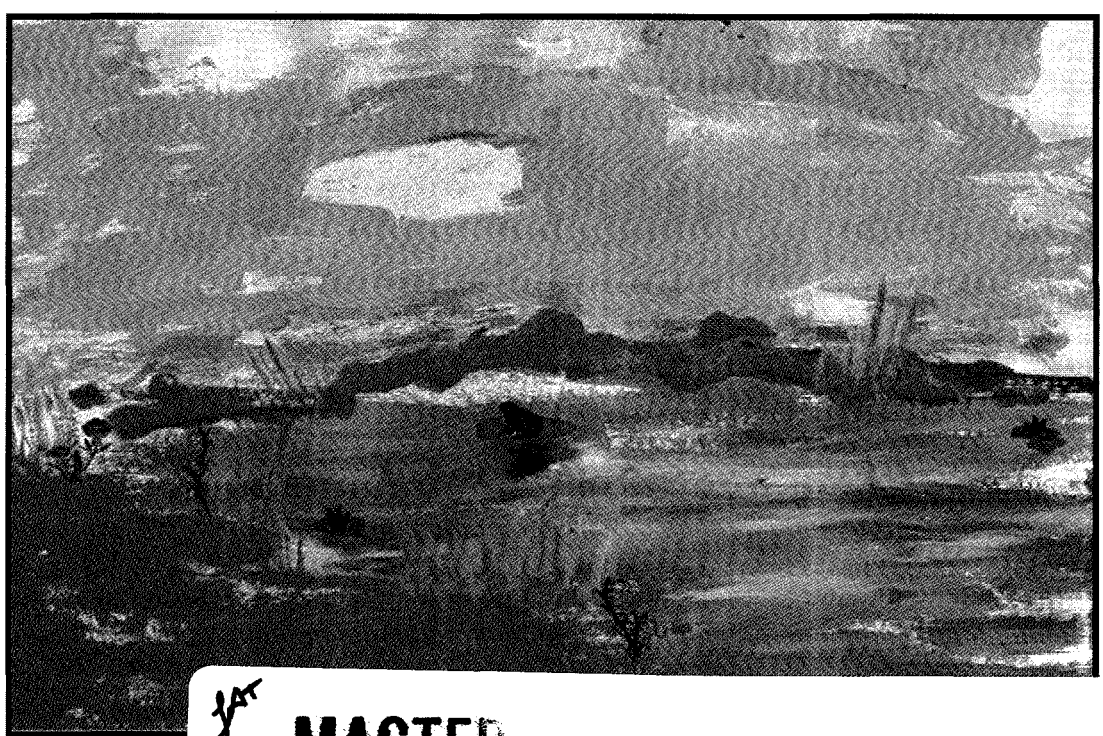
DOE/OR--11-1729 & D1

# U.S. Department of Energy

## Portsmouth Annual Environmental Report for 1997







*Reflecting on the past,*
*Looking toward the future...*

# On The Cover

***is a combination of environmental artwork submitted by Piketon Junior High School art students. Cover design is by Tina Dailey of Science Applications International Corporation, with the assistance of Piketon High School students Michael Davis and Steve Mines.***

***The Piketon Junior High School Art Class***

***Pictured left to right, Front row:*** *Krystal Parmeter, Krystal Bowen, Brandy Conley, Shannon Kinnison, Robert Delay, Keith Shanks.* ***Middle row:*** *Jackie Borders, Jessica McDaniel, Echo Smith, Nathan Theobald, Chason Voss, Joey Brewster, Tiffany Gullett, Steve Mines.* ***Back row:*** *Stacy Theobald, Heather McCann, Ryan Preston, Dedra Newton, Marinda Miller, Samantha Scott, Matthew Alley, Ryan Burkitt, Michael Davis. (Not pictured are Harley Borders, Andrew Foster, Tausha Graham, Wesley Jordan, Jamie McCoy, Samantha Mosely, Autumn Myers, Nicole Sheriff, Brittany Spradlin, Emily Wickham, and Jessica Woodruff.)*

## DISCLAIMER

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BJC/PORTS-13

# U.S. DEPARTMENT OF ENERGY
# PORTSMOUTH ANNUAL ENVIRONMENTAL REPORT
# FOR 1997

September 1998

Prepared by
Bechtel Jacobs Company LLC
Environmental Compliance Division

Prepared for
United States Department of Energy
Office of Environmental Restoration and Waste Management
Budget and Reporting Code EU 2010202

Bechtel Jacobs Company LLC
Environmental Management and Enrichment Facilities
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# Contents

# List of Figures

# List of Tables

# Executive Summary

## SITE AND OPERATIONS OVERVIEW

The Portsmouth plant is one of two U.S. Department of Energy (DOE)-owned, contractor-managed uranium enrichment facilities in operation (see Fig. 1). As of July 1, 1993, responsibility for implementing environmental compliance at the facility was split between DOE, as site owner, and the United States Enrichment Corporation (USEC), a government-owned corporation formed by the Energy Policy Act of 1992, to operate the nation's uranium enrichment business. The management contractor for DOE in 1997 was Lockheed Martin Energy Systems, which was responsible for environmental restoration, waste management, removal of highly enriched uranium, and operation of nonleased facilities at the Portsmouth Gaseous Diffusion Plant (DOE/PORTS). A new 5 $^{1}/_{2}$-year management and integration contract was awarded by DOE to Bechtel Jacobs Company LLC on December 18, 1997. Bechtel Jacobs Company officially assumed management responsibilities on April 1, 1998, when the Lockheed Martin Energy Systems contract expired. Lockheed Martin Utility Services provides management services for USEC. The Nuclear Regulatory Commission assumed direct oversight of USEC operations, formerly a DOE function, in March 1997.

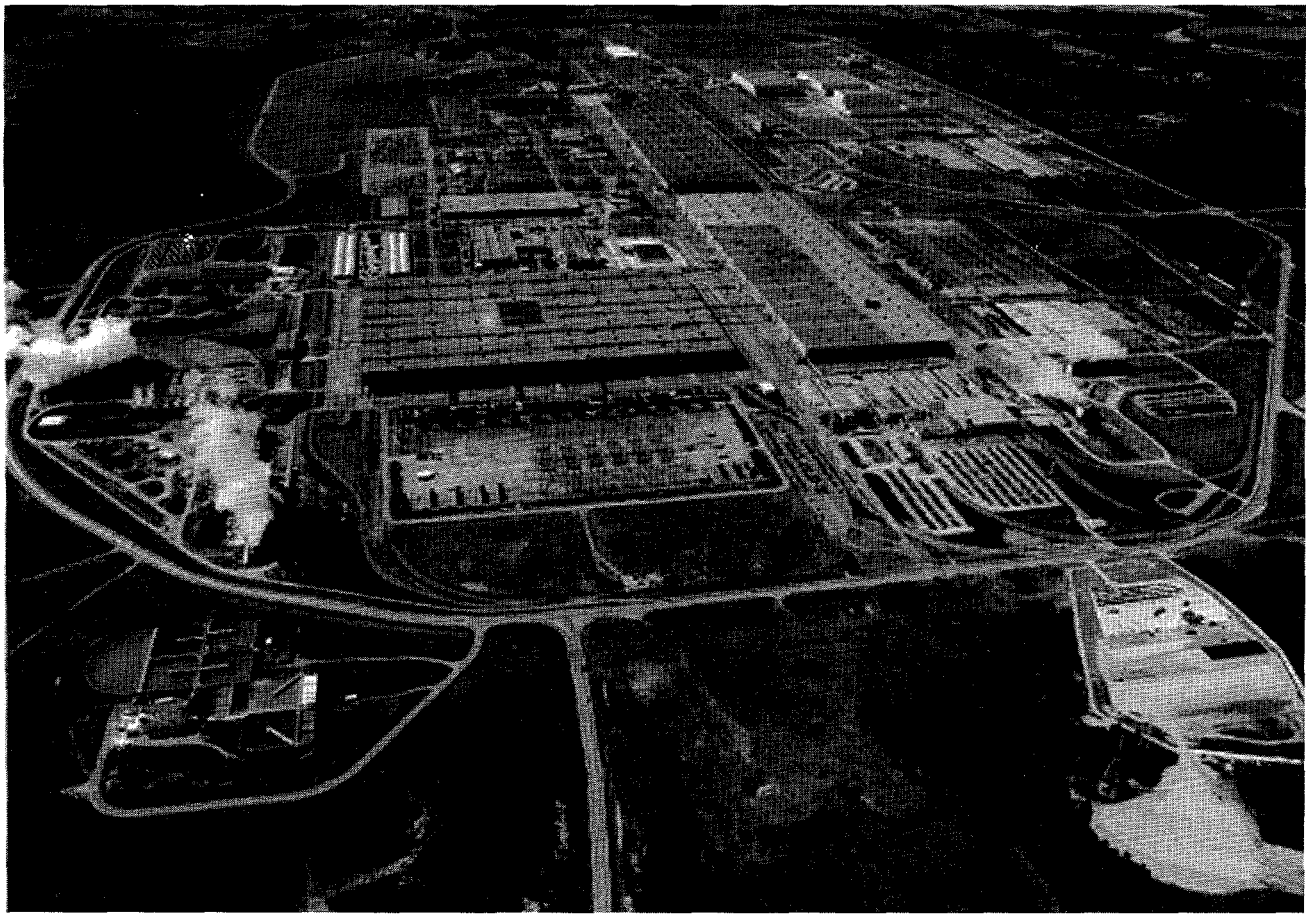


**Fig. 1. DOE/PORTS is one of two U.S. government-owned, contractor-managed uranium enrichment facilities in operation. The other facility is in Paducah, Kentucky.**

The Portsmouth Gaseous Diffusion Plant (PORTS) is located on about six square miles in Pike County, Ohio. The County has approximately 24,250 residents. The total population within 50 miles of the plant is about 900,000.

The main process at PORTS has been the separation of uranium isotopes through gaseous diffusion. Uranium is no longer enriched by DOE at PORTS. The uranium enrichment production operation facilities at the site are leased to USEC and are managed and operated by Lockheed Martin Utility Services.

## ENVIRONMENTAL COMPLIANCE

Several federal, state, and local agencies are responsible for enforcing environmental regulations at DOE/PORTS. As of July 1, 1993, responsibility for ensuring compliance was split between DOE and USEC. DOE is responsible for environmental restoration, waste management, removal of highly enriched uranium, and operation of nonleased facilities. USEC is responsible for operating the enrichment facilities and maintaining Nuclear Regulatory Commission compliance. DOE/PORTS conducts a self-assessment program, which addresses any environmental concerns and, when necessary, involves regulatory agencies to ensure that the appropriate actions are being taken to maintain compliance.

The Ohio Hazardous Waste Facility Board issued a Resource Conservation and Recovery Act (RCRA) Part B permit to DOE allowing storage of hazardous waste in buildings X-7725 and X-326 in 1995. In 1997, one Notice of Violation was issued to DOE by the Ohio Environmental Protection Agency (Ohio EPA). The Notice of Violation stated that weekly inspections in the X-7725 and X-326 facilities were not adequately recorded, and repairs were not made in a timely manner. In addition, quarterly noncompliance reports did not identify the above-mentioned violations, and the permit change requests did not contain certification statements. On September 10, 1997, the Ohio EPA determined that all violations had been corrected.

On August 11, 1997, the Ohio Consent Decree and the U.S. Environmental Protection Agency (USEPA) Administrative Consent Order were revised to grant the Ohio EPA day-to-day oversight of the environmental restoration activities at DOE/PORTS. The RCRA facility investigations required by the Consent Decree and Administrative Consent Order were approved in 1997. The cleanup alternatives study/corrective measures study, which are also required, were being developed throughout 1997 for submittal to the Ohio EPA in 1998.

On August 18, 1997, DOE/PORTS verbally agreed to the Ohio EPA Director's Findings and Orders to address the outstanding violations for the storage of lithium hydroxide monohydrate and depleted uranium hexafluoride. In addition, previous violations regarding the X-700 tanks 6, 7, and 8 and the X-740 and X-750 tanks were resolved through risk-based closures and a judicial consent order with the state of Ohio issued on July 24, 1996. Upon approval, the judicial consent order will release DOE/PORTS from liability of known past RCRA violations.

In 1997, the Ohio EPA denied the X-735 industrial solid waste landfill permit to install because the landfill did not meet the requirements of the new regulations in the Ohio Administrative Code. As a result of this denial, the Ohio EPA issued a Director's Findings and Orders, which directs the initiation of closure of the landfill no later than January 30, 1998. See Section 2, "Environmental Compliance," for details.

One National Pollutant Discharge Elimination System (NPDES) occurrence involving an exceedence at a DOE outfall was reported to the regulatory agencies during 1997. In April, the discharge limit for trichloroethene, a cleaning solvent formerly used in degreasing operations, was exceeded at the X-623 groundwater treatment facility. The incident was investigated, resolved, and corrected with no adverse impacts or reoccurrences. No violations of air permit or National Emission Standards for Hazardous Air Pollutants limits occurred in 1997 at DOE/PORTS.

# ENVIRONMENTAL PROGRAMS

Environmental restoration and waste management activities are conducted to protect the local population, improve the quality of the environment, and comply with federal and state regulations.

- ***Environmental restoration*** is the cleanup of wastes in the environment that originated from activities on the reservation.
- ***Waste management*** is the control of wastes, including treatment, temporary storage, disposal and/or permanent storage.

## Environmental Restoration Program

Environmental restoration is the process of cleaning up inactive waste sites and facilities to ensure 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. RCRA is a federal law that addresses the restoration of inactive waste sites. This legislation includes identification of waste sites with the need for cleanup due to potential risk to public health or the environment. The DOE/PORTS Environmental Restoration Program was developed in 1989 and was granted an initial budget of $13.8 million. Since then, annual program expenditures peaked at $75.9 million and are now declining as environmental restoration activities are progressing toward completion.

## 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. The primary goal is to ensure that waste materials do not migrate into the environment.

Waste management requirements are varied and often complex because of the variety of wastes generated by DOE/PORTS activities. DOE orders and Ohio EPA and USEPA regulations must be satisfied to ensure compliance of waste management activities. Supplemental policies have been implemented for management of radioactive, hazardous (chemical), polychlorinated biphenyl, asbestos, industrial, and mixed (radioactive and hazardous) wastes. These policies include the following:

- minimizing wastes;
- characterizing and certifying wastes before they are stored, processed, treated, or disposed;
- pursuing volume reduction and use of on-site storage when safe and cost-effective until a final treatment and/or disposal option is identified; and
- recycling.

## Public Awareness Program

A comprehensive community relations and public participation program within the DOE Program has been in place since early 1990. Its purpose is to conduct a proactive public involvement program, with outreach components, to foster a spirit of openness and credibility among local citizens and various segments of the public. The program is also geared to provide the public with opportunities to become involved in decisions affecting environmental issues at the site.

DOE opened a public Environmental Information Center in February 1993 in an effort to provide public access to all documents used to make decisions on remedial actions being taken at the plant. The information center has a full-time staff and is located about 10 miles north of the plant at 505 West Emmitt Avenue, Suite 3, Waverly, Ohio 45690. The center's hours are 10 a.m. to 4 p.m., Monday, Tuesday, Wednesday, and Friday, and 9 a.m. to 12 p.m. on Thursday, or after hours by appointment (740-947-5093).

A group of about 45 key stakeholders, composed of elected officials, community leaders, environmentalists, and other individuals who have expressed an interest in the DOE Program, is targeted for information and input on current activities and actions under consideration for cleanup. 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 within two miles of the plant site, and all plant employees and retirees.

Points of contact have been established for the public to obtain information or to direct questions regarding the DOE Program. The DOE Site Office may be contacted at 740-897-5510. The Bechtel Jacobs Company LLC project manager and the public affairs manager also provide information on the program.

## ENVIRONMENTAL MONITORING

Environmental monitoring systems at DOE/PORTS include emissions modeling for air and sampling of surface water discharges. Emissions modeling of the major radionuclide emission sources includes the X-326 "L-Cage" glove box and the X-744G glove box. Six sampling locations exist for discharges from DOE/PORTS activities to local surface waters.

### Airborne Discharges

The discharge of pollutants into the atmosphere from DOE/PORTS activities is regulated by permits from the state of Ohio. These pollutants include standard industrial pollutants, such as gasoline and diesel fuel vapors and cleaning solvent vapors. Airborne radionuclides are considered the main source of any radiation dose that might be received by the public from plant operations.

DOE/PORTS calculated the estimate of total pollutant emissions to be less than 9 tons per year, which was well below the limit of 100 tons per year for non-Title V facilities under 40 Code of Federal Regulations 70. A total of 0.00014361 curies (Ci) of radionuclides was discharged to the air in 1997, all of which consisted of uranium isotopes and short-lived uranium daughters, alpha emitters.

Historically, uranium has accounted for 75% to almost 90% of the public dose from DOE/PORTS emissions. Because DOE is no longer involved in the uranium enrichment process and because of the completion of highly enriched uranium production, the activity emissions (curies) of uranium decreased significantly after 1993.

### Liquid Discharges

Nonradiological plant-site liquid effluents related to DOE operations are regulated by the NPDES permit and are routinely monitored. Radiological analyses are also performed at NPDES sampling locations.

There are five radionuclides present in DOE/PORTS discharges that must be accounted for in the source term and dose assessment. Four of these are isotopes of uranium ($^{234}U$, $^{235}U$, $^{236}U$, and $^{238}U$) and the

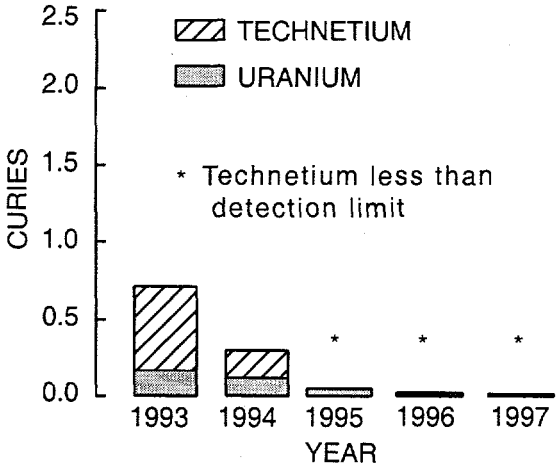



**Fig. 2. Waterborne radionuclides discharged at DOE/PORTS, 1993-1997.**

fifth is technetium ($^{99}Tc$). In addition, DOE/PORTS also accounts for three short-lived uranium daughters [thorium ($^{234}Th$ and $^{231}Th$) and palladium ($^{234m}Pa$)], which are present but do not add any significant contribution to the public dose. All of the uranium isotopes are alpha emitters; technetium is a weak beta emitter. The three uranium daughters are all beta or beta-gamma emitters.

A calculated total of 0.628 kg of radionuclides was discharged from DOE NPDES outfalls in 1997. This number represents a decrease in uranium emissions from 1996. The five-year trend for waterborne radionuclide discharges is shown in Fig. 2. Total radiological discharges from DOE NPDES outfalls were well below all applicable USEPA and DOE standards.

Nonradiological discharges from DOE NPDES outfalls are best summarized by the extent of compliance with the NPDES permit limits. The NPDES compliance rate for DOE outfalls was 99.8% for 1997.

## DOSE

The calculated maximum potential committed effective dose equivalent to any individual from DOE/PORTS operations during 1997 was 0.0074 mrem/year, much lower than the applicable USEPA standard of 10 mrem/year from the National Emission Standards for Hazardous Air Pollutants and the DOE standard of 100 mrem/year from all sources. None of the potential doses calculated resulting from DOE/PORTS operations is significant to public health.

### Comparison of Dose Levels

The dose received by a given individual can vary widely from year to year, depending on numerous factors. The average individual in the United States receives a dose from natural exposure that is more than 200 times higher than he or she receives from nuclear industry operations (see Fig. 3).

The average dose caused by background radiation (natural, not human-made radiation) also varies widely. In the United States, the average is about 300 mrem/year; however, some people in

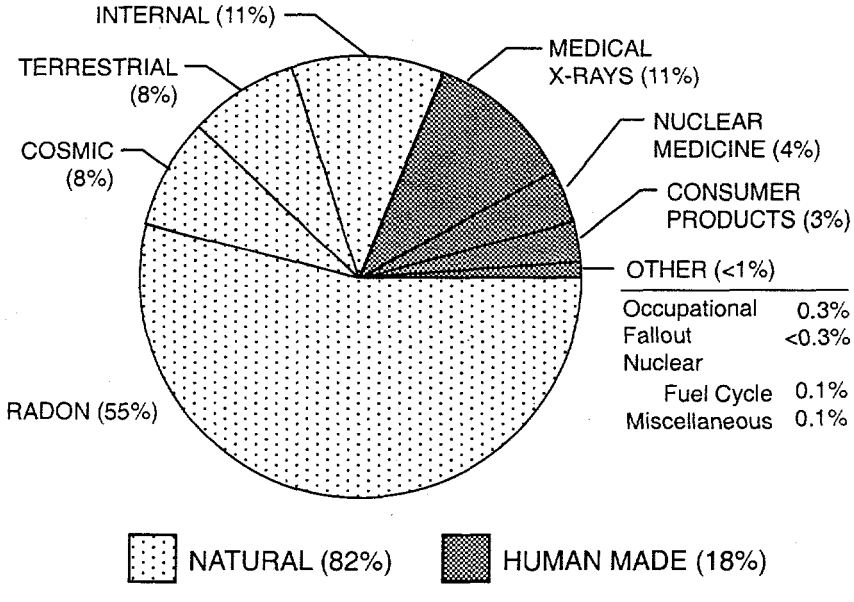



**Fig. 3. Sources of radiation.**

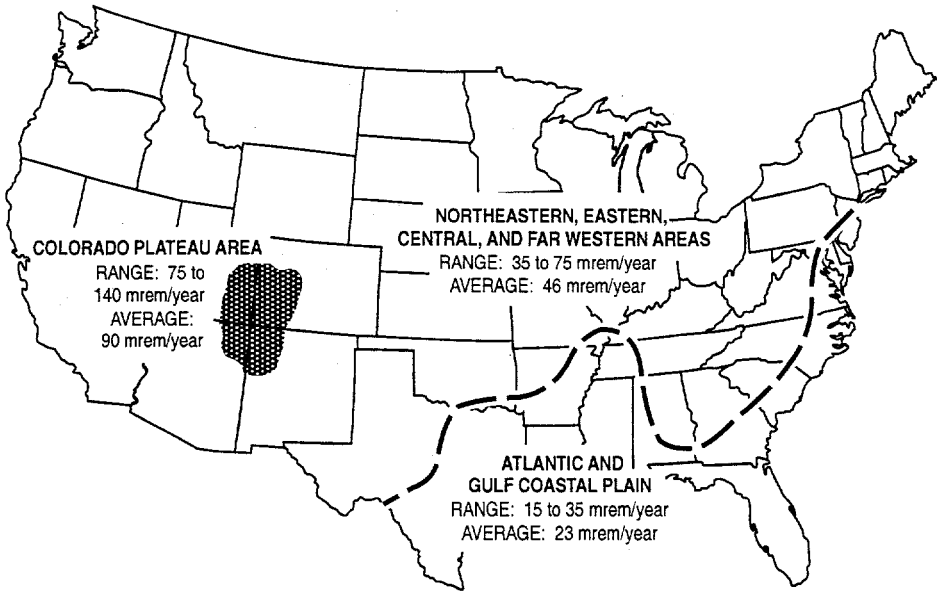



**Fig. 4. Average dose from terrestrial radiation in the United States.**

other parts of the world receive a dose more than four times this amount. For example, in some areas of Brazil, the dose to inhabitants can be more than 2,000 mrem/year from background radiation. These variations are caused by several factors, most notably the type and amount of radionuclides in the soil (see Fig. 4).

This diversity in background radiation is responsible for the large differences in the dose to average individuals. Because people living in areas with high levels of background radiation do so without proven harm, it is assumed by most in the scientific community that the extremely small variations in dose caused by DOE/PORTS releases have inconsequential, if any, effect on humans. See Fig. 5 for a comparison of various dose levels.

Employees at DOE/PORTS remain committed to working safely, with regard to each other, the public, and the environment. This goal will be accomplished by keeping emissions as low as reasonably achievable, enhancing the strict safety controls that are already in place, and by using state-of-the-art technology to complete environmental remediation projects in the most cost-effective and efficient manner possible.

## GROUNDWATER

The groundwater monitoring program at DOE/PORTS includes assessment monitoring and surface water monitoring associated with four RCRA land disposal units, detection monitoring associated with a sanitary landfill and a neutralization pit, detection monitoring in support of the environmental restoration program, and off-site monitoring of residential water sources (i.e., cisterns, springs, and wells).

