chosen for the site. DOE/PORTS is required to submit a corrective measures implementation plan that details the implementation of the final remedial actions listed in the decision document. Following the approval of the corrective measures implementation by the Ohio EPA, remedial action can begin.

The cleanup alternative studies/corrective measure studies for Quadrants III and IV were approved by Ohio EPA in 1998. The *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was submitted to Ohio EPA on May 28, 1999. Based on comments received from both the U.S. EPA and Ohio EPA, the *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was revised and resubmitted to Ohio EPA on December 28, 1999. Development of the *Quadrant II Cleanup Alternative Study/Corrective Measures Study* continued in 1999.

In 1999, Ohio EPA issued the decision document for Quadrant III and for the X-734 Landfill Area (part of Quadrant IV). A summary of these corrective measures is discussed in the next section. DOE received the decision document for Quadrant IV in 2000.

3.2.2 Corrective Measures Implementation

3.2.2.1 X-740 Waste Oil Handling Facility

The Quadrant III decision document identified only one solid waste management unit that required remedial action: the X-740 Waste Oil Handling Facility (groundwater only). During its period of operation, from 1982 to 1992, the facility was used as a drum-staging area of non-radionuclide contaminated waste oils and solvents generated by various plant site activities. This facility underwent RCRA closure in 1993 including decontamination of the floor and walls of the facility and removal of a tank/sump and surrounding contaminated soil. The remaining groundwater contamination (consisting mainly of trichloroethylene) at this facility is the basis for the remedial action recommended by Ohio EPA in its decision document.

Ohio EPA's preferred cleanup alternative involves institutional controls and the use of *in situ* (in place) phytoremediation for the X-740 groundwater plume. Phytoremediation is considered an emerging technology that uses plants to remove, degrade, or contain contaminants in soil and groundwater. Although phytoremediation is an emerging technology, it has been shown to remediate trichloroethylene at several Department of Defense and Superfund Sites.

A total of 765 one-year-old hybrid poplar trees were planted in rows about 10 feet apart over a 2.6-acre area above the X-740 groundwater plume. Planting was completed ahead of schedule on May 27, 1999. The poplar trees are expected to have a mature root system within 2 years. Mature trees can consume more than 3,000 gallons of groundwater per day per acre. Organic compounds are expected to be removed from the groundwater and captured in the trees' root systems. The organic compounds do not accumulate in the trees. As shown in Fig. 3.1, volatile organic compounds are degraded by ultraviolet light as they are transpired along with the water vapor through the leaves of the trees.

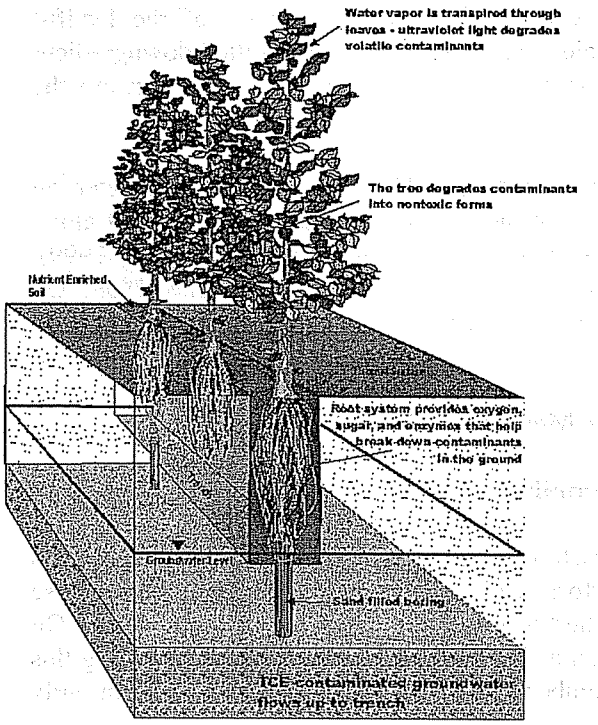

Fig. 3.1. Phytoremediation system.

Local experts offered assistance in tree species selection. Three different species of trees were chosen in order to provide greater resistance to various diseases. A multi-species approach ensures an increased success rate for the plantation. Even if one entire species were destroyed, the remaining two-thirds could continue to function.

The Ohio State University Department of Agriculture provided assistance with the tree planting plan. PORTS plans to partner with local forestry resource specialists and utilize their expertise to monitor and care for the trees at no cost after they are planted. In return, the trees will be donated to an area firm when they are mature and remediation is complete.

PORTS will realize an estimated cost savings of more than $31 million by implementing this phytoremediation technology rather than a standard groundwater pump-and-treat facility. It cost $500,000 to plant the trees for this project, whereas a treatment facility would cost $2 million to build and $1 million a year for 30 years to operate.

3.2.2.2 X-734 Landfill Area

Ohio EPA issued a decision document for the X-734 Landfill Area in April 1999. This area consists of the X-734 Old Sanitary Landfill, the X-734A Construction Spoils Landfill, and the X-734B Construction Spoils Landfill.

The X-734 Old Sanitary Landfill has a total of approximately 3.8 acres. Waste known to be disposed in this area includes trash and garbage, construction spoils, and waste containing metals. The X-734A Construction Spoils Landfill has a total area of approximately 3.5 acres and is adjacent to the southern boundary of X-734 Old Sanitary Landfill. In March 1985 empty drums were disposed in the spoils area; the practice was subsequently discontinued. Waste disposed of at X-734A included construction spoils, trees, railroad ties, broken concrete, stumps, roots, brush, and other wastes from clearing and grubbing operations.

The X-734B Construction Spoils Landfill is located south of X-734A and has a surface area of approximately 4.6 acres. A road and buffer zone separate the northern boundary of X-734B from X-734A. X-734B reportedly received the same type of waste as X-734A: construction spoils, trees, railroad ties, broken concrete, stumps, roots, brush, and other wastes from clearing and grubbing operations.

Ohio EPA's preferred alternative for the X-734 Landfill Area is a multi-media cap at X-734/ X-734A, a soil cap at X-734B, and phytoremediation. This project has been initiated in two phases. Phase I consists of the installation of an 18-inch soil cap on 4.6 acres of the southern portion of the

landfill (X-734B). The soil cap is covered with a 6-inch vegetative layer and planted with grass seed. Phase II consists of the installation of a multi-media cap on the northern portion of the landfill (X-734/X-734A). The phytoremediation portion of the project was designed to be installed downgradient of X-734B to capture and remediate any groundwater that could potentially migrate from beneath the landfill.

Construction of the soil cap at X-734B (Phase I) began on August 16, 1999, and was completed on September 24, 1999. The phytoremediation portion of this project was conducted in May 1999 along with the X-740 phytoremediation discussed in the previous section (40 trees were installed in May 1999). Construction of the multi-media cap at X-734/X-734A (Phase II) was initiated on November 8, 1999. On December 7, 1999, the Project Team decided to suspend construction of the multi-media cap for the winter. The project was completed in 2000.

3.2.3 Additional Cleanup Alternatives Study/Corrective Measures Study Activities

3.2.3.1 Quadrant III and Quadrant IV confirmatory sampling

In an effort to determine final disposition of solid waste management units within Quadrant III and Quadrant IV, DOE met with Ohio EPA and agreed to perform additional confirmatory sampling in these quadrants. A confirmatory sampling strategy was submitted to Ohio EPA on November 11, 1999. On November 22, 1999, Ohio EPA accepted the sampling plan and requested a schedule for performing this sampling. Sampling was completed by the end of December 1999, with the results available in early February 2000.

3.2.4 Technology Applications

The DOE/PORTS Technology Applications Program was established in 1993 to facilitate the introduction of innovative or experimental environmental technology into the DOE/PORTS Environmental Restoration Program. The primary function of the technology program is to identify, evaluate, and test/demonstrate innovative advancements in environmental characterization and cleanup. The goal is to incorporate the most practical, cost-effective cleanup approaches as they are evolving for full-scale application at the plant. By combining conventional research and development with cleanup efforts, technology demonstrations enable the site to solve real problems using innovative methods. The Technology Applications Program utilizes a team of DOE contractors, national laboratory scientists, university researchers, private industries, site engineers, and technical staff.

3.2.4.1 X-701B *in situ* chemical oxidation

Oxidation is a type of chemical reaction. *In situ* (in place) chemical oxidation is used to remediate volatile organic compounds such as trichloroethene in groundwater. With this technique, chemical oxidants are injected into the ground, a chemical reaction takes place, and the trichloroethene is changed into nontoxic chemical compounds. Laboratory experiments have demonstrated that potassium permanganate, sodium permanganate, and hydrogen peroxide can effectively oxidize trichloroethene.

The X-701B Holding Pond area was chosen for this technology demonstration because of the existing horizontal and vertical groundwater wells and the extensive site characterization data for the area. In 1998, groundwater was extracted from one horizontal well, pumped to an existing groundwater treatment facility, mixed with potassium permanganate, and reinjected into a parallel horizontal well approximately 90 ft away. The results of this test indicated that *in situ* chemical oxidation through recirculation effectively oxidized trichloroethene in groundwater in the area affected by the wells. Where the oxidant was found, trichloroethene was no longer detectable.

In 1999, another demonstration was conducted using sodium permanganate injected through vertical wells. This demonstration was conducted from August 9, 1999, through October 3, 1999. The system was shut down because the sodium permanganate was moving from below ground, where it had been injected, to the ground surface. Following a series of tests to identify and correct the problem, the demonstration was restarted in 2000.

3.2.4.2 X-749/X-120 vacuum enhanced recovery wells

This technology application uses a vacuum to increase the amount of water that can be pumped from a groundwater recovery well. Groundwater wells are often used to remove contaminated groundwater from an aquifer. The amount of water that can be removed from a well depends on the soil beneath the ground surface. If the groundwater is an area made up primarily of sand, which is a large soil particle, water can be easily removed from the ground. If the groundwater is in an area that is primarily clay, which is a small soil particle, it is much more difficult to remove groundwater. This type of soil is called a low permeability soil. Vacuum enhanced recovery wells are designed to increase the flow of water from a groundwater recovery well that is in an area made up of smaller soil particles.

In addition to increasing the amount of water recovered from a well, the movement of air due to the vacuum also causes chemicals in the groundwater to volatilize, or move from the soil or water into the air, which further aids the removal of contaminants.

The X-749/X-120 groundwater plume was the selected site for this demonstration because this groundwater plume contains volatile organic compounds such as trichloroethene and trichloroethane, and this area also has low permeability soils. These conditions met the location requirements for the primary test objective, which was to demonstrate the effectiveness of vacuum enhanced recovery technology in reducing chlorinated volatile organic compounds in low permeability geologic formations. The secondary objective of the project was to collect information for the design of a full-scale implementation of the technology.

Field work for this project began in August 1998 and was completed in December 1998. In total, five vacuum-enhanced extraction wells were installed and tested during the project. The final report was submitted to the Ohio EPA on March 10, 1999. Results of this pilot project have been incorporated for consideration as alternatives in the Quadrant I and Quadrant II cleanup alternatives study/corrective measures study reports.

3.2.4.3 5-Unit Area (Quadrant I Groundwater Investigative Area) oxidant injection

The 5-Unit Area Oxidant Injection Pilot Project used an *in situ* chemical oxidant injection and recirculation process, similar to that described for the X-701B *In Situ* Chemical Oxidation Project discussed previously in this chapter. The project at this area involves recirculation of groundwater through four pumping wells located at fixed distances from a central injection well. The oxidant permanganate, as either potassium permanganate or sodium permanganate, is added to extracted groundwater that is then reinjected into the aquifer.

The Ohio EPA and DOE/PORTS agreed to conduct a site-specific pilot project to provide additional data to facilitate the completion of the corrective measures study alternative development process for the remediation of the 5-Unit Area (Quadrant I Groundwater Investigative Area). A second objective of the pilot project was to obtain data to determine the amount of contaminants removed by the project.

The treatment system was used in two locations in 1999. The final report on this treatment technology was submitted to Ohio EPA on September 30, 1999, indicating the technology is an acceptable option for groundwater remediation in this area at PORTS.

3.2.4.4 X-701B underground steam stripping and hydrous pyrolysis/oxidation

The X-701B Underground Steam Stripping and Hydrous Pyrolysis/Oxidation Project implements a process called dynamic underground steam stripping to remove volatile organic compounds from groundwater. The process removes volatile organic compounds by injecting steam underground through multiple wells, thus heating the area to above the contaminants' boiling points. This heating vaporizes the compounds so that they can then be removed by vacuum extraction wells. An additional process called hydrous pyrolysis/oxidation destroys contaminants not removed by the extraction wells.

Installation of the wells and monitoring equipment was completed in December 1998. Equipment mobilization and set-up was completed on January 9, 1999. On January 28, 1999, the vacuum system was placed in service; steam injection began the next day. The system operated until June 12, 1999, when pumping and vapor extraction from the well field were terminated. Approximately 68 gallons of trichloroethene (or about 80% of the contaminant) were removed from the treatment area, confirming the technology as a viable alternative for use at PORTS.

3.3 WASTE MANAGEMENT PROGRAM

The DOE/PORTS Waste Management Program directs the safe storage, treatment, and disposal of waste generated by past and present operations and from current Environmental Restoration projects. DOE/ PORTS also stores USEC-generated waste in the RCRA Part B permitted storage areas. Waste managed under the program is divided into the following six categories, which are defined below:

- *Low-level radioactive waste (LLW)* – radioactive waste not classified as high level or transuranic and that does not contain any components regulated by RCRA or the Toxic Substances Control Act.

- *Hazardous (RCRA) waste* – waste that contains one or more of the wastes listed under RCRA or that exhibits one or more of the four RCRA hazardous characteristics: ignitability, corrosivity, reactivity, and toxicity.

- *RCRA/LLW mixed waste* – waste containing both hazardous and radioactive components. The waste is subject to RCRA, which governs the hazardous components, and to additional regulations that govern the radioactive components.

- *PCB wastes* – waste containing PCBs, a class of synthetic organic chemicals. Under Toxic Substances Control Act regulations, PCB manufacturing was prohibited after 1978. However, continued use of PCBs is allowed, provided that the use does not pose a risk to human health or the environment. Disposal of all PCB materials is regulated under the Toxic Substances Control Act.

- *PCB/LLW mixed waste* – waste containing both PCB and radioactive components. The waste is subject to the Toxic Substances Control Act that governs PCB components, and to additional regulations that govern radioactive components.

- *Industrial sanitary waste* – waste generated by commercial operations, such as office waste.

During 1999, approximately 4.6 million pounds of waste from PORTS were recycled, treated, or disposed (Table 3.1). Future waste management projects include the shipment for disposal of low-level radioactive waste and mixed waste, and the treatment of mixed and PCB/mixed waste at off-site commercial facilities.

Table 3.1. Waste Management Program treatment, disposal, and recycling accomplishments for 1999

Waste stream	Quantity	Treated, disposed, or recycled	Treatment, disposal, or recycling facility
Waste streams characterized	21 waste streams (2,120 drums)	Not applicable	Not applicable
X-701B Interceptor Trench soils	560 drums / 919,245 lbs	Disposed	Envirocare
X-701B sludge	384 B-25 boxes / 1,899,535 lbs	Disposed	Envirocare
X-705A/B soils	214 B-25 boxes / 1,260,009 lbs	Disposed	Envirocare
RCRA/PCB/LLW liquids	143 containers / 27,830 lbs	Treated	TSCA Incinerator
Hydrogen cyanide cylinder	One 3-liter cylinder / 20 lbs	Treated and disposed	SET Environmental
Aerosol cans liquids	Two drums / 642 lbs	Treated and disposed	Safety-Kleen
Waste water	175,621 lbs	Treated	Onsite Treatment Facilities
PCB mineral oil	29 drums / 12,250 lbs	Treated and disposed	S. D. Meyers
Radioactive empty drums	4,038 drums / 254,500 lbs	Recycled	U.S. Ecology
Fluorescent light bulbs	10,611 lbs	Recycled	Superior Special Services, Inc.
NiCad batteries	8,149 lbs	Recycled	InMetCo
Aluminum cans	1,578 lbs	Recycled	Star, Inc.
Cardboard	7,045 lbs	Recycled	Star, Inc.
Mixed office paper	36,980 lbs	Recycled	Star, Inc.

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

- minimizing waste generation;
- characterizing and certifying wastes before they are stored, processed, treated, or disposed;
- pursuing volume reduction (such as blending and bulking) as well as on-site storage in preparation for safe and compliant final treatment and/or disposal; and
- recycling.

3.4 WASTE MINIMIZATION AND POLLUTION PREVENTION PROGRAM

DOE/PORTS has combined its waste minimization and pollution prevention efforts to consolidate related activities. The objectives of the DOE/PORTS Waste Minimization and Pollution Prevention Program include the following:

- fostering a philosophy to conserve resources and create a minimum of waste and pollution;
- promoting the use of nonhazardous materials in DOE/PORTS operations to minimize potential risks to human health and the environment;
- reducing or eliminating the generation of wastes through material substitution, product reformulation, process modification, improved housekeeping, and on-site recycling; and
- complying with federal and state regulations and DOE policies and requirements for waste minimization.

The DOE/PORTS Waste Minimization and Pollution Prevention Program continues activities to achieve the waste minimization objectives. Typical projects include the following:

- maintaining a comprehensive waste tracking and reporting system;
- evaluating DOE/PORTS processes and activities to identify waste minimization opportunities;
- maintaining an effective DOE/PORTS waste minimization training program;
- maintaining a waste minimization and pollution prevention awareness promotional campaign; and
- providing a waste minimization and pollution prevention information exchange network.

The Pollution Prevention Awareness Program consists of (1) pollution prevention awareness through Earth Day events, newsletters, bulletins, and memoranda; (2) awards, recognition for employees, and performance indicators; (3) information exchange; and (4) training. Other recognized pollution prevention measures are the *Best Management Practices Plan* and the *Portsmouth Spill Prevention, Control, and Countermeasures Plan.*

Highlights of the Waste Minimization and Pollution Prevention Program in 1999 include the following:

- reused excess computer equipment by donating it to public schools through the Southern Ohio Diversification Initiative;
- sent empty drums contaminated with radioactivity to a facility that will reuse them instead of contaminating clean drums;
- participated in the Ohio Governor's Earth Day celebration at the state capital;
- provided sixth-grade students with lessons on using discarded materials for new purposes at the Environmental Fair;
- sent over 8,000 pounds of spent NiCad batteries to a recycling facility;
- recycled more than 44,000 pounds of sanitary waste including office paper, corrugated cardboard, and aluminum cans;

- recycled more than 5,700 oversized pallets through the Southern Ohio Diversification Initiative;
- sent 250 pounds of excess weapons to the Lawrence Livermore National Laboratory;
- started a project to reduce the inventory of mixed waste through releasing some lead liners and ductwork from radiological controls to be recycled as scrap metal.

Activities planned for 2000 include initiating a comprehensive training program for Environmental Restoration activities to support the goals established in Executive Order 13101, continuing the scrap metal recycling program, implementing programs to prevent managing spent batteries and light bulbs as waste, and conducting a Pollution Prevention Opportunity Assessment on low-volatile organic compound floor coverings for the RCRA storage area.

3.5 ENVIRONMENTAL TRAINING PROGRAM

DOE/PORTS provides environmental training to increase employee awareness of environmental activities and to enhance the knowledge and qualifications of personnel performing tasks associated with environmental assessment, planning, and restoration. The program includes on- and off-site classroom instruction, on-the-job training, seminars, and specialized workshops and courses. Environmental training conducted or prepared by DOE/PORTS includes hazardous waste training required by RCRA and numerous Occupational Safety and Health Administration training requirements.

3.6 INFORMATION EXCHANGE PROGRAM

To improve and update its environmental monitoring and research programs, DOE/PORTS exchanges information within the site and with other DOE facilities and other sources of information. DOE/PORTS representatives attend both DOE-sponsored and independent technical information exchange workshops, such as the annual DOE Model Conference, quarterly multi-plant team meetings, and professional conferences.

3.7 PUBLIC AWARENESS PROGRAM

A comprehensive community relations and public participation program has been in place since early 1990. The purpose of the program is to foster a spirit of openness and credibility between PORTS officials and local citizens, elected officials, business, media, and various segments of the public. The program also provides the public with opportunities to become involved in the decisions affecting environmental issues at the plant.

DOE/PORTS opened a public Environmental Information Center in February 1993 to provide public access to all documents used to make decisions on remedial actions being taken at the plant. The information center is on the plant site in a modular unit outside the E-Vehicle portal. The mailing address for the Information Center is U.S. DOE Environmental Information Center, P.O. Box 693, Piketon, Ohio 45661. The street address is 3930 U.S. Route 23 South, Perimeter Road West, Piketon, Ohio 45661. Hours for the Information Center are 9 a.m. to 12 p.m. Monday and Tuesday, 12 p.m. to 4 p.m. Wednesday and Thursday, or by appointment (740-289-3317).

A group of approximately 45 key stakeholders, composed of elected officials, community leaders, environ-mentalists, and other individuals who have expressed an interest in the Environmental

Restoration and Waste Management Programs, is targeted for information and input on current activities and actions under consideration at the plant. Semiannual public update meetings and public workshops on specific topics are also held to keep the public informed and to receive their comments and questions. Periodically, fact sheets about major projects are written for the public. Semiannual environmental bulletins are printed and distributed to more than 4,000 recipients, including those on the community relations mailing list, neighbors within 2 miles of the plant, and all plant employees and retirees.

Points of contact have been established for the public to obtain information or direct questions regarding the Environmental Restoration and Waste Management Programs. The DOE Site Office may be contacted at 740-897-2001. The Bechtel Jacobs Company Public Affairs Manager (740-897-2336) also provides information on the programs.

4. ENVIRONMENTAL MONITORING

4.1 SUMMARY

Environmental monitoring at PORTS includes air, water, soil, sediment, and biota (animals, vegetation, and crops) and includes measurement of both radiological and chemical parameters. Environmental monitoring programs are required by state and federal regulations, permit requirements, and DOE Orders, but also are developed to reduce public concerns about plant operations. In 1999, environmental monitoring information was collected by both DOE and USEC. Unlike other chapters of this report that focus on DOE activities at PORTS, this chapter includes monitoring information collected by USEC. Results of environmental monitoring in 1999 indicate that PORTS operations did not have a significant environmental impact inside or outside the reservation boundaries.

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 are analyzed for radionuclides and chemicals 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, permit requirements, 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 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment,* also address environmental monitoring requirements.

Environmental monitoring data is collected by both DOE and USEC. Because USEC data is important in developing a complete picture of environmental monitoring at PORTS, it is included in this report. USEC information is provided for informational purposes only; DOE cannot certify the accuracy of USEC data.

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

- Airborne discharges,
- Ambient air,
- Discharges to surface water,
- Surface water,
- Sediment,
- Soil,
- Vegetation, and
- Biota.

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

4.3 AIR

Air monitoring at PORTS includes monitoring of both radiological and chemical discharges from permitted air emission sources. In 1999, USEC also performed ambient air monitoring for radionuclides and fluorides to assess the release of these constituents from PORTS.

4.3.1 Airborne Discharges

4.3.1.1 Radiological airborne discharges

Airborne discharges of radionuclides from PORTS are regulated under the Clean Air Act National Emission Standards for Hazardous Air Pollutants. Releases of radionuclides are used to calculate a dose to members of the public. Chap. 5 discusses the results of this dose calculation.

Because USEC operates the uranium enrichment process at PORTS, USEC is responsible for most of the sources that emit radionuclides. In 1999, USEC reported emissions of 0.9 curie (a measure of radioactivity) from its radionuclide emission sources.

DOE/PORTS is responsible for two emission sources: the X-326 L-cage Glove Box and the X-744G Glove Box. These glove boxes are used to repackage wastes or other materials that contain radionuclides. Emissions from these sources are based on waste analysis data. Radiological emissions from these two DOE sources were 0.000064 curie in 1999.

4.3.1.2 Nonradiological airborne discharges

DOE/PORTS operates numerous small sources of conventional air pollutants such as nitrogen oxides, sulfur dioxide, and particulate matter. These emissions are estimated every two years for the Ohio EPA's biennial emission fee statement.

Emissions of nonradiological air pollutants at DOE/PORTS are estimated using various U.S. EPA-approved procedures. In calculating air emissions, DOE assumes that each source emits the maximum allowable amount of each pollutant as provided in the permit or registration for the source. Under this worst-case scenario, DOE/PORTS estimated emissions of sulfur dioxide, nitrogen oxides, organic compounds, and particulate matter in 1999 to be 13 tons per year. Most of these worst-case emissions resulted from particulate (dust) emissions from the X-734 Landfill Area closure. Worst-case air emissions excluding this source are no more than 1.5 tons per year.

Another potential air pollutant present at DOE/PORTS is asbestos released by renovation or demolition of plant facilities. Asbestos emissions are controlled by a system of work practices. The amount of asbestos removed and disposed is reported to the Ohio EPA. No asbestos was removed or disposed by DOE in 1999.

Nonradiological airborne discharges from USEC sources are not included in this report.

4.3.2 Ambient Air Monitoring

In 1999, USEC collected data from a monitoring network of 15 air samplers. Data was collected both on site at PORTS (Fig. 4.1) and in the area surrounding PORTS (Fig. 4.2). This monitoring network is intended to assess whether air emissions from PORTS affect air quality in the surrounding area. The air sampling stations measure gross alpha radiation, gross beta radiation, and fluorides.

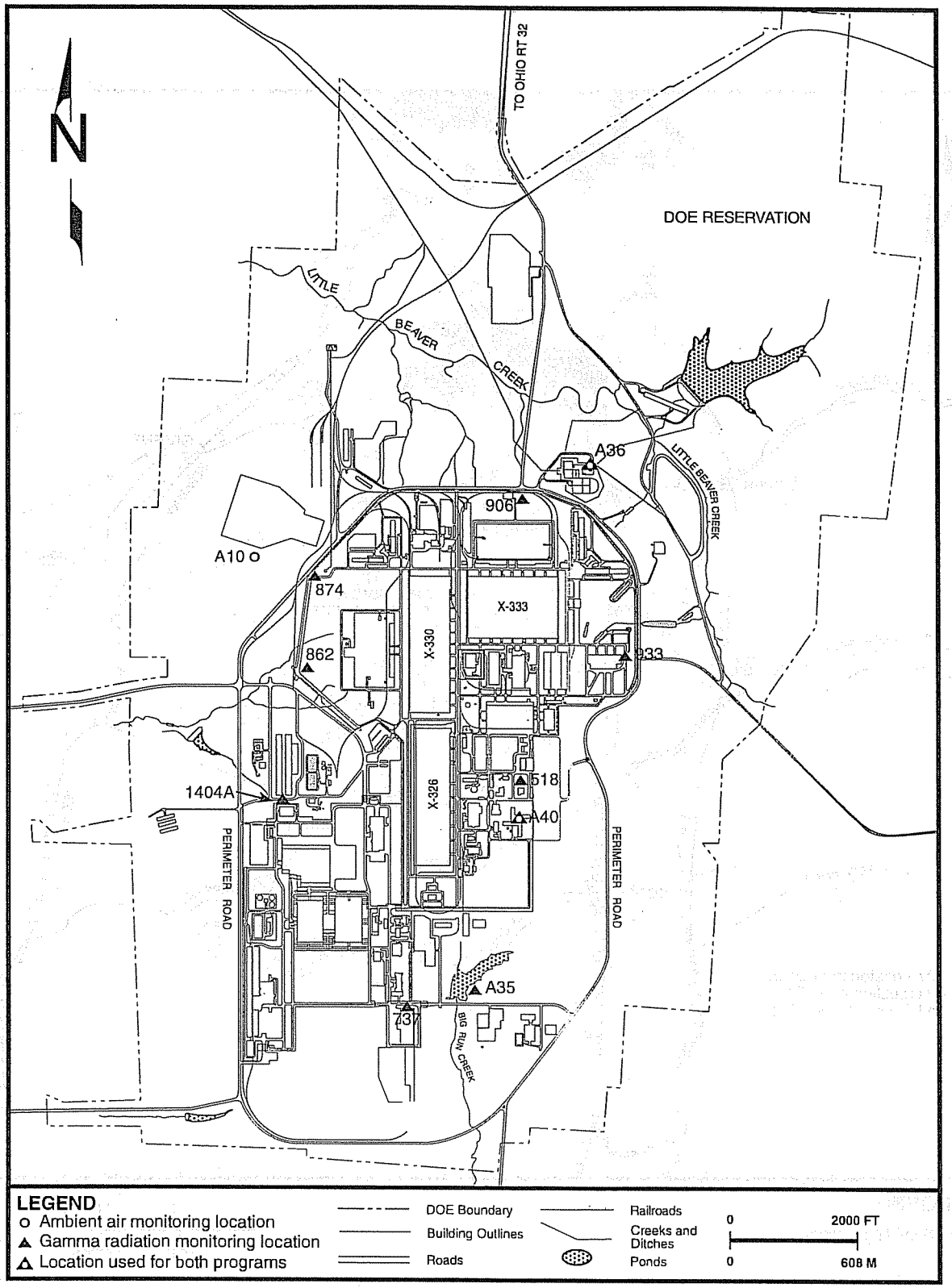

Fig. 4.1. On-site monitoring locations for the USEC ambient air and gamma radiation monitoring programs.

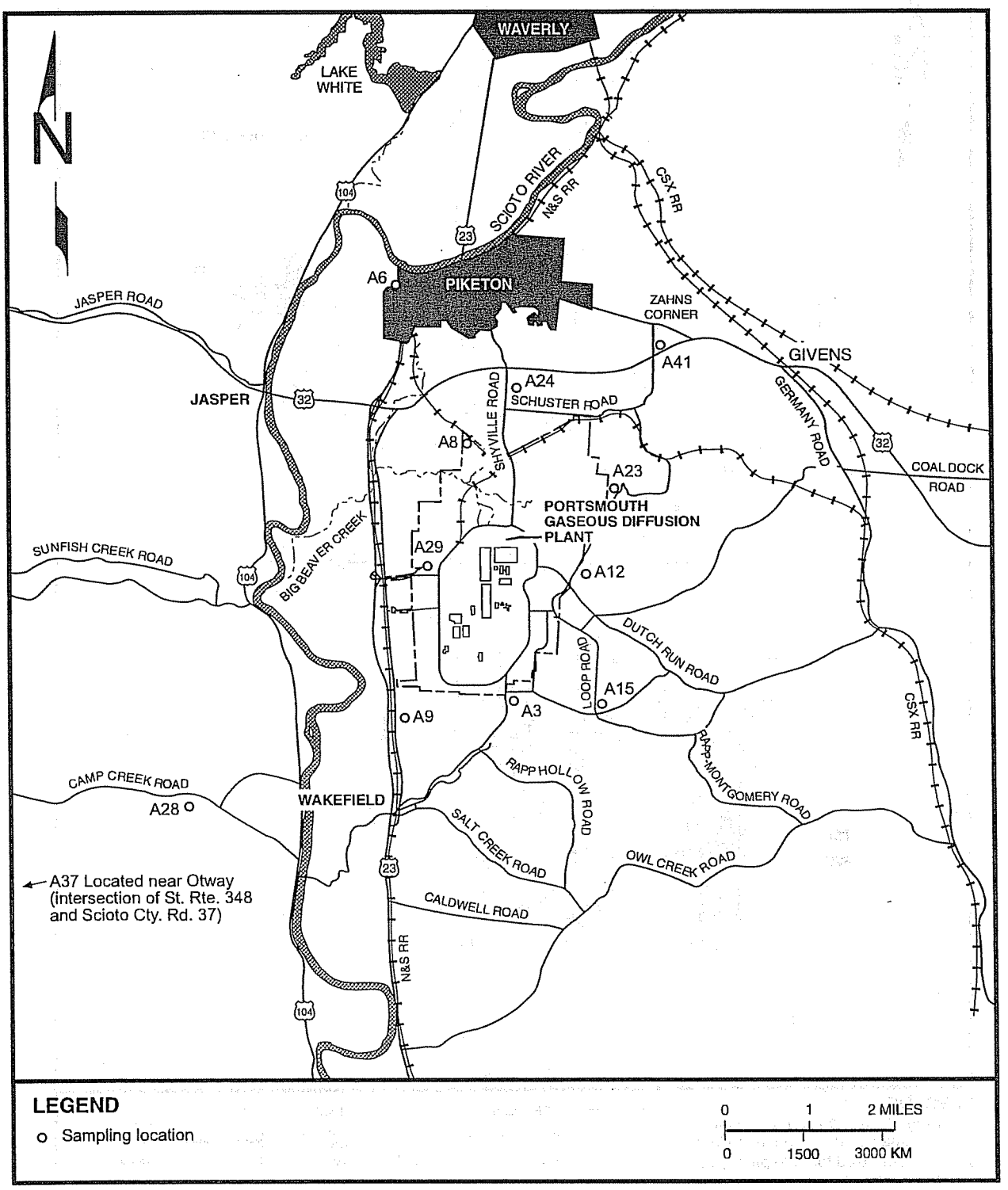

Fig. 4.2. Off-site monitoring locations for the USEC ambient air and gamma radiation monitoring programs.

A background ambient air monitoring station is located approximately 13 miles southwest of the plant. The analytical results from air sampling stations closer to the plant are compared to these background measurements.

The average concentration of gross alpha, gross beta, and gaseous fluorides at sampling stations around PORTS appears to be similar to the background sampling station (A37), with the possible exception of sampling station A12.

Direct radiation, or gamma radiation, is also measured by USEC and DOE at monitoring stations in and around PORTS (see Figs. 4.1 and 4.2). A discussion of the measurements made by DOE and the resulting potential dose to the public is discussed in Chap. 5. Direct radiation measurements collected by USEC indicate that the level of gamma radiation in and around PORTS is similar to background, with the exception of the DOE depleted uranium cylinder storage yards. DOE measurements confirm that cylinders in the storage yards emit higher than background levels of gamma radiation. Public access to radiation from these cylinder yards is controlled as described in Chap. 5.

4.4 WATER

Surface water and groundwater are monitored at PORTS. Groundwater monitoring is discussed in Chap. 6. Surface water monitoring consists of sampling water discharges associated with both DOE and USEC NPDES-permitted outfalls and sampling of local rivers and creeks including the Scioto River, Big Run Creek, Big Beaver Creek, and Little Beaver Creek. DOE also collects surface water samples as part of the groundwater monitoring program at PORTS. These results are also discussed in Chap. 6.

4.4.1 Water Discharges (NPDES Outfalls)

DOE/PORTS has six discharge points, or outfalls, through which water is discharged from the site (see Fig. 4.3). Three outfalls discharge directly to surface water, and three discharge to the USEC X-6619 Sewage Treatment Plant before leaving the site through USEC Outfall 003 to the Scioto River. A brief description of each DOE outfall at PORTS follows.

DOE NPDES Outfall 012 (X-2230M Holding Pond) – The X-2230M Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the southern portion of the PORTS reservation. 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.

DOE NPDES Outfall 013 (X-2230N Holding Pond) – The X-2230N Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the southwestern portion of the PORTS reservation. 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.

DOE NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – This facility removes volatile organic compounds from contaminated groundwater originating from the X-701B plume interceptor trenches. These groundwater interceptor trenches were constructed to control the migration of volatile organic compound-contaminated groundwater toward Little Beaver Creek. Treated water is released to an unnamed stream that flows to Little Beaver Creek.

DOE NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – This facility removes volatile organic compounds from contaminated groundwater originating from site remediation activities in the

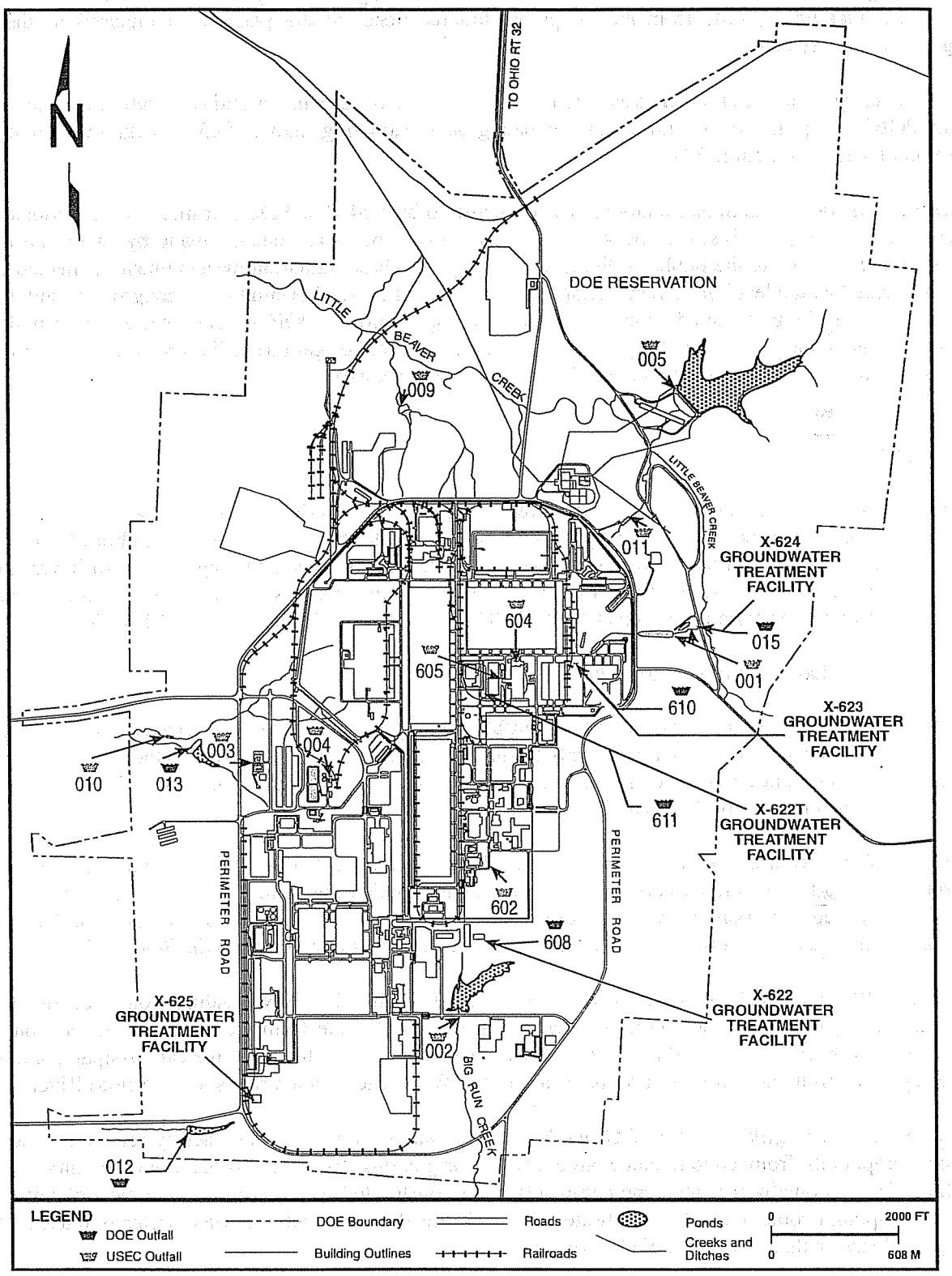

Fig. 4.3. PORTS NPDES outfalls and DOE groundwater treatment facilities.

southern portion of the site. Treated water is discharged to the sanitary sewer and then through USEC Outfall 003.

DOE NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – This facility removes volatile organic compounds from contaminated groundwater originating from site remediation activities and from miscellaneous well development and purge waters. Treated water is discharged to the sanitary sewer and then through USEC Outfall 003.

DOE NPDES Outfall 611 (X-622T Groundwater Treatment Facility) – This facility removes volatile organic compounds from groundwater collecting in sumps located in the basements of the X-705 and the X-700 buildings. Treated water is discharged to the sanitary sewer and then through USEC Outfall 003.

USEC is responsible for 11 NPDES outfalls at PORTS (see Fig. 4.3). 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, and storm runoff. 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 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, and storm runoff. 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 treats PORTS sewage as well as water discharged from 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 [X-616 Liquid Effluent Control Facility (inactive)] – This outfall receives water from various cooling towers on site. This facility is no longer required to treat the influent because the plant converted from a chromate-based to a phosphate-based corrosion inhibitor system in 1992. Water from this facility is discharged 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. Water from this facility is generally returned to the X-611 Water Treatment Plant for treatment. Direct discharges from this facility occur only during periods of excessive rainfall. During such rare events, the lagoon discharges to Little Beaver Creek.

USEC NPDES Outfall 009 (X-230L North Holding Pond) – The X-230L North Holding Pond receives non-contact cooling water, steam condensate, and storm runoff. The pond provides an area where materials suspended in the influent can settle and chlorine can dissipate. 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, and storm runoff. The pond provides an area

where materials suspended in the influent can settle and chlorine can dissipate. 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, and storm runoff. 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 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).

4.4.1.1 Radiological liquid discharges

Both DOE and USEC monitor NPDES outfalls for radiological discharges by collecting water samples and analyzing the samples for radionuclides. Samples are analyzed for gross alpha activity, gross beta activity, technetium, and total uranium.

Discharges of radionuclides in liquids through DOE NPDES outfalls have no significant impact on public health and the environment. Uranium discharges from DOE NPDES outfalls in 1999 totaled 0.59 kg. This value was calculated using monthly monitoring data from the DOE NPDES outfalls. Gross alpha and gross beta measurements at the DOE NPDES outfalls indicated that 0.0079 curie of radioactivity was discharged through these outfalls during 1999.

Data collected by USEC and provided to DOE showed that USEC released 21.14 kilograms of uranium through its NPDES outfalls in 1999. Total radioactivity (based on alpha and beta measurements) released through the USEC NPDES outfalls was 1.08 curies. 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 DOE and USEC NPDES outfalls.

4.4.1.2 Radiological monitoring results for surface water from DOE cylinder storage yards

Ohio EPA requires monthly collection of surface water samples from the X-745C and X-745E Depleted Uranium Hexafluoride Cylinder Storage Yards. All samples collected during 1999 were analyzed for gross alpha activity, gross beta activity, and total uranium. During 1999, gross alpha activity ranged from less than 1 pCi/L to 52 pCi/L; gross beta activity ranged from less than 3 pCi/L to 148 pCi/L; and total uranium ranged from less than 1 to 14.5 μg/L. Beginning in September 1999, samples were also analyzed for total PCBs, technetium, americium-241, americium-243, neptunium-237, plutonium-238, and plutonium-239. These parameters were not detected at levels greater than the applicable detection limits.

4.4.1.3 Nonradiological liquid discharges

Nonradiological discharges from DOE NPDES outfalls are regulated by the DOE NPDES permit. The permit was issued to DOE/PORTS on September 1, 1995 and modified on December 1, 1996, and May 1, 1997. Sampling of nonradioactive constituents is regulated under the DOE/PORTS NPDES permit, and analyses are performed in accordance with applicable regulations. In 1999, the DOE NPDES compliance rate was 100%. Compliance rates for individual parameters was 100%.

This report does not include results for nonradiological monitoring of USEC NPDES outfalls.

4.4.2 Surface Water Monitoring

In 1999, USEC collected water samples at locations upstream and downstream from the PORTS reservation. These samples were taken from the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek (see Fig. 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 weekly from the Scioto River and monthly from the other streams, with the exception of one of the downstream locations on Little Beaver Creek (RW-8), which was sampled weekly.

Each sample was analyzed for gross alpha activity, gross beta activity, total uranium, and technetium. Each of these measurements, with the exception of technetium, will detect naturally occurring radionuclides in the environment; therefore, gross alpha, gross beta, and uranium measurements from upstream locations are compared to downstream locations to assess whether PORTS activities have affected the river or stream. Natural variation and manmade activities not related to PORTS can also cause sample variation. In 1999, no significant differences were noted in the surface water samples collected at either the upstream or downstream sampling location. For the majority of samples, these constituents were not detected. Technetium was detected in only one sample in 1999 -- the upstream sampling location on the Scioto River (RW-6). Based on the results of this monitoring program, it does not appear that PORTS activities affected local surface waters in 1999.