The RCRA assessment monitoring program is based on results of a groundwater quality assessment completed in 1989 (*Groundwater Quality Assessment of Four RCRA Units*) and closure/post-closure plans approved by the Ohio EPA. Routine monitoring is accomplished by sampling wells. Sampling locations required by

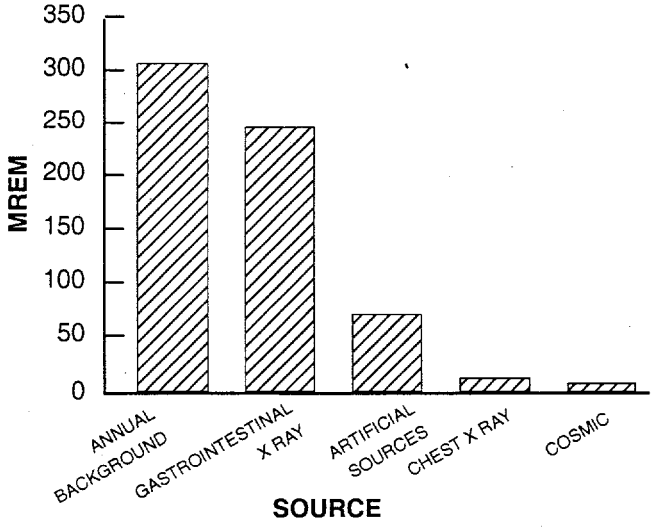



**Fig. 5. Comparison of dose from various common radiation sources.**

either regulations or closure plans include 30 wells at the X-701B holding pond, three wells at the X-749 contaminated materials storage yard, 15 wells at the X-616 chromium sludge surface impoundments, and 19 wells at the X-231B southwest oil biodegradation plot. In addition, points of groundwater discharge to surface water associated with these units are monitored at Little Beaver Creek, Big Run Creek, the southwest drainage ditch, the west drainage ditch, the east drainage ditch, and the north holding pond.

Detection monitoring at the X-735 RCRA landfill is accomplished by sampling 10 groundwater monitoring wells on the perimeter of the landfill. Detection monitoring is also conducted at three wells surrounding the X-701C neutralization pit.

The RCRA facility investigations for Quadrants I through IV were completed in accordance with the requirements and schedules specified in the consent decree issued by the state of Ohio on August 29, 1989, and with the Administrative Consent Order issued by USEPA Region V in 1989 and revised on August 11, 1994, and August 11, 1997. During the Quadrant I and Quadrant II RCRA facility investigations, 103 monitoring wells were installed, and 149 soil borings were drilled. A total of 34 solid waste management units were investigated, and the following units were identified as sources to the contaminated groundwater plumes: (1) the X-120 Goodyear training center; (2) the X-231A southeast oil biodegradation plot; (3) the X-710 neutralization pit, X-710 hot pit, and X-760 neutralization pit; and (4) the X-700 chemical cleaning facility, X-705 decontamination building, and X-720 maintenance and stores building. The final RCRA facility investigation reports for Quadrants I through IV were approved by the Ohio EPA and USEPA in September 1997.

The primary groundwater contaminant is trichloroethene, a cleaning solvent formerly used in degreasing operations, and its breakdown compounds. The drinking water maximum contaminant level for trichloroethene is 5 μg/L; this maximum contaminant level is exceeded at each of the plumes.

## QUALITY ASSURANCE AND QUALITY CONTROL

When monitoring releases and measuring radiation in the environment, the reliability of the data is of the utmost importance. To ensure that the monitoring and measurement results are accurate, DOE/PORTS has implemented a quality assurance and quality control program that is based on guidelines from the USEPA, the American Society for Testing and Materials, and other federal and state agencies. DOE/PORTS staff administer numerous quality control programs to ensure 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 USEPA and the National Institute of Occupational Safety and Health. These agencies prepare and distribute test samples for participating laboratories to analyze. The agencies then compile and evaluate the results and report to each laboratory on the accuracy of that laboratory's analyses.

## REFERENCE

Geraghty and Miller. 1989. *Groundwater Quality Assessment of Four RCRA Units.* Dublin, Ohio.

# 1. Site and Operations Overview


***Abstract***

The Portsmouth Gaseous Diffusion Plant (PORTS) is located in a sparsely populated, rural area of Pike County, Ohio, on a 5.8-square-mile site. U.S. Department of Energy (DOE) activities at PORTS include environmental restoration, waste management, removal of highly enriched uranium, 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.


## INTRODUCTION

The Portsmouth Gaseous Diffusion Plant (PORTS) is owned by the U.S. Department of Energy (DOE). Effective July 1, 1993, DOE leased the production facilities at the site to the United States Enrichment Corporation, which was established by the Energy Policy Act of 1992. Lockheed Martin Utility Services manages and operates the leased facilities for the United States Enrichment Corporation (USEC). Through March 31, 1998, Lockheed Martin Energy Systems was the management and operating contractor for DOE responsibilities, which included primarily environmental restoration, waste management, removal of highly enriched uranium, and operation of nonleased facilities at the plant (DOE/PORTS). On April 1, 1998, Bechtel Jacobs Company LLC assumed these responsibilities. DOE awarded Bechtel Jacobs Company a 5½-year management and integration contract on December 18, 1997.

## DESCRIPTION OF SITE LOCALE

DOE/PORTS is located in sparsely populated, rural Pike County, Ohio, on a 5.8-square-mile site (see Fig. 1.1). The site is two miles east of the Scioto River valley in a small valley running parallel to and approximately 120 ft 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 residential

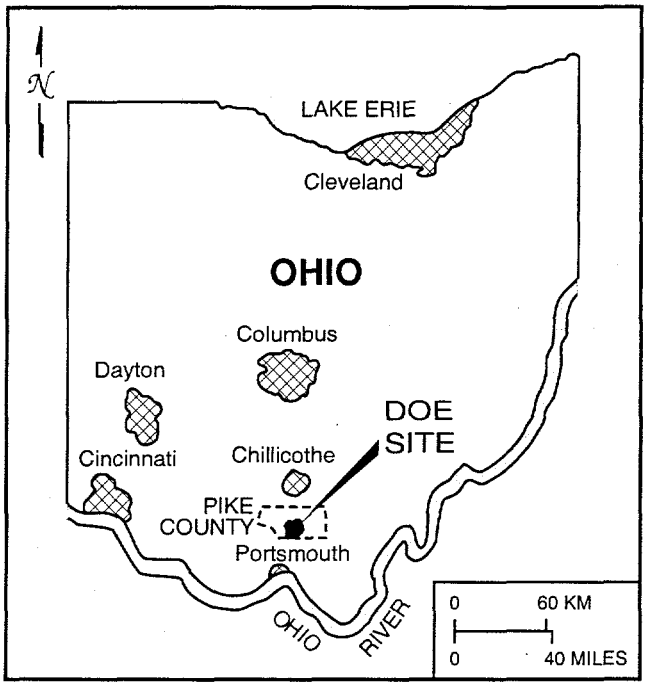



**Fig. 1.1. Location of DOE/PORTS within the state of Ohio.**

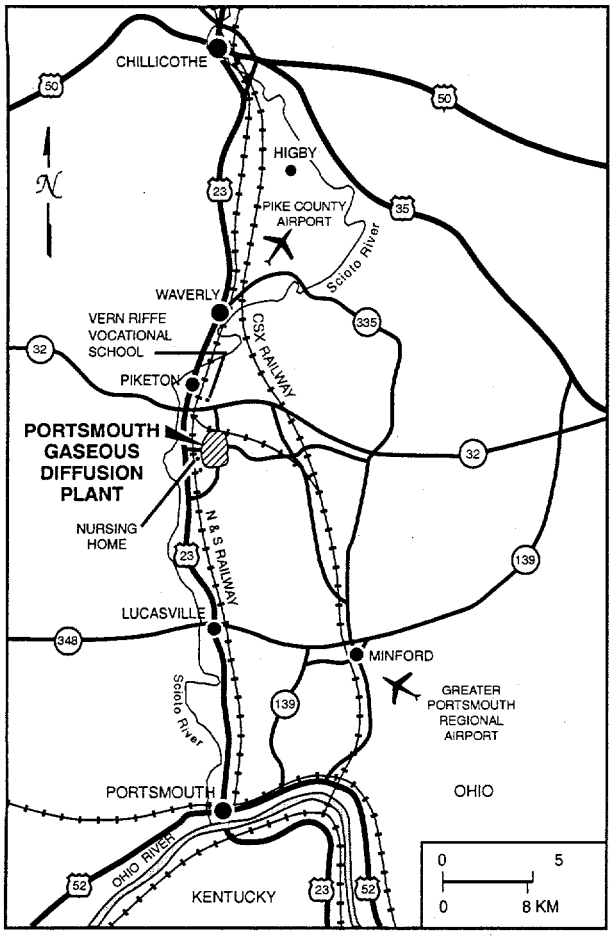



**Fig. 1.2. Location of DOE/PORTS in relation to the geographic region.**

center in this area is Piketon, which is about five 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 of the area lying within a 50-mile radius of the plant is approximately 900,000 (U.S. Department of Commerce 1991).

## DESCRIPTION OF SITE OPERATIONS

DOE, through its managing contractor, operates the environmental restoration, waste management, and highly enriched uranium removal programs at the plant, as well as other nonleased DOE property. The environmental restoration staff perform 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 ensure that releases from past operations and waste management at DOE/PORTS are thoroughly investigated and that appropriate remedial action is taken for the protection of human health and the environment.

# 2. Environmental Compliance

***Abstract***

Ongoing self-assessments are conducted at the U.S. Department of Energy/Portsmouth Gaseous Diffusion Plant (DOE/PORTS) site to identify environmental issues. These issues are discussed frequently with federal and state regulatory agencies to ensure that appropriate actions are taken to achieve compliance.

## INTRODUCTION

DOE/PORTS is required to operate in conformance with environmental requirements established by a number of federal and state statutes and regulations, executive orders, DOE orders, and compliance agreements. This section summarizes the plant's compliance status with regard to these various authorities.

As of July 1, 1993, responsibility for implementing environmental compliance was divided between DOE, site owner and operator of environmental restoration and waste management projects and other operations, and USEC, a government-owned corporation formed by the Energy Policy Act of 1992 to assume the nation's uranium enrichment business.

Under the terms of a lease, USEC assumed responsibility for compliance activities directly associated with uranium enrichment operations, such as air emission permits for cascade vents and maintenance facilities, and water permits for the X-6619 sewage treatment plant and other leased facilities. USEC is also responsible for the management of solid wastes generated by current enrichment operations. DOE manages "legacy" wastes, which contain constituents such as asbestos and polychlorinated biphenyls that were used in DOE operations and became prohibited from use by law prior to the lease agreement. DOE retains responsibility for the site environmental restoration program, the waste management program, the removal of highly enriched uranium, the operation of all nonleased facilities, and compliance with all applicable permits. DOE/PORTS currently operates under a National Pollutant Discharge Elimination System (NPDES) permit, several air emission permits, and a Resource Conservation and Recovery Act (RCRA) Part B permit for the storage of hazardous wastes.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at DOE/PORTS. Principal regulatory agencies are the U.S. Environmental Protection Agency (USEPA), the Ohio Environmental Protection Agency (Ohio EPA), and the 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.

On August 29, 1989, the Ohio Attorney General's Office issued the Consent Decree, and on September 29, 1989, the USEPA issued the Administrative Consent Order to direct the investigation and cleanup of the site. The RCRA facility investigation reports for Quadrants I through IV were approved in 1997, and the cleanup alternatives study/corrective measures study process is moving forward. Two corrective measures implementations have been approved, one of which was completed in 1997.

DOE/PORTS continues to conduct self-assessments to identify any environmental issues, and when necessary, consults the regulatory agencies to ensure that appropriate actions are implemented to achieve compliance status.

# COMPLIANCE PROGRAMS

## Ohio Consent Decree and USEPA Administrative Consent Order

A consent decree with the state of Ohio, issued on August 29, 1989, and an administrative consent order with the USEPA, issued on September 29, 1989, require the investigation and cleanup of surface water and air releases, groundwater contamination plumes, and solid waste management units. The reservation was divided into quadrants based on groundwater flow patterns as a management approach to facilitate the expedient cleanup of contaminated sites in accordance with RCRA corrective action and closure requirements. There are five groundwater contamination plumes and 80 solid waste management units on the property. RCRA facility investigations for all quadrants have been completed, and the reports were approved by the USEPA and the Ohio EPA in September 1997. In addition, the Air RCRA facility investigation and the Baseline Ecological Risk Assessment were approved in March 1997.

As required by the Consent Decree and Administrative Consent Order, cleanup alternatives study/corrective measures study reports are currently being developed. The cleanup alternatives study/corrective measures study reports explore the proposed remedial alternatives for the identified solid waste management units. Corrective measures implementation plans for the Peter Kiewit landfill and the X-611A lime sludge lagoons have been approved. The corrective measures implementation for X-611A has been completed, and the corrective measures implementation for the Peter Kiewit landfill is expected to be completed by the end of 1998.

The Administrative Consent Order with the USEPA was revised on August 11, 1994, to provide cost recovery funds to the state of Ohio. A second revision of the order on August 11, 1997, granted the Ohio EPA day-to-day oversight of the cleanup work at DOE/PORTS.

In 1993, the USEPA did not approve the Quadrant III RCRA facility investigation work plan and issued a Notice of Violation of the Administrative Consent Order to DOE/PORTS. Through a Dispute Resolution Agreement, DOE/PORTS agreed to pay a $50,000 fine and conduct a supplemental environmental project costing a minimum of $1 million. The supplemental environmental project, which involved the disposal of treated radiological sewage sludge generated at the X-6619 waste water treatment facility, was completed on December 15, 1997.

## Ohio Agreement in Principle

On October 26, 1993, an Agreement in Principle became effective between DOE and the state of Ohio regarding joint oversight of the three DOE facilities in Ohio (Fernald Environmental Management Project in Cincinnati, the Mound Plant in Miamisburg, and DOE/PORTS). The Agreement in Principle provided approximately $11 million over a five-year period to the state to be used to review the environmental compliance and monitoring programs and data, supplement existing state and local emergency management programs, and promote better state and public understanding of DOE environmental activities at the three sites. The grant authorization was approved in early 1994. The Ohio EPA is the lead state agency for the Agreement in Principle, which includes the Ohio Department of Health and the Ohio Emergency Management Agency.

In late 1996, DOE/PORTS met with the state agencies to discuss the work plan and budget development for the program. The significant overlap between the Agreement in Principle program and the cost recovery program implemented by the 1994 revision of the Administrative Consent Order was noted by the meeting participants. It was determined on June 30, 1997, that DOE/PORTS' participation in the Agreement in Principle program is unnecessary until the decontamination and decommissioning program for the site is initiated.

## Resource Conservation and Recovery Act

On July 21, 1995, the Ohio Hazardous Waste Facility Board conducted a final hearing on the RCRA Part B permit application to allow for the storage of hazardous waste in the X-7725 and X-326 facilities. The permit was issued to DOE/PORTS on July 21, 1995, and became effective on August 21, 1995. In accordance with the permit, DOE/PORTS conducts weekly inspections of the permitted facilities to ensure the storage areas have no cracks in the floors and no rain or surface water leaks, the containers are in good condition and are properly labeled, and sufficient personal protective equipment is available. A quarterly noncompliance report is submitted to the Ohio EPA on the 15th of January, April, July, and October.

On May 27, 1997, the Ohio EPA conducted an inspection of the RCRA storage facilities and operating record for compliance with the permit. A Notice of Violation was issued on June 24, 1997, because weekly inspections in the X-7725 and X-326 facilities were not adequately recorded and repairs were not made in a timely manner, quarterly noncompliance reports did not identify the above-mentioned violations, and the permit change requests did not contain certification statements. Corrective actions were implemented, and the Ohio EPA determined that the Notice of Violation was resolved on September 10, 1997, and that DOE had regained compliance.

The first risk-based closure under RCRA at DOE/PORTS was approved by the Ohio EPA on January 27, 1997, for the X-344 settling tank. As of December 31, 1997, certification of closure had been received from the Ohio EPA for 14 RCRA facilities. Two units, the X-740 waste oil facility and tank, are closed and awaiting certification. On October 23, 1997, DOE/PORTS submitted a RCRA closure plan to the Ohio EPA for the hazardous trap material storage area. The closure plan was prepared in accordance with Ohio Administrative Code 3745-66-12 to address closure of the storage area in which seven of the 93 drums of trap material had been recharacterized as hazardous. The seven drums have been moved to a RCRA-permitted storage area. Table 2.1 shows the current RCRA facility closure status.

The Ohio EPA has designated five RCRA units as "integrated units." Preliminary remedial action has been completed as required by closure plans and as directed by the Ohio EPA. Final remediation of the units will be addressed in an Ohio EPA Director's Findings and Orders. A schedule will be developed and implemented to facilitate the timely and efficient remediation of the units. See Table 2.1 for a list of these integrated units.

At DOE/PORTS, RCRA also requires groundwater monitoring be conducted at six hazardous waste units. The units, which are no longer in operation, are the X-231B southwest oil biodegradation plot, the X-616 chromium sludge surface impoundments, the X-701B holding pond, the X-701C neutralization pit, the X-735 RCRA landfill (northern portion), and the X-749 contaminated materials storage yard (northern portion). Refer to Section 6, "Groundwater," for details on groundwater monitoring of RCRA units.

## Federal Facility Compliance Act

DOE/PORTS currently stores a mixture of hazardous waste and low-level radioactive waste, which is subject to land disposal restriction provisions. This environmental law does not allow the storage of hazardous and low-level waste for longer than one year. The Federal Facility Compliance Act , enacted by Congress in October 1992, provides relief from this requirement. The Federal Facility Compliance Act allows for the storage of hazardous and low-level radioactive waste because treatment for this kind of waste is not yet available. The Act also requires federal facilities to develop and submit site treatment plans for treatment of mixed wastes. On October 4, 1995, a Director's Findings and Orders was issued by the Ohio EPA to implement the Federal Facility Compliance Act, allowing storage of mixed waste beyond one year and approving the DOE/PORTS Proposed Site Treatment Plan. The *Site Treatment Plan Annual Report for Mixed*

**Table 2.1. RCRA facility closure status at DOE/PORTS for 1997.**

| Status | Facility |
|---|---|
| Certification of closure received from the Ohio EPA as of 1997 | X-744G(U) container storage facility<br>X-735 landfill (cells 1-6)<br>X-616 surface impoundments<br>X-705A incinerator<br>X-749 landfill (northern portion)<br>X-749 landfill (southern portion)<br>X-750 waste oil tank<br>X-752 container storage facility<br>X-700 tank 6 generator closure<br>X-700 chromic acid tank 7<br>X-700 tank 8 generator closure<br>X-744G(R) container storage facility<br>X-749A classified landfill<br>X-344A settling tank |
| Closed and awaiting certification | X-740 waste oil facility<br>X-740 tank |
| Amended closure plans submitted to the Ohio EPA for review | X-735 industrial solid waste landfill |
| Designated as an "Integrated Unit" by the Ohio EPA | X-231B biodegradation plot<br>X-744Y container storage yard<br>X-701B surface impoundments<br>X-701C neutralization pit<br>X-230J7 holding pond |

*Wastes at the Portsmouth Gaseous Diffusion Plant* was submitted to the Ohio EPA on December 22, 1997, in accordance with Section V, *Orders,* Part C, *Annual Report* of the Director's Findings and Orders.

## Comprehensive Environmental Response, Compensation, and Liability Act

DOE/PORTS is not on the Comprehensive Environmental Response, Compensation, and Liability Act National Priorities List of sites requiring cleanup but is regulated under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act per the Ohio Consent Decree and USEPA Administrative Consent Order. The USEPA and the Ohio EPA have chosen to oversee environmental remediation activities at DOE/PORTS under the RCRA corrective action process.

The Comprehensive Environmental Response, Compensation, and Liability Act Section 103 requires notification to the National Response Center if hazardous substances are released to the environment in amounts greater than or equal to the reportable quantity. Reportable quantities are listed in the Comprehensive Environmental Response, Compensation, and Liability Act and vary depending on the type of hazardous substance. DOE/PORTS had no reportable quantity releases of hazardous substances subject to the

Comprehensive Environmental Response, Compensation, and Liability Act Section 103 notification requirements during 1997.

## Toxic Substances Control Act

The electrical power system at the Portsmouth Gaseous Diffusion Plant, which is leased by USEC, uses oil-blast circuit breaker transformers and large, high-voltage capacitors, both containing polychlorinated biphenyl oil, to supply electricity to the enrichment cascade, as permitted under the Toxic Substances Control Act. USEC leases 152 oil-blast circuit breaker transformers and 11,110 large capacitors from DOE. In 1997, DOE/PORTS retained ownership of one transformer, which was drained of all polychlorinated biphenyl oil. The polychlorinated biphenyls are managed as Toxic Substances Control Act-regulated waste, and the transformer carcass is managed as a polychlorinated biphenyl-contaminated article.

In February 1992, a federal facilities compliance agreement between DOE and USEPA Headquarters addressing polychlorinated biphenyl issues common to all three DOE uranium enrichment plants became effective and resolved several compliance issues. These issues included the use of polychlorinated biphenyls in systems that are not totally enclosed, storage of polychlorinated biphenyl-radioactive waste in accordance with nuclear criticality safety requirements, and storage of polychlorinated biphenyl-radioactive waste for longer than one year. The agreement required that troughs be installed under all motor exhaust duct gaskets to collect polychlorinated biphenyl oil leaks. When leaks or spills of polychlorinated biphenyl material occur, they are managed in accordance with the federal facilities compliance agreement. As of the end of 1997, DOE/PORTS was in compliance with the requirements and milestones of this federal facilities compliance agreement.

DOE/PORTS operates several storage areas for polychlorinated biphenyl wastes. The storage areas meet all applicable requirements of 40 Code of Federal Regulations 761.65 and the federal facilities compliance agreement. All PORTS solid polychlorinated biphenyl wastes are in long-term storage because of the lack of commercially available disposal facilities authorized to dispose of wastes containing both polychlorinated biphenyls and radionuclides.

An annual report of progress made toward milestones specified in the federal facilities compliance agreement is compiled and submitted to the USEPA. In addition, DOE and USEPA 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 Toxic Substances Control Act, the specific regulations applicable to the site are duplications of other state and federal regulations, specifically, the National Emission Standards for Hazardous Air Pollutants and Occupational Safety and Health Administration (OSHA) regulations. DOE/PORTS also responds to USEPA requests for health and safety data as required, but because the site neither imports chemicals nor manufactures, processes, or distributes chemical substances for commercial purposes, such responses are generally negative.

## Solid Waste

The X-735 industrial solid waste landfill was the only landfill operating during 1997 at DOE/PORTS, and it was closed on December 31, 1997. A license to operate the landfill was obtained annually from the Pike County Health Department. Wastes formerly accepted at the X-735 landfill included cafeteria wastes, industrial wastes, disinfected medical wastes (except drugs), construction and demolition debris, and asbestos (in designated locations). Asbestos disposal was conducted in accordance with the National Emission

Standards for Hazardous Air Pollutants and Ohio Administrative Code 3745-20, *Asbestos Handling—Demolition, Renovation, Disposal.* No hazardous wastes, Toxic Substances Control Act wastes, or radioactive wastes above 30 piC/g were permitted in this facility. On October 11, 1996, the Ohio EPA denied the permit to install for the X-735 industrial solid waste landfill because the landfill did not meet some new requirements of the Ohio Administrative Code. Although the landfill met all existing requirements at the time it was constructed, the Ohio EPA issued a Director's Findings and Orders, which became effective on January 31, 1997, stating closure of the facility must be initiated by January 30, 1998. The Closure/Post-closure Plan was approved by the Ohio EPA on January 23, 1998, and construction of the cap began on March 30, 1998.

The X-736 construction and demolition debris landfill, located immediately west of the X-735 industrial solid waste landfill, ceased accepting waste and was closed on October 1, 1996. Materials disposed in this facility included construction and demolition debris that did not contain hazardous waste, radioactive waste above 30 piC/g, or toxic substances.

The Ohio Solid Waste regulations, Ohio Administrative Code 3745-29-10, require groundwater monitoring to detect releases from solid waste disposal sites. In the event of discovered contamination, a groundwater quality assessment plan must be implemented to assess the extent of the contamination. Groundwater monitoring is required throughout the post-closure care period. Groundwater monitoring information for solid waste units can be found in Section 6, "Groundwater."

## Clean Air Act

Under Ohio Administrative Code 3745-35, any air contaminant source not specifically exempted under Ohio Administrative Code 3745-31-03C(A) or Ohio Administrative Code 3745-35-02(B) that emits more than 10 lb/day must apply for and obtain a permit to operate. As of the end of 1997, DOE/PORTS held 13 state air permits to operate, nine registered sources ("registered" sources are listed by the Ohio EPA in lieu of receiving a formal permit), and four exempt sources. Of the 13 DOE/PORTS permits to operate, eight are currently involved in an appeal with Ohio's Environmental Board of Review. No violations of air permit limits occurred during 1997.

A verbal exemption from the reporting requirements was granted by the Ohio EPA in February 1997 for the eight permits that are under appeal.

An air source permit to install application and fee were submitted to the Ohio EPA for the construction of a cap on the Peter Kiewit landfill. Construction activities began on July 15, 1997, in accordance with the permit to install requirements.

The permit to install for roadways and parking areas at the X-611A remediation project was terminated upon construction completion on September 11, 1997.

### Clean Air Act, Title VI, Stratospheric Ozone Protection

Several activities are proceeding to ensure compliance with Title VI of the Clean Air Act amendments. As part of the Stratospheric Ozone Protection Plan, DOE has instituted a record-keeping system consisting of forms and labels to ensure compliance 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 lb. The refrigeration equipment disposal log and associated appliance disposal label have been developed to be used by all units regardless of capacity. More than 140 air conditioning/refrigeration units and 30 motor vehicle air-conditioning units under DOE control have been identified. Maintenance and service of these units is conducted under contract. The contractor technicians who service the equipment have been properly trained in accordance with USEPA requirements.

## National Emission Standards for Hazardous Air Pollutants

Gaseous radiological emissions were modeled rather than monitored during 1997. The X-345 high-assay sampling area was out of service for all of 1997 but could become active when needed. Radiological emissions were estimated for the X-326 "L-Cage" glove box and the X-744G glove box.

The radionuclides managed on site are the three natural uranium isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) plus trace concentrations of the human-made radionuclides $^{236}U$ and technetium-99 ($^{99}Tc$) and the short-lived uranium daughters thorium-231 ($^{231}Th$), thorium-234 ($^{234}Th$), and protactinium-234 ($^{234m}Pa$). The uranium isotopes are all alpha radiation emitters, with the $^{234}U$ isotope accounting for the bulk of the alpha radiation released from the plant. The uranium daughters are all beta-gamma emitters. Technetium is a beta emitter that originally entered the process as a contaminant from reprocessed reactor fuel.

DOE/PORTS is in compliance with the 10 mrem/year radiological emission limit established by the USEPA; 1997 emissions from DOE activities were .0074 mrem/year. Emissions from other minor sources are estimated based on process knowledge and the emission factors in Appendix D of 40 Code of Federal Regulations 61, "NESHAP (National Emission Standards for Hazardous Air Pollutants)." The radiological emissions value calculated in 1997 included all uranium isotopes, while the value calculated in 1996 addressed only $^{235}U$.

The Ohio EPA conducted the annual air compliance inspection on September 19, 1997. There were no findings as a result of the inspection.

## Clean Water Act

DOE was issued an NPDES permit, which became effective September 1, 1995, and was modified in December 1996 and May 1997. This permit encompasses six monitored outfalls, three of which are classified as point-source discharges to waters of the state, and three internal outfalls that are classified as effluents that go through another monitored outfall before reaching waters of the state. The annual inspection of all DOE/PORTS outfalls was conducted on March 17, 1997, and no problems were noted.

Compliance rates (by individual parameter) at DOE outfalls ranged from 96% to 100%. The overall DOE compliance rate for 1997 was 99.8%. (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.) There was one exceedence at a DOE outfall during 1997. In April 1997, the discharge limit of 10 µg/L for trichloroethene, a common industrial solvent, was exceeded at the X-623 groundwater treatment facility. The concentration of trichloroethene in the sample was 54 µg/L. The presence of foam in the system, believed to have resulted from the X-701B surfactant technology demonstration, may have caused the air stripper and carbon vessels to perform less efficiently. An anti-foaming agent was applied to the system, and no other exceedences have occurred.

On March 17 and 18, 1997, the Ohio EPA collected confirmatory water samples at the X-2230N holding pond effluent (outfall 013) in support of the NPDES permit. The samples, which were split with DOE/PORTS, were analyzed for bioassay, chemical, and organic parameters. Analytical results indicated that pollutants were not discharged from the outfall at levels that exceed effluent permit limitations. Furthermore, no volatile organic compounds were detected. Although similar results were obtained by the Ohio EPA for the chemical and organic analyses, the Ohio EPA sample failed the bioassay analysis. The DOE/PORTS bioassay results indicated a passing survival rate of test specimens. Upon evaluation of the results, the Ohio EPA indicated that the effluent was not acutely toxic.

A general storm water discharge permit for the Peter Kiewit landfill seep collection interim remedial measure was in effect for the first half of 1997. Following an inspection of the area, it was determined that the

final stability of the disturbed areas was complete. In accordance with the provisions of the general storm water discharge permit issued for the Peter Kiewit landfill interim remedial measure, a notice of termination of coverage under the permit was provided to the Ohio EPA on July 28, 1997.

In October 1997, DOE/PORTS participated in the USEPA Discharge Monitoring Report Quality Assurance Study 17. The study evaluates the analytical and reporting ability of the laboratories that routinely perform analyses required in NPDES permits. DOE/PORTS uses the Portsmouth Analytical Laboratory for all NPDES sampling. The results of the study were satisfactory. Participation in the study is a requirement in the Clean Water Act.

## Underground Storage Tank Regulations

The Underground Storage Tank Program is managed in accordance with the regulations of DOE, the USEPA, Ohio EPA, and the Ohio State Fire Marshal's Bureau of Underground Storage Tank Regulations. The Bureau of Underground Storage Tank Regulations are codified in the Ohio Administrative Code, Rule Chapter 1301:7–9. DOE/PORTS renewed the registration of 12 tanks in May 1997. DOE leases 11 of the underground storage tanks at the site to USEC. DOE has retained responsibility for environmental compliance for one underground storage tank.

The soil disposal/treatment notification form regarding the shipment of petroleum-contaminated soil generated from the X-751 west underground storage tank excavation was transmitted to the Bureau of Underground Storage Tank Regulations on February 18, 1997. The *Modified Closure Assessment Report* for the X-751 west underground storage tank was submitted to the Bureau of Underground Storage Tank Regulations on March 20, 1997.

All DOE underground storage tanks and former underground storage tank sites are in compliance with current Bureau of Underground Storage Tank Regulations. The remaining underground storage tank will be closed by December 22, 1998, in accordance with regulatory requirements.

## 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.

The Emergency Planning and Community Right-To-Know Act Section 304 requires reporting of off-site reportable quantity releases to state and local authorities. During 1997, DOE/PORTS had no reportable quantity releases. As required by Section 311, the material safety data sheets of the hazardous chemicals in use at DOE/PORTS were updated and provided to state and local authorities. The hazardous chemical inventory report for 1997, required by Section 312, was submitted to state and local authorities. The report included the identity, location, storage information, and hazards of the eight hazardous chemicals that exceeded the threshold planning quantities and were stored by DOE/PORTS. These eight hazardous chemicals were aluminum oxide, diesel fuel, ethylene glycol, lithium hydroxide, polychlorinated biphenyls, sodium fluoride, triuranium octaoxide, and uranium hexafluoride. Section 313 requires annual reporting of specified toxic chemicals based on usage rate threshold quantities. The toxic chemical release inventory reports are sent annually to the USEPA and to the Ohio EPA. Two listed toxic chemicals, ethylene glycol and zinc compounds, exceeded usage rate thresholds and were reported for 1997 releases within DOE held properties.

No toxic chemical release inventory report was necessary for the reporting year 1996. This was as a result of decreased sitewide usage rates of certain toxic chemicals listed in the report and a general decrease in project activity involving listed toxic chemicals at DOE/PORTS.

## 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 related 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*;
- the potential habitat (including critical habitat) of federally listed endangered, threatened, proposed, or candidate species or of state-listed endangered and threatened species;
- federally listed endangered, threatened, proposed, or candidate species or state-listed endangered and threatened species;
- floodplains and wetlands;
- natural areas such as federally and state-designated 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).

Impacts to air, surface water, groundwater, biota, socioeconomics, environmental justice, and worker safety and health are also reviewed.

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 operations and maintenance activities are also evaluated to assess potential environmental impacts. Most activities performed on site qualify for categorical exclusion as defined in 10 Code of Federal Regulations 1021, *NEPA* (National Environmental Policy Act) *Implementing Procedures*, and as listed in Subpart D, Appendices (a) and (b). These activities are considered routine and have no significant individual or cumulative environmental impacts.

In 1997, 17 generic and three specific categorical exclusions were referenced for DOE/PORTS project activities. The Environmental Assessment, *Sale of Excess Lithium Hydroxide Stored at Oak Ridge and Portsmouth*, and *Findings of No Significant Impact*, approved on May 7, 1993, were in effect for the staging areas for off-site shipment of lithium hydroxide. DOE published the May 1997 Waste Management Programmatic Environmental Impact Statement as a nationwide study examining the environmental impacts of managing radioactive and hazardous wastes generated by past and future nuclear defense and research activities at a variety of sites in the country, including DOE/PORTS. Waste management activities at DOE/PORTS are not expected to cause major impacts to ecological resources, land use, infrastructure, or environmental justice.

## Federal Insecticide, Fungicide, and Rodenticide Act

Application of pesticides by DOE/PORTS and contractor personnel must be documented and approved by the DOE/PORTS pesticide coordinator. Plant personnel apply general-use pesticides according to product labeling, and all product warnings and cautions are strictly obeyed. No restricted-use pesticides are used by DOE/PORTS personnel. When application of a restricted-use pesticide is required, a certified contractor is employed. No restricted-use pesticides were applied at DOE/PORTS in 1997.

## DOE Orders

### DOE Order 5400.1, *General Environmental Protection Program*

DOE Order 5400.1 provides direction for compliance with the USEPA and state and local environmental regulations, and establishes requirements for internal environmental protection programs. DOE Order 5400.1 states that "it is DOE policy to conduct the Department's operations in compliance with the letter and spirit of applicable environmental statutes, regulations, and standards." The order recognizes that where USEPA, state, and local environmental agencies "clearly exercise environmental protection authority through permitting and compliance administrative procedures applicable to DOE, they establish and regulate required performance for environmental protection."

DOE/PORTS environmental protection programs mandate the creation of several environmental reports. These reports include the five-year plan required by the Office of Management and Budget Circular A-106; the annual site environmental report; and reports of significant nonroutine releases of hazardous substances, consistent with DOE Order 232.1, and *Occurrence Reporting and Processing of Operations Information*. An environmental protection implementation plan is required to be prepared and updated annually. The environmental protection implementation plan defines specific environmental objectives, including the means and schedules for accomplishing those objectives. An environmental monitoring plan is to be prepared, reviewed annually, and updated every three years. The environmental monitoring plan defines a comprehensive system to provide effluent monitoring and environmental surveillance of effluents from DOE/PORTS. The environmental monitoring plan is designed to meet federal and state regulatory requirements as well as those internal to DOE/PORTS. The monitoring program includes all environmental media—air, earth, biological media, surface water, and groundwater.

DOE Order 5400.1 defines environmental monitoring as consisting of effluent monitoring and environmental surveillance and establishes detailed requirements for both a groundwater protection management program and a groundwater monitoring program.

DOE Order 5400.1 specifies the development of three individual documents relating to groundwater monitoring: an environmental monitoring plan (discussed previously), a groundwater protection program management plan, and a groundwater monitoring plan. The groundwater protection program management plan formalizes and structures the DOE/PORTS groundwater protection program by identifying and assigning specific roles and responsibilities to the various staff. The groundwater protection program management plan meets the requirements for a groundwater protection program as described in DOE Order 5400.1. The contents of this plan were updated in 1996 to reflect the following scope:

- Define the purpose, policies, objectives, and history.
- Define regulations, requirements, and guidance applicable to groundwater monitoring.
- Provide a brief description of the hydrogeologic conditions and known groundwater contamination.

- Describe the groundwater monitoring procedures used to meet the applicable regulations and requirements.
- Define organizational roles and responsibilities, including interfaces with other programs.
- Define the documentation required for projects.
- Provide the most effective overall management possible.

The DOE/PORTS groundwater protection program management plan is a dynamic document compiled in a format that allows updating of individual sections independent of the rest of the document. The plan is required to be reviewed annually, and revised and reissued every three years. Sections that are revised between reissue dates are numbered and dated. Where appropriate, the groundwater protection program management plan incorporates material by reference; all referenced materials are subject to annual review, revision, and reissue.

The purpose of the DOE/PORTS groundwater protection program is to characterize the hydrogeology and monitor the groundwater quality at DOE/PORTS and its environs. Related tasks are conducted primarily in support of (1) environmental surveillance activities, (2) land disposal units requiring groundwater monitoring under RCRA, (3) the remedial action program, and (4) land disposal units requiring groundwater monitoring under state solid waste regulations (Ohio Administrative Code 3745-27 and 3745-29). Support for this program is provided in many forms, including technical advice and assistance, well installation and development, sampling and analysis, data management, data interpretation, report preparation, regulatory negotiation, and implementation of monitoring and corrective actions.

In addition to these general requirements, DOE Order 5400.1 contains recommendations regarding monitoring well construction and location, groundwater sampling frequency, sampling and analytical methods, sample sizes, and methods of sample preservation.

## DOE Order 5400.2A, *Environmental Compliance Issue Coordination*

The purpose of this order is to establish the DOE requirements for coordination of significant environmental compliance issues to ensure timely development and consistent application of departmental environmental policy and guidance. A significant environmental compliance issue is one that is or has the potential of being precedent-setting or controversial and/or which involves DOE Headquarters notification, concurrence, or approval.

This order requires coordination of environmental issues that are of significance to DOE, such as the following:

- settlement agreements;
- hazardous waste and mixed waste permits and permit applications;
- proposed consent decrees and consent administrative orders;
- notifications from regulatory authorities alleging lack of compliance with environmental regulations or requirements;
- lawsuits pertaining to environmental compliance;
- results of verification activities; and
- reports or other notifications to or from regulatory authorities concerning violations of environmental regulations, permits, or agreements.

## DOE Order 5400.4, *Comprehensive Environmental Response, Compensation, and Liability Act Program*

The purpose of this order is to establish and implement Comprehensive Environmental Response, Compensation, and Liability Act policies and procedures as prescribed by the National Oil and Hazardous Substances Pollution Contingency Plan and under the authority of Executive Order 12580 within the framework of the environmental programs established under DOE Order 5400.1. This order does not address Title III of the Superfund Amendments and Reauthorization Act.

DOE/PORTS implements corrective actions under Section 3008(h) of RCRA, as indicated by the Consent Decree and Administrative Consent Order. DOE/PORTS is responsible for ensuring that corrective actions are consistent with the requirements in the order as well.

## 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 against undue radiological risk from operations of DOE and DOE contractors. The order requires that off-site radiation doses not exceed 100 mrem/year above background.

The purpose of this order is to protect the public and the environment from risk of radioactive contamination. The order establishes (1) a standard of high quality for DOE monitoring and surveillance programs, (2) authorized contamination limits for release of property, and (3) as-low-as-reasonably-achievable considerations. The order mandates that drinking water criteria be consistent with 40 Code of Federal Regulations 141, *National Interim Primary Drinking Water Regulations*. Derived concentration guides, or the concentration of radionuclides in water that under conditions of continuous exposure for one year by one exposure mode would result in an effective dose equivalent of 100 mrem, are established. The order limits storm water and sanitary sewer discharge of radioactive effluents to groundwater. Finally, the order states that long-term management of groundwater shall be in accordance with legally applicable federal and state standards.

DOE/PORTS is also well below all applicable media-specific dose limits, such as the USEPA limit of 10 mrem/year from airborne emissions and the DOE derived concentration guides for specific nuclides in wastewater and storm water discharges. DOE/PORTS conducts various modeling and dose assessment activities from samples and other information collected to address the potential for multiple-pathway exposures of the public. DOE/PORTS is in compliance with the requirements of this order.

## DOE Order 5820.2A, *Management of Low-Level Waste*

DOE Order 5820.2A establishes policies, guidelines, and minimum requirements for managing radioactive waste and contaminated facilities.

All radioactive wastes generated at DOE/PORTS are classified as low-level waste or mixed waste and are subject to DOE Order 5820.2A, Chapter III, "Management of Low-Level Waste." This order requires that all radioactive wastes be treated, stored, or disposed at DOE facilities. Facilities have been identified for this purpose (e.g., DOE's Hanford facility in Richland, Washington), and procedures and protocols have been established to provide proper access to these facilities.

Low-level waste is segregated into four primary waste types according to applicable treatment technology and/or regulatory requirements. These waste types are (1) burnables, (2) scrap metal, (3) other nonburnables, and (4) mixed (RCRA-low-level waste, polychlorinated biphenyl-low-level waste, and RCRA/

polychlorinated biphenyl-low-level waste). Storage requirements for each of these waste types are designed to eliminate the potential for environmental release. DOE/PORTS is in compliance with the requirements of this order.

The order also establishes that environmental monitoring associated with low-level and mixed radioactive waste management activities shall be conducted in accordance with DOE Order 5400.1 and may include groundwater monitoring. The monitoring program must be able to measure the following:

- operational effluent releases,
- migration of radionuclides,
- disposal unit subsidence or stability, and
- changes in disposal facility and disposal site parameters that may affect long-term site performance.

Moreover, the monitoring program is capable of detecting changing trends in time to apply appropriate corrective action measures. This order also establishes policies and guidelines for decontamination and decommissioning of DOE facilities. Programs must follow all applicable federal, state, and local requirements. Finally, this order requires that a waste management plan outline be prepared to address, among other items, the environmental monitoring programs at individual waste management facilities.

## Other Environmental Acts and Federal Regulations

### 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 with the U.S. Fish and Wildlife Service and the Ohio Department of Natural Resources are made. A sitewide threatened and endangered species habitat survey and an Indiana bat (*Myotis sodalis)* survey were completed in August 1996. Few potentially critical habitats were identified, and an annual report of the survey activities and results was provided to the Ohio Department of Natural Resources as required by the Federal Fish & Wildlife permit obtained to conduct the survey. No Indiana bats were found on the reservation.

### 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. Field work for Phase II of the project was completed in May 1997. Artifacts from the 1940s and 1950s were uncovered, as well as remains of former dwellings that were present prior to the gaseous diffusion plant construction. Results from the survey will be coordinated with the State of Ohio Historic Preservation Office, and a Cultural Resources Management Plan will be developed.

## Archaeological and Historic Preservation Act, and Archaeological Resources Protection Act

The Secretary of the Department of the Interior is required to report to Congress on various federal archaeological activities by the Archaeological and Historic Preservation Act and by the Archaeological Resources Protection Act, as amended. 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 for forwarding to the Department of Interior in 1997 to satisfy this requirement.

## 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.

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

Title 10 Code of Federal Regulations 1022 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 first require that a notice of involvement be published 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 beginning 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.

A 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 the Portsmouth Gaseous Diffusion Plant. Activities in jurisdictional wetlands require a Clean Water Act Section 404 permit to be obtained from the Corps of Engineers. In 1997, the Corps of Engineers authorized DOE/PORTS to conduct a radiological survey to determine the rate and extent of contamination, and if necessary, to conduct remedial action in a wetland area on site under Nationwide Permit No. 6, Survey Activities, and Nationwide Permit No. 38, Cleanup of Hazardous and Toxic Waste, respectively.

## Baseline Ecological Risk Assessment

In the summer and fall of 1993, DOE began preparing a baseline ecological risk assessment for DOE/PORTS. Included as part of the risk assessment were a wetland survey; a threatened and endangered species

habitat survey; a bat survey; fish community surveys; benthic macroinvertebrate community studies; water, sediment, and soil toxicity testing; and fish tissue analyses. The baseline ecological risk assessment was approved by the Ohio EPA in March 1997.

### Pollution Prevention and Waste Minimization

Pollution prevention activities are administered at DOE/PORTS through the Waste Minimization/ Pollution Prevention Awareness Program. The purpose of this program is to foster the philosophy that source reduction is preferred over reclamation, reuse, or recycling. Reclamation, reuse, or recycling is preferred over treatment, and treatment is preferred over disposal, which is the last resort in the pollution prevention hierarchy, as referenced in the Pollution Prevention Act of 1990. DOE/PORTS has implemented a *Waste Minimization/Pollution Prevention Awareness Program Plan* that outlines the site waste minimization and pollution prevention policy, roles and responsibilities, program goals, sitewide analysis, pollution prevention activities and resource requirements, and an updated status of the program.

As a voluntary participant at the industrial leadership level in the "Ohio Prevention First" program, DOE/PORTS provided the Annual Progress Report to the Office of Pollution Prevention at the Ohio EPA. The goal of the program, sponsored by the state of Ohio, is to incorporate pollution prevention into the decision-making process at every level throughout the organization. The pollution prevention program, required by DOE Order 5400.1, has been incorporated into the site Waste Minimization Program because both programs have compatible goals and program elements.

### Environmental Training

Environmental training is a continuous process at DOE/PORTS. During 1997, training was conducted in environmental compliance, hazardous waste operations and emergency response, and RCRA-generator training. Hazardous waste operations and emergency response training is conducted at three levels, including a 24-hour course, a 40-hour course, and an 8-hour refresher course. The training program satisfies occupational safety and health requirements specified in 29 Code of Federal Regulations 1910.120, *Hazardous Waste Operations and Emergency Response*; as well as RCRA requirements specified in 40 Code of Federal Regulations 265.16, Section H of the RCRA Part B permit, and Ohio Administrative Code 3745-54-16(D), all entitled "Personnel Training."

## Environmental Permits

DOE/PORTS activities require many environmental permits in order to operate in compliance. A complete list of active permits for 1997 can be found in Appendix B. Information pertaining to specific permits may be found in their respective sections in this chapter (e.g. RCRA, Clean Air Act, etc.).

## Notices of Violation

One Notice of Violation was issued to DOE/PORTS during 1997. On May 27, 1997, the Ohio EPA conducted a RCRA inspection and issued a Notice of Violation as a result of the following:

- weekly inspections of the X-326 and X-7725 facilities were not adequately recorded, and repairs were not made in a timely manner;

- quarterly noncompliance reports did not identify these violations; and
- permit change requests did not contain certification statements.

Corrective actions were implemented, and the Ohio EPA determined the Notice of Violation was resolved on September 10, 1997.

On August 18, 1997, DOE/PORTS signed the Director's Findings and Orders to address the outstanding violations for the storage of lithium hydroxide monohydrate and depleted uranium hexafluoride ($UF_6$). In addition, previous violations regarding the X-700 tanks 6, 7 and 8 and the X-740 and X-750 tanks were resolved through risk based closures and through a judicial consent order with the state of Ohio issued on July 24, 1996. Upon approval, the judicial consent order will release DOE/PORTS from liability of known past RCRA violations.

## Occurrences Reported to Regulatory Agencies

Because the potential exists to generate reportable quantity releases from PORTS operations, DOE/PORTS is required to evaluate spills and unanticipated releases to determine whether such incidents are reportable as prescribed in 40 Code of Federal Regulations 117.2, *Notice of Discharge of a Reportable Quantity*; 40 Code of Federal Regulations 302.6, *Notification Requirements*; 40 Code of Federal Regulations 355.40, *Emergency Release Notification*; 40 Code of Federal Regulations 761.125, *Requirements for PCB* (polychlorinated biphenyl) *Spill Cleanup*; the Emergency Planning and Community Right-to-Know Act; the Comprehensive Environmental Response, Compensation, and Liability Act; or Ohio NPDES permit conditions.

In 1997, DOE/PORTS reported two occurrences to regulatory agencies. An exceedence of the 10 µg/L limit for trichloroethene established by the NPDES permit occurred at the X-623 groundwater treatment facility (outfall 610), with a concentration of 54 µg/L. The exceedence is believed to have been caused by the X-701B surfactant technology demonstration. The presence of foam in the system may have caused the air stripper and carbon vessels to perform less efficiently. An anti-foaming agent was added to the system to prevent the foam from affecting the performance of the air stripper and carbon vessels.

On April 29, 1997, seeps were discovered along the north side of the Peter Kiewit landfill. Construction of a RCRA Subtitle D cap over the landfill began shortly after the seeps were discovered, as part of the corrective measures implementation process. The work plan and pre-final design were approved by the Ohio EPA.

Both of these occurrences were adequately addressed and caused no harm to human health or the environment.

## Environmental Program Audits

During 1997, 18 audits, appraisals, or inspections of the DOE/PORTS programs were conducted. The audits, appraisals, and inspections are listed in Table 2.2 and are summarized as follows:

On January 2, 1997, the Ohio EPA conducted a closure inspection of the X-344A settling tank, and closure certification was granted on January 27, 1997.

The Pike County Health Department conducted inspections of the X-749 and X-749A landfills on January 23, May 13, and September 23, 1997. No discrepancies were noted during the inspections. The quarterly inspections of the X-735 industrial solid waste landfill were conducted by the Pike County Health Department on January 23, May 13, September 23, and December 19, 1997. No problems were noted.