4.5 SEDIMENT

In 1999, USEC collected sediment samples at the same locations upstream and downstream from the PORTS reservation where surface water samples are collected and at the NPDES outfalls on the west side of the reservation (see Fig. 4.4). Samples were collected in the spring and fall and were analyzed for 21 metals, PCBs, gross alpha activity, gross beta activity, total uranium, and technetium. Metals, uranium, gross alpha activity, and gross beta activity occur naturally in the environment; therefore, these constituents detected in the samples may not result from activities at PORTS. The results of sampling conducted in 1999 appear to indicate that there are no appreciable differences in the levels of these constituents found in the samples taken upstream and downstream from PORTS.

Historically, PORTS sediment sampling has detected low levels of technetium and PCB contamination in the Little Beaver Creek east of PORTS. This contamination was caused by discharges of treated process water before 1988. Although these discharges have stopped, sediment contamination still remains. The level of contamination is decreasing over time, however. In 1999, low concentrations of technetium and PCBs were detected in samples collected from downstream sampling locations on the Little Beaver Creek (RM-7, RM-8, and RM-11). In the fall of 1999, technetium was also detected at one of the west outfalls (RM-10) at a concentration just above the detection limit. PCBs and technetium were not detected at the two outfall sampling locations at any other time in 1999.

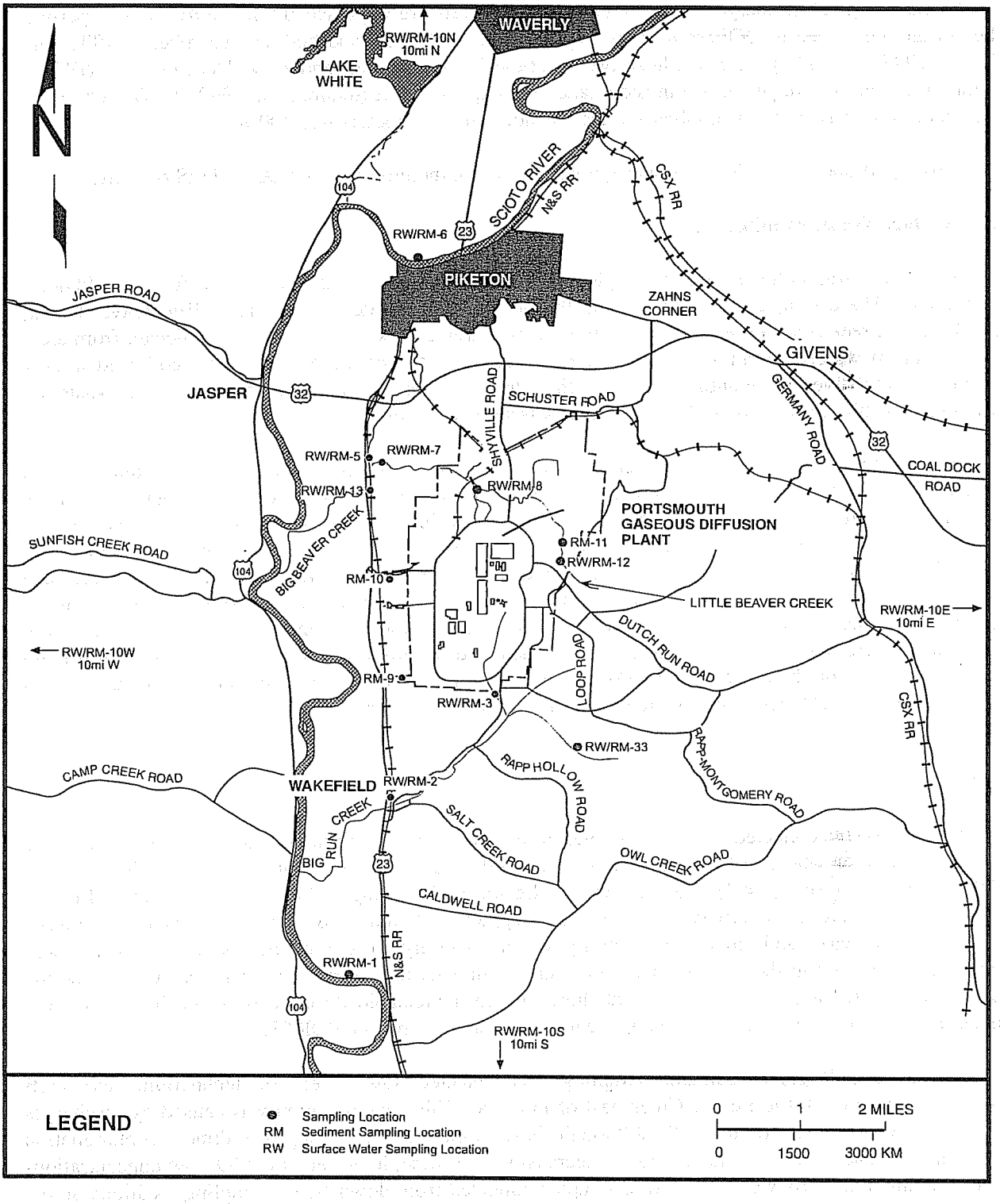

Fig. 4.4. USEC surface water and sediment monitoring locations.

Technetium was also detected at downstream sampling locations on Big Beaver Creek and Big Run Creek. PCBs were not detected in samples collected from Big Run Creek and Big Beaver Creek in 1999.

There were no appreciable differences in concentrations of detected constituents in upstream and downstream samples collected from the Scioto River in 1999. PCBs and technetium were not detected in upstream or downstream samples collected from the Scioto River.

4.6 SOIL

USEC collects soil samples in the process area of the PORTS reservation, on unused land on the PORTS reservation, and in off-site locations up to 10 miles from PORTS (see Figs. 4.5 and 4.6). Samples are analyzed for gross alpha activity, gross beta activity, total uranium, and technetium. Analytical results from the external samples (samples not collected in the process area of PORTS) represent natural background radionuclides and deposition of airborne radionuclides from PORTS. Analytical results from samples collected in the process area of PORTS also represent background radionuclides and airborne deposition, but can also include radionuclides deposited from spills or other plant operations.

Both the historical and 1999 sampling programs have identified areas of soil contamination within the process area of PORTS. Analytical results from the external samples collected near PORTS are not appreciably different from results of samples collected 10 miles from PORTS. These results appear to indicate that PORTS activities have not resulted in soil contamination outside the process area of PORTS.

4.7 BIOLOGICAL MONITORING

Biological monitoring at PORTS is used to assess the uptake of radionuclides and other constituents into local biota (deer, fish, vegetation, and crops). DOE collects samples of deer harvested during the hunting season. USEC collects data to assess potential impacts to vegetation, crops, and fish at or near PORTS.

4.7.1 Deer

Sixteen deer were harvested at PORTS during the 1999-2000 hunting season (December 1999 through January 2000). The kidneys and liver were collected from each deer for analysis because these organs concentrate any radiological constituents ingested by the deer. Each kidney and liver sample was analyzed for americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, total uranium, uranium-233/234, uranium-235, uranium-236, and uranium-238.

Naturally-occurring uranium was detected in most of the samples at concentrations just above detection limits. None of the other radionuclides listed above were present above detection limits.

4.7.2 Fish

USEC collects fish at some of the surface water sampling locations shown in Fig. 4.4 and analyzes the fish for chromium, PCBs, gross alpha activity, gross beta activity, technetium, and total uranium. In 1999, PCBs were detected in 10 of 13 fish sampled. PCBs, a widespread environmental contaminant, are often detected in fish and may or may not be present as a result of PORTS activities. Chromium was detected in one of the fish samples collected in 1999.

Gross alpha activity, gross beta activity, technetium, and total uranium were not detected in any of the fish samples collected in 1999.

4.7.3 Vegetation

To assess the uptake of radionuclides into plant material, USEC collects vegetation samples in the same areas where soil samples are collected (see Figs. 4.5 and 4.6). Vegetation is analyzed for fluoride, technetium, and total uranium. Vegetation collected in 1999 within the process area of PORTS and within PORTS boundaries contained detectable concentrations of fluorides and technetium. No uranium was detected in the vegetation collected within the process area or PORTS boundaries in 1999.

Vegetation samples collected off site in 1999 did not contain technetium above detection limits. One sample contained uranium at the detection limit. Fluorides were present in samples at concentrations that are most likely indicative of background levels.

4.7.4 Crops

In addition to vegetation samples, USEC also collects crop samples both on site and off site to assess the uptake of radionuclides into crops. In 1999, four samples were collected from PORTS (apples and persimmons) and 20 samples were collected from locations near PORTS. Crops collected from locations near PORTS included apples, corn, tomatoes, pumpkins, peppers, and raspberries. Each sample was analyzed for technetium and total uranium. Neither constituent was detected in any of the samples collected in 1999.

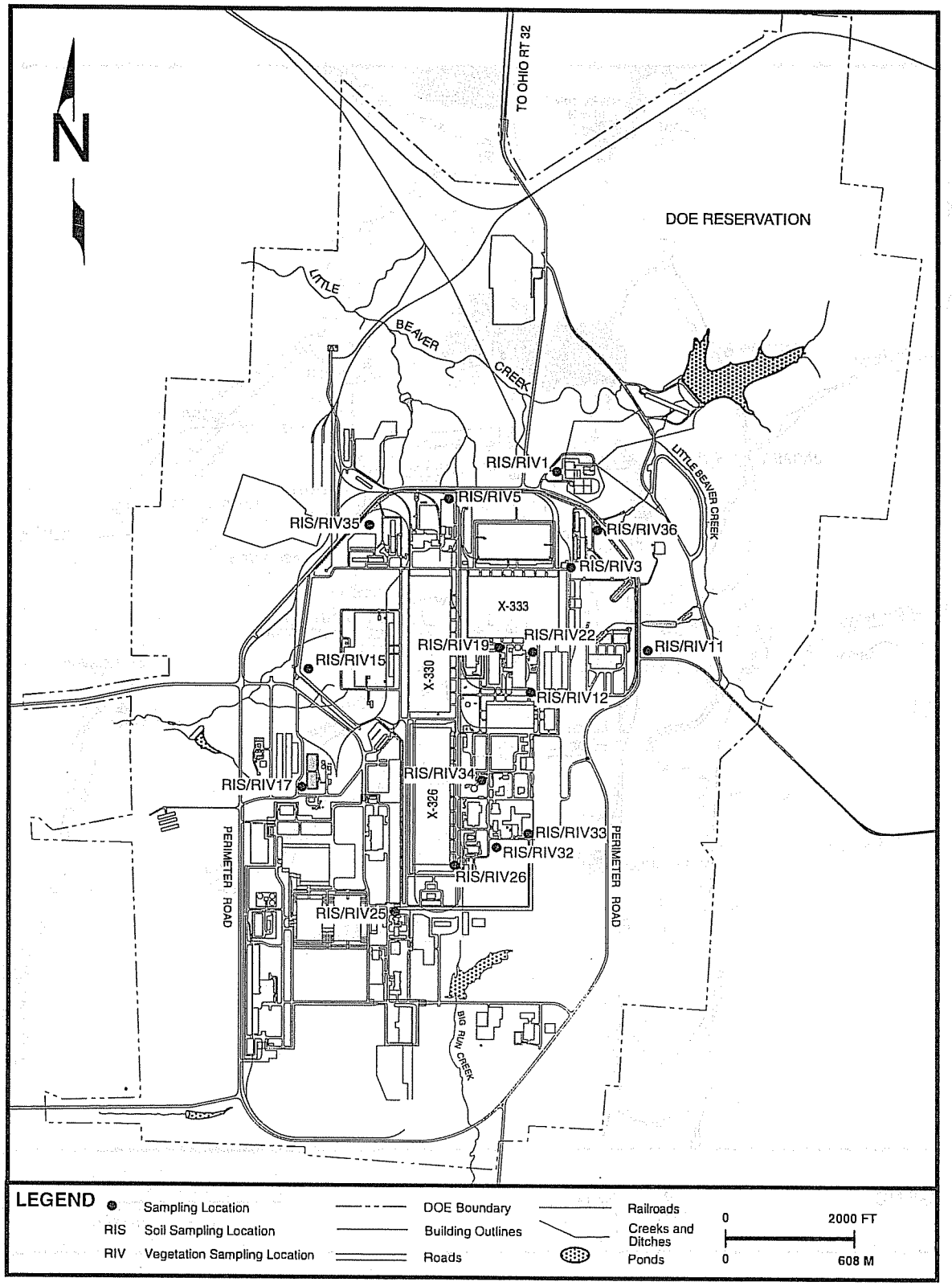

Fig. 4.5. On-site monitoring locations for the USEC soil and vegetation monitoring programs.

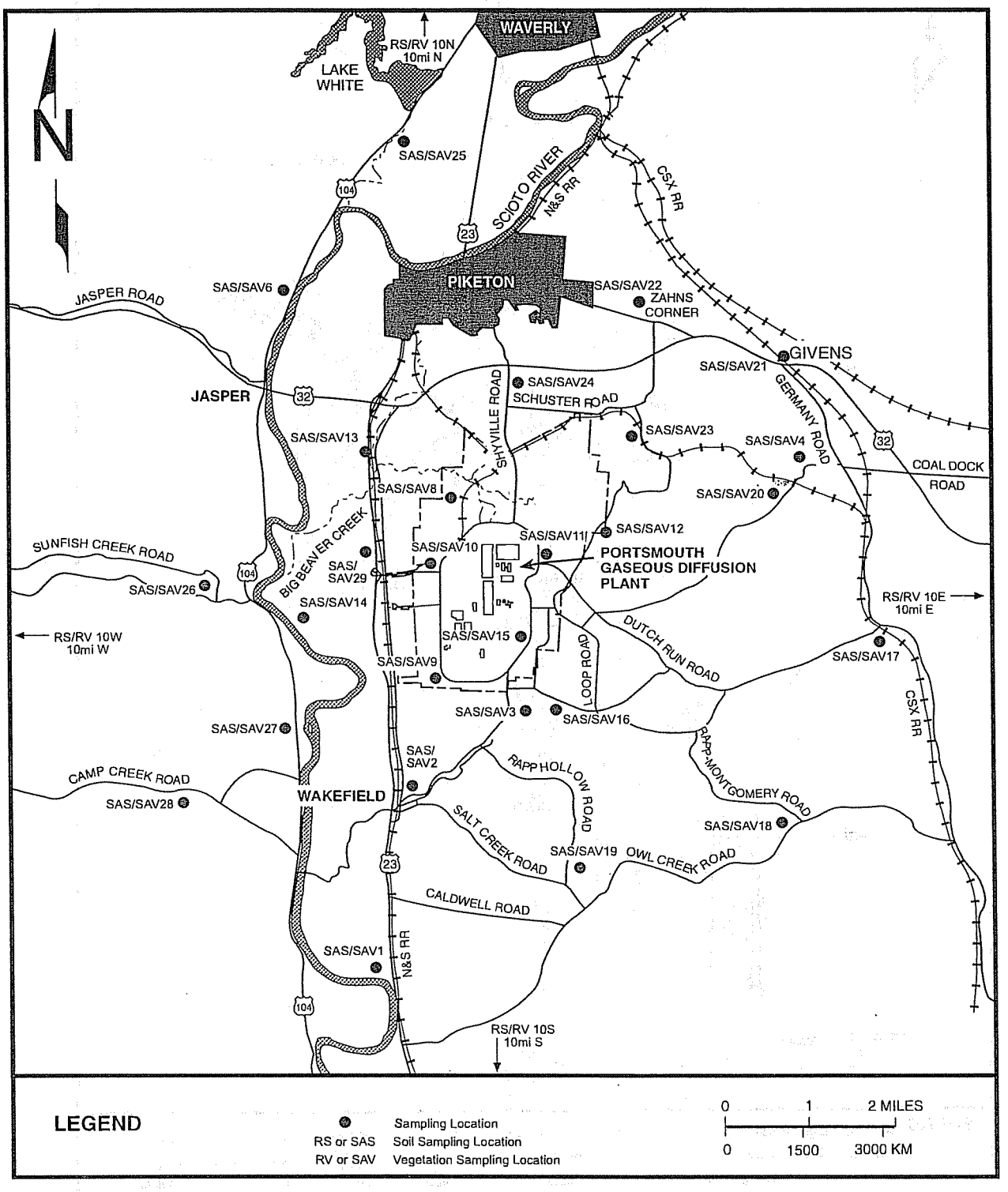

Fig. 4.6. Off-site monitoring locations for the USEC soil and vegetation monitoring programs.

5. DOSE

5.1 SUMMARY

Potential impacts on human health from radionuclides released by PORTS operations are calculated based on environmental monitoring data. 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 millirem (mrem)/year limit for dose from radionuclides released to the air and the DOE sets a 100 mrem/year limit for dose from radionuclides from all potential pathways (air, water, and direct radiation). A person living in southern Ohio receives a dose of approximately 300 mrem/year from natural sources of radiation. This chapter includes radiological dose calculations for the dose to the public from radionuclides released to the air and surface water, and from direct radiation. The maximum dose a member of the public could receive from radiation released by PORTS in 1999 is 0.92 mrem, based on a maximum dose of 0.28 mrem from airborne radionuclides, 0.053 mrem from radionuclides released to the Scioto River, and 0.59 mrem from direct radiation from the PORTS depleted uranium cylinder storage yards. Table 5.1 summarizes this dose information.

Table 5.1. Summary of potential doses to the public from radiation released by PORTS operations in 1999

Source of dose	Dose (mrem)
Airborne radionuclides	0.28
Radionuclides released to the Scioto River	0.053
Direct radiation from depleted uranium cylinder storage yards	0.59
Total	0.92

5.2 INTRODUCTION

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 Portsmouth area receives a dose of approximately 300 mrems/year from sources of natural radiation. Appendix A provides additional information on radiation and dose.

Releases of radionuclides such as uranium from PORTS activities can cause 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 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. These regulations set an annual dose limit of 10 mrem/year to any member of the public as a result of airborne radiological releases. Airborne radionuclide discharges may also be regulated, along with all other atmospheric pollutants, under the State of Ohio Permit to Operate requirements for sources of air emissions.

DOE also regulates radionuclide emissions to all environmental media through DOE Orders 5400.1, *General 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, unlike the National Emission Standards for Hazardous Air Pollutants, which apply to only airborne radiological releases.

Small quantities of radionuclides were released to the environment from DOE/PORTS operations during 1999. This chapter describes the methods used to estimate the potential doses that could result from radionuclides released from PORTS operations.

5.3 RADIOLOGICAL DOSE CALCULATION

Exposure to radioactive materials can occur from releases to the atmosphere, surface water, or groundwater. In addition, a dose could be received through direct external irradiation by radiation emanating from buildings and other objects located within PORTS boundaries. Doses are estimated for all potentially significant exposure pathways relevant to the exposure modes just described. For 1999, doses are estimated for exposure to atmospheric releases, releases to surface water, and direct radiation. Exposure to the radionuclides from groundwater is not included because contaminated groundwater at PORTS is contained on site and is not a source of drinking water.

In addition, DOE Order 5400.5 sets an absorbed dose rate of 1 rad per day to native aquatic organisms. This chapter contains the dose calculations required to demonstrate compliance with this requirement.

DOE/PORTS workers and visitors who may be exposed to radiation are also monitored. These results are discussed at the end of this chapter.

5.3.1 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, possibly 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 significant radionuclides when calculating the radiation dose received by the public around PORTS. Other radioactive isotopes are also part of the radioactive dose received from PORTS operations.

A number of specialized units have been defined for characterizing exposures to ionizing radiation. Because the damage associated with such exposures results primarily from the deposition of radiant energy in tissue, the units are defined in terms of the amount of incident radiant energy absorbed by tissue and in terms of the biological consequences of the absorbed energy. These units include the following:

- *Absorbed dose* – a physical quantity that defines the amount of incident radiant energy absorbed per unit mass of an irradiated material; its unit of measure is the rad. The absorbed dose depends on the type and energy of the incident radiation and on the atomic number of the absorbing material.

- *Dose equivalent* – a quantity that expresses the biological effectiveness of an absorbed dose in a specified human organ or tissue; its unit of measure is the rem. The dose equivalent is numerically

equal to the absorbed dose multiplied by modifying factors that relate the absorbed dose to biological effects.

- *Effective dose equivalent* – a weighted sum of dose equivalents to specified organs that can be used to estimate health-effect risk to exposed persons. In this report, the term "effective dose equivalent" is often shortened to "dose."

- *Committed (effective) dose equivalent* – the total (effective) dose equivalent that will be received over a specified time period (in this document, calculations are based on a 50-year period) because of radionuclides taken into the body during the current year.

- *Collective dose equivalent* – the sum of committed (effective) dose equivalents to all individuals in an exposed population. The unit of measure is the person-rem. The collective dose is also frequently called the "population dose."

- *Total effective dose equivalent* – the sum of the effective dose equivalent for external exposures and the committed (effective) dose equivalent for internal exposure.

5.3.2 Dose Calculation for Atmospheric Releases

A dose calculation for atmospheric, or airborne, radionuclides is required by the U.S. EPA under the program called the National Emission Standards for Hazardous Air Pollutants. The effect of radionuclides released to the atmosphere by DOE/PORTS during 1999 was characterized by calculating effective dose equivalents to the maximally exposed person (the individual who resides at the most exposed point near the plant) and to the entire population (approximately 600,000 residents) within 50 miles of the plant. Dose calculations were made using a computer program called CAP-88 (Beres 1990), which was developed under sponsorship of the U.S. EPA for use in demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants for radionuclides. The program uses a model to calculate concentrations of radionuclides in the air and on the ground and uses *Nuclear Regulatory Commission Regulatory Guide* 1.109 food-chain models to calculate radionuclide concentrations 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 release data were modeled for two DOE/PORTS permitted sources: the X-326 L-cage Glove Box and the X-744 Glove Box. 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 National Emission Standards for Hazardous Air Pollutants 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 1999 was 0.00048 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). USEC calculated the maximum potential dose to an off-site individual in 1999 to be 0.28 mrem/year. The combined dose from USEC and DOE sources is well below the 10-mrem/year limit

applicable to PORTS and the approximate 300-mrem/year dose that the average individual in the United States receives from natural sources of radiation.

The collective dose equivalent to the entire population within 50 miles of PORTS was 1.0 person-rem/year, based on USEC calculations of 1.0 person-rem/year from USEC sources and 0.00077 person-rem/year from DOE sources. The collective dose equivalent to the nearest community, Piketon, was calculated to be 0.15 person-rem/year, based on USEC calculations of 0.15 person-rem/year from USEC sources and 0.00014 person-rem/year from DOE sources.