**Table 2.2. Environmental audits and inspections at DOE/PORTS for 1997.**

| Date | Auditor | Type |
|---|---|---|
| January 2 | Ohio EPA | X-344A settling tank closure inspection |
| January 23 | Pike County Health Dept. | X-749 inspection |
| January 23 | Pike County Health Dept. | X-749A inspection |
| January 23 | Pike County Health Dept. | Quarterly X-735 industrial solid waste landfill inspection |
| Feb. 27-Mar. 6 | Ohio EPA | Toxic Substances Control Act/Polychlorinated biphenyls program audit |
| March 17 | Ohio EPA Division of Surface Water | DOE/PORTS NPDES permitted outfalls inspection |
| March 18 | Ohio EPA Division of Solid Waste | X-735 industrial solid waste landfill solid waste audit |
| May 13 | Pike County Health Dept./Ohio EPA | Quarterly X-735 industrial solid waste landfill inspection |
| May 13 | Pike County Health Dept./Ohio EPA | X-749 inspection |
| May 13 | Pike County Health Dept./Ohio EPA | X-749A inspection |
| May 27 | Ohio EPA | Annual RCRA compliance inspection |
| June 2 | Ohio EPA | Final X-611A lime sludge lagoons inspection |
| June 9 | USEPA | Final X-611A lime sludge lagoons inspection |
| September 19 | Ohio EPA | Annual air compliance inspection |
| September 23 | Pike County Health Dept. | Quarterly X-735 industrial solid waste landfill inspection |
| September 23 | Pike County Health Dept. | X-749 inspection |
| September 23 | Pike County Health Dept. | X-749A inspection |
| September 25 | Federal Energy Regulatory Commission | Annual impoundment inspection |
| December 19 | Pike County Health Dept. | Quarterly X-735 industrial solid waste landfill inspection |

The Ohio EPA, under contract to the USEPA, conducted a Toxic Substances Control Act audit from February 27 through March 6, 1997. The inspector noted that DOE/PORTS has a well-managed polychlorinated biphenyl program. The polychlorinated biphenyl troughing systems, polychlorinated biphenyl spill sites, and Toxic Substances Control Act storage areas were all inspected, and no deficiencies were identified. Only one field citation was issued to DOE/PORTS for missed transformer inspections of the X-770 in the fourth quarter of 1993 and the first quarter of 1994.

No problems were identified by the Ohio EPA Division of Surface Water during the March 17, 1997, inspection of all DOE/PORTS NPDES permitted outfalls. Ohio EPA noted that DOE/PORTS was substantially in compliance with the terms and conditions of the permit at the time of the inspection.

On March 18, 1997, the Ohio EPA Division of Solid Waste observed groundwater sampling as part of a solid waste audit at the X-735 industrial solid waste landfill and identified no problems.

The Ohio EPA conducted a RCRA inspection at DOE/PORTS on May 27, 1997, which resulted in one Notice of Violation. The Notice of Violation was issued for the following reasons: weekly inspections of the X-326 and X-7725 facilities were not adequately recorded, and repairs were not made in a timely manner; quarterly noncompliance reports did not identify the aforementioned violations; and permit change requests did not contain certification statements.

Final inspections of the X-611A lime sludge lagoons by the Ohio EPA and USEPA were completed on June 2 and 9, 1997, respectively.

The Ohio EPA conducted the annual air compliance inspection on September 19, 1997. There were no findings as a result of the inspection.

On September 25, 1997, the Federal Energy Regulatory Commission conducted its annual dam stability inspection at DOE/PORTS. The purpose of the Federal Energy Regulatory Commission inspection is to determine the potential for failure of impoundments. The X-611A former lime sludge lagoons and the X-735B borrow area were inspected, and no noncompliance items were noted.

## Regulatory Visits

On May 20, 1997, the Ohio EPA visited DOE/PORTS to observe the newly discovered seeps near the Peter Kiewit landfill. Representatives from the Ohio EPA walked along the tributary into which the seeps are discharging to assist in evaluating DOE's proposed remedy and to determine any impact on the Peter Kiewit landfill remediation project. Additional samples were taken, and additional modeling was completed in response to a request by the Ohio EPA. Ohio EPA comments were incorporated into the design and construction of the Peter Kiewit corrective measures implementation.

On July 30, 1997, the Ohio EPA was onsite to collect groundwater samples for the Berea Metals Study. Samples were split at the time of collection with DOE/PORTS. Results of the Ohio EPA analysis of the collected samples were incorporated into the final report for the Berea Metals Study.

The Ohio EPA visited PORTS on August 4 and 5, 1997, and again from September 10 through 12, 1997, to conduct a fish study. The August study was conducted along four different sections of Little Beaver Creek, and the September study was done along various sections of Little Beaver and Big Beaver creeks. The fish were collected with nets, counted by species, and examined for deformities and parasites. Sampling conducted five years ago in Little Beaver Creek resulted in an exceptional rating, and an Ohio EPA representative indicated that this had not changed. The Ohio EPA is also studying the macroinvertebrate communities in these streams to assess stream quality. Results of the study are available from the Ohio EPA.

The Ohio EPA visited the site to observe the east drainage ditch remediation project, the Peter Kiewit landfill cap construction project, the Big Run Creek Tributary seep interim action, and the X-740 natural attenuation project on September 18, 1997. On October 14, 1997, representatives from the Ohio EPA, Southeast District Office were onsite to discuss the placement of groundwater wells for the Peter Kiewit landfill and the Big Run Creek tributary seep interim action areas. The Ohio EPA agreed to the proposed locations, as well as the proposed monitoring schedule.

On October 28, 1997, the Ohio EPA visited DOE/PORTS to collect sediment samples at Little Beaver Creek and Big Beaver Creek to determine the extent of hazardous chemical and/or radiological constituents in the creeks. The samples will identify any relevant significance of PORTS site contaminants on any demonstrated impairment of the biological communities. DOE/PORTS split samples with the Ohio EPA up to the confluence of Little Beaver and Big Beaver creeks. Results of the study are available from the Ohio EPA.

On December 2, 1997, two representatives from the Southeast District Office of the Ohio EPA visited the site for an informational tour of the groundwater treatment facilities and the associated NPDES outfalls. During the visit, the Ohio EPA scheduled the annual inspection of NPDES outfalls for March 1998.

# 3. Environmental Programs

***Abstract***

Environmental programs at the U.S. Department of Energy/Portsmouth Gaseous Diffusion Plant (DOE/PORTS) include environmental restoration, waste management, waste minimization and pollution prevention, training, information exchanges, and public and employee awareness.

## ENVIRONMENTAL RESTORATION PROGRAM

DOE established the Environmental Restoration Program to identify and correct site contamination areas as quickly and cost-effectively as possible. The Environmental Restoration Program addresses inactive sites through remedial action and active facilities with eventual decontamination and decommissioning. Options for correcting or mitigating the contaminated sites and facilities include removal, containment, and treatment of contaminants.

The Environmental Restoration program is the subject of two enforcement actions. The state of Ohio issued a Consent Decree on August 29, 1989, in accordance with RCRA of 1976 and its implementing regulations; Comprehensive Environmental Response, Compensation, and Liability Act of 1980; the National Contingency Plan; and applicable USEPA policy. USEPA Region V issued an Administrative Consent Order on September 29, 1989, under the authority of Section 3008(h) of RCRA of 1976. The Ohio Consent Decree requires a cleanup alternatives study, and the USEPA Administrative Consent Order requires a corrective measures study. The Ohio EPA and USEPA have agreed to a single document, the cleanup alternatives study/ corrective measures study report, to fulfill the requirements for these essentially equivalent documents. The Ohio EPA was granted day-to-day oversight of the remediation activities through an amendment to the Administrative Consent Order executed on August 11, 1997.

As required by these agreements, 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.
- ***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.

The DOE/PORTS Environmental Restoration Program was developed in 1989 and was granted an initial budget of $13.8 million. In fiscal year 1994, Environmental Restoration Program expenditures peaked at $75.9 million. The 1997 budget was $22 million. RCRA facility investigations have been approved for all quadrants, and cleanup alternatives study/corrective measures study reports are being developed in coordination with the agencies. To prevent potential threats to human health and the environment, six interim remedial measures have been implemented.

## Cleanup Alternatives Study/Corrective Measures Study Reports

As required by the Consent Decree and the Administrative Consent Order, the cleanup alternatives study/corrective measures study reports explore the remedial alternatives and identify the solid waste management units within Quadrant I, Quadrant II, Quadrant III, and Quadrant IV. Following the approval of the final cleanup alternatives study/corrective measures study reports, the Ohio EPA selects the remedial alternatives presented in the respective cleanup alternatives study/corrective measures study reports. Upon concurrence from the USEPA and completion of the public review and comment period, the USEPA and Ohio EPA select the final remedial actions for each of the respective areas. A Decision Document is issued by the USEPA notifying 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. Development of the cleanup alternatives study/corrective measures study documents was in progress in 1997.

Corrective measures implementation plans for the Peter Kiewit landfill and the X-611A lime sludge lagoons have been approved and are discussed below.

## Corrective Measures Implementations

### Peter Kiewit Landfill

The Peter Kiewit landfill is located west of Big Run Creek just south of the X-230K holding pond. The landfill, opened in 1952, was used as the salvage yard, burn pit, and trash area during construction of the plant. After the initial construction, the disposal site was operated as a sanitary landfill until 1968, when soil was distributed over the site and graded, and the area was seeded with native grasses. No manifests or records exist to characterize the material in the landfill. In addition, construction details and operation records are not available.

In 1994, the portion of Big Run Creek contiguous to the Peter Kiewit landfill was relocated to the east side of the creek valley. An interceptor trench was installed in the former Big Run Creek channel to capture seeps emanating from the landfill. Contaminated water from the interceptor trench is processed at the X-622 groundwater treatment facility.

Two wells (Gallia well PK-12G and Berea well PK-13B) were installed in 1995 north of the seep zone to monitor the groundwater. Semiannual sampling results indicated that vinyl chloride (a volatile organic compound) was detected once in only one well (Berea) at a concentration of 4 ppb. The total uranium concentration ranged from 15 to 40 ppb (Berea), and no technetium was detected.

In 1995, the USEPA approved the cleanup alternatives study/corrective measures study report for the construction of a RCRA Subtitle D cap on the Peter Kiewit landfill, and pre-design studies began in 1996. The corrective measures implementation work plan and pre-final design were submitted to the Ohio EPA, and construction of the cap began in mid-1997. The current schedule projects that construction will be complete by mid-September, 1998.

### X-611A Lime Sludge Lagoons

The X-611A lime sludge lagoons, located in the eastern portion of Quadrant IV along the west side of Little Beaver Creek, consisted of three adjacent, unlined lagoons with a total capacity of approximately 295,000 cubic yds. The lagoons received waste lime sludge from 1954 to 1960.

As a result of the Phase I and Phase II Quadrant IV RCRA facility investigation in 1992 and 1994, respectively, the X-611A lime sludge lagoons unit was identified as a candidate for a corrective measure. Construction of a pre-engineered prairie habitat has been recently completed through the corrective measures implementation process.

Approval of the final operations and maintenance plan was received from the USEPA and Ohio EPA on September 19 and 22, 1997, respectively. The plan requires a groundwater monitoring program, and six groundwater wells are being sampled semiannually.

## Interim Remedial Measures

### X-749/X-120 Collection Trench

An interim remedial measure was initiated on July 20, 1997, to contain seeps discovered south of the Peter Kiewit landfill. Soil and bedrock characterization was completed on August 10, 1997, and installation of a collection trench overlapping the existing system at the Peter Kiewit landfill was completed in October 1997. The groundwater collected in the trench is being treated at the X-622 groundwater treatment facility. Due to the physical location of the trench in relation to the Peter Kiewit landfill, the groundwater monitoring wells have been strategically placed in coordination with both the Peter Kiewit landfill and the X-749/X-120 interim remedial measure.

### X-705A/B Soil Removal

In 1996, contaminated soil at the X-705A/B incinerator was excavated and containerized. Split sampling was conducted with the Ohio EPA on January 8, 1997, and the results were submitted on April 7, 1997. Upon review of the results, the USEPA and Ohio EPA approved the completion of the action, which included grading the site for proper drainage and covering it with a layer of geotextile fabric. Clean soil was brought in and seeded to prevent erosion. DOE/PORTS received notification from the USEPA on August 25, 1997, and the Ohio EPA on October 23, 1997, that the interim remedial measure was complete.

## Additional Cleanup Alternatives Study/Corrective Measures Study Activities

### Sitewide Surface Drainage Ditches

In 1997, a radiological contamination survey for the sitewide drainage ditches was initiated. The areas being investigated include the east drainage ditch, Big Run Creek, the southwest drainage ditch, the north drainage ditch, and the northeast drainage ditch.

Sampling at the east drainage ditch began on July 8, 1997, and was completed on July 26, 1997, and the *Rate and Extent of Radiological Contamination Report* and the *Source Report* are currently under review. Sampling of Big Run Creek and the southwest drainage ditch began on August 23, 1997, and was completed on September 29, 1997, and the *Data Assessment and Risk Evaluation Report* was submitted to the Ohio EPA for review on December 19, 1997. Sampling at the north drainage ditch was initiated on September 12, 1997, with field work beginning on December 1, 1997. The northeast drainage ditch is scheduled to be evaluated in 1998.

### Natural Attenuation

Soil and groundwater sampling and analysis are currently being conducted at DOE/PORTS to evaluate the extent at which natural attenuation is occurring at the various groundwater investigative areas. Natural attenuation is the intrinsic capacity of aquifers to clean themselves without proactive remedial measures. This effort is part of the cleanup alternatives study/corrective measures study process. Groundwater samples were collected at the Quadrant I investigative area in October 1997, and sampling is planned the Quadrant II investigative area. The results will be evaluated, and a determination will be made regarding the presence of natural attenuation.

## 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 uses a team of DOE contractors, national laboratory scientists, university researchers, private industries, site engineers, and technical staff.

### X-231B Technology Demonstration Field Tests

Four *in situ* (or "in place" in the soil) treatment technologies were successfully demonstrated in May 1992 at the X-231B oil biodegradation plot. These treatments offer an effective alternative of cleaning up sites without requiring extensive excavation of soils for storage, treatment, or disposal at an off-site landfill. The field demonstrations have also provided invaluable information that is being used for treating certain contaminants, primarily volatile organic compounds, in wet, clay soils at DOE/PORTS and other facilities throughout the country with similar soil conditions.

The four processes demonstrated involved subsurface clay soil mixing combined with the following:

- ***solidification/stabilization***—a grout mixture is injected under pressure into the soil to solidify and immobilize the contaminated soil into a concrete-like form;
- ***isothermal vapor extraction***—contaminated soil is mixed with ambient, or normal, air to vaporize the volatile organic compounds. The vapors are collected in a shroud covering the treatment area and are run through a mobile treatment unit containing a carbon filter and a high-efficiency particulate air filter to remove contaminants;
- ***thermally enhanced vapor extraction***—soil is mixed in the same manner as the isothermal process, but using hot air or steam injection instead of normal air; and
- ***peroxidation destruction***—volatile organic compounds are destroyed by chemical reaction when diluted hydrogen peroxide solution is applied as a mist through an ambient air stream.

Preliminary calculations showed *in situ* soil mixing with thermally enhanced vapor extraction and isothermal vapor extraction exhibited more than 90% volatile organic compound removal during a four-hour experimental treatment. DOE recommended using thermal vapor extraction enhanced by peroxidation de-

struction at the X-231B oil biodegradation plot. It was projected that the treatment could be optimized by varying air temperature, air flow, soil mixing, and peroxide concentrations. It was also estimated that both removal efficiency and performance criteria could be achieved at the site within a 300-day closure schedule using this method.

## X-701B *In Situ* Chemical Oxidation

*In situ* chemical oxidation is an emerging technique for the remediation of dense nonaqueous phase liquids, such as trichloroethene. With this technique, chemical oxidants are delivered to the subsurface to rapidly degrade organic contaminants. Laboratory experiments have demonstrated that potassium permanganate and hydrogen peroxide can effectively oxidize trichloroethene. Between the two oxidants, potassium permanganate is more stable and may result in a higher rate of trichloroethene degradation.

In 1996, researchers at the Oak Ridge National Laboratory in Oak Ridge, Tennessee, proposed an oxidant delivery technique involving injection and recirculation of the oxidant solution into a contaminated aquifer through multiple horizontal and vertical wells. In Spring 1997, DOE/PORTS agreed to conduct a treatability study using *in situ* chemical oxidation through recirculation at the X-701B holding pond site.

The purpose of the demonstration was to assess the feasibility of recirculating strong oxidants to destroy volatile organic compound contaminants *in situ* at PORTS. The goals of the *in situ* chemical oxidation through recirculation were to:

- evaluate the process for delivering oxidants to saturated, permeable subsurface materials;
- assess the performance of the system in degrading dense nonaqueous phase liquids within an aquifer; and
- obtain cost information for future applications at PORTS and other sites.

The *in situ* chemical oxidation through recirculation field demonstration took advantage of the existing infrastructure and extensive site characterization data generated from previous field demonstrations at X-701B. The *in situ* chemical oxidation through recirculation field test was implemented using a pair of previously installed horizontal wells that transect an area of dense nonaqueous phase liquid contamination. In the *in situ* chemical oxidation through recirculation demonstration, groundwater was extracted from one horizontal well, pumped to an existing groundwater treatment facility, dosed with potassium permanganate, and reinjected into a parallel horizontal well approximately 90 ft away.

Prior to the demonstration, soil borings and groundwater samples from the treatment zone between the horizontal wells were analyzed to establish preexisting conditions. The field demonstration lasted about one month. The effectiveness of recirculating an oxidant into the subsurface was determined by comparing pre-, during, and post-test groundwater samples and pre- and post-test soil samples.

The results indicate that *in situ* chemical oxidation through recirculation effectively oxidized trichloroethene in the saturated zone. Where the oxidant was found, trichloroethene levels were not detectable. Additional future sampling and modeling will be required to more fully assess the long-term impact of this demonstration.

## X-701B Surfactant Studies

The contamination of alluvial aquifers by dense nonaqueous phase liquids, such as trichloroethene and other toxic chlorinated hydrocarbons, has caused well closure throughout the United States. Surfactant-enhanced aquifer remediation has been acknowledged to be a promising, innovative technology for the removal of dense nonaqueous phase liquids. A field test of surfactant-enhanced aquifer remediation was

conducted at DOE/PORTS. However, an inadequate knowledge of the dense nonaqueous phase liquid zone and its hydrogeological conditions played a negative role in the solubilization test. The team characterized the dense nonaqueous phase liquid zone in the alluvium by using an innovative tracer test, which measured the volume and spatial distribution of dense nonaqueous phase liquid in the aquifers before and after the solubilization tests. The successful demonstration of the dense nonaqueous phase liquid-detection tests allowed the team to assess the performance of the solubilization test by direct measurement of the average residual dense nonaqueous phase liquid saturation both before and after the solubilization test.

The solubilization test at DOE/PORTS was conducted in the Gallia alluvium beneath the X-701B holding pond. The main objective of this study was to demonstrate that multicomponent dense nonaqueous phase liquids (consisting of trichloroethene, polychlorinated biphenyls, and other chlorinated solvents) can be readily solubilized and removed from sand and gravel aquifers by dilute surfactant solutions. The field work at DOE/PORTS was conducted between December 1995 and September 1996.

The benefits of surfactant-enhanced aquifer remediation arise from the high effective solubilities that can be obtained by using dilute surfactant solutions to solubilize dense nonaqueous phase liquid. Because of this enhanced solubilization, it is possible to accelerate the rate of dense nonaqueous phase liquid removal from the subsurface, which in turn reduces overall operations and maintenance costs for any particular pump-and-treatment facility. The technology can also be superimposed on an existing pump-and-treatment system so that the infrastructure at the site can be used more efficiently.

The continuing costs of pump-and-treatment operations (approximately $500,000/year per site and $30,000/gal of dense nonaqueous phase liquid recovered) and risk based cleanup goals are making dense nonaqueous phase liquid removal more attractive. The results of the surfactant-enhanced aquifer remediation studies indicate how dense nonaqueous phase liquid sites might be characterized and remediated in the 21st century.

## X-623 Inorganic Photocatalytic Membrane Treatability Study

A small-scale demonstration of a new photocatalytic membrane reactor was conducted at the X-623 groundwater treatment facility at DOE/PORTS. The X-623 facility is one of five groundwater pump-and-treatment facilities in operation at the plant. Together these five facilities treat approximately 23 million gal of water per year at an annual cost of $3 million. This demonstration was motivated by the need to find a more efficient, cost-effective treatment method for these aquifers.

The purpose of the demonstration was to develop a photocatalytic membrane to decompose volatile organic compounds in groundwater. Currently, groundwater containing volatile organic compounds is pumped from two pumping wells and a holding pond into an air sparger which removes a large portion of the volatile organic compounds. This water is pumped through an activated carbon bed to absorb the remaining volatile organic compounds. The carbon must be replaced or regenerated periodically, and the used absorbent must be handled as RCRA waste. The carbon bed in a pump-and-treatment facility can be replaced with a photocatalytic reactor, which has a long lifetime and has the potential to produce significantly less waste. Photocatalysis is a process whereby a semiconductor is activated by the absorption of light to decompose organic compounds.

A new reactor, being patented by DOE, combines advanced membrane technology and fiber optic light delivery and couples a mercury arc lamp with an optical fiber to carry the light to the photocatalytic reactor. The polished end of the fiber acts as a mini flashlight to illuminate the interior of the photocatalytic membrane. Water containing contaminants is forced through the porous membrane by pressure. The large number of small pores in the membrane increase the probability of a contaminant molecule contacting the catalyst.

When the field demonstration was scheduled to begin, the groundwater at the X-623 site had high levels of acetone due to an earlier treatment demonstration. It was hoped that the level of acetone would decrease if the project were delayed, but after several weeks the levels had not decreased significantly. To avoid further delays, it was decided to conduct the demonstration at X-623 but using water from the X-625 groundwater treatment facility.

The photocatalytic membrane reactor initially removed 60% to 65% of the trichloroethene in a single pass. With all of the unforeseen problems that were encountered, the system proved to be effective in destroying organic contaminants. This demonstration indicates that improved methods of light delivery to modules should be researched and methods to reduce membrane fouling must be improved. The knowledge obtained in this demonstration with real contaminated groundwater will improve the chances of success of a future demonstration.

## X-231A Soil Fracturing Demonstrations

In September 1997, field activities were completed on a technology demonstration at the X-231A oil biodegradation plot, where assessment and remediation of volatile organic compound compounds in low-permeability media are required as part of the RCRA cleanup alternatives study/corrective measures study program. This demonstration focused on soil fracturing to increase mass recovery of contaminants by soil vapor extraction and on placement of reactive horizontal barriers for *in situ* destruction of contaminants.

The active demonstration phase at X-231A began in August 1996 when four primary test cells (A through D) were established with hydraulic fractures. Each cell encompassed a subsurface region of approximately 30 ft in diameter and up to 18 ft below ground surface, and each was comprised of a set of stacked horizontal fractures. Test cell A consisted of sand propped fractures for injection of steam from an in-well steam generator and vapor extraction via overlying and underlying fractures. Test cell B consisted of sand propped fractures for injection of hot air from an in-well hot air generator with vapor extraction via overlying and underlying fractures. Test cell C contained iron-metal propped fractures to create a set of permeable barriers for interception and *in situ* destruction by reductive dechlorination. Test cell D was comprised of fractures that were placed and propped with a new permanganate particle grout. These stacked horizontal fractures were used to create a set of permeable reactive barriers for interception and *in situ* destruction by oxidation of organic compounds.

Active operation of test cells A and B began on October 19, 1996. To establish baseline ambient air flushing characteristics, the initial operation was ambient air injected into a sand propped fracture at 8 ft below ground surface with active vapor extraction occurring at the 4-foot and 12-foot below ground surface sand propped fractures.

The X-231A field activities were completed in September 1997. Final analysis, interpretation and reporting on the methods and results of the demonstration are planned for the first half of fiscal year 1998. The hot air flushing and permanganate grout barriers appear most promising for further demonstration and implementation.

Several issues will need to be addressed prior to further application of these processes. First, long-term performance has not been verified. Second, significant mechanical problems were experienced with the *in situ* steam generator.

## X-625 Passive Groundwater Treatment Through Reactive Media

A testing and research facility was constructed at DOE/PORTS to evaluate reactive barrier technology for remediating groundwater contaminated with trichloroethene under realistic field conditions.

The facility consists of three parallel treatment trains that can accommodate canisters filled with reactive materials. Water is supplied to the facility from a horizontal well that collects trichloroethene-contaminated groundwater from the Gallia formation underlying the X-749/X-120 solid waste management unit.

Construction of the facility was completed on February 29, 1996, and a treatability study began on March 3, 1996. The treatability study consisted of a five-month evaluation of three reactive media materials: (1) fine-grade iron filings, (2) stock iron filings, and (3) palladized iron filings. In general, trichloroethene was degraded from about 50 to 150 ppb to less than 5 ppb; however, all three materials exhibited decreasing hydraulic conductivity and eventual clogging. Clogging in the treatment canisters caused by chemical precipitation and filtration of suspended solids led to reduced permeability. Based on the available information, the operational life of the reactive media is limited by the plugging in the canisters. Of the three, the stock iron filings remained hydraulically conductive for the longest time due to its coarser grain size. The estimated life of a reactive barrier using stock iron filings, based on a flow rate of one ft per day, is 10 years.