5.3.3 Dose Calculation for Releases to Surface Water

Radionuclides are measured at each of the DOE and USEC NPDES outfalls. Water from these outfalls is either directly discharged to the Scioto River or eventually flows into the Scioto River from the 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 average annual flow rate of the Scioto River.

Total uranium, americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99 and thorium-230 (selected outfalls) were measured in the water discharged from the DOE or USEC outfalls. Total uranium was assumed to be 94% uranium-235, 5.2% uranium-238, and 0.8% uranium-234. The maximum individual dose was calculated using the above mentioned measured radionuclide discharges from the plant outfalls and the average annual flow rate of the Scioto River. All discharge radioactivity levels were expressed in activity per year (Ci/yr) and used along with the average river flow to calculate radioactivity per volume.

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. The assumption was made that a person eats 21 kg (46 lb) of fish caught in the Scioto River, drinks 730 L (190 gal) of river water, swims for 27 hours, boats for 105 hours, and occupies the shoreline for 69 hours during the year. Based on the calculations across all isotopes found in the outfalls, this individual could receive an annual dose of about 0.053 mrem. This is a very conservative exposure scenario because the Scioto River is not used for drinking water downstream of PORTS (about 90 percent of the hypothetical dose from liquid effluents is from drinking water).

5.3.4 Radiological Dose Calculation for Direct Radiation

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.

Thermoluminescent dosimeters (TLDs) are used to measure beta, gamma, and neutron radiation. The TLD consists of four crystals that store radiation as potential energy. When the TLD crystals are heated, this stored energy is released as light. This light is quantifiable and correlates directly to the amount of ionizing radiation to which the TLD was exposed. The TLD can differentiate exposure to beta, gamma, and neutron radiation as well as shallow and deep radiation. Shallow radiation penetrates only the outer portion of the skin. Deep radiation penetrates the entire body (similar to an x-ray).

Five major DOE/PORTS facilities are monitored for direct radiation exposure levels: the X-7725 Waste Storage Facility, X-326 Process Building, X-345 SNM Storage Building, X-744G Bulk Storage Building, and the X-745C and X-745E Depleted Uranium Cylinder Storage Yards.

None of these facilities are readily accessible to the public; however, Perimeter Road passes close to the edge of the cylinder yards. Therefore, data from direct radiation monitoring at the cylinder yards are used to assess potential exposure to the public from passing traffic on Perimeter Road.

The radiological exposure data provided from the TLDs at each facility are based on exposure to ionizing radiation for an entire year (i.e., 24 hours/day, 7 days/week, 52 weeks/year - 8,736 hours/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. Public traffic is not allowed to stop in this area, and past tests provide the estimate that a car traveling slightly under the posted speed limit passes by the cylinder yards in 20 to 30 seconds. Potential public exposure to radiation from the cylinder yards is calculated as follows:

Assumptions:

- A person driving to and from work (2 exposures/day) is the most conservative plausible scenario.
- The driver will pass by the cylinder yards within 1 minute.

Calculation:

1. Add the deep and shallow dose rates to get a combined dose for the year.

2. Subtract natural background radiation – 78 mrem/year. Natural background radiation consists of 50 mrem/year cosmic radiation and 28 mrem/year terrestrial radiation (see Appendix A).

3. Divide this dose measurement by 8736 hours to determine the exposure per hour.

4. Multiple this exposure by 8.7 hours/year (1 minute/trip x 2 trips/day x 5 work-days/week x 52 weeks/year).

The average deep dose and shallow dose reported in Table 5.2 represent the gross exposure levels at each facility. These levels include ionizing radiation from PORTS activities in those areas and natural background radiation (i.e., terrestrial and cosmic radiation). The final column provides the potential dose to the public from each area.

Table 5.2. Direct radiation doses at DOE/PORTS facilities – 1999

Facility	Average deep dose (mrem/year) continuous exposure (8736 hours)	Average shallow dose (mrem/year) continuous exposure (8736 hours)	Estimated public dose (mrem/year) 8.7 hours exposure
X-7725	20	43	NA[a]
X-326	3	16	NA[a]
X-345	5	11	NA[a]
X-744G	103	85	NA[a]
X-745C	161	134	0.22
X-745E	242	203	0.37

[a] Not applicable - no public exposure to radiation from these buildings.

Based on the assumptions and calculations provided, exposure to the public from radiation from the cylinder yards is approximately 0.59 mrem/year. The average yearly dose to a person in the United States is approximately 366 mrem: 300 mrem from natural radiation sources and 66 mrem from manmade radiation sources (see Appendix A). The potential estimated dose from the cylinder yards to a member of the public is less than 0.2 percent of the average yearly radiation exposure for a person in the United States.

5.3.5 Radiological Dose Calculation for Aquatic Biota

DOE Order 5400.5 sets an absorbed dose rate of 1 rad/day to native aquatic organisms. To demonstrate compliance with this limit, absorbed dose rates to crustacea, mollusks, and fish were calculated using the CRITR2 computer code (Baker and Soldat 1992) and average annual radionuclide concentrations in the Scioto River. The CRITR2 computer model estimates dose rates from internally deposited radionuclides, from immersion in water, and from sediment irradiation.

Modeling results indicate that the aquatic biota in the Scioto River did not receive an absorbed dose of more than 1 rad/day in 1999. Internal and external dose rates were 0.0000032 rad/day to fish, and 0.000006 rad/day to crustacea and mollusks.

5.3.6 Radiological Dose Results for DOE/PORTS Workers and Visitors

The Radiation Exposure Information Reporting System report is an electronic file created annually to comply with DOE Order 231.1. This report contains exposure results for all monitored individuals at DOE/PORTS, including visitors, with a positive exposure during the previous calendar year. The 1999 Radiation Exposure Information Reporting System report indicated that there were no visitors with a positive exposure.

The average total effective dose in 1999 for all monitored DOE/PORTS employees and subcontractors was 0.83 mrem.

6. GROUNDWATER PROGRAMS

6.1 SUMMARY

Groundwater monitoring at DOE/PORTS is required by legal agreements with Ohio EPA and U.S. EPA and DOE Orders. More than 400 monitoring wells are used to track the flow of groundwater and to identify and measure groundwater contaminants. Groundwater programs also include on-site surface water monitoring and residential water supply monitoring. The contaminated groundwater plumes present at PORTS did not change significantly in 1999.

6.2 INTRODUCTION

Groundwater is used as a domestic, municipal, and industrial water supply in the vicinity of DOE/ PORTS. Most municipal and industrial water supplies in Pike County are developed from the Scioto River Valley buried aquifer. Domestic (household) water supplies are developed from sand and/or gravel deposits, tributaries to the Scioto River Valley aquifer, or fractures in bedrock. Groundwater beneath PORTS is not used as a domestic, municipal, or industrial water supply and contaminants in the groundwater beneath PORTS do not affect the quality of the water in the Scioto River Valley buried aquifer.

The PORTS reservation is the largest industrial user of water in the vicinity and obtains its water from three water supply well fields that are next to the Scioto River south of Piketon. The wells tap the Scioto River Valley buried aquifer. Total groundwater production averages 13 million gallons per day for the entire site, including USEC activities.

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

6.3 GROUNDWATER MONITORING AT DOE/PORTS

Groundwater water monitoring at PORTS was initiated in the 1980s. Groundwater monitoring has been conducted in response to regulatory requirements from state and/or federal regulations, regulatory documents prepared by DOE/PORTS, legal agreements between DOE and Ohio EPA or U.S. EPA, and DOE Orders. Groundwater monitoring at DOE/PORTS includes RCRA hazardous waste units, solid waste disposal units, and RCRA Corrective Action Program units.

Because of these numerous regulatory programs, DOE/PORTS developed the *Integrated Groundwater Monitoring Plan* to minimize the potential for confusion in interpreting requirements and to maximize resources for collecting the data needed for sound decision making. The *Integrated Groundwater Monitoring Plan* was designed to establish all groundwater monitoring requirements for PORTS and has been reviewed and approved by Ohio EPA. Prior to April 1999, groundwater monitoring

at PORTS was performed under the varying programs and requirements applicable to each groundwater monitoring area. On April 1, 1999, the *Integrated Groundwater Monitoring Plan* became the implementing document for groundwater monitoring at PORTS. Therefore, this Annual Environmental Report includes data collected under the *Integrated Groundwater Monitoring Plan* and first quarter 1999 data collected under previous program requirements.

Additional groundwater monitoring is completed to meet DOE Order requirements. Exit pathway monitoring assesses the effect of DOE/PORTS on regional groundwater quality and quantity. Baseline monitoring is conducted to establish background data for use in assessing the effect of DOE/PORTS operations on the groundwater. DOE Orders are also the basis for the radiological monitoring of groundwater at PORTS.

Two aquifers, or underground areas that contain significant amounts of water, are present at PORTS. These aquifers are called the Gallia and Berea. The Gallia is the uppermost aquifer, or closest to the ground surface, and contains most of the groundwater contamination at PORTS. The Berea aquifer is deeper than the Gallia and is usually separated from the Gallia by material that limits the movement of groundwater from the Gallia to the Berea.

Several areas of groundwater contamination have been identified at PORTS. Groundwater contamination consists of volatile organic compounds, primarily trichloroethene, and radionuclides such as uranium and technetium. In general, groundwater monitoring results for 1999 indicate that:

- Groundwater flow directions have remained generally the same, although the rate of flow was slower in many areas in 1999, possibly due to the lack of precipitation.
- Contaminants appear to be contained within the reservation's boundaries.
- The concentration of contaminants and the lateral extent of plume boundaries did not significantly increase in 1999.

The *1999 Annual Groundwater Monitoring Report* provides further details on the groundwater plumes at DOE/PORTS, specific monitoring well identifications, and analytical results for monitoring wells.

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

6.4 GROUNDWATER MONITORING AREAS

Prior to implementation of the *Integrated Groundwater Monitoring Plan,* routine groundwater monitoring was performed at six RCRA hazardous waste units, three solid waste units, and two RCRA Corrective Action Program units. With implementation of the *Integrated Groundwater Monitoring Plan*, these units were consolidated into eight groundwater monitoring areas within the four quadrants of the site designated by the RCRA Corrective Action Program. These areas (see Fig. 6.1) are:

- X-749 Contaminated Materials Disposal Facility/X-120 Old Training Facility/Peter Kiewit Landfill (formerly the X-749 Contaminated Materials Storage Yard and X-749B Peter Kiewit Landfill),

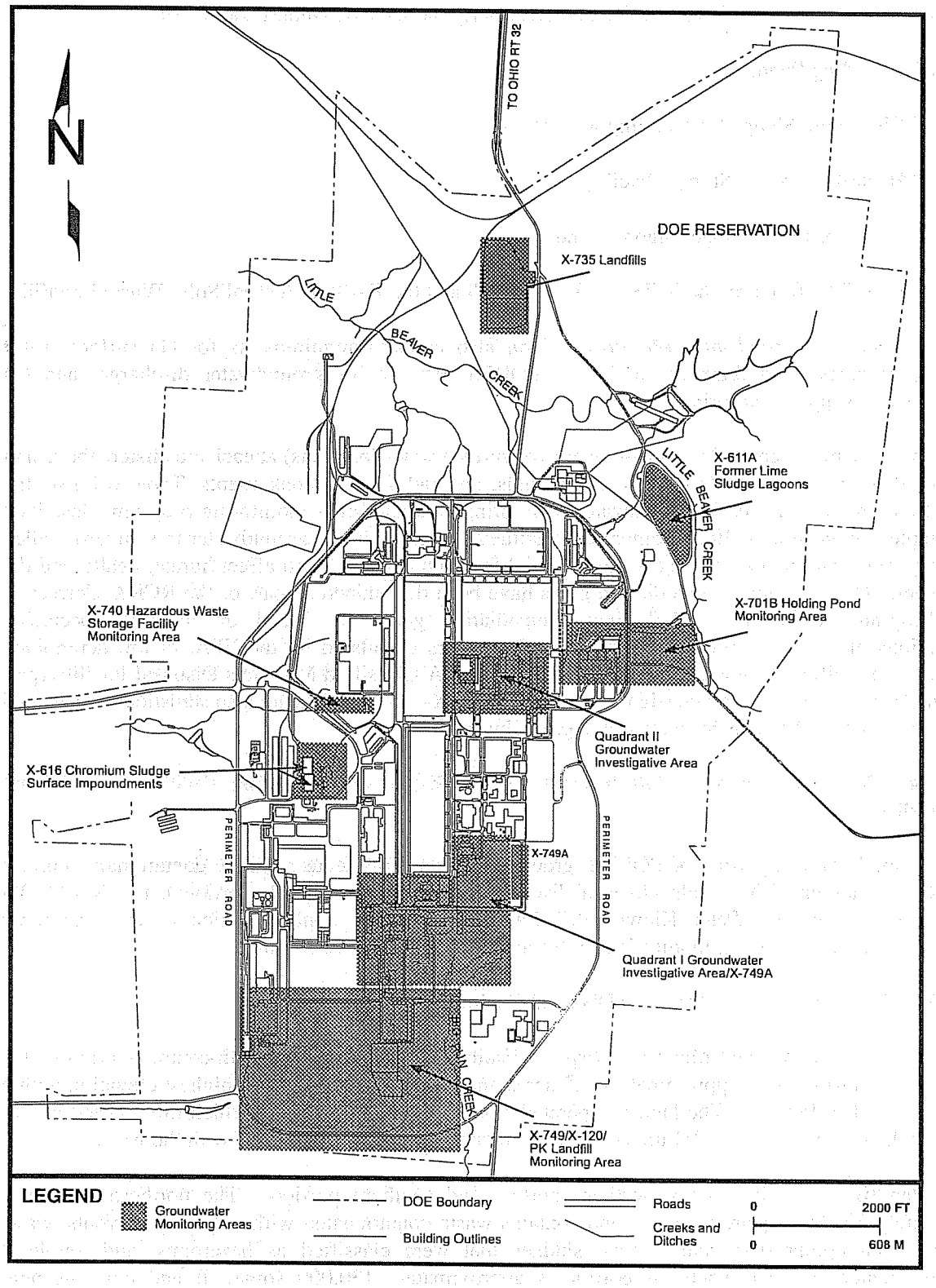

Fig. 6.1. Groundwater monitoring areas at PORTS.

- Quadrant I Groundwater Investigative Area/X-749A Classified Materials Disposal Facility (formerly the X-231B Southwest Oil Biodegradation Plot and X-749A Classified Materials Disposal Facility,)
- Quadrant II Groundwater Investigative Area (formerly the X-701C Neutralization Pit),
- X-701B Holding Pond,
- X-616 Chromium Sludge Surface Impoundments,
- X-740 Hazardous Waste Storage Facility,
- X-611A Former Lime Sludge Lagoons, and
- X-735 Landfills (formerly the X-735 RCRA Landfill and the X-735 Industrial Solid Waste Landfill).

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

In general, samples are collected from wells (or surface water locations) at each area listed above and are analyzed for metals, volatile organic compounds, and radiological constituents. Table 6.1 lists the analytical requirements for each groundwater monitoring area and other monitoring programs described in this chapter. In general, PORTS compares constituents detected in the groundwater to standards called preliminary remediation goals to assess the potential for each constituent to affect human health and the environment. The preliminary remediation goals have been determined as part of the RCRA Corrective Action Program at PORTS. Preliminary remediation goals are based on naturally occurring concentrations of some constituents, on risk-based numbers calculated by the EPA, or are determined through a site-specific risk assessment. Data for the X-749A Classified Materials Disposal Facility (part of the Quadrant I Groundwater Investigative Area) and the X-735 Landfills are also statistically evaluated to determine whether the areas have impacted groundwater.

6.4.1 X-749 Contaminated Materials Storage Facility/X-120 Old Training Facility/Peter Kiewit Landfill

In the southernmost portion of PORTS, groundwater concerns focus on three contaminant sources: the X-749 Contaminated Materials Disposal Facility (both north and south portions), the X-120 Old Training Facility, and the Peter Kiewit (PK) Landfill. Prior to implementation of the *Integrated Groundwater Monitoring Plan,* monitoring in this area focused on the X-749 unit.

6.4.1.1 X-749 Contaminated Materials Disposal Facility

The X-749 Contaminated Materials Disposal Facility is located in the south-central section of the facility. The landfill covers approximately 7.5 acres and was built in an area of highest elevation within the southern half of PORTS. The landfill operated from 1955 to 1990, during which time buried wastes were generally contained in metal drums or other containers that were compatible with the waste.

The landfill is divided into a northern portion and southern portion. The northern portion is approximately 200,000 square ft in size and contains waste contaminated with industrial solvents, waste oils from plant compressors and pumps, sludges that were classified as hazardous, and low-level radioactive materials. The southern portion is approximately 130,000 square ft and contains non-hazardous, low-level radioactive scrap materials.

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

Monitoring Area or Program	Analytes		
X-749/X-120/PK Landfill[a]			
X-749/X-120 plume	volatile organic compounds[b]	chloride	
	technetium-99	sulfate	
	total uranium	total metals[d]:	Ca, Fe, Mg, K, Na
	alkalinity	transuranics[d,e]:	^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu
PK Landfill	volatile organic compounds[b]	total metals[d]:	As, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Ni, K, Se, Na, V, Zn
	technetium-99		
	total uranium		
	% uranium-235	fluoride	
	alkalinity	mercury	
	chloride	Arochlor-1260	
	sulfate		
Quadrant I Groundwater Investigative Area[a]			
X-231B plume	volatile organic compounds[b]	chloride	
	technetium-99	sulfate	
	total uranium	total metals[d]:	Ca, Fe, Mg, K, Na
	alkalinity	transuranics[d,e]:	^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu
X-749A Classified Materials Disposal Facility	volatile organic compounds[c]	total metals[d]:	Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn
	gross alpha, gross beta		
	technetium-99		
	total uranium		
	alkalinity		
	chloride	ammonia	
	sulfate	chemical oxygen demand	
	nitrite	total dissolved solids	
	nitrate	turbidity	
Quadrant II Groundwater Investigative Area[a]	volatile organic compounds[b]	chloride	
	technetium-99	sulfate	
	total uranium	total metals[d]:	Ca, Fe, Mg, K, Na
	alkalinity	transuranics[d,e]:	^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu, ^{230}Th
X-701B Holding Pond[a]	volatile organic compounds[b]	chloride	
	technetium-99	sulfate	
	total uranium	total metals[d]:	Ca, Fe, Mg, K, Na
	alkalinity	transuranics[d,e]:	^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu, ^{230}Th
X-616 Chromium Sludge Surface Impoundments	volatile organic compounds[b]	chloride	
	gross alpha, gross beta	sulfate	
	technetium-99	total metals[d]:	Ca, Fe, Mg, K, Na, Ba, Cd, Cr, Pb, Mn, Ni, Sb, Tl
	total uranium		
	alkalinity		

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

Monitoring Area or Program	Analytes		
X-740 Hazardous Waste Storage Facility[a]	volatile organic compounds[b] technetium-99 total uranium alkalinity	chloride sulfate total metals[d]:	 Ca, Fe, Mg, K, Na
X-611A Former Lime Sludge Lagoons	total metals[d]:		
X-735 Landfills	volatile organic compounds[c] gross alpha, gross beta technetium-99 total uranium alkalinity chloride sulfate nitrite nitrate	total metals[d]: ammonia chemical oxygen demand total dissolved solids turbidity	Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn
Surface Water	volatile organic compounds[b] technetium-99 total uranium alkalinity	chloride sulfate total metals[d]: transuranics[d]:	 Ca, Fe, Mg, K, Na ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu
Residential Water Supply	volatile organic compounds[b] technetium-99 total uranium alkalinity	Chloride Sulfate total metals[d]: transuranics[d]:	 Ca, Fe, Mg, K, Na ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu
Exit Pathway and Baseline	volatile organic compounds[b] technetium-99 total uranium alkalinity	chloride sulfate total metals[d]:	 Ca, Fe, Mg, K, Na

[a] Selected well(s) in this area are sampled once every two years for a comprehensive list of over 200 potential contaminants (40 CFR Part 264 Appendix IX – Appendix to OAC Rule 3745-54-98).

[b] Acetone, benzene, bromodichloromethane, bromoform, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, dibromochloromethane, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, bromomethane, chloromethane, methylene chloride, 2-butanone (methyl ethyl ketone), 4-methyl-2-pentanone (methyl isobutyl ketone), 1,1,2,2-tetrachloroethane, tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, trichlorofluoromethane (CFC-11), vinyl chloride, 1,3 (1,4)-dimethylbenzene (xylenes).

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

[d] Appendix C lists the symbols for metals and transuranic radionuclides.

[e] Samples from selected wells at this area are analyzed for these parameters

Closure of the X-749 landfill included installation of (1) a multimedia cap, (2) a slurry wall along the north side and northwest corner of X-749, and (3) subsurface groundwater drains on the northern half of the east side and the southwest corner, including one groundwater extraction well within each of the groundwater drains. The slurry wall and subsurface drains extend down to bedrock. Groundwater from the subsurface drains is treated on site and discharged in accordance with the DOE/PORTS NPDES permit.

The leading edge of the contaminated groundwater plume emanating from the X-749 landfill has been approaching the southern boundary of the PORTS reservation. In 1995, a subsurface diversion wall was completed across a portion of this southern boundary. The diversion wall is designed to inhibit migration of the plume off plant property prior to the implementation of a final remedial measure.

Three wells monitor the subsurface diversion wall at the leading edge of the groundwater plume. These wells are sampled quarterly. Twenty-one additional wells (19 monitoring wells and 2 extraction wells) are sampled semiannually to monitor the X-749 plume. Twenty additional wells are sampled annually or biennially to monitor both the X-749 and the X-120 plumes. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.1.2 X-120 Old Training Facility

The X-120 Old Training Facility covered an area of approximately 11.5 acres near the present-day XT-847 building. The X-120 facility, which no longer exists, included a machine shop, metal shop, paint shop, and several warehouses used during the construction of PORTS in the 1950s. The shops may have used solvents and various other materials; disposal practices of these solvents are unknown.

Groundwater in the vicinity of this facility contains primarily trichloroethene. The upgradient portion of the X-120 plume co-mingles with a portion of the X-749 plume; however, downgradient the X-120 plume migrates independently to the southwest. In 1996, a horizontal well was installed along the approximate axis of the X-120 plume. This well passively transmits contaminated groundwater by gravity drainage to the X-625 Groundwater Treatment Facility.