Additional efforts began in July 1997 to evaluate the applicability of reactive barriers at DOE/PORTS. Objectives of these efforts were to: (1) predict the hydraulic life of reactive barriers made from the materials tested in 1996, (2) better understand what caused the clogging in the canisters installed in March 1996, and (3) evaluate other reactive materials that may be used to remove trichloroethene from groundwater at the site.

Cercona iron foam pellets were installed at the X-625 facility in July 1997. This material was chosen because of its coarse mesh size (to reduce clogging) and potentially high reactivity (to compensate for the lower surface area of the coarser material). All materials tested in 1996 relied on reductive dechlorination to destroy trichloroethene in groundwater. An alternative involves oxidative degradation using permanganate. Laboratory experiments were conducted to examine the effectiveness of low levels of permanganate for oxidizing trichloroethene. These were followed by the installation of slow release permanganate diffusers in one of the treatment trains in September 1997.

About two months after the iron materials were installed in July 1997, it was noted that trichloroethene appeared to degrade more rapidly in the cercona iron foam pellets train, and aside from fluctuations in flow rates due to gas generation, clogging was not observed in either of the treatment trains. The use of a permanganate oxidation system was preliminarily evaluated. The results of the tests were inconclusive because the feed apparatus provided too low a release rate, and the dose of permanganate was insufficient for effective oxidation. Additional monitoring will be necessary to evaluate long-term performance, and additional media also need to be evaluated. The applicability of using reactive media is very site specific.

## *In Situ* Radiological Decontamination Demonstration in X-326

The long-term low-temperature process is a gas-phase *in situ* decontamination technique that was tested by Energy Systems in Oak Ridge, Tennessee, on the laboratory scale with promising results. The purpose of the gas-phase radiological decontamination demonstration at the Portsmouth site was to evaluate the long-term low-temperature process on an actual diffusion cascade cell in conditions similar to those used in the laboratory testing. The demonstration was conducted on a diffusion cell in the X-326 building. This was one of the cells that was permanently shut down as part of the suspension of highly enriched uranium at DOE/PORTS.

The full-scale demonstration consisted of rendering the cell leak-tight, exposing the cell to oxidants, and evaluating the effect of the cleanup treatment on cell samples. Nondestructive assay measurements were obtained before, during and after exposure to cleanup gases. Radiochemistry analyses were used to determine the pre- and post-exposure levels of uranium isotopes and other nuclides present. Based on nondestructive

assay measurements, 48% of the uranium material originally contained in the cell was removed. Based on gas sample analysis, 11.8 lbs of uranium hexafluoride ($UF_6$) were removed from the cell.

An economic evaluation of a full-scale decontamination and decommissioning program comparing long-term low-temperature decontamination to existing wet decontamination technology indicated that approximately $210 million could be saved over the complex using long-term low-temperature *in situ* technology. The evaluation also indicated that a decontamination and decommissioning program using long-term low-temperature technology could be completed in a reasonable amount of time (two to four years) with minimal initial capital expenditure.

## TechXtract™ Surface Decontamination Process

A test of a surface decontamination technique (the EET, Inc., TechXtract™ process) was conducted at the X-705A facility in December 1994 in support of the X-705A/B decontamination and decommissioning project. The purpose of the test was to assess the capability of the process to decontaminate surfaces of the X-705A building components and associated equipment to below release limits for alpha, beta, and gamma radiation. The test was performed on a variety of sample surfaces, including brick, concrete, cinder block, transite, and steel.

The X-705A building, which was located in the west central area of the plant site prior to its ultimate decontamination and decommissioning in 1997, housed an incinerator that was used to burn solids that were known or suspected to have been in contact with radioactive materials. These burnable solids included paper, cardboard, sweepings, plastic shoe covers, wood and assorted rags. The incinerator was shut down in 1986.

During the test, each building sample surface was surveyed for alpha and beta/gamma radioactivity. Only the highest reading in each subsection was noted. As many as three solutions (the chemicals in each solution were proprietary) were sprayed onto each surface and were allowed to dwell as determined, until each surface was rinsed with water. The rinse water was collected with a wet/dry vacuum for containerization as waste. Testing ceased on a given surface when radioactivity levels consistently below release limits were achieved.

This process appeared to be effective in removing radioactive contaminants from the surfaces tested. Painted areas may pose a problem, and removal of the paint before decontamination either by abrasion or stripping may generate a RCRA-regulated waste that would require treatment and disposal.

The testing at the X-705A facility was focused on the reduction or elimination of surface contamination to obtain free release of materials during decontamination of the building. No comments can be made as to the feasibility of the process in reducing overall radioactivity in a complex, massive media. Areas of a structure that may contain massive amounts of radioactive contamination that may have been deeply absorbed through normal operations may not be effectively or economically treated using this approach. The TechXtract™ process has also been applied for removal of metals, polychlorinated biphenyls and other hazardous constituents from surfaces similar to the ones tested at X-705A.

## Accelerated Technology Deployment Proposal with Fernald

In March 1997, DOE's Office of Science and Technology requested DOE field office proposals for multiple deployment of technologies and processes for DOE cleanup (environmental restoration, decontamination and decommissioning, waste management, etc.). There was no set period of performance for funded projects.

The mission is to deploy technologies and processes that reduce the DOE Environmental Restoration mortgage and accelerate site cleanup. Deployment is defined as implementation of a technology or process

through multiple sites or applications. Broad-scale deployment of technologies or processes has the potential to significantly reduce costs and accelerate cleanup schedules.

In fiscal year 1997, DOE/PORTS collaborated with the Fernald Environmental Management Project, Terra-Kleen, Envirocare in Utah, Argonne National Laboratory-East, and Battelle in Columbus, Ohio, to submit a proposal entitled *Terra-Kleen Solvent Extraction Technology for the Treatment of PCB* (polychlorinated biphenyl)-*Contaminated Low-Level Mixed Waste.* These tri-mixed wastes (low-level radioactive waste containing RCRA-designated hazardous constituents and polychlorinated biphenyl wastes) have long been a challenge for DOE. The K-25 Toxic Substances Control Act incinerator in Oak Ridge, Tennessee, is used for treatment of liquid Toxic Substances Control Act waste; however, solid and semisolid wastes are not accepted. Although the Hanford site in Washington had been considered a potential option for polychlorinated biphenyl waste disposal, no polychlorinated biphenyl wastes can be sent to that site. Innovative, readily available, proven treatment technologies were needed to address this situation and move the DOE sites closer to meeting final remediation goals.

The Fernald Environmental Management Project has experience with such previously demonstrated technologies and processes. The Fernald Environmental Management Project has initiated a technology, Mobile Solvent Extraction, that has proven effective in treating these waste streams. In 1993, the Fernald Environmental Management Project became the first DOE site to initiate a contract with Envirocare for disposal of waste streams from the Fernald site. Through a complex-wide contract with DOE, the Terra-Kleen Solvent Extraction Project at Envirocare can be deployed for treatment of polychlorinated biphenyl and tri-mixed wastes at the Envirocare facility.

Implementation of this method consists of the completion of the current contract at the Fernald Environmental Management Project with Terra-Kleen for the treatment of polychlorinated biphenyl and RCRA-designated organic contaminated low-level waste. This implementation is scheduled for completion in July 1998. Remediation consists of the treatment of low-level mixed waste by a nonthermal solvent extraction process to remove polychlorinated biphenyls and RCRA-designated organic contaminants to meet Toxic Substances Control Act permit requirements and RCRA land disposal restrictions.

The Terra-Kleen equipment will be decontaminated and mobilized from the Fernald Environmental Management Project facility to the Envirocare facility. The Terra-Kleen equipment will be installed in a permanent structure at Envirocare, and a complex-wide DOE contract will be established.

The DOE complex is poised for utilization of this technology. Because there will be significant cost savings and start-up has already been accomplished, this technology can be deployed rapidly. The proposed project reduces the DOE environmental restoration mortgage costs at each of the partner sites and accelerates site cleanups by up to four years. It is expected to save approximately $8 million for DOE/PORTS.

## 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. The primary objective is to ensure that waste materials do not migrate into the environment. Waste managed under the program is divided into the following six categories, which are defined below:

- ***Low-level radioactive waste***—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 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.

**Table 3.1. Waste management treatment, dispoal, and recycling accomplishments for 1997.**

| Waste Stream | Quantity | Treated, Disposed or Recycled | Treatment, Disposal, or Recycling Facility |
|---|---|---|---|
| Lead-acid battery recycling | 249,970 lbs | Recycled | Exide |
| X-701B soils | 40 B-25 boxes/324,197 lbs | Disposed | Envirocare |
| X-623 soils | 2,022 drums/1.23 million lbs | Disposed | X-735 landfill |
| X-6619 sludge (supplemental environmental project) | 108 B-25 boxes/621,606 lbs | Disposed | Envirocare |
| X-705 microfiltration sludge | 443 drums/138,675 lbs | Disposed | Envirocare |
| Sodium metal and oil | 3 drums/1,479 lbs | Treated | Lockheed Martin Utility Services |
| X-705 motor cleaning solution | 2 drums/801 lbs | Treated | Lockheed Martin Utility Services |
| Mixed waste and polychlorinated biphenyl liquids | lbpounds | Disposed | Toxic Substances Control Act Incinerator |
| Waste water | 132,743 lbs | Treated | On-site treatment facilities |
| Fluorescent light bulbs | 3 pallets/2,000 lbs | Recycled | Dynex Corporation |

- ***Mixed waste***—waste containing both hazardous and radioactive components. Mixed waste is subject to RCRA, which governs the hazardous components, and to additional regulations that govern the radioactive components.
- ***Polychlorinated biphenyl and polychlorinated biphenyl-radioactive wastes***—waste containing poly chlorinated biphenyls, a class of synthetic organic chemicals. Under Toxic Substances Control Act regulations, polychlorinated biphenyl manufacturing was prohibited after 1978. However, continued use of polychlorinated biphenyls is allowed, provided that the use does not pose a risk to human health or the environment. Disposal of all polychlorinated biphenyl materials is regulated.
- ***Asbestos waste***—friable asbestos materials from renovation and demolition activities.
- ***Sanitary waste***—solid waste, such as office waste, generated by commercial operations.

During 1997, approximately 2.95 million lbs of waste from the Portsmouth site 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 polychlorinated biphenyl/mixed waste at off-site commercial facilities.

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 and USEPA regulations must be satisfied to ensure compliance for waste management activities. Additional policies have been implemented for management of radioactive, hazardous, and mixed wastes. These policies involve the following:

- minimizing wastes;
- characterizing and certifying wastes before they are stored, processed, treated, or disposed;
- pursuing volume reduction and use of on-site storage when safe and cost-effective until a final treatment and/or disposal option is identified; and
- recycling.

# WASTE MINIMIZATION AND POLLUTION PREVENTION PROGRAM

DOE/PORTS has combined its waste minimization and pollution prevention efforts to consolidate related activities. 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 plant 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 all plant processes and activities to identify waste minimization opportunities (e.g., conducting process waste assessments and identifying procedures that are barriers to waste minimization);
- maintaining an effective plant-wide 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 1997 include the following:

- reusing excess computer equipment by donating it to local public schools;
- removing approximately 250,000 lbs of spent lead-acid batteries from the hazardous waste inventory and sending them to an approved reclamation facility;
- conducting a Pollution Prevention Opportunity Assessment to determine the best course of action regarding DOE/PORTS inventory of spent waste water carbon filters;
- recycling more than 47,000 lbs of sanitary waste in the form of used office paper, corrugated cardboard, and aluminum beverage cans;
- sending approximately 2,000 lbs of spent fluorescent light bulbs to a recycling facility;
- celebrating Earth Day at the plant site by distributing white oak saplings as gifts to the employees;
- reducing RCRA storage space used by 6,000 cubic ft by reclassifying and recycling spent lead-acid batteries and spent fluorescent light bulbs;
- maintaining 100% purchasing of post-consumer recycled office paper, and purchasing other items made from post-consumer material.

In 1997, DOE/PORTS was nominated for the Eleventh Annual Governor's Award for Pollution Prevention in recognition of recycling more than 1 million lbs of idle circuit breakers and transformers as scrap metal in 1996. Additional program accomplishments are noted in Table 3.1

Activities planned for 1998 include reducing and sending for reclamation the inventory of nickel-cadmium batteries, starting a scrap metal recycling program, recycling the inventory of spent incandescent light bulbs, implementing programs to prevent managing spent batteries and light bulbs as waste, conducting a Pollution Prevention Opportunity Assessment on low-volatile organic compound floor coverings for the RCRA storage area, and implementing routine tracking of hazardous materials through use of a chemical product inventory tracking data base purchased in 1997.

## 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 the following:

- hazardous waste training for workers;
- hazardous waste training for managers/supervisors;
- RCRA training for treatment-, storage-, and disposal-facility workers;
- environmental laws and regulations training; and
- water/wastewater treatment training.

## 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 task team meetings, and professional conferences.

## PUBLIC AWARENESS PROGRAM

A comprehensive community relations and public participation program on the Environmental Restoration and Waste Management programs has been in place since early 1990. The purpose of the program is to conduct a proactive public involvement program, with outreach components, to foster a spirit of openness and credibility among local citizens, elected officials, business, media, and various segments of the public. The program is also geared to provide 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 in an effort to provide public access to all documents used to make decisions on remedial actions being taken at the plant. The information center has a full-time staff and is located about 10 miles north of the plant at 505 West Emmitt Avenue, Suite 3, Waverly, Ohio 45690. The center's hours are 10 a.m. to 4 p.m., Monday, Tuesday, Wednesday, and Friday, and 9 a.m. to 12 p.m. on Thursday, or after hours by appointment (740-947-5093).

A group of about 45 key stakeholders, composed of elected officials, community leaders, environmentalists, 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 those 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 two 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 740-897-5510. The Bechtel Jacobs Company LLC project manager and the public affairs manager also provide information on the program.

# 4. Environmental Monitoring

***Abstract***

Environmental monitoring at the U.S. Department of Energy/Portsmouth Gaseous Diffusion Plant (DOE/PORTS) involves monitoring air, surface water, and groundwater. Monitoring is based on critical pathways analyses, public concerns, measurement capabilities, and environmental regulations. Samples are analyzed for radiological contaminants, as well as potentially harmful nonradiological pollutants. The release of airborne pollutants from DOE/PORTS is regulated by permits from the state of Ohio. The majority of liquid effluents from DOE/PORTS are regulated by the National Pollutant Discharge Elimination System (NPDES). A total of 0.0009 Ci of radioactivity was released to surface water from DOE/PORTS outfalls in 1997. This level represents a decrease in uranium and technetium emissions from 1996. For nonradiological releases, overall compliance with the NPDES permit limits was 99.8%. Results for 1997 indicate that DOE/PORTS operations did not have a significant environmental impact outside the reservation boundaries.

## INTRODUCTION

DOE/PORTS practices a progressive environmental strategy for pollution control in compliance with requirements of the Clean Air Act and the Clean Water Act. This strategy uses modern technology to decrease pollution coupled with continual review of treatment facility performance to meet current regulations regarding airborne and liquid effluents in the most cost-effective manner. DOE/PORTS activities have historically contributed minimal pollutants to the environment.

This document contains a summary of DOE-related environmental monitoring activities at DOE/PORTS. Environmental monitoring consists of two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is direct measurement or the collection and analysis of samples of gaseous and liquid discharges to the environment. Environmental surveillance is direct measurement or the collection and analysis of samples of air, water, and soil. Environmental monitoring is performed to characterize and quantify contaminants and to demonstrate compliance with applicable standards and permit requirements.

The goal of the environmental monitoring program is to detect and assess the effects (if any) of DOE/PORTS operations on human health and the environment. Multiple samples are collected throughout the year and are analyzed for radioactivity, chemical content, and various physical attributes. The results of these samples are used to gauge the environmental impact of DOE/PORTS operations and to set priorities for further environmental improvements. The justification for choosing certain environmental media to be sampled, specific sampling locations, sampling frequencies, and parameters is referred to as the rationale. Environmental regulations, critical pathways analyses, public concerns, and measurement capabilities must all be considered in the rationale for the establishment of a successful environmental monitoring program. The rationale for the establishment of the DOE/PORTS environmental monitoring program is found in the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (Martin Marietta Energy Systems 1994), which was revised to address only DOE/PORTS activities and was distributed in November 1996.

## Environmental Regulations

Numerous state and federal regulations that encompass radiological and nonradiological programs determine much of the monitoring conducted at DOE/PORTS. These regulations include the National Emission Standards for Hazardous Air Pollutants, NPDES, and RCRA. Compliance with these regulations involves a number of regulators, including the USEPA and the Ohio EPA, which oversee various site activities to help ensure compliance. In addition to these regulations are DOE orders in the 5400 series, in particular 5400.1, *General Environmental Protection Program,* and 5400.5, *Radiation Protection of the Public and the Environment.* A complete discussion of the site's compliance activities is in Section 2, "Environmental Compliance," of this report.

Acceptable levels of contaminants are generally specified in regulations or permits relating to nonradioactive substances. Regulations relating to radioactive materials generally include limits for exposure to the public. Radioactive materials are regulated at the point of discharge and are monitored as they disperse into the surrounding environment. However, most radionuclides are released in such small amounts that it is not possible to detect them after they disperse into a medium, such as air, water, soil, or vegetation. For this reason, DOE/PORTS uses USEPA-approved mathematical models to estimate the transport and dispersion of radioactive contaminants in the environment and the resulting exposures to the off-site population, as discussed in Section 5, "Dose." This involves monitoring the discharge stack or pipe where higher concentrations than those found in a sampling medium may be readily obtained. Modeling can then be used to calculate the expected concentrations of contaminants in environmental media. Models also help optimize the effectiveness of the existing radiological monitoring program. Modeling contributes to the best use of resources available for sampling and analysis and helps to verify that a sampling network is performing adequately.

Extensive monitoring is also conducted for nonradioactive contaminants. The nonradiological monitoring program is designed to ensure that the physical and chemical properties of air and liquid discharges comply with state and federal standards. Monitoring of atmospheric releases is designed to ensure compliance with permits issued by the Ohio EPA. Monitoring requirements for liquid effluents vary at each outfall, or discharge point, depending on the type of facility and the known characteristics of the wastewater.

## Critical Pathways Analysis

Individuals can be exposed to airborne and liquid releases of radioactive and chemical materials through various routes. These routes are referred to as pathways. Environmental reports are examined to determine which radionuclides and exposure pathways are most important in terms of the quantity of radionuclides released, the dose received by the maximally exposed individual, and the collective dose received by the population as a whole. This type of analysis, called a critical pathways analysis, helps determine which radionuclides and pathways at a particular site deserve the most attention. Critical pathways analyses have been used historically at DOE/PORTS as input for the environmental monitoring program. The following sections summarize the results of a critical pathways analysis of DOE/PORTS operations. The analysis includes radionuclide releases to the atmosphere and surface water, which are the principal media that could transport radioactive contaminants from the site.

Models used to assess any environmental impact relating to the transport of radionuclides and chemicals, and human exposures to these substances released from DOE/PORTS are appropriate for the situation encountered. Those pathways of exposure to the most-exposed individual and to the entire population residing within 50 miles of DOE/PORTS are evaluated.

Each assessment is documented. A file is created that contains the results of each calculation, a description of models used, a description of any computer codes used to implement the models, and a com-

plete list of the values and sources of all input data and assumptions used. Surface water and groundwater modeling are conducted as necessary to conform with applicable requirements of the state government and of the regional USEPA office. The effect on human health and the environment is a great concern of DOE/PORTS. Such concern can arise if a release could be transported to neighborhoods or schools. Concern can also exist for releases of long-lived radionuclides that remain in the environment for many years.

Many of the radioactive and nonradioactive materials released from DOE activities exist in such low concentrations in the environment that they cannot be measured readily. Thus, measurement capabilities become determining factors in the rationale for monitoring certain materials. In these cases, modeling as previously discussed, can be used to estimate concentration levels. Environmental monitoring practices are reevaluated as new methods and the need for monitoring evolve. Types of measurements and their frequencies are reviewed routinely, and monitoring locations are sometimes changed.

The *Environmental Monitoring Plan for DOE Activities* has been revised to address DOE/PORTS activities only. The plan, required by DOE Order 5400.1, was distributed in November 1996. The plan documents DOE effluent monitoring and environmental surveillance activities conducted at DOE/PORTS. The plan also includes the rationale and design criteria for the environmental monitoring program, the frequency of monitoring and analysis, specific analytical and sampling procedures, quality assurance requirements, and guidance on preparing and distributing reports.

## AIRBORNE DISCHARGES

Airborne discharges of radionuclides from DOE/PORTS facilities are regulated by the USEPA under the Clean Air Act and National Emission Standards for Hazardous Air Pollutants. These regulations set (1) an annual dose limit of 10 mrem/year to any member of the public as a result of airborne releases and (2) certain minimum performance standards for demonstrating compliance with the dose limit.

Gaseous radionuclide discharges are also regulated, along with all other atmospheric pollutants, under the Ohio permit to operate requirements. However, Ohio does not yet have any standards governing radionuclide emission limits and defers to the federal National Emission Standards for Hazardous Air Pollutants program instead of acting on permit applications filed by DOE/PORTS.

In addition to these outside authorities, DOE 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. Unlike the National Emission Standards for Hazardous Air Pollutants limit of 10 mrem/year, the DOE limit includes the impacts of radioactivity releases from a facility through all pathways.

DOE Order 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, DOE Order 441.1, *Department of Energy Radiological Health and Safety Policy*, and 10 Code of Federal Regulations Part 835, *Occupational Radiation Protection*, require DOE facilities to establish effluent monitoring programs sufficient to ensure that no unrecognized environmental impact is occurring as a result of DOE operations. The details of the DOE/PORTS environmental monitoring program are documented in the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*, which is discussed in detail in Section 2, "Environmental Compliance."

### Radiological Airborne Discharges

As a result of the formation of USEC, DOE leased the enrichment operations facilities at DOE/PORTS to USEC. Under the terms of the lease, USEC assumed responsibility for most of the existing radio-

nuclide point-source discharges. DOE/PORTS is responsible for the X-345 high-assay sampling area, the X-326 "L-Cage" glove box, and the X-744G glove box. The X-345 high-assay sampling area, formerly a cascade support facility, is now owned by DOE/PORTS as a continuously monitored source. This source is currently out of service but could become operational again if necessary.

### Radiological Air Sample Collection and Analytical Procedure

A waste stream analysis was performed to determine which radionuclides are present on site. These radionuclides are the naturally occurring uranium isotopes $^{234}U$, $^{235}U$, and $^{238}U$; two trace impurities from recycled uranium, $^{236}U$ and technetium ($^{99}Tc$); and equilibrium concentrations of short-lived uranium daughters. The uranium daughters included in the equilibrium calculations are the thorium and protactinium isotopes $^{234}Th$, $^{231}Th$, and $^{234m}Pa$. Alumina from the sampler is analyzed for total uranium, $^{235}U$, and technetium. The ratio of $^{235}U$ to total uranium (i.e., the "assay") and the process data are used to calculate the fractions of $^{234}U$ and $^{236}U$ in emissions. Because of their short half-lives, uranium daughter emissions cannot be reliably measured in weekly samples and are assumed to be in equilibrium with their parent nuclides.

Dose estimate calculations for the X-326 and X-744G glove boxes are performed annually to demonstrate compliance with the radionuclide National Emission Standards for Hazardous Air Pollutants federal standard. Calculations are based on amounts of materials handled by each glove box in 1997 and the radionuclide characteristics of those materials.

### Radiological Air Estimation Results

Radionuclide emissions from DOE/PORTS, all currently based on estimating procedures, had no significant impact on public health or the environment. There were no unplanned releases during 1997. DOE/PORTS emissions estimates still remain well below the applicable USEPA standard and far below the levels listed as safe by national and international regulatory bodies such as the Occupational Safety and Health Administration, the Nuclear Regulatory Commission, and the International Committee on Radiation Protection.

Historically, uranium has accounted for 75% to almost 90% of the public dose from DOE/PORTS emissions. Uranium emissions are depicted in curies (a measure of radioactivity). For the future, it is expected that the activity emissions (curies) of uranium should continue to decrease because of the absence of highly enriched uranium in the emissions.

## Nonradiological Airborne Discharges

Nonradiological releases to the atmosphere are permitted under the Ohio permit to operate regulations. Under Ohio regulations, the Ohio EPA can "register" small emission sources rather than issue a formal permit. Permits to operate must be renewed every three years and must set out explicit numerical limits on emission rates or operating restrictions and on monitoring and reporting requirements. A registration is valid until revoked by the Ohio EPA and presumes that the registered source is too small to have a significant environmental impact. Most of the nonradiological sources at DOE/PORTS are either registered or are expected to be registered when the Ohio EPA acts on the submitted applications.