Three wells are sampled semiannually to monitor the plume associated with the X-120 area. Twenty additional wells are sampled annually or biennially to monitor both the X-749 and the X-120 plumes. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.1.3 PK Landfill

The PK Landfill is located west of Big Run Creek just south of the X-230K Holding Pond. The landfill, which began operations in 1952, was used as a salvage yard, burn pit, and trash area during the construction of PORTS. After the initial construction, the disposal site was operated as a sanitary landfill until 1968, when soil was graded over the site and the area was seeded with native grasses. No records exist that characterize the material in the landfill.

During site investigations, intermittent seeps were observed emanating from the PK Landfill into Big Run Creek. In 1993, sampling was conducted at three of the seeps and at Big Run Creek approximately 40 ft downstream of the seeps. Sample results indicated that the seeps contained vinyl chloride; however, no vinyl chloride was detected in Big Run Creek.

In 1994, a portion of Big Run Creek was relocated approximately 50 ft to the east. A groundwater collection system was installed in the old creek channel to capture the seeps emanating from the landfill. A second collection system was constructed on the southeastern boundary to contain the groundwater

plume migrating toward Big Run Creek from the southern portion of the PK landfill in 1997. A cap was constructed over the landfill in 1998.

Ten wells were sampled quarterly from the fourth quarter of 1998 through the third quarter of 1999 to monitor this area. Beginning in the fourth quarter of 1999, sampling at the wells takes place semiannually. Two sumps that collect groundwater from the plume are sampled quarterly. Table 6.1 lists the analytical parameters for the wells and sumps in this area.

6.4.1.4 Monitoring results for the X-749/X-120/PK Landfill in 1999

Contaminated groundwater plumes are associated with the X-749/X-120/PK Landfill groundwater monitoring area (see Fig. 6.2). The most extensive and most concentrated constituents associated with the X-749/X-120 plume are volatile organic compounds, particularly trichloroethene and trichloroethane. Remediation of these constituents may be required as part of the RCRA Corrective Action Program.

In 1999, the X-120 and X-749 plumes became less separated based on the detection of trichloroethene in the sample collected from well X120-09G. No other significant changes to the plume boundaries were identified in 1999.

Inorganics (metals) and radiological constituents (uranium and technetium) have also been detected in the groundwater beneath the X-749 area. Remediation of these constituents may be required as part of the RCRA Corrective Action Program at the X-749.

Some of the wells associated with the PK Landfill also appear to be contaminated with low levels of volatile organic compounds, but usually at concentrations below preliminary remediation goals. However, vinyl chloride was detected in two wells in 1999 above its preliminary remediation goal. Remediation of these constituents may be required as part of the RCRA Corrective Action Program.

6.4.2 Quadrant I Groundwater Investigative Area/X-749A Classified Materials Disposal Facility

In the northern portion of Quadrant I, groundwater concerns focus on two areas: the Quadrant I Groundwater Investigative Area and the X-749A Classified Materials Disposal Facility. The X-231B Southwest Oil Biodegradation Plot is a part of the Quadrant I Groundwater Investigative Area and was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*. The X-749A was also monitored prior to implementation of the *Integrated Groundwater Monitoring Plan* under requirements for solid waste landfills.

6.4.2.1 X-231B Southwest Oil Biodegradation Plot

The X-231B Southwest Oil Biodegradation Plot was used from 1976 to 1983 for land application of contaminated oil/solvent mixtures generated from the enrichment process and maintenance activities. The X-231B area is located west of the X-600 Steam Plant, and consisted of two disposal plots, each surrounded by an elevated soil berm, which were periodically fertilized and disked to enhance aeration and promote biological degradation of waste oil. The X-231B area was not operated as a RCRA-regulated land treatment unit. Since ceasing operation in 1983, these plots have been remediated to remove volatile organic compound contamination present in the soil and an interim cap has been installed over the area.

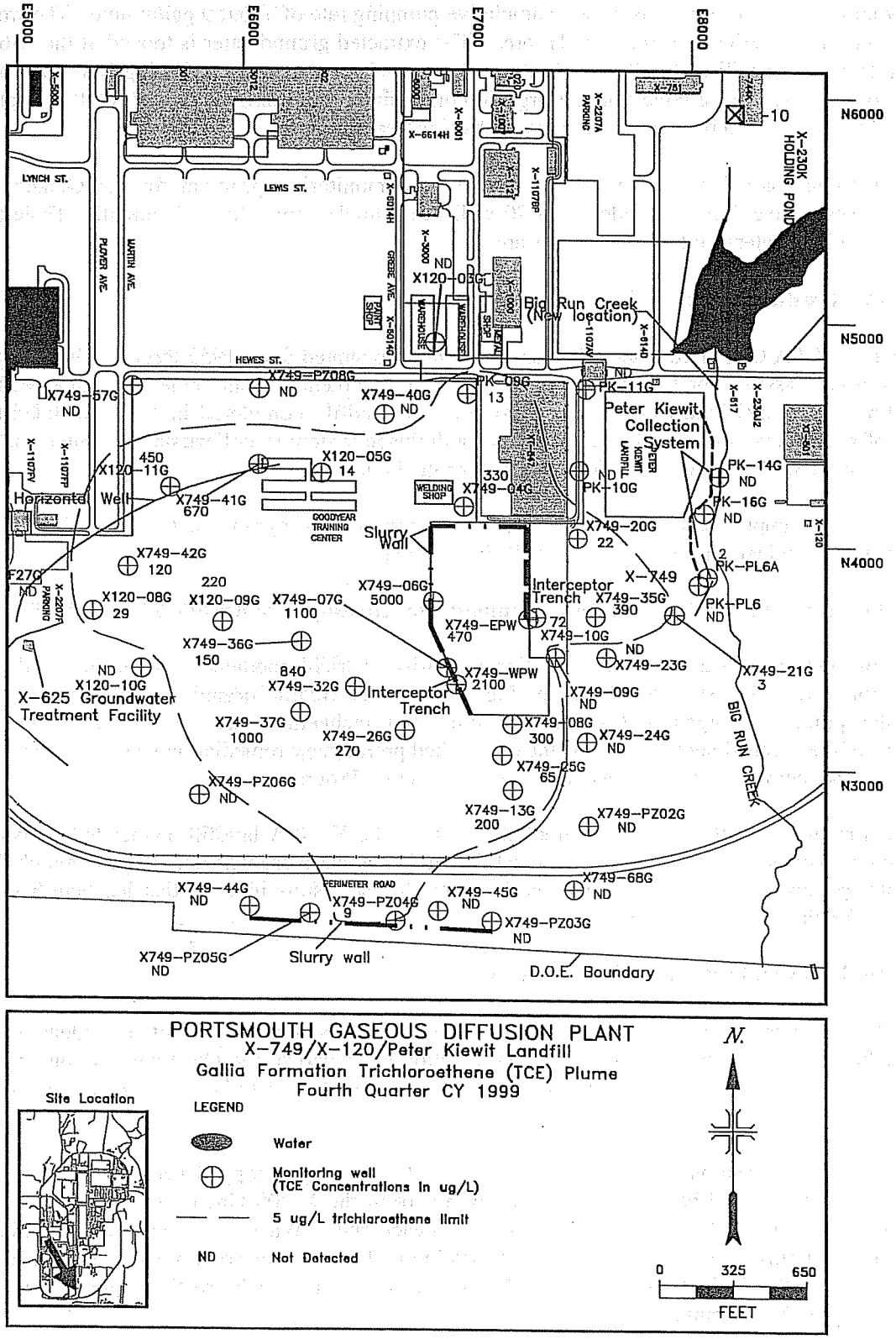

Fig. 6.2. Trichloroethene-contaminated Gallia groundwater plume at the X-749/X-120/PK Landfill (1999).

Three groundwater extraction wells were installed in the Gallia in 1991 as part of the X-231B interim remedial measure. These wells have a cumulative pumping rate of about 9 gal/minute. The wells are located south (downgradient) of the X-231B area. The extracted groundwater is treated at the X-622 Groundwater Treatment Facility. In 1994, soils above the groundwater were treated using *in situ* thermal enhanced vapor extraction to remove volatile organic compounds. Approximately 80% of the volatile organic compounds present in the soils were removed by this treatment.

Fifteen wells are sampled semiannually as part of the monitoring program for the Quadrant I Groundwater Investigative Area. An additional 20 wells are sampled annually or biennially. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.2.2 X-749A Classified Materials Disposal Facility

The 6-acre X-749A Classified Materials Disposal Facility operated from 1953 through 1988 for the disposal of wastes classified under the Atomic Energy Act. Potential contaminants include PCBs, asbestos, radionuclides, and industrial waste. Closure of the landfill, completed in 1994, included the construction of a multilayer cap and the installation of a drainage system to collect surface water runoff. The drainage system discharges via a USEC NPDES-permitted outfall.

Eight wells are sampled semiannually as part of the monitoring program for the X-749A landfill. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.2.3 Monitoring results for the Quadrant I Groundwater Investigative Area/X-749A in 1999

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the Quadrant I Groundwater Investigative Area (see Fig. 6.3). Other volatile organic compounds are also present in the plume. Inorganics (metals), uranium, and technetium are also present, but the concentrations of these constituents are below the established preliminary remediation goals and therefore do not require remediation as part of the RCRA Corrective Action Program.

Analytical results from the two 1999 sampling events at the X-749A landfill, associated statistical analyses, and comparisons of 1999 data to historical data indicate that there was not a significant change in the indicator parameters evaluated at this area in 1999. These results indicate that leachate has not been released from this unit to the groundwater.

6.4.3 Quadrant II Groundwater Investigative Area

In the western portion of Quadrant II, groundwater concerns are focused on the Quadrant II Groundwater Investigative Area. The X-701C Neutralization Pit is part of the Quadrant II Groundwater Investigative Area and was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*.

The X-701C Neutralization Pit is an 18-ft-deep 25-ft by 25-ft open-topped neutralization pit that received process effluents and basement sump wastewater from the X-700 Chemical Cleaning Facility from approximately 1953 to 1988, when the X-701C was deactivated. Waste received included acid and alkali solutions, and rinse water contaminated with trichloroethene and/or trichloroethane from metal cleaning operations. The X-701C Neutralization Pit is located within a trichloroethene plume centered around the X-700 and X-705 buildings.

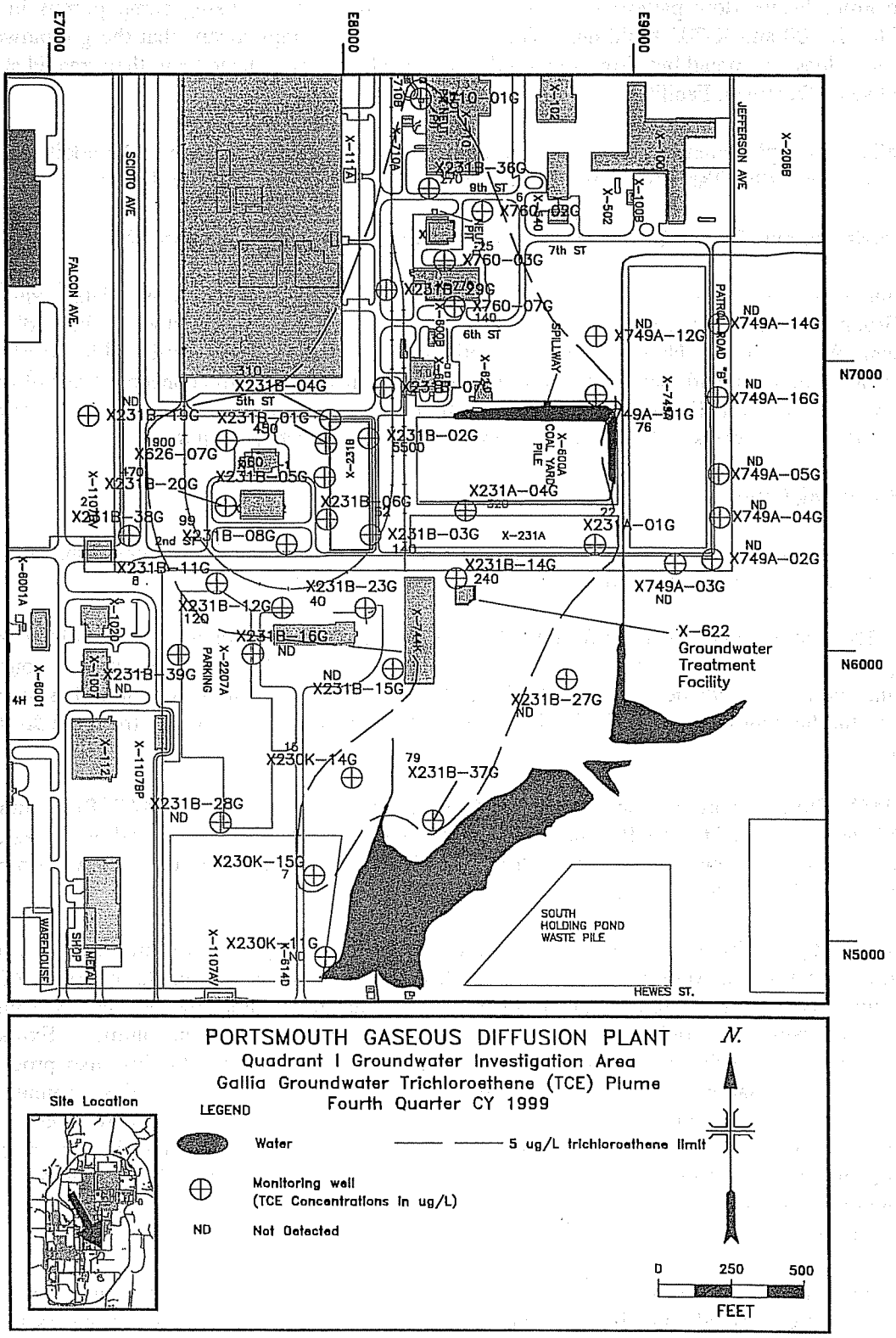

Fig. 6.3. Trichloroethene-contaminated Gallia groundwater plume at the Quadrant I Groundwater Investigative Area (1999).

The natural groundwater flow direction in this area is to the east toward Little Beaver Creek. However, the groundwater flow pattern has been changed in this area by using sump pumps in the basements of the X-700 and X-705 buildings. The use of the sump pumps means that the groundwater plume in this area does not spread but flows toward the sumps where it is collected and then treated at the X-622 Groundwater Treatment Facility.

Eight wells are sampled annually as part of the monitoring program for this area. An additional 16 wells are sampled biennially. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.3.1 Monitoring results for the Quadrant II Groundwater Investigative Area in 1999

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the Quadrant II Groundwater Investigative Area (see Fig. 6.4). The extent of this groundwater plume did not change between 1998 and 1999. Numerous other volatile organics were also detected within the plume. Inorganics (metals), uranium, and technetium were also detected in 1999, but the concentrations of these constituents are below the established preliminary remediation goals. Thorium-230 was also detected in samples collected from two wells in 1999 at concentrations less than 1 picocurie/liter.

6.4.4 X-701B Holding Pond

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

The X-701B Holding Pond was used from the beginning of plant operations in 1954 until November 1988. The pond was designed for neutralization and settlement of acid waste from several sources. Trichloroethane and trichloroethene were also discharged to the pond. Two sludge retention basins were located west of the holding pond. The X-230J7 Holding Ponds received wastewater from the X-701B Holding Pond.

The X-744Y Storage Yard is approximately 15 acres and surrounds the X-744G Bulk Storage Building. This area is one of the RCRA hazardous waste management units considered an "integrated unit" in the 1999 Director's Final Findings and Orders and is therefore included in the RCRA Corrective Action Program (see Chap. 2, Sect. 2.3.2.1).

A contaminated groundwater plume extends from the X-701B Holding Pond to Little Beaver Creek. Three groundwater extraction wells were installed southeast of X-701B as part of the ongoing RCRA closure of the unit. These wells were designed to intercept contaminated groundwater emanating from the holding pond area before it could join the existing groundwater contaminant plume. Extracted groundwater is processed at the X-623 Groundwater Treatment Facility. This facility also processes water recovered from a shallow sump in the bottom of the X-701B Holding Pond. Two groundwater interceptor trenches (French drains) are used to intercept trichloroethene-contaminated groundwater emanating from X-701B. The X-237 Groundwater Collection System has significantly reduced trichloroethene migration into Little Beaver Creek. The 660-foot-long primary trench has two extraction wells completed in the backfill, and a 440-foot-long secondary trench intersects the primary trench. The extracted groundwater is treated at the X-624 Groundwater Treatment Facility.

Fifteen wells are sampled semiannually as part of the monitoring program for this area. An additional 17 wells are sampled annually or biennially. Table 6.1 lists the analytical parameters for the wells in this area.

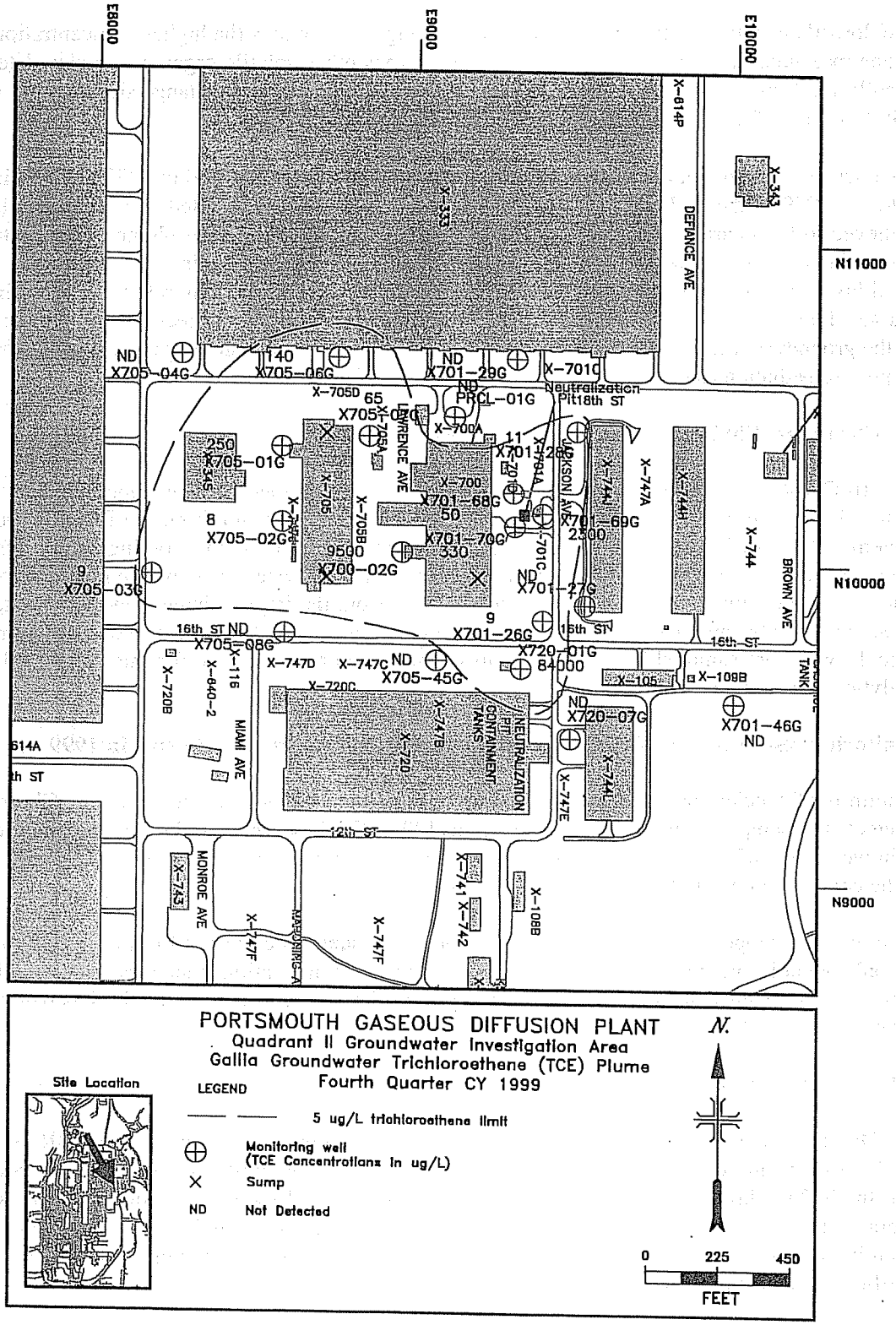

Fig. 6.4. Trichloroethene-contaminated Gallia groundwater plume at the Quadrant II Groundwater Investigative Area (1999).

6.4.4.1 Monitoring results for the X-701B Holding Pond in 1999

The trichloroethene plume at this groundwater monitoring area contains the highest concentrations of trichloroethene measured in groundwater at PORTS. Numerous other volatile organics are also detected in samples collected from the monitoring wells in this area. The plume did not change significantly from 1998 to 1999 (see Fig. 6.5).

A second trichloroethene plume at the X-701B monitoring area was identified in 1998 and continued to be detected in 1999 in the X-744Y Storage Yard area. This apparently isolated and crescent-shaped plume is believed to be separate from and unrelated to the X-701B Holding Pond plume. Flow data for this new plume indicates the flow direction is to the northeast, or toward the main X-701B plume. This flow data and historical sampling data support the theory that this new plume is unrelated to the primary X-701B plume. Inorganics (metals) and radiological constituents (uranium and technetium-99) are also detected in the groundwater in this area. These constituents are being evaluated as part of a special study and may require remediation as part of the RCRA Corrective Action Program.

6.4.5 X-616 Chromium Sludge Surface Impoundments

The X-616 Chromium Sludge Surface Impoundments are two unlined surface impoundments used from 1976 to 1985 for storage of sludge generated by the treatment of water from the PORTS process cooling system. A corrosion inhibitor containing chromium was used in the cooling water system. Sludge containing chromium was produced by the water treatment system and was pumped into and stored in the X-616 impoundments. The sludge was removed from the impoundments and remediated as an interim action in 1990 and 1991. The unit was certified closed in 1993. Six wells are sampled annually and 10 wells are sampled biennially as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.5.1 Monitoring results for the X-616 Chromium Sludge Surface Impoundments in 1999

Chromium is of special concern at the X-616 because of the previous use of the area. Chromium was only detected in samples from 4 of the 16 wells in 1999. Of these wells, only the concentration of chromium in well X616-05G exceeded the preliminary remediation goal for chromium of 100 μg/L. Fig. 6.6 shows the concentrations of chromium in wells at the X-616.

Volatile organic compounds were detected at low levels in samples collected from four wells at this area. The only volatile organic detected above its preliminary remediation goal was trichloroethene. Remediation of constituents detected above preliminary remediation goals may be required as part of the RCRA Corrective Action Program.

6.4.6 X-740 Hazardous Waste Storage Facility

The X-740 Hazardous Waste Storage Facility, which is located on the western half of PORTS south of the X-530A Switchyard, consists of two hazardous waste management units: the X-740 Waste Storage Facility and the X-740 Hazardous Waste Storage Tank (sump) located within the building. The X-740 facility operated from 1983 until 1991; the tank/sump was only operated until 1990. The units were initially identified as hazardous waste management units in 1991. The unit underwent closure, and closure certification was approved by Ohio EPA in 1998.

Constructed in 1982, the facility consists of a diked concrete pad, a roof, corrugated steel siding on three sides, and a plastic windbreak on the fourth side. The unit is approximately 120-ft by 50-ft. During

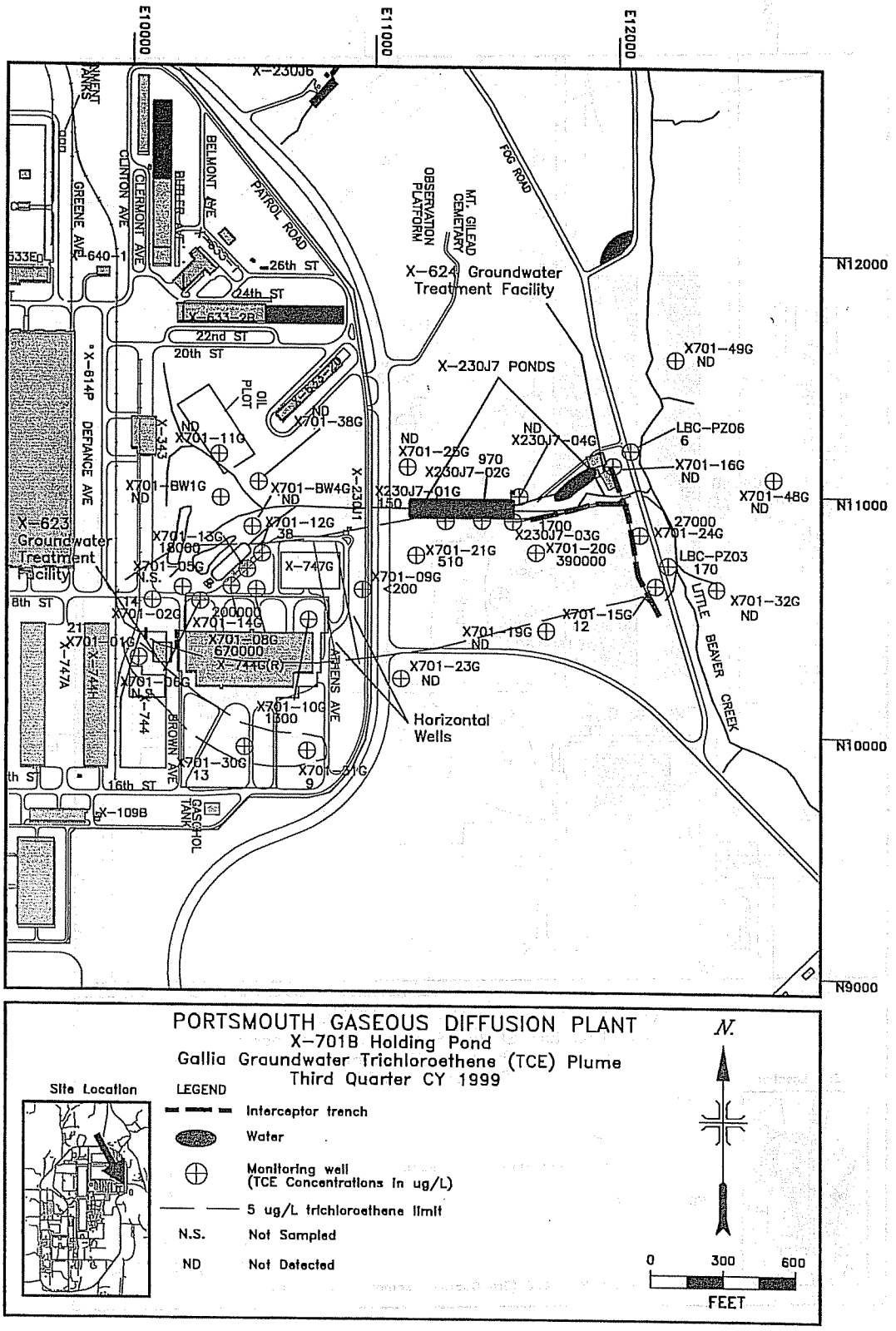

Fig. 6.5. Trichloroethene-contaminated Gallia groundwater plume at the X-701B Holding Pond (1999).

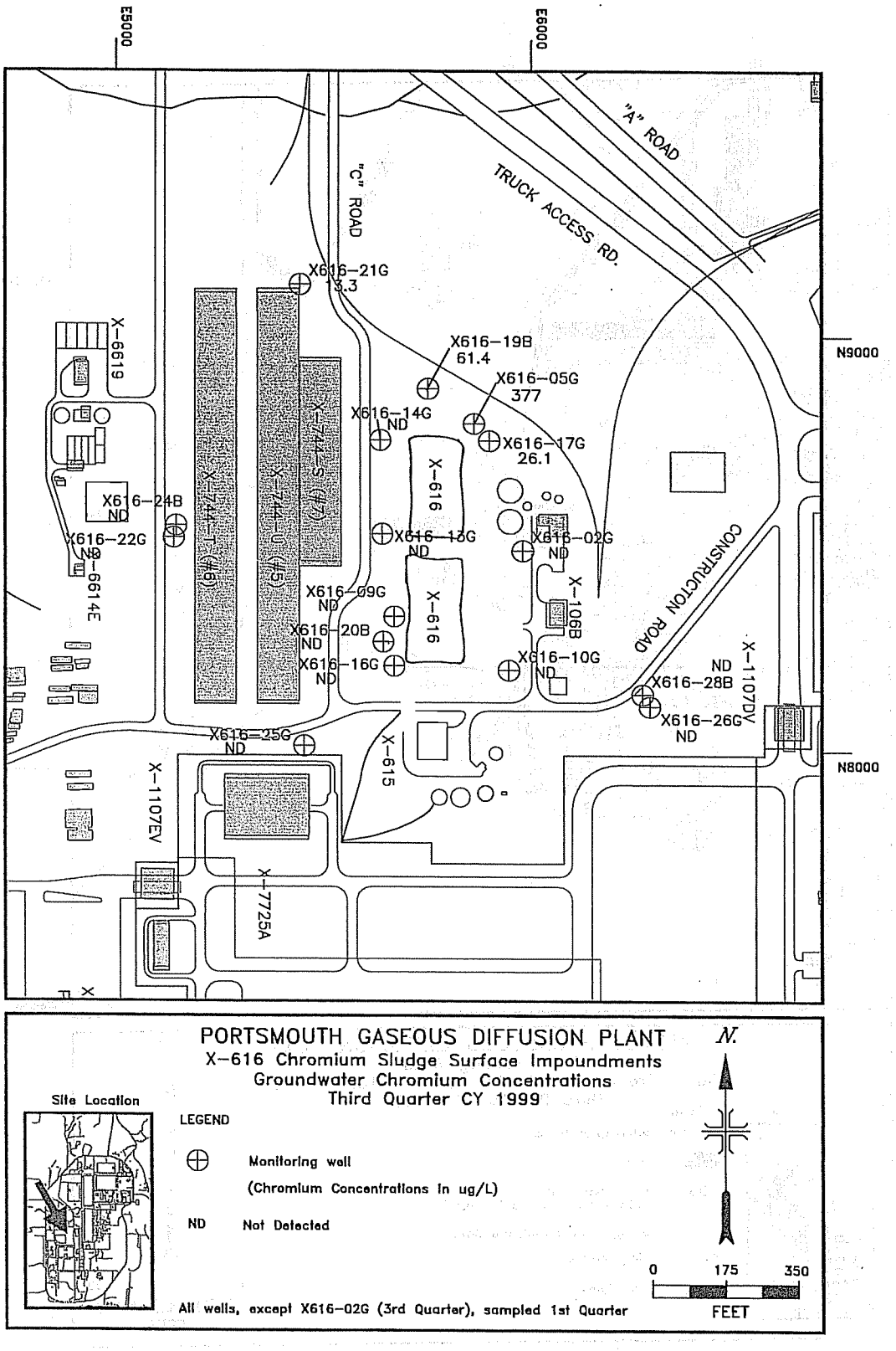

Fig. 6.6. Chromium concentrations in groundwater at the X-616 Chromium Sludge Surface Impoundments (1999).

its period of operation, the facility was used as an inventory and staging facility for waste oil and waste solvents that were generated from various plant operational and maintenance activities. The drums were staged at the facility pending analysis of their contents and subsequent final disposition. Empty drums, resulting from combining partially full drums, were crushed in a hydraulic drum crusher located in the northwest corner of the X-740 building and then disposed of at the X-735 Landfill. The tank/sump was installed in 1986 and was used to collect residual waste oil and waste solvents from the drum crushing operation. No drainage system was associated with the tank/sump area.

Eleven wells are sampled semiannually as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.6.1 Monitoring results for the X-740 Hazardous Waste Storage Facility in 1999

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the X-740 Hazardous Waste Storage Facility (see Fig. 6.7). The volatile organic compounds detected in 1999 were restricted to the previously defined plume perimeter. Remediation of these constituents is proceeding as part of the RCRA Corrective Action Program. Chap. 3 describes the phytoremediation project at the X-740 area.

Several metals and uranium were also detected in samples collected in 1999, but the concentrations of these constituents are below the established preliminary remediation goals.

6.4.7 X-611A Former Lime Sludge Lagoons

The X-611A Former Lime Sludge Lagoons are three adjacent unlined sludge retention lagoons constructed in 1954 and used for disposal of lime sludge waste from the site water treatment plant from 1954 to 1960. The lagoons, which had a capacity of approximately 295,000 cubic yards, cover a surface area of approximately 18 acres. The lagoons were constructed in a low-lying area that included Little Beaver Creek. As a result, approximately 1500 feet of Little Beaver Creek was relocated to a channel just east of the lagoons.

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

6.4.7.1 Monitoring results for the X-611A Former Lime Sludge Lagoons in 1999

The six monitoring wells at X-611A (see Fig. 6.8) are sampled and analyzed for beryllium and chromium. Chromium was not detected in any of the wells in 1999. Beryllium has been detected in samples collected from four of the X-611A monitoring wells.

6.4.8 X-735 Landfills

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

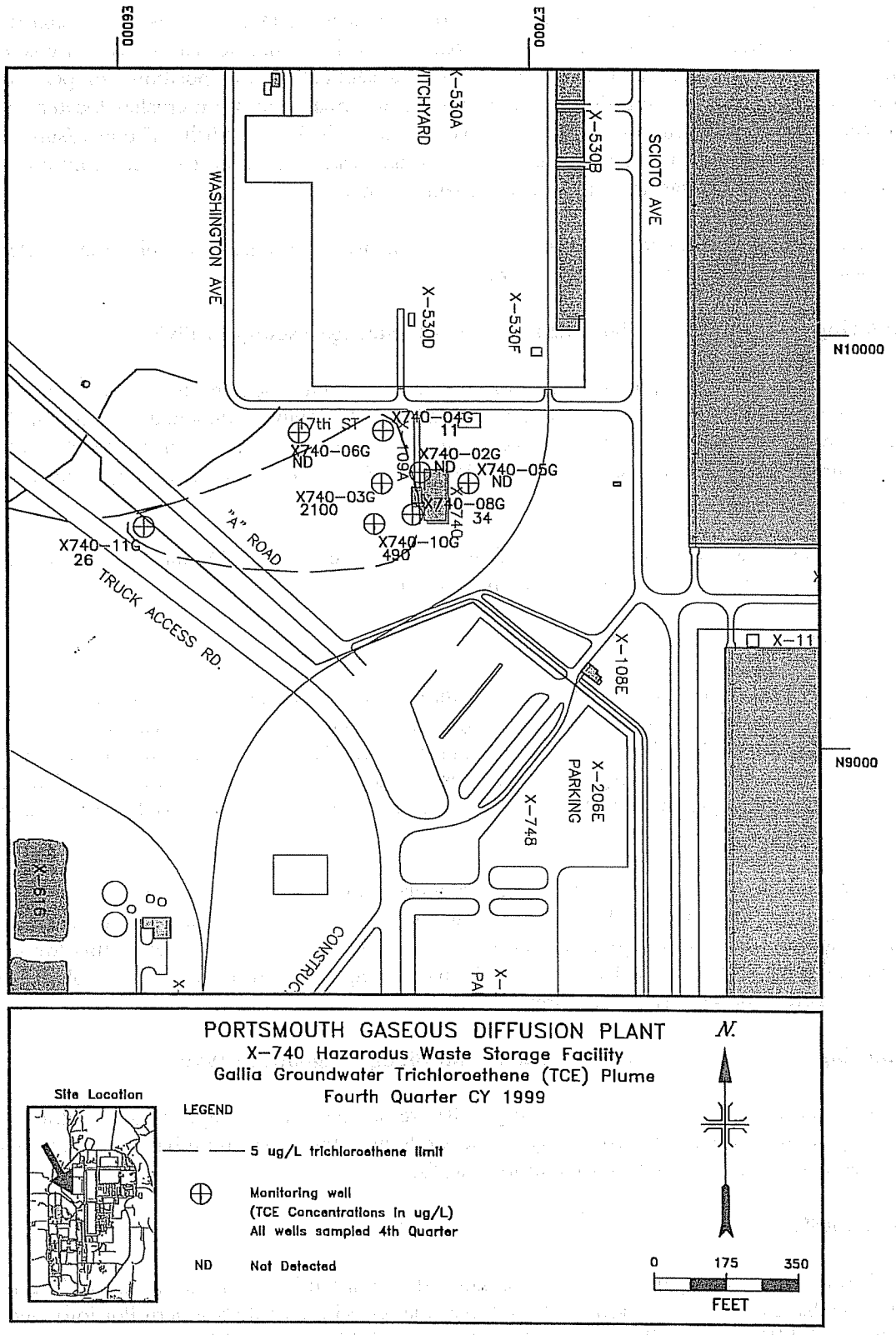

Fig. 6.7. Trichloroethene-contaminated Gallia groundwater plume at the X-740 Hazardous Waste Storage Facility (1999).

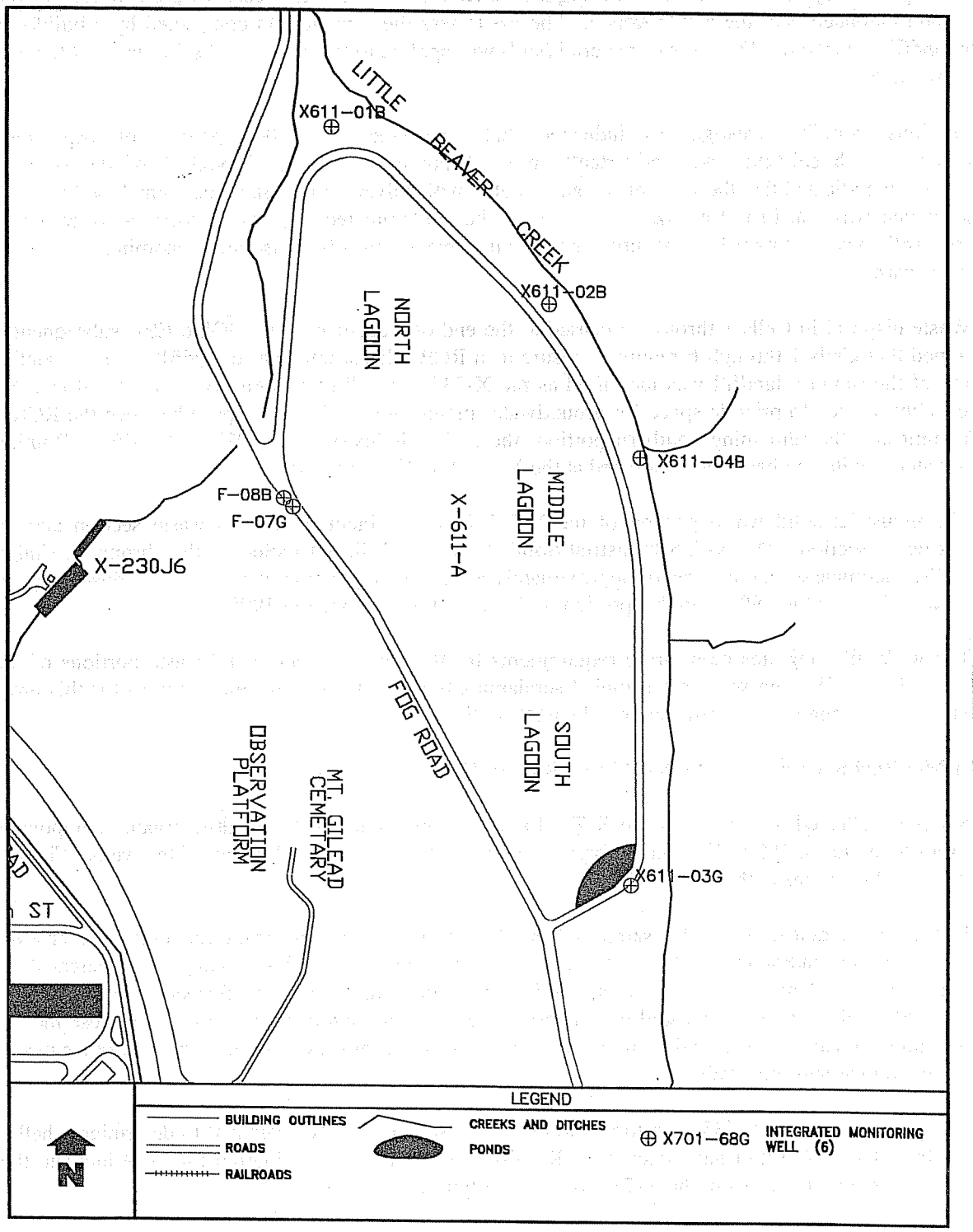

Fig. 6.8. Monitoring wells at the X-611A Former Lime Sludge Lagoons.

Initially, a total of 17.9 acres was approved by the Ohio EPA and Pike County Department of Health for landfill disposal of conventional solid wastes. The landfill began operation in 1981, and the original design of the facility included 15 cells for solid waste disposal. The term "cells" refers to sections of the landfill that outline the locations where trenches were constructed for material disposal. Waste disposal was accomplished by shallow land burial using the trench and fill method. Wastes were delivered to the landfill and unloaded near the active trench. The waste was then spread and compacted by a bulldozer and/or landfill compactor. Daily cover material (soil) was applied to the compacted solid waste at the end of each work day.

Previous PORTS investigations indicated that approximately 12,000 pounds of wipe rags contaminated with solvents had inadvertently been disposed in Cells 1 through 6 of the landfill. Historical data indicated that the wipe rags contaminated with solvents most likely contained methyl ethyl ketone, which was considered a hazardous waste. The contaminated rags were immediately removed from the solid waste stream by instituting new management controls to isolate contaminated rags as hazardous waste.

Waste disposal in Cells 1 through 6 ceased at the end of December 1991. Ohio EPA subsequently determined that Cells 1 through 6 required closure as a RCRA hazardous waste landfill. Consequently, this unit of the sanitary landfill was identified as the X-735 Landfill (Northern Portion). A buffer zone was left unexcavated to provide space for groundwater monitoring wells and a space between the RCRA landfill unit and the remaining southern portion, the X-735 Industrial Solid Waste Landfill. Routine groundwater monitoring has been conducted at the X-735 Landfills since 1991.

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

The IGWMP integrates monitoring requirements for the hazardous and solid waste portions of the X-735 Landfills. Thirteen wells are sampled semiannually under the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.8.1 Monitoring results for the X-735 Landfills in 1999

Samples collected from wells at the X-735 Landfills were analyzed for volatile organic compounds in the fourth quarter of 1999. No volatile organic compounds were detected in any of the wells. Fig. 6.9 shows the well locations at this area.

In the fourth quarter of 1999, samples from X-735 wells were analyzed for antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, magnesium, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. The former X-735 hazardous waste landfill wells were also analyzed for numerous metals in the first quarter of 1999. Of these metals, only antimony, arsenic, cobalt, and mercury were not detected in any well during 1999; all other metals were detected in at least one well.

Analytical data from X-735 monitoring wells were also statistically evaluated to determine whether releases from the X-735 unit have occurred. Results of the statistical evaluation for 1999 indicate that there have been no releases from the X-735 to the underlying groundwater.