### Nonradiological Air Sample Collection and Analytical Procedure

Emissions of nonradiological air pollutants at DOE/PORTS are estimated using various USEPA-approved procedures. These procedures are used to estimate emissions from sources such as storage tanks and boilers. No air sample collection procedures are used or required for use at DOE/PORTS.

### Nonradiological Air Estimation Results

DOE/PORTS operates numerous small sources of criteria (or 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. This statement is required for facilities such as DOE/PORTS that do not have to comply with the federal operating permit program (Title V) under 40 Code of Federal Regulations 70. For the *Biennial Non-Title V Emission Report,* DOE/PORTS estimated total pollutant emissions to be less than 9 tons per year, which is well below the limit of 100 tons per year for Non-Title V facilities.

Other air pollutants emitted from DOE/PORTS include fluorine, hydrogen fluoride, methanol, ethylene glycol and coating solvents. The amounts of these chemicals emitted are estimated for annual reports to the USEPA as required under Section 313 of the Emergency Planning and Community Right-to-Know Act. In 1997, mass-balance calculations indicated only ethylene glycol was emitted to the atmosphere at an estimated 3 lbs.

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 supervised by the Industrial Hygiene Department. The amount of asbestos removed and disposed is reported quarterly to the Ohio EPA. No asbestos was removed or disposed in 1997.

## LIQUID DISCHARGES

The quality of surface waters at DOE/PORTS is affected by wastewater discharges and groundwater transport of contaminants from land disposal of waste. Although bedrock characteristics differ somewhat among the watersheds of these surface waters, the observed differences in water chemistry are attributed to different contaminant loadings rather than geologic variation. Water quality, radioactivity, and flow measurements are made at a number of stations operated by DOE. Water samples are collected and analyzed at various intervals (weekly, monthly, etc.) for radiological and nonradiological parameters.

## Radiological Liquid Discharges

Virtually all radiological liquid discharges from DOE activities come from remediation activities. The exceptions are trace concentrations of naturally occurring uranium in storm water runoff. The locations of remediation activities are dispersed throughout DOE/PORTS and may be discharged from any of the NPDES outfalls.

### Radiological Liquid Sample Collection and Analytical Procedure

All DOE outfalls are monitored by taking grab samples. Aliquots from these samples are analyzed for total uranium concentrations, gross alpha, gross beta, and technetium ($^{99}$Tc)-beta radioactivity. The ratio of

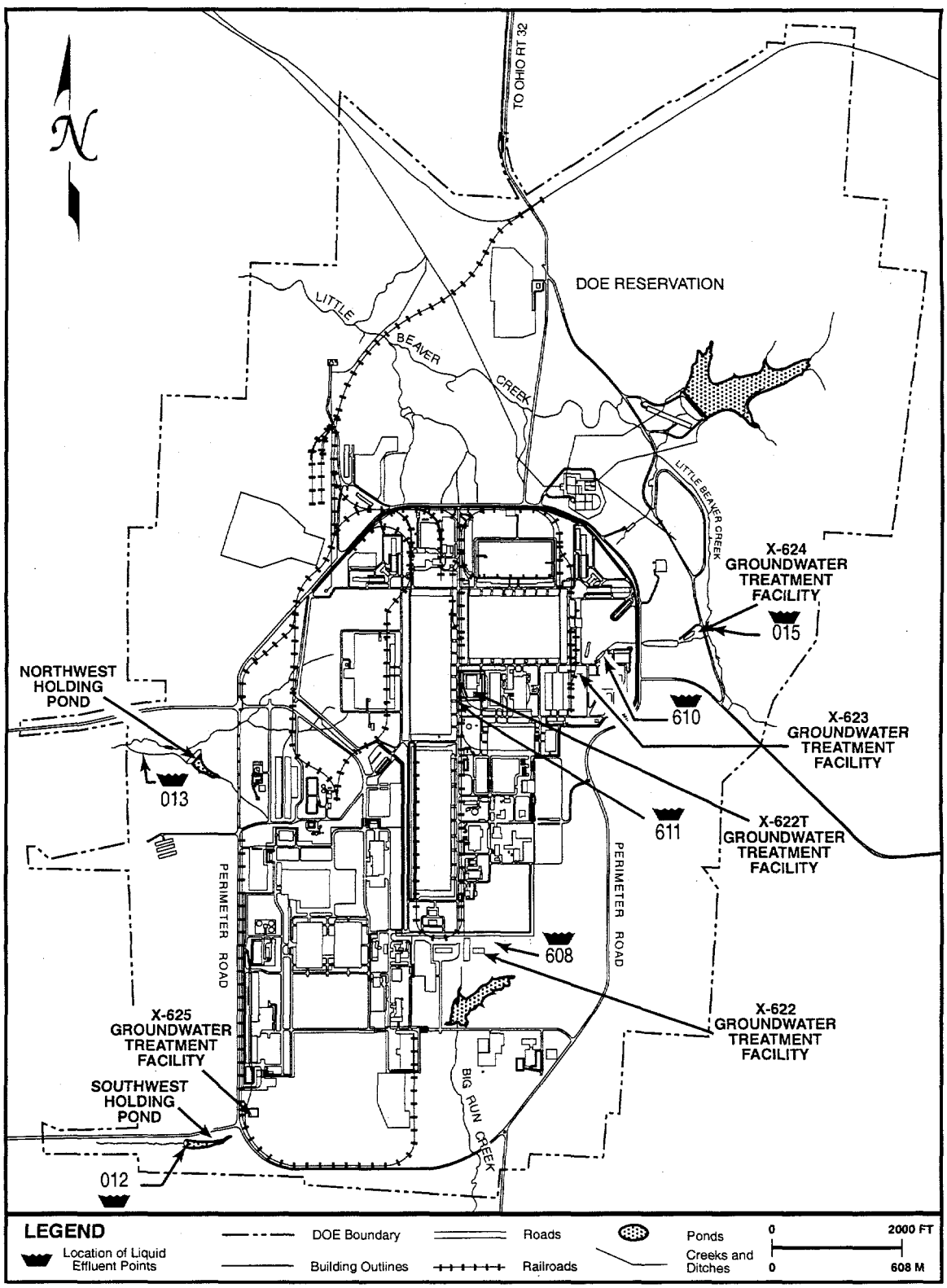



**Fig 4.1. NPDES water sampling locations, and major wastewater sources and systems at DOE/PORTS.**

alpha activity to total uranium is used along with process data to calculate the proportions of the individual uranium isotopes.

### Radiological Liquid Monitoring Results

Liquid radiological discharges from DOE/PORTS had no significant impact on public health or the environment. Uranium discharges from DOE/PORTS sources in 1997 totaled 0.628 kg. A total of 0.0009 Ci of radionuclides was discharged in 1997 from DOE/PORTS sources. No unplanned releases to surface water occurred during 1997.

The secondary standard for multiple nuclides is that the sum of the fractional derived concentration guide values shall not exceed 1.0. In 1997, DOE/PORTS discharges remained well below the applicable DOE standard (100 mrem/year) and far below the levels listed as safe by national and international regulatory bodies such as the Occupational Safety and Health Administration, the Nuclear Regulatory Commission, and the International Committee on Radiation Protection (5 rem/year).

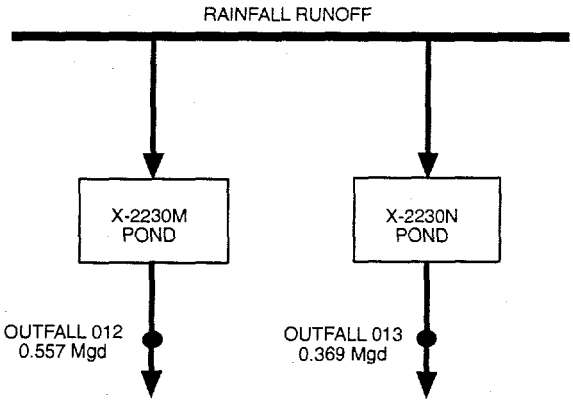



**Fig. 4.2. Flow diagram for outfalls 012 and 013 (X-2230M holding pond and X-2230N holding pond).**

## Nonradiological Liquid Discharges

Nonradiological discharges are regulated by the NPDES permit. The permit was issued to DOE/PORTS on September 1, 1995. The permit was modified on December 1, 1996, and May 1, 1997. DOE/PORTS has six discharge points, or outfalls, through which water is discharged from the site. Three outfalls discharge directly to surface water, and three discharge to the X-6619 waste water treatment facility before leaving the site through USEC outfall 003 to the Scioto River. A brief description of each outfall for which DOE/PORTS is responsible follows, and the locations of the outfalls are shown in Fig. 4.1.

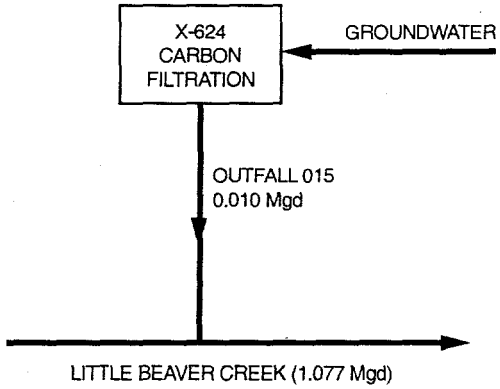



**Fig. 4.3. Flow diagram for outfall 015 (X-624 carbon filtration facility).**

*NPDES 012 (X-2230M holding pond, formerly Gas Centrifuge Enrichment Plant 001)*—The X-2230M holding pond provides a quiescent zone for settling of suspended solids, dissipation of chlorine, and containment of oil with effluent baffling.

*NPDES 013 (X-2230N holding pond, formerly Gas Centrifuge Enrichment Plant 002)*—The X-2230N holding pond provides a quiescent zone for settling of suspended solids, dissipation of chlorine, and containment of oil with effluent baffling. A flow diagram for NPDES outfalls 012 and 013 is shown in Fig. 4.2.

*NPDES 015 (X-624 carbon filtration facility—formerly outfall 609)*—This facility provides for removal of 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. A flow diagram for outfall 015 is shown in Fig. 4.3.

*NPDES 608 (X-622 groundwater treatment facility)*—This facility provides for removal of volatile organic compounds from contaminated groundwater originating from X-231B, X-749, and Peter Kiewit landfill site remediation activities. Treated water is discharged to the sanitary sewer and then to USEC outfall 003.

*NPDES 610 (X-623 carbon filtration facility—formerly outfall 606)*—This facility replaced the X-701E in June 1994 and provides for removal of 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 to USEC outfall 003.

*NPDES 611 (X-622T/X-705 sump water treatment facility)*—This facility provides for the removal of volatile organic compounds from sump water from the X-705 decontamination facility. Treated water is discharged to the sanitary sewer and then to USEC outfall 003.

### Nonradiological Liquid Sample Collection and Analytical Procedure

Sampling of nonradioactive constituents is regulated under the DOE/PORTS NPDES permit. Analyses are performed in accordance with 40 Code of Federal Regulations 136.

### Nonradiological Liquid Monitoring Results

The 1997 NPDES compliance rate for DOE outfalls was 99.8%. Compliance rates for individual parameters ranged from 96% to 100%.

Discharge data for the X-2230M holding pond (NPDES 012 and 022), as well as the X-2230N holding pond (NPDES 013 and 023), indicate no exceedences. The compliance rate for all parameters was 100%. Discharge data for the X-622, X-622T, and X-624 carbon absorption facilities indicate a compliance rate of 100% for all parameters.

One exceedence of the trichloroethene limit at the X-623 carbon filtration facility (NPDES 610) resulted in a compliance rate of 96%. (See Section 2, "Environmental Compliance," for details on this exceedence.) The compliance rate for all other parameters was 100%.

## Radiological and Nonradiological Groundwater Monitoring Results

Radiological and nonradiological results for groundwater monitoring at DOE/PORTS can be found in Section 6, "Groundwater."

# 5. Dose

***Abstract***

Potential impacts on human health from U.S. Department of Energy/Portsmouth Gaseous Diffusion Plant (DOE/PORTS) operations are calculated based on environmental monitoring and surveillance data. The maximum potential committed effective dose equivalent that a person living off site could receive from airborne radiological releases from DOE activities at PORTS is 0.0074 mrem/year. This potential dose is well below the 10 mrem/year limit set by the U.S. Environmental Protection Agency, the 100 mrem/year limit set by DOE, and the 300 mrem/year (approximate) dose the average person in the United States receives from natural sources of radiation. Chemical releases were also well below applicable standards, and dose calculations show that any potential chemical doses to the public would be minute and would not have any adverse health effects.

## INTRODUCTION

Airborne releases of radionuclides from DOE facilities are regulated by the USEPA 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 releases, and also set performance standards for demonstrating compliance with the dose limit. Airborne radionuclide discharges are also regulated, along with all other atmospheric pollutants, under the Ohio permit to operate requirements. However, Ohio does not yet have standards governing radionuclide emission limits and therefore defers to the federal National Emission Standards for Hazardous Air Pollutants regulations.

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. The DOE limit includes all radionuclide releases from a facility, unlike the National Emission Standards for Hazardous Air Pollutants limit of 10 mrem/year.

Airborne discharges of chemical agents are regulated under the Ohio permit to operate requirements issued under the state equivalent of the Clean Air Act. Enforceable limits on emissions listed in these permits are based on maintaining normal ambient air concentrations within ambient air quality standards (i.e., the limits are not directly enforceable on individual sources).

Liquid discharges are regulated by the NPDES permit issued under the Clean Water Act. Enforceable limits in the permit are based on maintaining appropriate water quality in receiving streams.

## DOSE CALCULATION

Exposure to radioactive materials could 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 (e.g., depleted uranium drum and disposal areas) located within plant and reservation boundaries. Doses are estimated for all potentially significant exposure pathways relevant to the exposure modes just described. (Refer to "Appendix A: Radiation" for detailed information about radiation and radioactivity.)

Small quantities of radionuclides were released to the environment from DOE/PORTS operations during 1997. This section summarizes estimates of the potential consequences of the releases and describes the methods used to make the estimates.

## Radiological Dose Calculation

### 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; 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 ($^{234}U$, $^{235}U$, and $^{238}U$) and technetium ($^{99}Tc$) are potentially significant when calculating the radiation dose received by the public around DOE/PORTS. Each of these radionuclides has a half-life that exceeds 200,000 years; consequently, the sampling frequency does not need to allow for radioactive decay. The types of radiation emitted vary from one radionuclide to the next. The predominance of beta and alpha emitters indicates the importance of internal exposures resulting from possible ingestion or inhalation of radionuclides.

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 of the biological consequences of that 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. In this report, the term "dose equivalent" is often shortened to "dose."
- ***Effective dose equivalent***—a risk-equivalent dose equivalent that can be used to estimate health-effect risk to exposed persons; it is a weighted sum of dose equivalents to specified organs.
- ***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 radionu clides 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."
- ***Dose conversion factor***—the dose equivalent received from exposure to a unit quantity of a radionuclide by a specific exposure pathway. Two types of dose conversion factors exist. One type gives the committed dose equivalent (rem) resulting from intake (by inhalation and ingestion) of a unit activity [1.0 μCi

(37 Bq)] of a radionuclide. The second type gives the dose equivalent rate (mrem) per unit activity [1.0 μCi (37 Bq)] of a radionuclide in a unit ($cm^3$ or $cm^2$) of an environmental compartment (air or ground surface).

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

## Dose Calculation for Airborne Radionuclides

Characterizing the effects of radionuclides released to the atmosphere by site activities during 1997 was accomplished by calculating effective dose equivalents to the maximally exposed person (a hypothetical individual who is assumed to reside at the most exposed point on the plant boundary) and to the entire population (approximately 918,000) residing within 50 miles of the plant. Dose calculations were made using the Clean Air Act Assessment Package-88 of computer codes (Beres 1990), which was developed under sponsorship of the USEPA for use in demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants concerning radionuclides (40 Code of Federal Regulations 61). This package contains the most recently approved version of the AIRDOS-EPA and DARTAB computer codes and of the ALLRAD88 radionuclide data file. The AIRDOS-EPA computer code implements a steady-state, Gaussian plume, atmospheric dispersion model to calculate concentrations of radionuclides in the air and on the ground; it uses *NRC* (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 concentrations and human intakes are used by the USEPA's latest version of the DARTAB computer code to calculate effective dose equivalents to humans from radionuclides released to the atmosphere. The dose calculations use the dose conversion factors contained in the ALLRAD88 data file.

Radionuclide release data were modeled for three release points. The radionuclide release inventory is detailed in Section 4, "Environmental Monitoring." Meteorological data used in the calculations consisted of joint frequency distributions of wind direction, wind speed, and atmospheric stability that were prepared from data collected during 1997 at the 40 m station on the DOE/PORTS meteorological tower. Rainfall during 1997 was 45.68 in, the average air temperature was 52.28°F, and the average mixing layer height was 2,000 m.

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 (USEPA 1989b). This pattern specifies that 70% of the vegetables and produce, 44.2% of the meat, and 39.9% 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. For collective effective dose equivalent estimates, production of beef, milk, and crops within 50 miles of DOE/PORTS was calculated using the state-specific production rates provided with the Clean Air Act Assessment Package-88.

## Dose Calculation for Waterborne Radionuclides

Water is sampled at all plant outfalls and in the receiving streams. DOE/PORTS sources had 0.628 kg of uranium discharges and 0.0009 Ci of radionuclides. DOE/PORTS discharges remained well below the DOE standard, as well as limits set by the National Emission Standards for Hazardous Air Pollutants, the Occupational Safety and Health Administration, the Nuclear Regulatory Commission, and the International Committee on Radiation Protection.

## Chemical Dose Calculation

Varying amounts of chemicals were released to the environment from DOE/PORTS operations during 1997. This section contains estimates of potential human exposure to these chemicals and compares the exposures to acceptable levels of exposure as defined by federal standards and regulations.

### Terminology

Terms pertinent to discussion of chemical exposure include the following:

- ***Acceptable daily intake***—intake of a chemical (measured in milligrams per day) that is not anticipated to result in any adverse health effects over a lifetime of exposure. Acceptable daily intakes are calculated from several different federal standards and regulations.
- ***Ambient air quality standard***—national or state standard for maximum concentration of an airborne pollutant that is not expected to adversely affect the public health (primary ambient air quality standard) or the public welfare (secondary ambient air quality standard).
- ***Chronic daily intake***—intake of a chemical (expressed in mg/day) from drinking 2 L (2 qt) of surface water per day.
- ***Maximum contaminant level***—maximum concentration legally allowable in drinking water under the USEPA national interim primary and national primary drinking water regulations that apply to all community or public water systems.
- ***Maximum-contaminant-level goal***—maximum concentration desirable in drinking water under USEPA national secondary drinking water regulations that apply to public water systems.
- ***Reference dose***—an estimate of the daily exposure to the human population, including sensitive individuals, that is likely to be without an appreciable risk of harmful effects during a lifetime.

### Dose Calculation for Waterborne Chemicals

The USEPA has set acceptable daily intake standards for some chemicals in the form of maximum contaminant levels and maximum-contaminant-level goals (in mg/L), which were converted to acceptable daily intake values by multiplying by the average daily adult water intake of 2 L (2 qt). Drinking water regulations and standards apply to community or public water systems and thus are conservative when applied to surface water.

For chemicals for which maximum contaminant levels or maximum-contaminant-level goals were not available, acceptable daily intakes were calculated from oral reference doses. These values are available from the USEPA Integrated Risk Information System (USEPA 1991). For noncarcinogenic chemicals, daily exposure to the reference dose (in mg/kg/day) should result in no adverse effect over a lifetime. Acceptable daily intakes were calculated from reference doses by multiplying by 154.35 lbs, the average human body weight.

Outfalls are not readily accessible to the general public; therefore, ingestion of water directly from outfalls is unlikely. Although it is possible for a member of the public to ingest water from either Big Beaver Creek or Big Run Creek, both of these water bodies run through active agricultural operations (i.e., farms and cattle pastures) along their entire length between DOE/PORTS and the Scioto River and are classified as unsuitable for use as potable water sources because of agricultural runoff. In addition, there are no identified drinking water intakes in the Scioto River downstream of DOE/PORTS.

Sampling data for two metals and three organic chemical compounds are available for NPDES outfall stations. (Not all chemicals were measured at each outfall.) Annual average values of the sampling data (in μg/L) were multiplied by 2 L to estimate routine daily intake levels. Much of the sampling data for individual chemicals were reported as "less-than" (<) values, indicating that concentrations were below the limits of detection of the analytical methods used. Because average sample concentrations were reported as less-than values, the chronic daily intakes are also reported as less-than values. The chronic daily intakes were compared with the acceptable daily intakes to establish whether ingestion of water could result in an exposure above the acceptable daily intake. Chronic daily intake/acceptable daily intake ratios of less than 1 indicate an acceptable level of risk; chronic daily intake/acceptable daily intake ratios greater than 1 could indicate an unacceptable risk or the need for further study.

### Calculation of Direct Exposure to Chemicals

Direct exposure to chemicals does not represent a likely pathway of exposure at DOE/PORTS. For airborne releases, concentrations off site are too small to present problems through the skin exposure pathway. For water releases, outfalls are generally located within areas of the site that are not readily accessible to the general public. Although exposures for consumption of drinking water at the discharge sites were calculated, public exposure to water from the area of the discharge on a daily basis is highly unlikely.

## DOSE CALCULATION RESULTS

## Radiological Dose Results

The Radiation Exposure Information Reporting System report is an electronic file created annually to comply with DOE Order 5484.1. This report contains exposure results for all monitored individuals at DOE/PORTS, which includes visitors, with a positive exposure during the previous calendar year. The 1997 Radiation Exposure Information Reporting System report indicated that there were no visitors with a positive exposure.

Federal regulation 10 Code of Federal Regulations 835 requires that a visitor report be sent to all individuals visiting DOE/PORTS who have been monitored for external and/or internal exposure to radiation or radioactive material. Any member of the public exposed to radiation or radioactive material during direct on-site access at a DOE site or facility shall not exceed 100 mrem total effective dose equivalent in a year.

The average total effective dose equivalent in 1997 for all DOE employees and DOE subcontractors was 1.645 mrem, with the highest total effective dose equivalent for an individual being 221 mrem.

### Airborne Radionuclide Results

The maximum potential effective dose equivalent to an off-site individual from 1997 radiological releases from DOE/PORTS was 0.0074 mrem, which is well below the 10-mrem National Emission Standards for Hazardous Air Pollutants limit applicable to DOE/PORTS and the approximate 300-mrem dose/year that the average individual in the United States receives from natural sources of radiation. It is unlikely that any one person would be exposed to maximum doses from both airborne and liquid effluents because the points of maximum exposure are on opposite sides of the plant. Furthermore, no one is known to draw drinking water from the Scioto River downstream of the plant.

The collective effective dose equivalent to the entire population around DOE/PORTS in 1997 was 0.00036 person-rem, which is a minute fraction of the approximate 276,000 person-rem that this population received from natural sources of radiation during 1997. The collective effective dose equivalent to the nearest community, Piketon, was calculated to be less than 0.00279 person-rem.

# 6. Groundwater

***Abstract***

The purpose of groundwater monitoring at the U.S. Department of Energy/Portsmouth Gaseous Diffusion Plant (DOE/PORTS) is to characterize the hydrogeology and monitor groundwater quality at the plant and its environs. More than 600 monitoring wells are used to track the flow of groundwater and to measure any contaminants present both on and off site. Groundwater monitoring extends to surface water that receives direct input from groundwater sources. Off-site sampling is conducted to assess the effects of PORTS operations on nearby public and residential water supplies.

## INTRODUCTION

Groundwater monitoring activities include effluent surveillance monitoring; synoptic groundwater level measurements; and various types of monitoring of RCRA units, solid waste disposal units, special investigation units, groundwater treatment units, and RCRA facility investigation quadrant location units.

Detailed information on the following characteristics of DOE/PORTS can be referenced in the *U.S. Department of Energy Portsmouth Annual Environmental Report for 1995:*

- groundwater hydrology,
- geological and hydrogeological setting,
- topography,
- stratigraphy,
- geologic history, and
- groundwater hydrogeology.

Refer to the groundwater monitoring section of the *1997 RCRA Annual Hazardous Waste Report* for further details on the groundwater plumes at DOE/PORTS, specific monitoring well identifications, and monitoring well results.

## USES OF GROUNDWATER IN THE VICINITY

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. Groundwater in the Berea sandstone and Gallia sand formations that underlie PORTS are not used as domestic, municipal, or industrial water supplies. Domestic water supplies are obtained from either unconsolidated deposits in preglacial valleys, major tributaries to the Scioto River Valley, or from fractured bedrock encountered during drilling.

The PORTS reservation is the largest industrial user of water in the vicinity and obtains its water from the X-608, X-605G, and X-6609 water supply well fields, which are next to the Scioto River south of Piketon. The wells tap the Scioto River Valley buried aquifer. Total groundwater production averages 13 million gal/day for the entire site, including USEC activities.