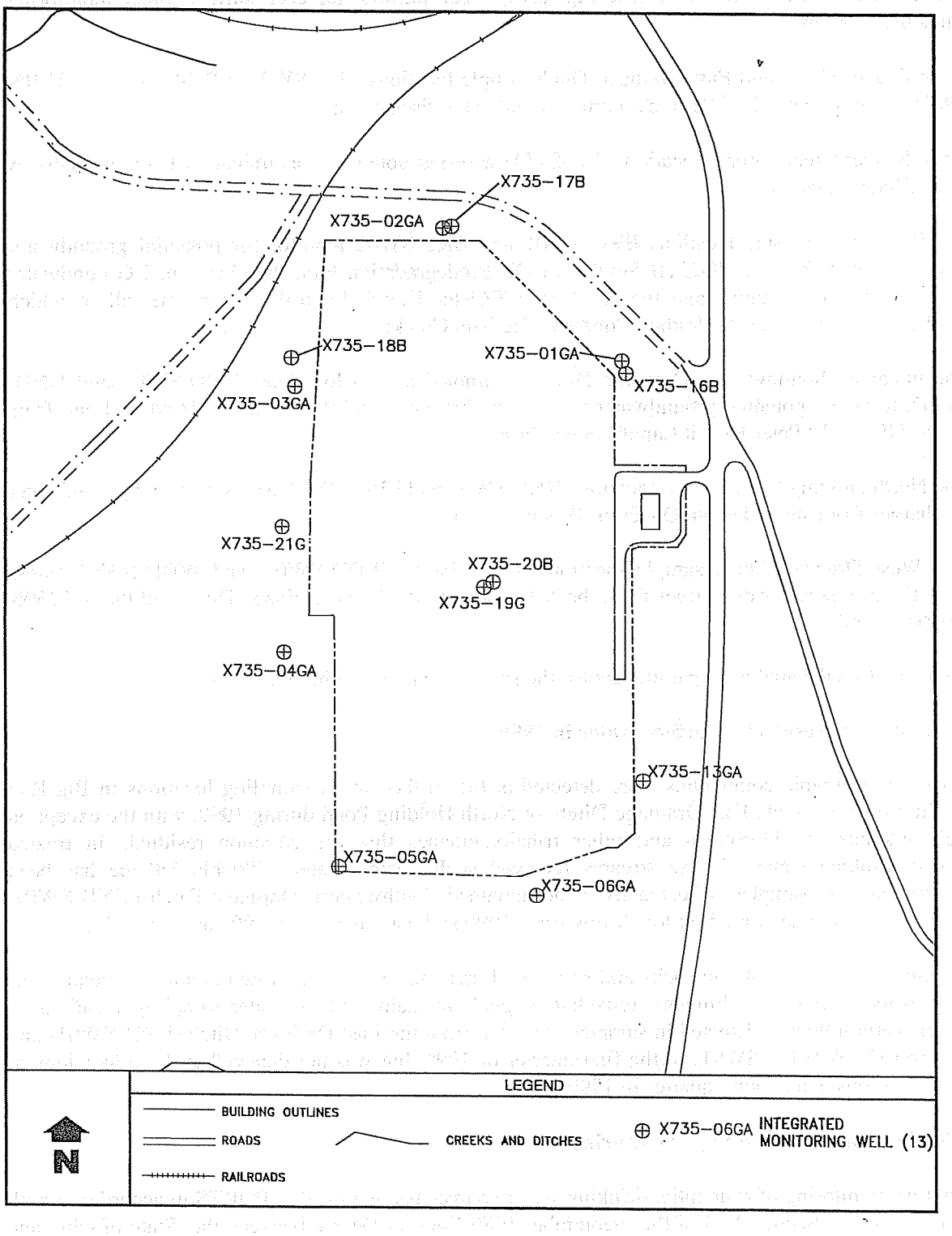

Fig. 6.9. Monitoring wells at the X-735 Landfills.

6.4.9 Surface Water Monitoring

Surface water monitoring is conducted in conjunction with groundwater assessment monitoring to determine if contaminants present in groundwater are detected in surface water samples. Surface water is collected quarterly from 13 locations (see Fig. 6.10). The purpose for each surface water monitoring location is listed below:

- Little Beaver Creek and East Drainage Ditch sample locations LBC-SW01, LBC-SW02, and EDD-SW01 assess possible X-701B area plume groundwater discharges;

- Little Beaver Creek sample location LBC-SW03 assesses potential contamination from the X-611A Lime Sludge Lagoons;

- Big Run Creek sample locations BRC-SW01 and BRC-SW02 monitor for potential groundwater discharges related to the X-231B Southwest Oil Biodegradation Plot, the Quadrant I Groundwater Investigative Area plume, and the X-749/X-120/Peter Kiewit Landfill area plume, all of which discharge into the X-230K Holding Pond and Big Run Creek;

- The unnamed Southwestern Drainage Ditch is sampled at two locations, UND-SW01 and UND-SW02, to assess potential groundwater releases to this creek and the X-2230M Holding Pond from the X-749/X-120/Peter Kiewit Landfill area plume;

- The North Holding Pond sample locations NHP-SW01 and LBC-SW04 assess potential groundwater discharges from any unknown Quadrant IV sources; and

- The West Drainage Ditch sample locations WDD-SW01, WDD-SW02, and WDD-SW03 assess potential groundwater discharges from the X-616 area to the West Drainage Ditch and the X-2230N Holding Pond.

Table 6.1 lists the analytical parameters for the surface water sampling locations.

6.4.9.1 Monitoring results for surface water in 1999

No volatile organic compounds were detected at the surface water sampling locations in Big Run Creek, Little Beaver Creek, East Drainage Ditch, or North Holding Pond during 1999, with the exception of small amounts of chloroform and other trihalomethanes that are common residuals in treated chlorinated drinking water. These streams received such treated water. Trichloroethene has been detected regularly in samples collected from the unnamed Southwestern Drainage Ditch (UND-SW01, located inside the perimeter road) at low levels since 1990 and was detected in 1999 at 4 - 5 μg/L.

Uranium occurs naturally in rocks and soil, which may account for the low uranium concentrations that were detected below preliminary remediation goals at many surface water sampling locations in 1999. Technetium-99 was detected in samples collected from the East Drainage Ditch (EDD-SW01) and Little Beaver Creek (LBC-SW01) in the first quarter of 1999, but was not detected at these locations or any other locations in any other quarter in 1999.

6.4.10 Residential Water Supply Monitoring

Routine monitoring of residential drinking water sources is completed at PORTS in accordance with the requirements of Section VIII of the September 1989 Consent Decree between the State of Ohio and

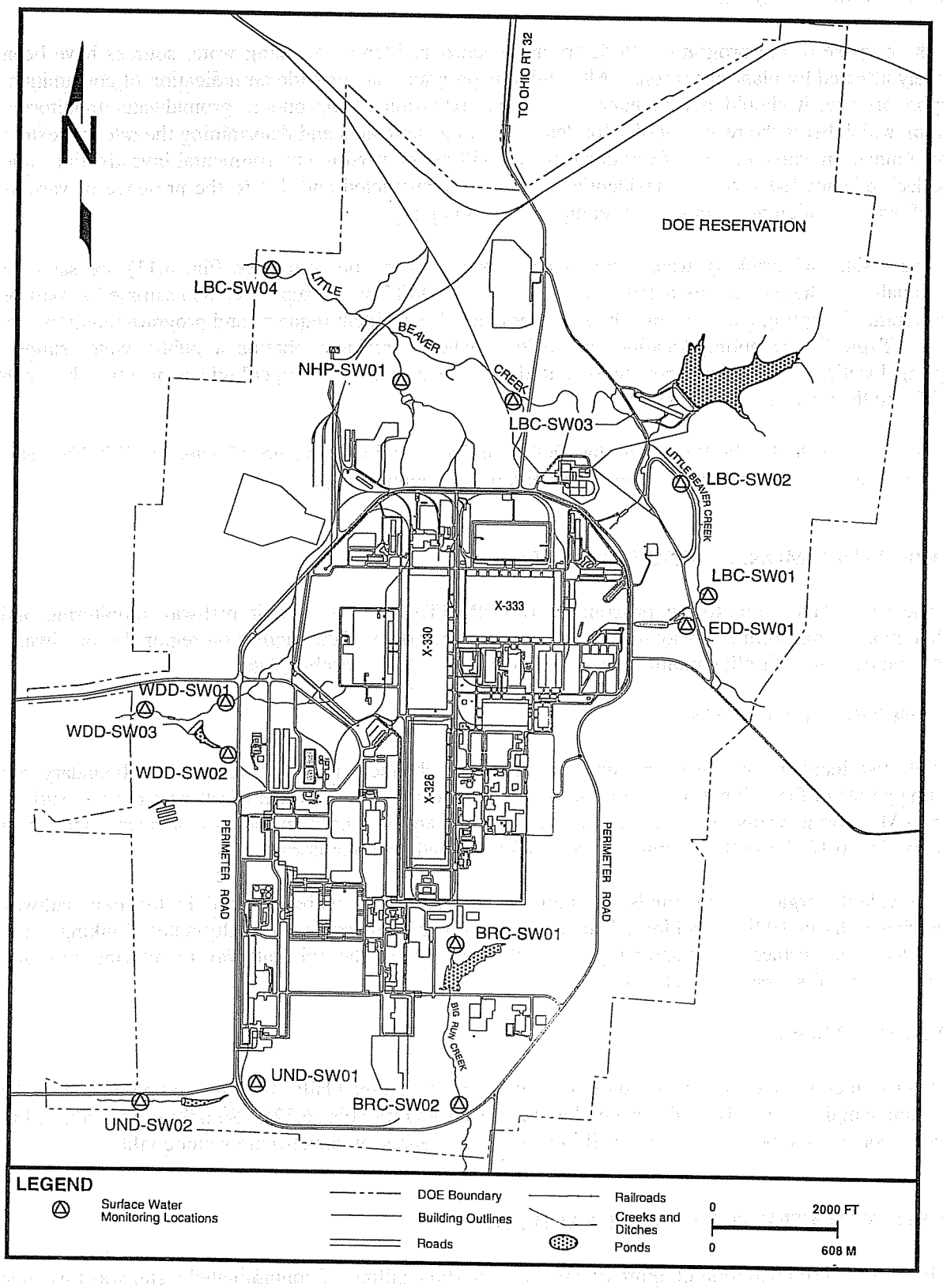

Fig. 6.10. Surface water monitoring locations.

DOE and the Residential Groundwater Monitoring Requirements contained in the *Integrated Groundwater Monitoring Plan.*

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

Five residential drinking water sources participating in the program (see Fig. 6.11) are sampled semiannually for the parameters listed in Table 6.1. The PORTS water supply is also sampled as part of this program. Sampling locations may be added or deleted as resident requests and program requirements dictate. Typically, sampling locations are deleted when a resident obtains a public water supply. Sampling locations are added upon request if there is a probable hydrogeologic connection between PORTS and the resident's water supply.

Sampling results for 1999 indicate that DOE/PORTS operations have not affected the PORTS water supply or residential water supplies sampled as part of this monitoring program.

6.5 DOE ORDER MONITORING PROGRAMS

The surveillance monitoring program at DOE/PORTS consists of exit pathway monitoring and baseline monitoring. Exit pathway monitoring assesses the effect of the facility on regional groundwater quality and quantity. Baseline monitoring is conducted to establish baseline data.

6.5.1 Exit Pathway Monitoring

Selected locations on local streams and drainage channels near the reservation boundary are sampling points of the exit pathway monitoring program because groundwater discharges to these surface waters. Monitoring wells near the reservation boundary are also used in the exit pathway monitoring program. Fig. 6.12 shows the sampling locations for exit pathway monitoring.

No volatile organic compounds, uranium, or technetium-99 were detected in the exit pathway monitoring wells in 1999. Trichloroethene and other compounds present in chlorinated drinking water were detected at surface water sampling points that are part of the exit pathway monitoring program. These results are discussed in Sect. 6.4.9.1.

6.5.2 Baseline Monitoring

Four well clusters, each composed of one well completed in the Gallia and one well completed in the Berea, are sampled annually to determine baseline water quality (Fig. 6.12). Sampling is conducted to provide a comparison between on-site wells and wells that represent background water quality.

6.6 GROUNDWATER TREATMENT FACILITIES

In 1999, a combined total of approximately 24.7 million gallons of contaminated water was treated at the X-622, X-622T, X-623, X-624, and X-625 Groundwater Treatment Facilities. Approximately 100

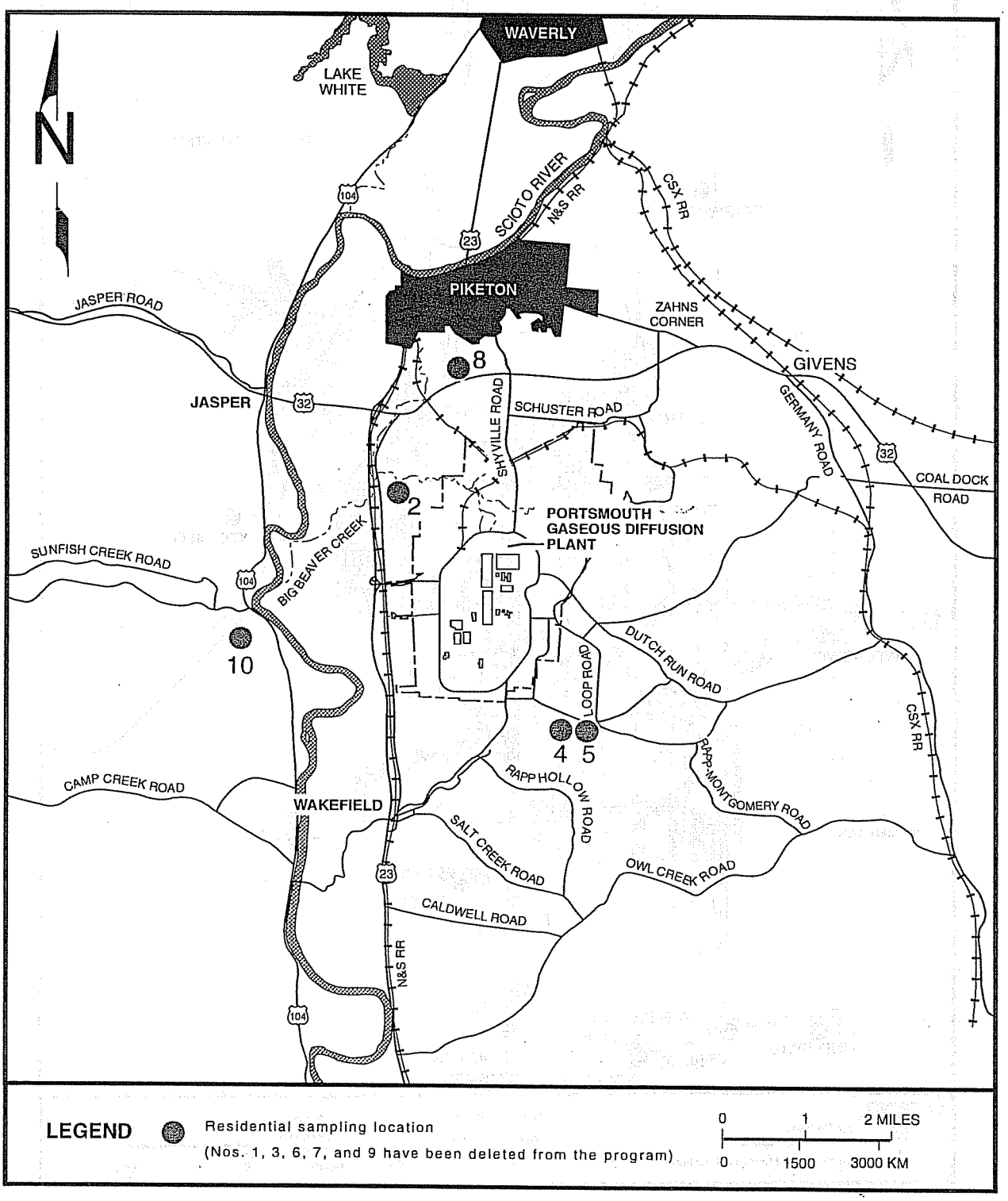

Fig. 6.11. Residential water supply monitoring locations.

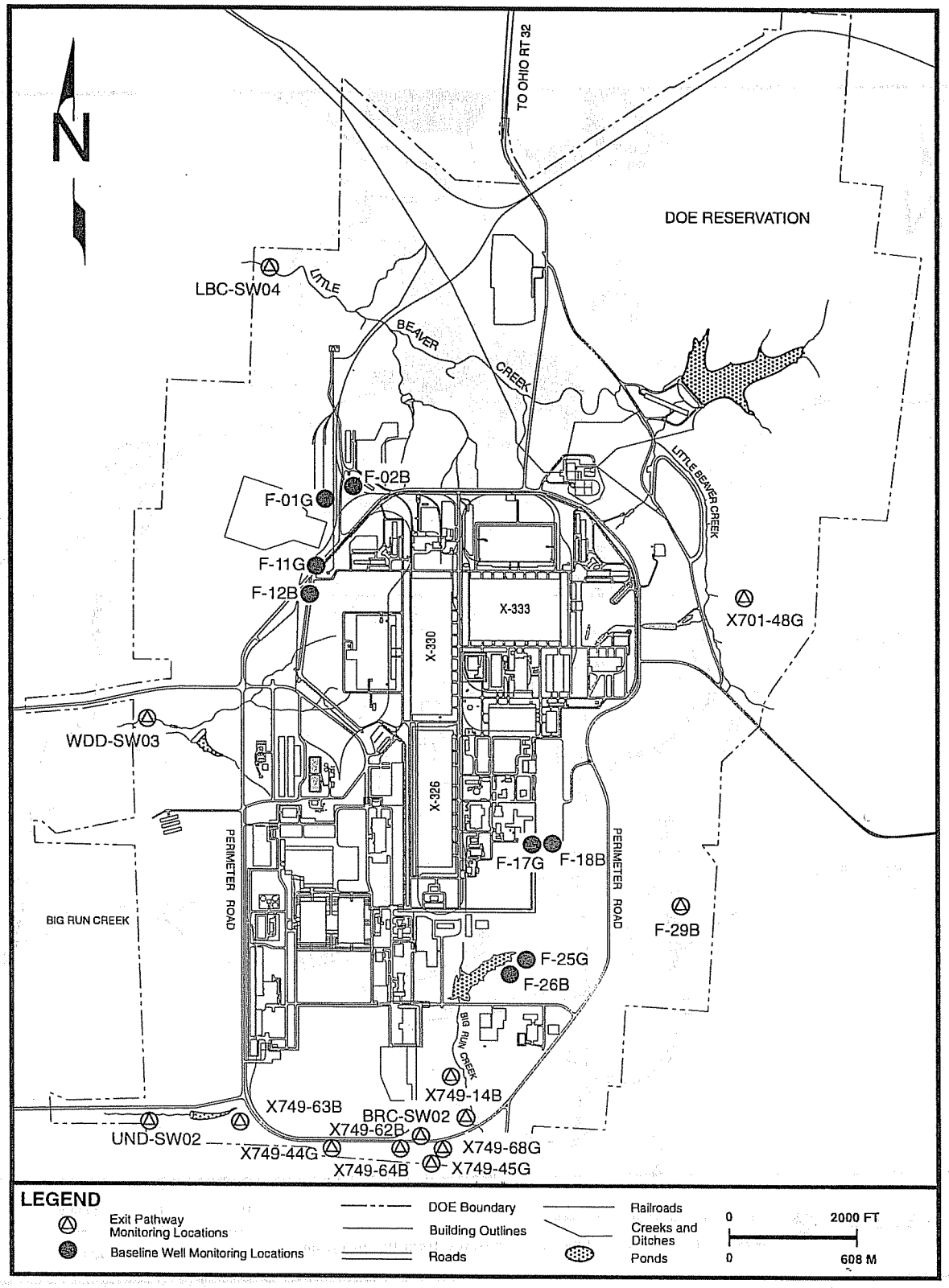

Fig. 6.12. Exit pathway and baseline monitoring locations.

gallons of trichloroethene were removed from the groundwater. All processed water is discharged through NPDES outfalls before exiting PORTS. Facility information is summarized in Table 6.2.

Table 6.2. Summary of trichloroethene removed by DOE/PORTS groundwater treatment facilities in 1999

Facility	Gallons of water treated	Gallons of trichloroethene removed
X-622	7,600,000	1
X-622T	10,700,000	12
X-623	3,300,000	55
X-624	2,900,000	33
X-625	142,000	0.015

6.6.1 X-622 Groundwater Treatment Facility

Activated carbon and green sand filtration are used to treat water at the X-622 Groundwater Treatment Facility. This facility processes groundwater from the Quadrant I Groundwater Investigative Area and the X-749 Contaminated Materials Disposal Facility/X-120 Old Training Facility/Peter Kiewit Landfill groundwater collection systems. In 1999, the unit processed approximately 7.6 million gallons of groundwater, removing 1 gallon of trichloroethene from the water.

Water treated in the X-622 Groundwater Treatment Facility is released through DOE/PORTS NPDES Outfall 608. One sample of water from this outfall was analyzed for americium-241, neptunium-237, plutonium-238, and plutonium-239/240 in 1999. None of these constituents was detected in the sample.

6.6.2 X-622T Groundwater Treatment Facility

At the X-622T Groundwater Treatment Facility, activated carbon is used to treat contaminated groundwater from the X-700 and X-705 buildings. These buildings are located above the Quadrant II Groundwater Investigative Area plume, and contaminated groundwater is extracted from sumps located in the basement of each building. In 1999, approximately 10.7 million gallons of groundwater were processed, thereby removing 12 gallons of trichloroethene from the water.

Water treated in the X-622T Groundwater Treatment Facility is released through DOE/PORTS NPDES Outfall 611. One sample of water from this outfall was analyzed for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and thorium-230 in 1999. None of these constituents was detected in the samples.

6.6.3 X-623 Groundwater Treatment Facility

The X-623 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. The X-623 Groundwater Treatment Facility treats trichloroethene-contaminated groundwater from the X-701B Holding Pond and three groundwater extraction wells in the X-701B plume area. The facility treated approximately 3.3 million gallons of water in 1999, thereby removing 55 gallons of trichloroethene from the water.

Water treated in the X-623 Groundwater Treatment Facility is released through DOE/PORTS NPDES Outfall 610. One sample of water from this outfall was analyzed for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and thorium-230 in 1999. None of these constituents was detected in the samples.

6.6.4 X-624 Groundwater Treatment Facility

At the X-624 Groundwater Treatment Facility, groundwater is treated via an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. This facility processes trichloroethene-contaminated groundwater from the X-237 interceptor trench associated with the X-701B plume. The facility treated approximately 2.9 million gallons of water in 1999, thereby removing 33 gallons of trichloroethene from the water.

Water treated in the X-624 Groundwater Treatment Facility is released through DOE/PORTS NPDES Outfall 015. One sample of water from this outfall was analyzed for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and thorium-230 in 1999. None of these constituents was detected in the samples.

6.6.5 X-625 Groundwater Treatment Facility

Groundwater is gravity-fed from a horizontal well associated with the X-749/X-120 groundwater plume to the X-625 Groundwater Treatment Facility. As part of an ongoing technology demonstration, water at this facility has been treated with various passive media such as iron filings. During 1999, iron filings were the primary media used for treatment. The water is further treated by being passed through activated carbon filtration prior to being discharged. In 1999, approximately 142,000 gallons of groundwater were treated, thereby removing 0.015 gallon of trichloroethene.

Water treated in the X-625 Groundwater Treatment Facility combines with other wastewaters and is released through DOE/PORTS NPDES Outfall 012. One sample of water from this outfall was analyzed for americium-241, neptunium-237, plutonium-238, and plutonium-239/240 in 1999. None of these constituents was detected in the samples.

7. QUALITY ASSURANCE

7.1 SUMMARY

Quality assurance and quality control are essential components of environmental monitoring at DOE/PORTS. Quality is integrated into sample preservation, field data and sample collection, sample transportation, and sample analysis. Numerous program assessment activities in the field and within the facilities are conducted at regular intervals to demonstrate that quality is built into and maintained in all DOE/PORTS programs.

7.2 INTRODUCTION

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

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

Environmental sampling is conducted at DOE/PORTS in accordance with state and federal regulations. Sampling plans and procedures are prepared, and appropriate sampling instruments or devices are selected in accordance with practices recommended by the U.S. EPA, the American Society for Testing and Materials, or other authorities. Chain-of-custody documentation is prepared from the point of sampling. The samples remain in the custody of the sampling group until they are transferred to the sample custodian at the chosen laboratory.

The analytical data are reviewed to determine compliance with applicable regulations and permits. The data are used to identify locations and concentrations of contaminants of concern, to evaluate the rate and extent of contamination at the site, and to help determine the need for remedial action. Adequate and complete documentation generated as a result of these efforts support the quality standards established at DOE/PORTS.

7.3 FIELD SAMPLING AND MONITORING

Personnel involved in field sampling and monitoring are properly trained. Procedures are developed from guidelines and regulations created by DOE or other regulatory agencies that have authority over DOE/PORTS activities. These procedures specify sampling protocol, sampling devices, and containers and preservatives to be used. Chain-of-custody procedures (used with all samples) are documented, and samples are controlled and protected from the point of collection to the generation of analytical results.

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

7.4 ANALYTICAL QUALITY ASSURANCE

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

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

After it is received by DOE/PORTS, analytical laboratory data is independently evaluated using a systematic process that compares the data to established quality assurance/quality control criteria. An independent data validator checks documentation produced by the analytical laboratory to verify that the laboratory has provided data that meets established criteria.

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APPENDIX A

RADIATION

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This appendix presents basic facts concerning radiation. The information is intended as a basis for understanding the dose associated with releases from DOE/PORTS, not as a comprehensive discussion of radiation and its effects on the environment and biological systems. *The McGraw-Hill Dictionary of Scientific and Technical Terms* defines radiation and radioactivity as follows.

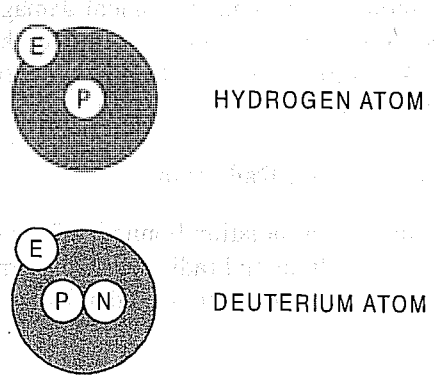
> *radiation* — (1) The emission and propagation of waves transmitting energy through space or through some medium; for example, the emission and propagation of electromagnetic, sound, or elastic waves. (2) The energy transmitted through space or some medium; when unqualified, usually refers to electromagnetic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

> *radioactivity*—A particular type of radiation emitted by a radioactive substance, such as alpha radioactivity (McGraw-Hill 1989).

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

A.1 ATOMS AND ISOTOPES

All matter is made up of atoms. An atom is "a unit of measure consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (American Nuclear Society 1986). The number of protons in the nucleus determines an element's atomic number, or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the number of neutrons may vary among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element with a different number of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights. Fig. A.1 depicts isotopes of the element hydrogen. Another example is the element uranium, which has 92 protons; all isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons. Uranium-238 (also denoted ^{238}U) has 92 protons and 146 neutrons; uranium-235 has 92 protons and 143 neutrons; uranium-240 has 92 protons and 148 neutrons.



	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1

Fig. A.1. Isotopes of the element hydrogen.

Some isotopes are stable, or nonradioactive; some are radioactive. Radioactive isotopes are called radioisotopes, or radionuclides. In an attempt to become stable, radionuclides "throw away," or emit, rays or particles. This emission of rays and particles is known as radioactive decay.

A.2 RADIATION

Radiation, or radiant energy, is energy in the form of waves or particles moving through space. Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from the sunlight, they are actually absorbing the radiant energy emitted by the sun.

Electromagnetic radiation is radiation in the form of electromagnetic waves; examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles; examples include alpha and beta particles. Radiation also is characterized by the way in which it interacts with matter.

A.2.1 Ionizing Radiation

Normally, an atom has an equal number of protons and electrons; however, atoms can lose or gain electrons in a process known as ionization. Some form of radiation can ionize atoms by "knocking" electrons off atoms. Examples of ionizing radiation include alpha, beta, and gamma radiation. Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage and thus is potentially harmful to human health. Figure A.2 shows the penetrating potential of different types of ionizing radiation.

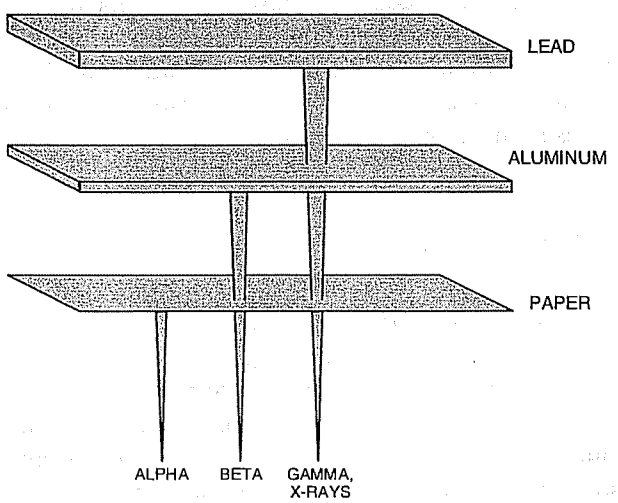


Fig. A.2. Penetrating power of radiation.

A.2.2 Nonionizing Radiation

Nonionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. Currently, it is unclear whether nonionizing radiation is harmful to human health. In the discussion that follows, the term radiation is used to describe ionizing radiation.

A.3 SOURCES OF RADIATION

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

A.3.1 Background Radiation

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

Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as cosmic, terrestrial, or internal, depending on its origin.

A.3.1.1 Cosmic Radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For example, a person in Denver, Colorado, is exposed to more cosmic radiation than a person in Death Valley, California.

A.3.1.2 Terrestrial Radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny, the relatively short-lived decay products of radium-235 (^{235}Ra); potassium (^{40}K); isotopes of thorium (Th); and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.

A.3.1.3 Internal Radiation

Radioactive material in the environment enters the body through the air people breathe and the food they eat; it also can enter through an open wound. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, and lead in the ^{238}U and ^{232}Th decay series. In addition, the body contains isotopes of potassium (^{40}K), rubidium (^{87}Rb), and carbon (^{14}C).

A.3.2 Human-Made Radiation

Most people are exposed to human-made sources of radiation. Examples include consumer products, medical sources, and fallout from atmospheric atomic bomb tests. (Atmospheric testing of atomic weapons has been suspended in the United States and most parts of the world.) Also, about one-half of 1% of the U.S. population performs work in which radiation in some form is present.

A.3.2.1 Consumer Products

Some consumer products are sources of radiation. In some of these products, such as smoke detectors and airport X-ray baggage inspection systems, radiation is essential to the performance of the device. In other products, such as television and tobacco products, the radiation occurs incidentally to the product function.

A.3.2.2 Medical Sources

Radiation is an important tool of diagnostic medicine and treatment, and, in this use, is the main source of exposure to human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. Generally, medical exposures from diagnostic or therapeutic X-rays result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Radiation and radio-active materials are also used in a wide variety of pharmaceuticals and in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Nuclear medicine examinations and treatment involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body.

A.3.2.3 Other Sources

Other sources of radiation include fallout from atmospheric atomic bomb tests; emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; emissions from mineral extraction facilities; and the transportation of radioactive materials.

Transuranic materials are man-made radiological elements. They are created as a reaction in a reactor where uranium fuel is used. These elements are a group of isotopes that are all alpha emitting. They emit alpha particles similar to uranium alpha particles and are monitored by Health Physics at PORTS in the same manner as uranium. Some of the transuranic isotopes that are detectable at PORTS are thorium-228, thorium-230, americium-241, neptunium-237, and plutonium-239/240.

A.4 PATHWAYS OF RADIATION

Radiation and radioactive materials in the environment can reach people through many routes. Potential routes for radiation are referred to as pathways. For example, radioactive material in the air could fall on a pasture. The grass could then be eaten by cows, and the radioactive material on the grass would be present in the cow's milk. People drinking the milk would thus be exposed to this radiation. Or people could simply inhale the radioactive material in the air. The same events could occur with radioactive material in water. Fish living in the water would be exposed; people eating the fish would then be exposed to the radiation in the fish. Or people swimming in the water would be exposed (see Fig. A.3.).

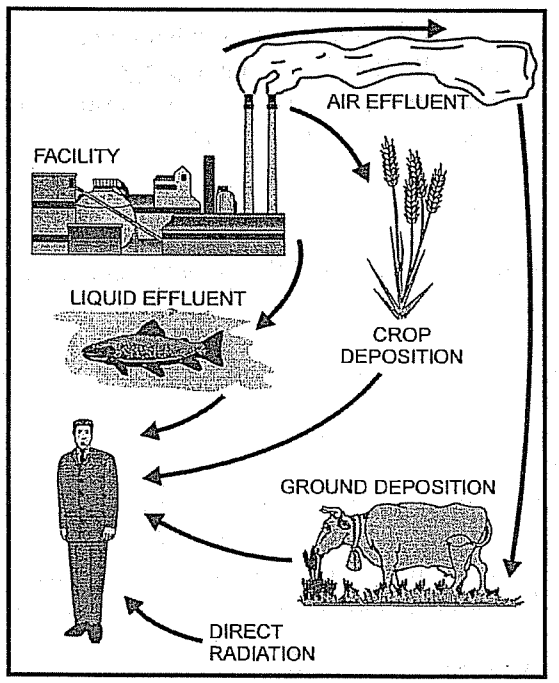


Fig. A.3. Possible radiation pathways.

A.5 MEASURING RADIATION

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

A.5.1 Activity

When measuring the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radioisotopes. For that reason, 1 gram of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, 1 Ci = 3.75E+10 (37,000,000,000) atom disintegrations per second (dps). In the international system of units, 1 dps = 1 becquerel (Bq). Refer to Table A.1 for units of radiation measure and applicable conversions.

Table A.1. Units of radiation measures

Current System	International System	Conversion
curie (Ci)	Becquerel (Bq)	1 Ci = 3.7 x 10^{10} Bq
rad (radiation absorbed dose)	Gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	Sievert (Sv)	1 rem = 0.01 Sv

A.5.2 Absorbed Dose

The total amount of energy absorbed per unit mass as a result of exposure to radiation is expressed in a unit of measure known as a rad. In the international system of units, 100 rad equals 1 gray (Gy). In terms of human health, however, it is the effect of the absorbed energy that is important, not the actual amount.

A.5.3 Dose Equivalent

The measure of potential biological damage caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large dose, dose is expressed as a millirem (mrem) or 1/1000 of a rem. In the international system of units, 100 rem equals 1 sievert (Sv); 100 mrem equals 1 millisievert (mSv).

A.6 DOSE

Many terms are used to report dose. Several factors are taken into account, including the amount of radiation absorbed, the organ absorbing the radiation, and the effect of the radiation over a 50-year period. The term "dose" in this report includes the committed effective dose equivalent and effective dose equivalent attributable to penetrating radiation from sources external to the body.

Determining dose is an involved process using complex mathematical equations based on several factors, including the type of radiation, the rate of exposure, weather conditions, and typical diet. Basically, radiant energy is generated from radioactive decay, or activity. People absorb some of the energy to which they are exposed. This absorbed energy is calculated as part of an individual's dose. Whether radiation is natural or human-made, its effects on people are the same.

A.6.1 Comparison of Dose Levels

A scale of dose levels is presented in Table A.2. Included is an example of the type of exposure that may cause such a dose or the special significance of such a dose. This information is intended to familiarize the reader with the type of doses individuals may receive.

A.6.1.1 Dose from Cosmic Radiation

The average annual dose received by residents of the United States from cosmic radiation is about 27 mrem (0.27 mSv) (National Council on Radiation Protection 1987). The average annual dose from cosmic radiation received by residents in the Portsmouth area is about 50 mrem (0.50 mSv).

Table A.2. Comparison and description of various dose levels

Dose level	Description
1 mrem (0.01 mSv)	Approximate daily dose from natural background radiation, including radon
2.5 mrem (0.025 mSv)	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles
10 mrem (0.10 mSv)	Annual exposure limit, set up by the U.S. EPA, for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants and uranium mines and mills
46 mrem (0.46 mSv)	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear power plant accident
50 mrem (0.50 mSv)	Average yearly dose from cosmic radiation received by people in the Portsmouth area
66 mrem (0.66 mSv)	Average yearly dose to people in the United States from human-made sources
100 mrem (1.00 mSv)	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker
110 mrem (1.10 mSv)	Average occupational dose received by U.S. commercial radiation workers in 1980
244 mrem (2.44 mSv)	Average dose from an upper gastrointestinal diagnostic X-ray series
300 mrem (3.00 mSv)	Average yearly dose to people in the United States from all sources of natural background radiation
1-5 rem (0.01-0.05 Sv)	U.S. EPA protective action guideline calling for public officials to take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range
5 rem (0.05 Sv)	Annual limit for occupational exposure of radiation workers set by the Nuclear Regulatory Commission and DOE
10 rem (0.10 Sv)	The Biological Effects of Ionizing Radiations V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer of 0.8% (Biological Effects of Ionizing Radiation 1990)
25 rem (0.25 Sv)	U.S. EPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency
75 rem (0.75 Sv)	U.S. EPA guideline for maximum dose to emergency workers volunteering for lifesaving work
50-600 rem (0.50-6.00 Sv)	Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people would die within 60 days

Adapted from Savannah River Site Environmental Report for 1993, Summary Pamphlet, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

A.6.1.2 Dose from Terrestrial Radiation

The average annual dose received from terrestrial gamma radiation is about 28 mrem (0.28 mSv) in the United States. This dose varies geographically across the country (National Council on Radiation Protection 1987); typical reported values are 16 mrem (0.16 mSv) at the Atlantic and Gulf coastal plains and 63 mrem (0.63 mSv) at the eastern slopes of the Rocky Mountains.

A.6.1.3 Dose from Internal Radiation

Short-lived decay products of radon are the major contributors to the annual dose equivalent for internal radionuclides (mostly ^{222}Rn). They contribute an average dose of about 200 mrem (2.00 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (National Council on Radiation Protection 1987).

The average dose from other internal radionuclides is about 39 mrem (0.39 mSv) per year, most of which can be attributed to the naturally occurring isotope of potassium, ^{40}K. The concentration of radioactive potassium in human tissues is similar in all parts of the world (National Council on Radiation Protection 1987).

A.6.1.4 Dose from Consumer Products

The U.S. average annual dose received by an individual from consumer products is about 10 mrem (0.10 mSv) (National Council on Radiation Protection 1987).

A.6.1.5 Dose from Medical Sources

Nuclear medicine examinations, which involve the internal administration of radiopharmaceuticals, generally account for the largest portion of the dose received from human-made sources. The radionuclides used in specific tests, however, are not distributed uniformly throughout the body. In these cases, comparisons are made using the concept of effective dose equivalent, which relates exposure of organs or body parts to one effective whole-body dose. The average annual effective dose equivalent from medical examinations is 53 mrem (0.53 mSv), including 39 mrem (0.39 mSv) for diagnostic X-rays and 14 mrem (0.14 mSv) for nuclear medicine procedures (National Council on Radiation Protection 1989). The actual doses received by individuals who complete such medical exams are much higher than these values, but not everyone receives such exams each year (National Council on Radiation Protection 1989).

A.6.1.6 Doses from Other Sources

Small doses received by individuals occur as a result of radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (National Council on Radiation Protection 1987).

A comprehensive U.S. EPA report of 1984 projected the average occupational dose to monitored radiation workers in medicine, industry, the nuclear fuel cycle, government, and miscellaneous industries to be 105 mrem (1.05 mSv) per year for 1985, down slightly from 110 mrem (1.10 mSv) per year in 1980 (Kumazawa et al. 1984).

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APPENDIX B

ENVIRONMENTAL PERMITS

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Table B.1. DOE/PORTS environmental permits and registrations

Permit/registered source	Source no.	Issue date	Expiration date	Status
		Clean Air Act Permits		
Permit to Install X-734 Landfill Unpaved Road and Storage Piles	F010	10/6/99	None	Active
Permit to Operate X-326 L-cage Glove Box	P022	5/5/95	PTO renewal submitted 4/27/98	Active
Permit to Operate X-624 Groundwater Treatment Facility	P019		PTO renewal submitted 11/4/98; PTO under appeal	Active
Permit to Operate X-735 Landfill Cap and Venting System (northern portion)	P023	5/26/95	PTO renewal submitted 4/27/98	Active
Permit to Operate X-744G Glove Box	P007		PTO renewal submitted 11/4/98; PTO under appeal	Active
Registered Source X-345 Emergency Generator	B005		None	Active
Registered Source X-345 Security Fuel Oil Tank	T005		None	Active
Registered Source X-623 Groundwater Treatment Facility	P018		None	Active
Registered Source X-7725 Fluorescent Bulb Crusher	P028		None	Active
Registered Source X-744G Oil-fired Furnace	B006		None	Active
Registered Source X-749 Contaminated Materials Disposal Facility	P027		None	Active
Registered source X-744G Fuel Oil Tank (south)	T008		None	Source no longer operating
Registered Source X-744G Alumina Melter	P020		None	Source no longer operating
Registered Source X-735 Landfill Storage Piles	F006		None	Source no longer operating
		Clean Water Act Permits		
NPDES Permit DOE	OI00000*GD	8/5/95	3/31/99[a]	Active
Permit to Install X-622 Groundwater Treatment Facility	06-2951	11/20/90	None	Active
Permit to Install X-622T Groundwater Treatment Facility	06-3520	11/24/92	None	Active
Permit to Install X-623 Groundwater Treatment Facility	06-3528	1/9/96	None	Active
Permit to Install X-624 Groundwater Treatment Facility	06-3556	10/28/92	None	Active
U.S. Army Corps of Engineers-Section 404, Nationwide Permit No.6, Radiological Survey		4/30/97		

Table B.1. DOE/PORTS environmental permits and registrations (continued)

Permit/registered source	Source no.	Issue date	Expiration date	Status
	Hazardous Waste Permit			
RCRA Part B Permit	RCRA-LQG/TSDF OH789000089 83/04-57-0680	8/25/95	8/25/00	Active
	Registrations			
Underground Storage Tank Registration	6651067		Renewed annually	Active

[a] Permit will remain active until renewal application is acted upon by Ohio EPA. The NPDES Permit renewal application was submitted to the Ohio EPA on September 23, 1998.

APPENDIX C

RADIONUCLIDE AND CHEMICAL NOMENCLATURE

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Table C.1. Nomenclature and half-life for radionuclides

Radionuclide	Symbol	Half-life
Actinium-228	^{228}Ac	6.2 hours
Americium-241	^{241}Am	458 years
Beryllium-7	^{7}Be	53.3 days
Bismuth-210	^{210}Bi	5.01 days
Bismuth-214	^{214}Bi	19.7 minutes
Lead-206	^{206}Pb	Stable
Lead-210	^{210}Pb	22.3 years
Lead-212	^{212}Pb	10.6 hours
Lead-214	^{214}Pb	26.8 minutes
Neptunium-237	^{237}Np	2,140,000 years
Plutonium-238	^{238}Pu	86.4 years
Plutonium-239	^{239}Pu	24,390 years
Plutonium-240	^{240}Pu	6,580 years
Plutonium-241	^{241}Pu	13.2 years
Plutonium-242	^{242}Pu	379,000 years
Plutonium-244	^{244}Pu	76,000,000 years
Polonium-210	^{210}Po	138.9 days
Polonium-214	^{214}Po	164 microseconds
Polonium-218	^{218}Po	3.05 minutes
Potassium-40	^{40}K	1,260,000,000 years
Protactinium-233	^{233}Pa	27.0 days
Protactinium-234	^{234}Pa	6.7 hours
Protactinium-234m	^{234m}Pa	1.17 minutes
Radium-224	^{224}Ra	3.7 days
Radium-226	^{226}Ra	1,602 years
Radium-228	^{228}Ra	5.8 years
Radon-222	^{222}Rn	3.821 days
Technetium-99	^{99}Tc	212,000 years
Thallium-208	^{208}Tl	3.1 minutes
Thorium-228	^{228}Th	1.9 years
Thorium-230	^{230}Th	75,400 years
Thorium-231	^{231}Th	25.5 hours
Thorium-232	^{232}Th	14,000,000,000 years
Thorium-234	^{234}Th	24.1 days
Uranium-234	^{234}U	247,000 years
Uranium-235	^{235}U	710,000,000 years
Uranium-236	^{236}U	23,900,000 years
Uranium-238	^{238}U	4,510,000,000 years

Table C.2. Nomenclature for elements and chemical constituents

Constituent	Symbol
Aluminum	Al
Ammonia	NH_3
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Calcium carbonate	$CaCO_3$
Carbon	C
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Fluorine	F
Hydrogen fluoride	HF
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Nitrogen	N
Nitrate	NO_3
Nitrite	NO_2
Oxygen	O
Ozone	O_3
Phosphorus	P
Phosphate	PO_4
Potassium	K
Radium	Ra
Radon	Rn
Selenium	Se
Silver	Ag
Sodium	Na
Sulfate	SO_4
Sulfur dioxide	SO_2
Thorium	Th
Thallium	Tl
Uranium	U
Vanadium	V
Zinc	Zn

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