Contaminants in the groundwater beneath DOE/PORTS do not affect the quality of the water in the Scioto River Valley buried aquifer.

## APPLICABLE MONITORING STANDARDS

The USEPA develops and enforces federal groundwater monitoring regulations. DOE/PORTS is located in USEPA Region V, which is headquartered in Chicago and encompasses the Midwestern states. The Ohio EPA creates and enforces state groundwater monitoring regulations, which must be consistent with federal regulations. DOE/PORTS is located within the jurisdiction of the Ohio EPA Southeast District Office in Logan, Ohio. The Ohio EPA is authorized to manage the RCRA and Hazardous and Solid Waste Amendment programs in Ohio, excluding the authority to issue interim status corrective orders. The Ohio EPA has primary enforcement authority for RCRA requirements within Ohio.

RCRA, with its accompanying regulations, is the primary federal law establishing groundwater monitoring requirements, and it exists in phases. Initial requirements, or interim status requirements, are prescribed by 40 Code of Federal Regulations 265 and Ohio Administrative Code 3745-65-90 through -94. Interim status groundwater monitoring requirements are applied to all authorized interim status hazardous waste management units. Basically, the 40 Code of Federal Regulations 265 standards require that a facility (1) monitor for detection of contaminants in groundwater; (2) prepare a groundwater quality assessment plan to be implemented if contaminants are discovered; and (3) monitor to assess the extent of contamination, as required by the groundwater quality assessment plan. Groundwater monitoring requirements are to continue through the post-closure period of the facility. Upon receipt of their final administrative permit, issued pursuant to a RCRA permit application, facilities must meet the more stringent standards prescribed in 40 Code of Federal Regulations 264, Subpart F, and Ohio Administrative Code 3745-54-90 through -99.

Closure and post-closure care include requirements for groundwater monitoring. Federal closure and post-closure interim status requirements are found in 40 Code of Federal Regulations 265, Subpart G. Corresponding state regulations are in Ohio Administrative Code 3745-66. Final standards, which apply upon issuance of the final administrative permit, are found in 40 Code of Federal Regulations 264, Subpart G. Corresponding state regulations are in Ohio Administrative Code 3745-55.

Ohio Administrative Code 3745-27-10 and 3745-29-10 require groundwater monitoring for releases at solid waste disposal sites. The code includes detailed sampling and analysis plan requirements and requirements for monitoring well construction and installation. State solid waste groundwater monitoring requirements parallel those for hazardous waste.

## GROUNDWATER MONITORING AT DOE/PORTS

There are six RCRA units at DOE/PORTS for which groundwater monitoring is specified in 40 Code of Federal Regulations 265 Subparts F and G, and Ohio Administrative Code 3745-65 and Ohio Administrative Code 3745-66 (Fig. 6.1). In addition, the solid waste regulations in Ohio Administrative Code sections 3745-27 and 3745-29 require groundwater monitoring for three solid waste landfill units (Fig. 6.2). Under the regulations for both hazardous and solid waste, different types of groundwater monitoring are conducted, based on the conditions present at each unit. Detection monitoring is performed at units where there has been no significant change of groundwater indicator parameters for upgradient and downgradient wells. These parameters are listed in Table 6.1. In the event of such a change, the groundwater contaminant plume associated with the unit is characterized during a groundwater quality assessment, and assessment monitoring is performed according to a groundwater quality assessment plan. Assessment monitoring is conducted to characterize the extent, rate of migration, and concentration of hazardous and solid waste and hazardous and solid waste constituents in groundwater. After a unit has been certified closed, detection or assessment monitoring continues according to an approved closure/post-closure plan as agreed upon by the Ohio EPA

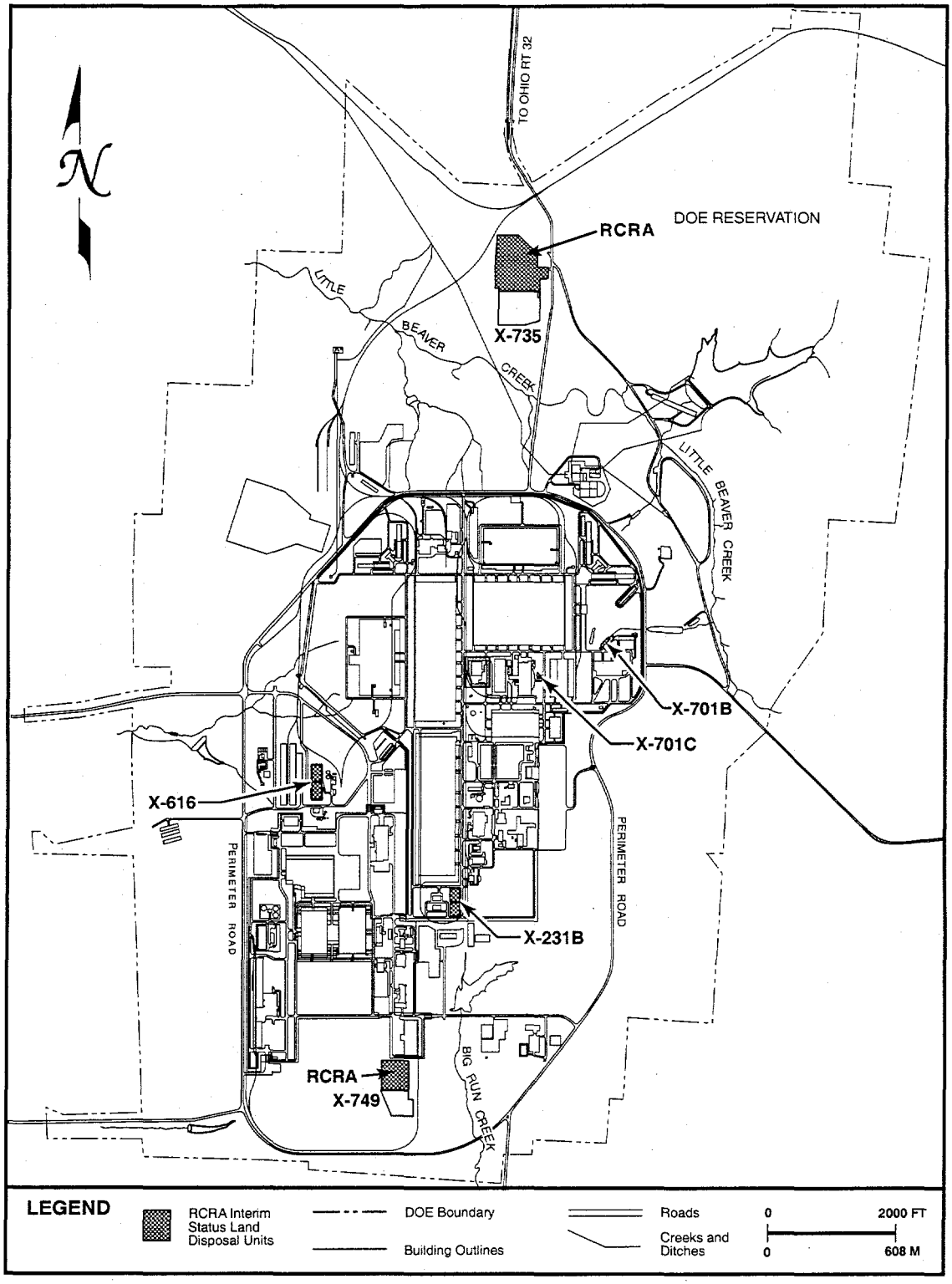



**FIG. 6.1. RCRA interim status land disposal unit locations at DOE/PORTS.**

**Table 6.1. Analyte analysis required for groundwater monitoring at RCRA units, industrial landfills, surface water locations, off-site locations, and the X-701C neutralization pit at DOE/PORTS.**

| Analyte | Monitoring location | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | X-701B [a] | X-749 [a,b] | X-231B [a] | X-616 [a] | X-735 [a,b] | Surface water | Off-site | X-701C [a] | X-749A [b] |
| | | | | *Volatile organic compounds (Method 8240)* | | | | | |
| Acetone | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Benzene | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Bromodichloromethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Bromoform | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Bromomethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 2-butanone | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Carbon disulfide | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Carbon tetrachloride | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Chlorobenzene | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Chlorodibromomethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Chloroethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Chloroform | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Dichlorobenzenes | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 1,1-dichloroethane | √ | c | √ | √ | √ | √ | √ | √ | √ |
| 1,2-dichloroethane | √ | c | √ | √ | √ | √ | √ | √ | √ |
| 1,1-dichloroethene | √ | c | √ | √ | √ | √ | √ | √ | √ |
| 1,2-dichloroethene (*cis/trans*) | √ | c | √ | √ | √ | √ | √ | √ | √ |
| Ethyl benzene | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Freon-113 | √ | c | √ | √ | √ | √ | √ | √ | √ |
| Freon-114 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 4-methyl-2-pentanone | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 1,1,2,2-tetrachloroethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Tetrachloroethene | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Toluene | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| 1,1,1-trichloroethane | √ | c | √ | √ | √ | √ | √ | √ | √ |
| 1,1,2-trichloroethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Trichloroethene | c | c | c | c | c | c | √ | c | c |
| Trichlorofluoromethane | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Vinyl chloride | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Xylenes | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| | | | | *Radionuclide parameters* | | | | | |
| Gross alpha | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Gross beta | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Total uranium | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Technetium beta | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Transuranics | √ | √ | √ | | √ | √ | | | |
| Isotopic uranium | √ | √ | √ | | √ | √ | | | |

**Table 6.1. Analyte analysis required for groundwater monitoring at RCRA units, industrial landfills, surface water locations, off-site locations, and the X-701C neutralization pit at DOE/PORTS (continued).**

| Analyte | Monitoring location | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | X-701B [a] | X-749 [a,b] | X-231B [a] | X-616 [a] | X-735 [a,b] | Surface water | Off-site | X-701C [a] | X-749A [b] |
| *Metals* | | | | | | | | | |
| Arsenic | | | | | √ | | | | √ |
| Barium | | | √ | √ | √ | | | | √ |
| Cadmium | √ | √ | | √ | √ | | | √ | √ |
| Chromium | √ | √ | √ | √ | √ | | | √ | √ |
| Copper | | | | | √ | | | | √ |
| Iron | √ | √ | √ | √ | √ | √ | | √ | √ |
| Lead | √ | √ | √ | √ | √ | √ | | | √ |
| Magnesium | √ | √ | √ | √ | √ | √ | | √ | √ |
| Manganese | | | | √ | √ | | | | √ |
| Mercury | | | | | √ | | | | √ |
| Nickel | √ | | √ | √ | √ | | | √ | √ |
| Potassium | √ | √ | √ | √ | √ | √ | | √ | √ |
| Selenium | | | | | √ | | | | √ |
| Silver | | | | | √ | | | | √ |
| Sodium | √ | √ | √ | √ | √ | √ | | √ | √ |
| Zinc | | | | | √ | | | | √ |
| *Other chemical parameters* | | | | | | | | | |
| Ammonia | | | | | √ | | | | |
| Nitrate | | | | | √ | | | | √ |
| Nitrite | | | | | √ | | | | √ |
| Chloride | √ | √ | √ | √ | √ | √ | | √ | √ |
| Calcium | √ | √ | √ | √ | √ | √ | | √ | √ |
| Sulfates | √ | √ | √ | √ | √ | √ | | √ | √ |
| Phosphorus | | | | | √ | | | | |
| Phenols | | | | | √ | | | | √ |
| *Other physical parameters* | | | | | | | | | |
| Total dissolved solids | | | | | | | | | √ |
| Total organic carbon | | | | | √ | | | √ | √ |
| Chemical oxygen demand | | | | | √ | | | | √ |
| Total alkalinity | √ | √ | √ | √ | √ | √ | | √ | √ |
| Turbidity | | | | | √ | | | | √ |

[a] RCRA unit.
[b] Solid Waste landfills.
[c] Primary volatile organic compounds of concern.

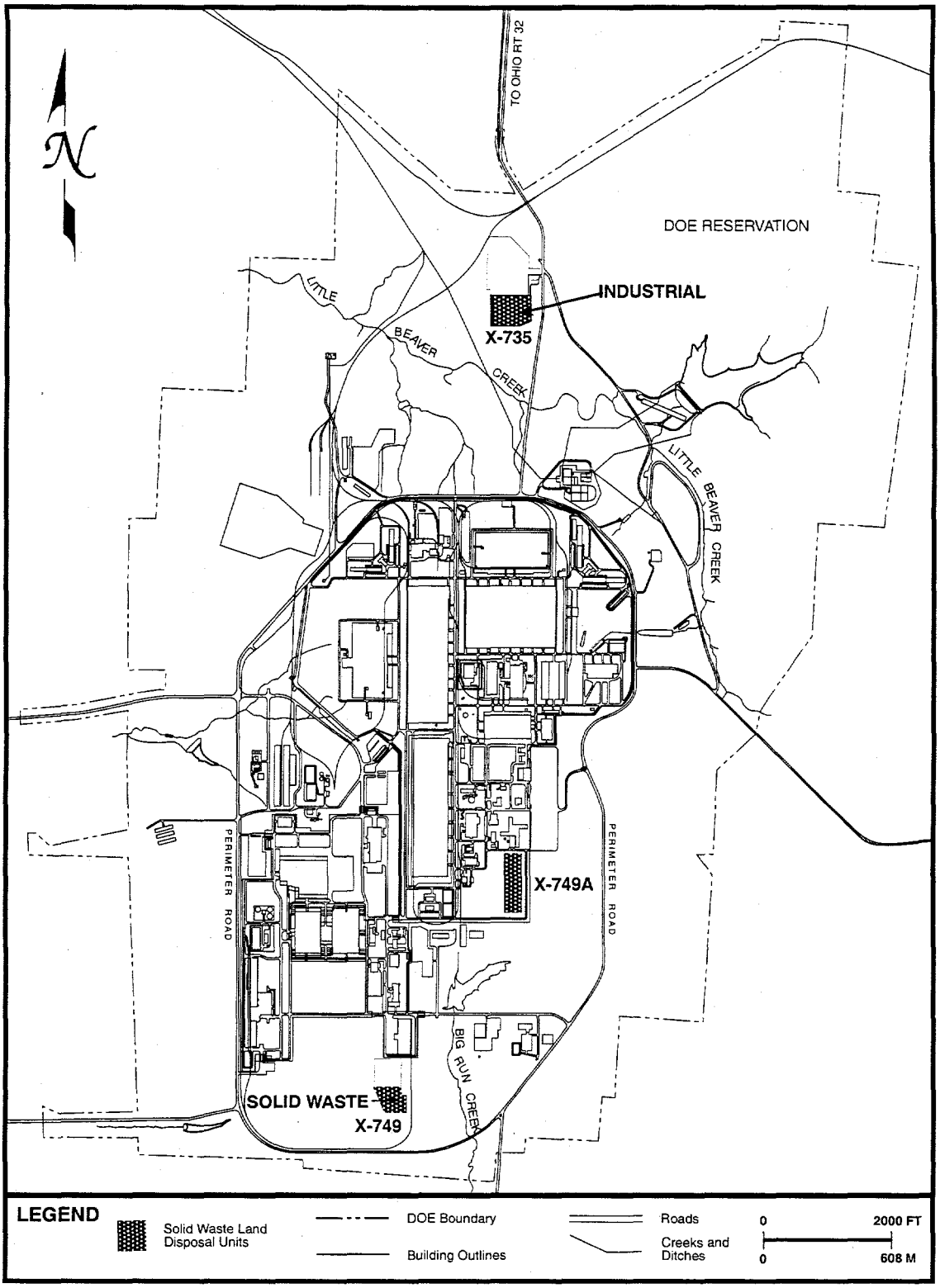



**FIG. 6.2. Solid waste land disposal unit locations at DOE/PORTS.**

and DOE. In general, all of the monitoring wells at DOE/PORTS, with the exception of a few bedrock wells, are completed in the Gallia sand, just above bedrock, an average depth of 35 ft.

The surveillance monitoring program at DOE/PORTS consists of perimeter exit pathway monitoring, off-site sampling, water supply well field sampling, and baseline monitoring. The purpose of perimeter exit pathway monitoring is to assess the effect of DOE/PORTS on regional groundwater quality and quantity. The off-site sampling and DOE/PORTS water supply well field sampling provide information to document any effect of DOE/PORTS operations on nearby residential and public water supplies. Baseline monitoring is conducted to establish background data for use in assessing the effect of DOE/PORTS operations on the groundwater. In addition, a one-time sampling event was conducted in 1994 to determine the background metals concentration. The results were used to establish upper tolerance limits for total mobile metals in the Gallia and Berea groundwater. Upper tolerance limits represent the maximum concentration of naturally occurring constituents that could be expected.

The closures for several units at PORTS are to be integrated into the RCRA corrective actions process, as defined in Section 3, "Environmental Programs." Future groundwater monitoring requirements for these units will be addressed in the Integrated Groundwater Monitoring Plan upon issuance of a Director's Findings and Orders.

Detection monitoring is being performed at three units: (1) the X-701C neutralization pit, (2) the X-735 RCRA landfill (northern portion), and (3) the X-735 industrial solid waste landfill (southern portion). Assessment monitoring is being performed at five units: (1) the X-231B southwest oil biodegradation plot, (2) the X-616 chromium sludge surface impoundments, (3) the X-701B holding pond, (4) the X-749 north contaminated materials storage yard, and (5) the X-749A classified materials disposal facility. An assessment sampling event was also conducted at the X-735 industrial solid waste landfill independently of the detection monitoring program in August 1997.

## SOLID WASTE UNITS

### X-735 Industrial Solid Waste Landfill

The X-735 industrial solid waste landfill was licensed by the state of Ohio for the disposal of industrial solid waste generated by activities at DOE/PORTS. Initially, a total of 17.9 acres was approved for disposal by the Ohio EPA and the Pike County Health Department; however, an investigation conducted by DOE/PORTS indicated that wipe rags contaminated with solvents had inadvertently been disposed in cells one through six. Therefore, the northern portion of the landfill was closed as a RCRA hazardous waste landfill and is referenced in the "RCRA Units" section of this chapter. The remaining three cells, A through C, continued to be regulated by the solid waste regulations and operated until December 31, 1997. The Director's Findings and Orders issued to DOE/PORTS on January 30, 1997, requires closure of the facility to be completed in 1998.

In the southern area of X-735, groundwater flow direction is toward the southwest. The calculated hydraulic conductivity in the Gallia sand ranges from a high of 1,440 ft/day to a low of 4.3 ft/day. The groundwater flow velocity, using the arithmetic mean hydraulic conductivity value of 430 ft/day, ranges from 1.7 ft/day to 3.4 ft/day.

Thirteen groundwater monitoring wells were installed around the entire facility, including both the RCRA and the industrial solid waste landfill. Five of those wells, surrounding the southern part of the facility, are used for semiannual detection monitoring for the industrial solid waste landfill (Fig. 6.3). Two of the five wells are also included in the monitoring program for the RCRA portion of the landfill. Statistical analysis of reported sampling results from calendar year 1996 indicated a need to conduct assessment monitoring in

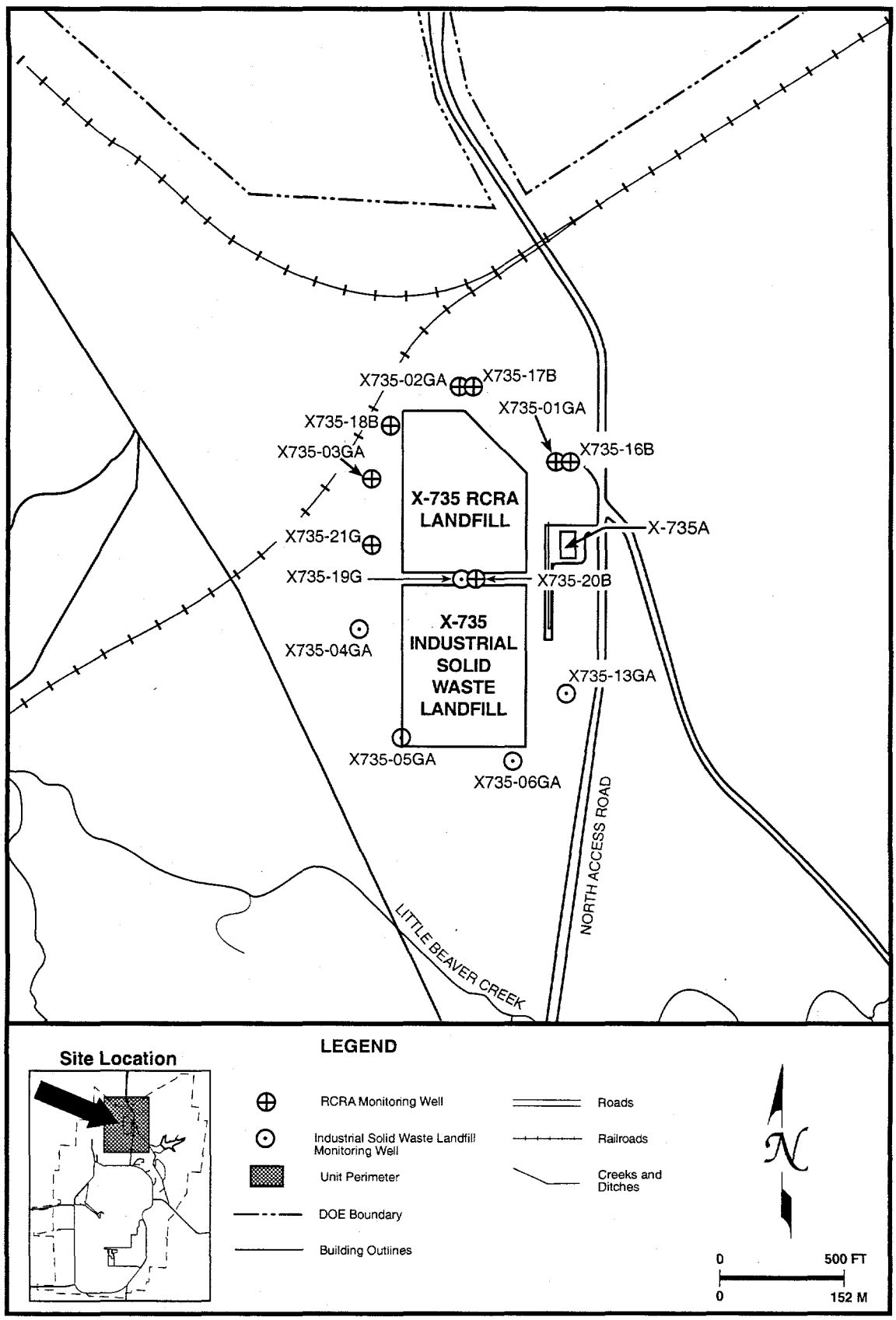



**Fig. 6.3. X-735 landfill monitoring well locations.**

August 1997 in addition to the detection monitoring. No volatile organic compounds or radiological analytes were detected. Several inorganics were detected in both upgradient and downgradient wells, indicating that the groundwater quality has not been impacted.

## X-749A Classified Materials Disposal Facility

The six-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 polychlorinated biphenyls, asbestos, radionuclides, and industrial waste. Closure of the unit, 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.

Groundwater at the site generally flows to the southeast toward Big Run Creek, and the calibrated hydraulic conductivity for the Minford and Gallia sand in the vicinity of the unit is 0.73 ft/day and 34 ft/day, respectively. The Gallia sand in the area of X-749A is comprised of sand, rounded gravel, and weathered shale fragments that range in thickness from 0 to 5 ft. Sunbury shale under the unit is approximately 10 ft thick.

Sixteen groundwater monitoring wells have been installed at the facility (Fig. 6.4). Eleven of these wells were sampled quarterly during the first half of 1995 and semiannually thereafter, in accordance with the approved closure plan. Sampling results indicate that the X-749A is not a source of contamination for the five-unit investigative area of the Quadrant I RCRA facility investigation groundwater plume. A groundwater quality assessment plan was developed due to a statistically significant difference in the pH level in one downgradient well compared to upgradient wells. Results from the assessment monitoring did not indicate the release of leachate or leachate-derived constituents to the groundwater from the X-749A; therefore, the Ohio EPA reinstated the detection monitoring program on December 11, 1997, for the second semester of 1997. Only two volatile organic compounds, dichloroethene (cis-1,2 DCE) and trichloroethene, were detected in one upgradient well, and several inorganics were detected in both upgradient and downgradient wells. Therefore, there is no significant difference in the quality of groundwater upgradient or downgradient from the facility.

## X-749 Contaminated Materials Storage Yard (Southern Portion)

Operation of the X-749 contaminated disposal facility began in the 1950s, but no detailed records of the waste disposed at the unit were kept until 1976. The facility was closed in accordance with RCRA requirements; however, a closure plan for the southern portion of this unit was prepared in accordance with the solid waste regulations based on historical information about the types of wastes placed in the southern portion of the unit. The closure plan for the southern portion was approved on July 17, 1991. Closure of both units occurred concurrently and was completed in 1994 in accordance with both approved closure plans. Because a groundwater contaminant plume underlies both portions, the X-749 is considered a single unit for the purposes of groundwater monitoring. Thus, in this document, the term "X-749" refers to the entire unit, including the north and south portions, and is discussed in the "RCRA Units" section of this chapter.

# RCRA UNITS

## X-231B Southwest Oil Biodegradation Plot

The X-231B southwest oil biodegradation plot, used from 1976 to 1983 for land application of waste oils and degreasing solvents, consists of two disposal plots, each surrounded by an elevated soil berm. The

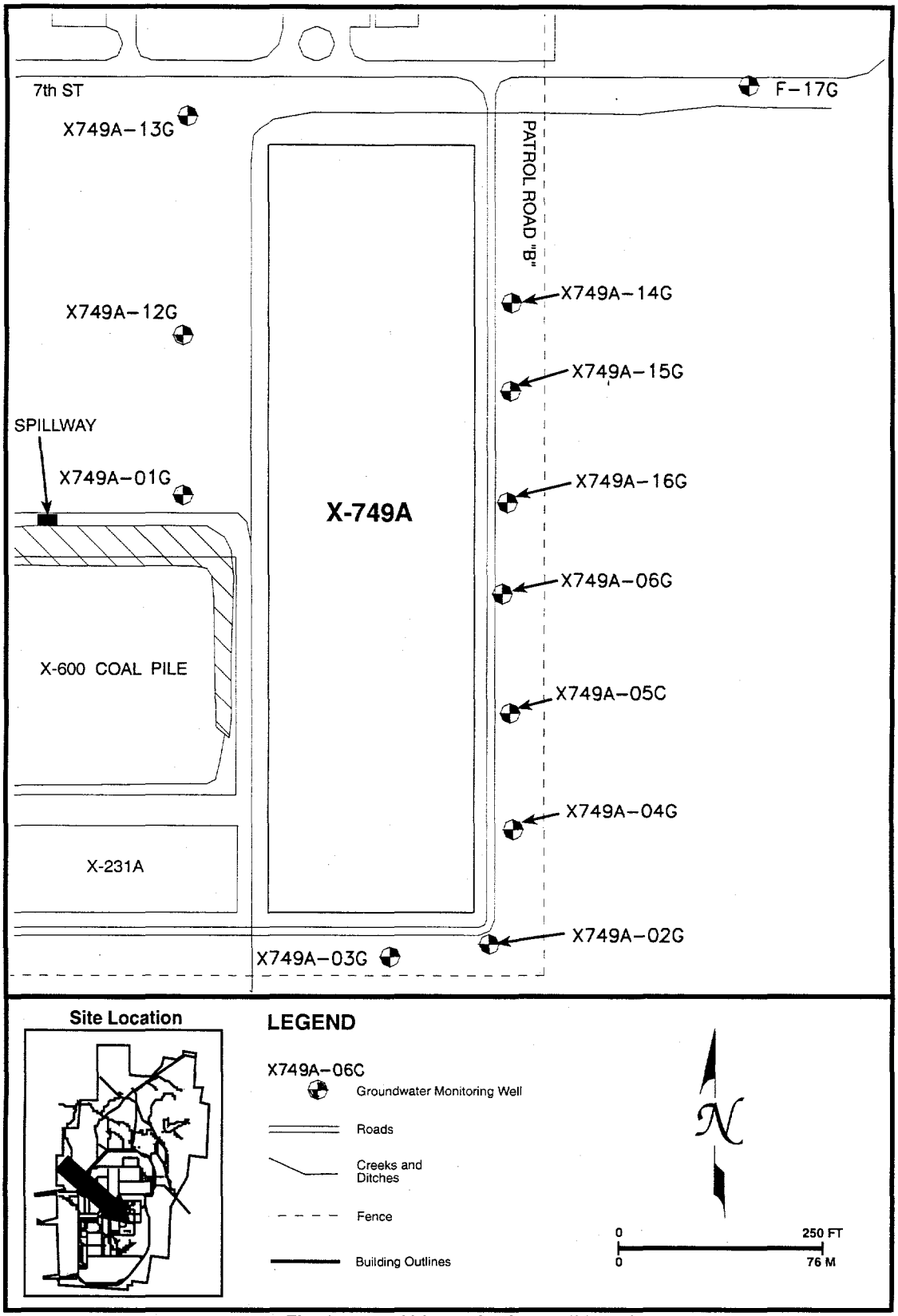



**Fig. 6.4. X-749A monitoring well locations.**

plots were periodically fertilized and tilled to enhance aeration and promote natural biological degradation of waste oil. Since ceasing operation in 1983, these plots have been remediated to remove volatile organic compound contamination present in the soil.

Groundwater in the Gallia in the vicinity of X-231B flows toward the south/southeast across the site. The average hydraulic gradient is 0.009 ft/day, with a flow velocity of 1.2 ft/day, and the hydraulic conductivity of the Gallia for the X-231B area is 62 ft/day. The assumed effective porosity for the Gallia is 25%. The Berea groundwater flow direction is similar to that of the overlying Gallia except that its gradient slopes more uniformly to the south/southeast. The hydraulic gradient for the Berea is consistently 0.007 ft/ft, the mean hydraulic conductivity is 1.4 ft/day, and a representative groundwater velocity is less than 0.1 ft/day.

The Quadrant I groundwater investigative area plume includes the X-231B unit. Although X-231B is the unit for which monitoring is required by RCRA, many additional wells in the area are used to determine the boundaries of the plume. The Quadrant I groundwater investigative area plume and the associated monitoring wells are depicted in Fig. 6.5.

Thirty-five monitoring wells were installed in the vicinity of the unit, 19 of which have been routinely sampled as part of the quarterly assessment monitoring program for this unit, and they have been analyzed for the parameters in Table 6.1. Assessment monitoring will continue until final closure and the initiation of post-closure monitoring. The most extensive and concentrated contaminant constituents at X-231B were volatile organic compounds, particularly trichloroethene and trichloroethane. See Fig. 6.6 for the five-year trend in trichloroethene concentrations at selected wells in the X-231B area. Other volatile organic compounds detected above maximum contaminant levels were dichloroethane (1,1-DCA), 1,1-DCE and cis-1,2-DCE. There were detections of inorganics, including cadmium, iron, and manganese. Uranium and technetium were also detected, but they were well below the proposed DOE/PORTS action level.

Three groundwater extraction wells were installed in the Gallia sand 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 unit. The extracted groundwater is treated by activated carbon filters at the X-622 south groundwater treatment facility. Assessment monitoring results indicate that the three extraction wells are locally reducing volatile organic compound concentrations in the existing groundwater contaminant plume. In 1994, the X-231B vadose zone was remediated using *in situ* thermal enhanced vapor extraction to remove volatile organic compounds. The process utilized an 8-ft diameter auger to mix the vadose soils, and heated air was injected into the soils. The offgas was collected in a 12-ft diameter shroud and transferred to a carbon absorption filter. Approximately 80% of the volatile organic compounds present in the vadose zone were removed by this treatment. An interim cap has been installed over the unit until final closure can be completed.

## X-616 Chromium Sludge Surface Impoundments

The X-616 liquid effluent control facility consisted of two unlined surface impoundments that were used from 1976 to 1985 for storage of sludge generated by the treatment of recirculating cooling water blowdown from the PORTS process cooling system. A hexavalent chromium-based corrosion inhibitor was used in the cooling water system. The chromium in the blowdown was reduced to a trivalent chromium at the X-616 liquid effluent control facility by adding sulfur dioxide to the water, which produced sulfurous acid ($H_2SO_3$). The resulting chromium hydroxide sludge was then precipitated in a clarifier by pH adjustment with slaked lime and a polymer coagulant. The sludge was then pumped into and stored in the X-616 impoundments.

Groundwater flow in the Gallia near X-616 is predominantly west and northwest toward the west drainage ditch. The reported hydraulic conductivity for the Gallia is 36.7 ft/day. Effective porosity is assumed to be 25%. The average hydraulic gradient is approximately 0.015 ft/ft, with a velocity of about 2.1 ft/day.

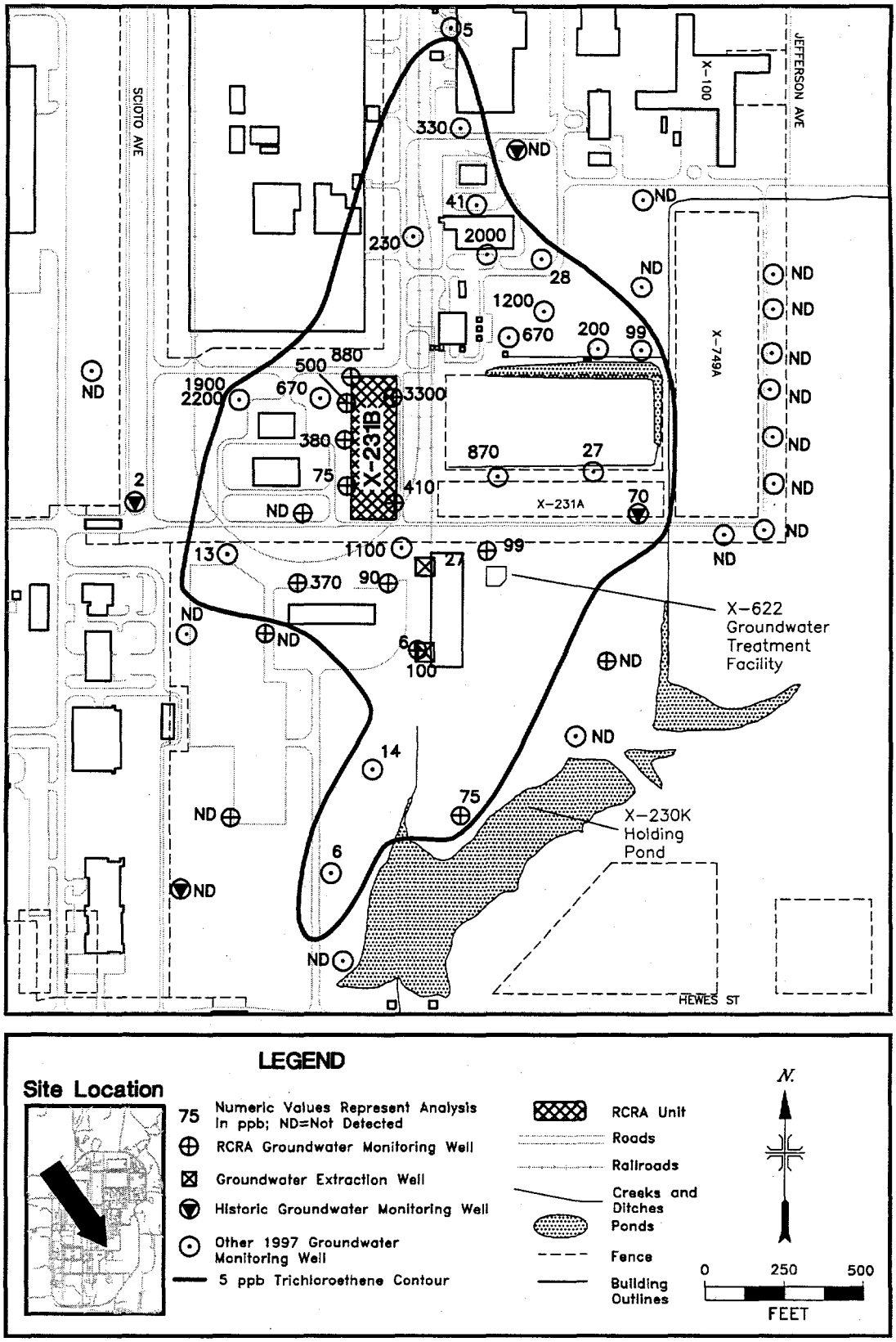



**Fig. 6.5 X-231B southwest oil biodegradation plot Gallia groundwater trichloroethene plume fourth quarter, 1997.**

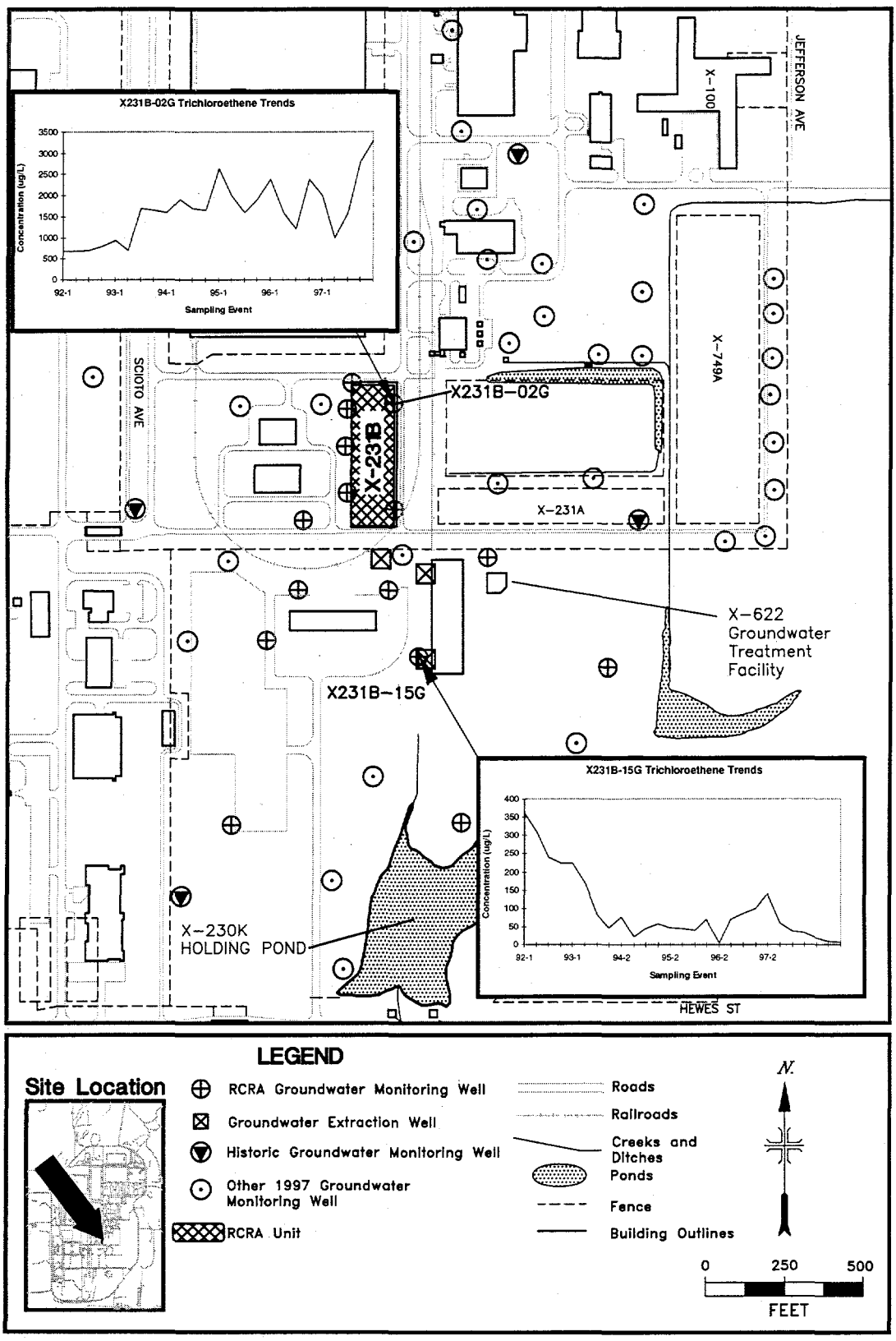



**Fig. 6.6 X-231B southwest oil biodegradation trends in trichloroethene concentrations at selected wells.**

Groundwater flow in the Berea is primarily to the northwest. The Berea's hydraulic conductivity is about 7.5 ft/day. Because the Sunbury shale is absent at X-616, the Gallia and Berea are in direct hydrologic communication.

Twenty-eight wells were installed in the vicinity of the X-616, 15 of which are sampled semiannually in accordance with the post-closure plan. Chromium, both dissolved and total, is the primary contaminant of concern. Only one well exceeded the preliminary remediation goal for total chromium. Chromium was not detected in any other well at X-616. The only significant volatile organic compound detected in 1997 was trichloroethene, which exceeded the maximum contaminant level in only one well (Fig. 6.7). Metals were also monitored for levels in excess of their maximum contaminant levels. Iron and manganese, common rock- and soil-forming elements, were detected in both filtered and unfiltered samples in only two wells. In general, low sample turbidities, which were improved through the use of dedicated bladder pumps and low-flow sampling techniques, correlated with low metals results.

The sludge was removed from the impoundments and remediated as an interim action in 1990 and 1991. The unit was certified closed in 1993 and is in post-closure care.

## X-701B Holding Pond

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. Degreasing solvents, including trichloroethane and trichloroethene, were also discharged to the pond. Two sludge retention basins were located west of the holding pond. The contaminated groundwater plume extends from the holding pond to Little Beaver Creek (Fig. 6.8).

Groundwater in the Gallia flows eastward toward Little Beaver Creek, and the flow converges from both the north and the south, forcing a narrowing of flow. The measured hydraulic conductivities for the Gallia range two orders of magnitude from 0.5 ft/day to 57.5 ft/day. There are two distinct hydraulic gradients. The steeper hydraulic gradient is near the X-237 trench and X-230J7 pond. Groundwater in the Berea flows across the site from the west to east toward Little Beaver Creek. The eastward-dipping Berea unit is confined due to the overlying Sunbury shale, which ranges from 10 to 15 ft in thickness across X-701B. The mean hydraulic conductivity for the Berea sandstone is 2.5 ft/day.

Several groundwater investigations have occurred at this unit and have included the installation of 92 groundwater monitoring wells. Thirty of these wells have been selected for quarterly assessment sampling at this unit. Twenty-seven Gallia wells and three Berea sandstone wells were analyzed for parameters listed in Table 6.1. Laboratory analyses of the groundwater samples identified trichloroethene concentrations in 13 Gallia wells that exceeded the maximum contaminant level of 5 µg/L. The past five-year trend in trichloroethene concentrations at two selected X-701B wells is shown in Fig. 6.9. Other volatile organic compounds that were detected at concentrations exceeding their maximum contaminant levels were dichloroethene (cis-1,2-DCE) in six wells and vinyl chloride in one well. No volatile organic compounds were detected in the Berea wells, with the exception of xylenes, a naturally occurring petroleum constituent, in one well. Berea sandstone is a proven producer of petroleum to the east (downdip) of PORTS. Chloride was also detected in the same well, which is common in the Berea where petroleum is present. No volatile organic compounds were detected in the monitoring wells sampled north of the plume area or at any of the Little Beaver Creek sampling locations. Iron and nickel were detected at concentrations above their secondary maximum contaminant levels of 300 and 100 µg/L, respectively. Dissolved iron detections were inconsistent, with only one or two of the quarterly samples from a given well exceeding the secondary maximum contaminant level. By comparison, dissolved iron has been detected at concentrations as high as 29,000 µg/L in background water samples from the PORTS facility. Dissolved nickel was detected only once in one well.

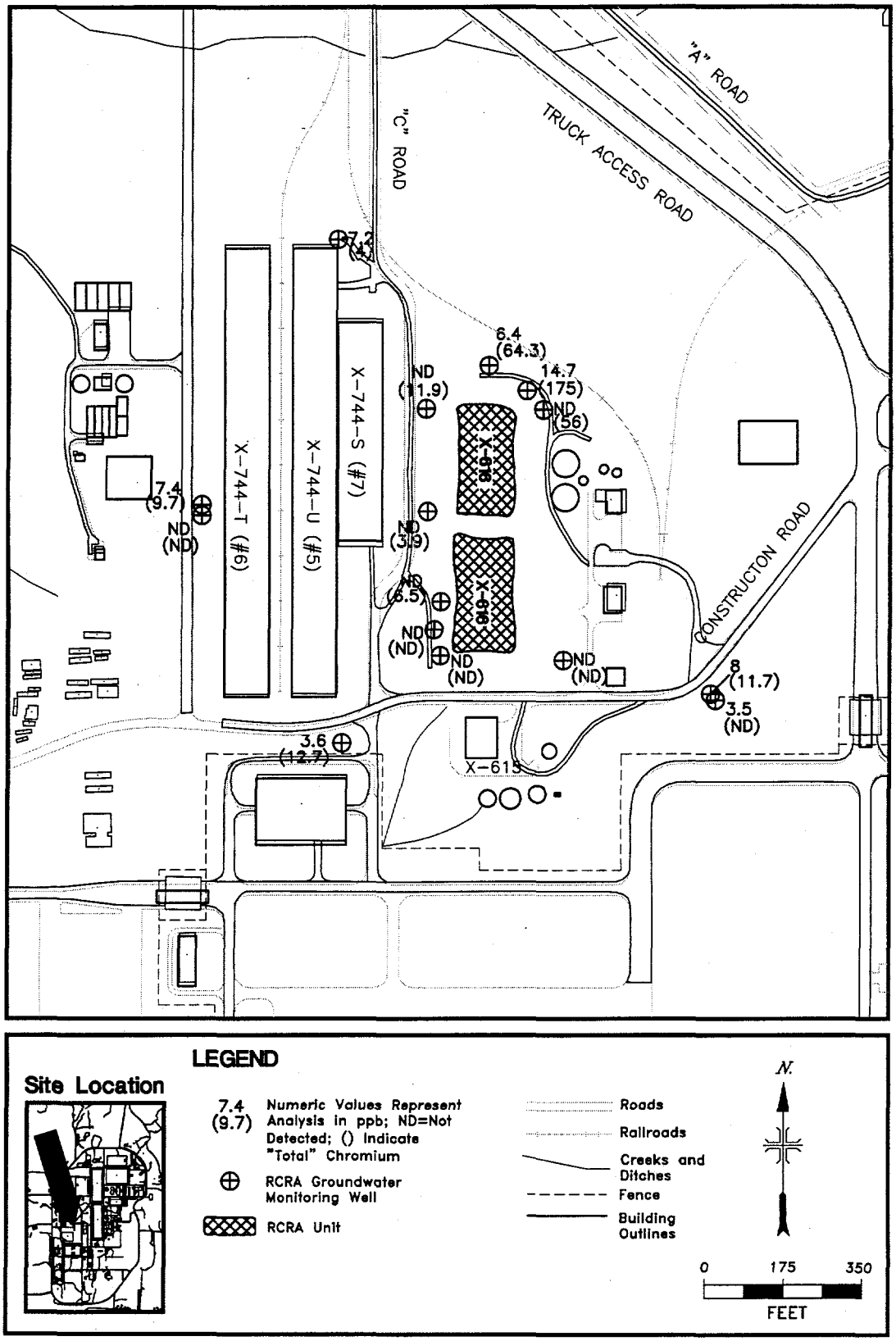



**Fig. 6.7 X-616 chromium sludge surface impoundments groundwater dissolved chromium results second semester, 1997.**

Technetium was detected in nine Gallia wells at levels far below the comparison value of 3,790 pCi/L. No technetium was detected in the Berea wells. Uranium was not detected in any of the monitoring wells in the X-701B area.

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.

## X-701C Neutralization Pit

The X-701C unit consists of a neutralization pit and a pump pit. The neutralization pit is 18 ft deep and has horizontal dimensions of 25 ft by 25 ft. The floors and walls are constructed of concrete and are lined with acid-proof brick. A sump in the bottom of the neutralization pit formerly discharged into an adjacent pump pit. The concrete pump pit is 9 ft deep and covers approximately 81 square ft. This unit is currently undergoing closure integration with the RCRA corrective action process.

Groundwater flow in the vicinity of the X-701C is to the west toward the X-700 building. The hydraulic gradient is induced by means of sump pumps in the X-700 and X-705 buildings. A local cone of depression has been established around these buildings. This is a local reversal of the natural hydraulic gradient; typically, the natural hydraulic gradient is to the east toward Little Beaver Creek. The 1997 hydraulic gradient for the X-701C site ranged from 0.011 ft/ft to 0.015 ft/ft. The Gallia effective porosity is assumed to be 25%. Using these values, the average linear velocities ranged from 1.5 ft/day to 2.3 ft/day. The hydraulic conductivity is 36.8 ft/day.

Detection monitoring at X-701C is conducted semiannually and utilizes the three existing wells installed into the Gallia sand. Data was analyzed for parameters listed in Table 6.1. The statistical analysis of indicator parameters was performed, and the contaminant concentration was higher in the upgradient well than it was in the downgradient and sidegradient wells. Trichloroethene was detected in all three monitoring wells, with the highest concentrations occurring in the upgradient well. Dissolved manganese was detected in two wells at levels above the secondary maximum contaminant level of 50 µg/L. None of the other inorganic analytes exceeded maximum contaminant levels or secondary maximum contaminant levels. Neither uranium nor technetium was detected above action levels.

The X-701C neutralization pit is located within a trichloroethene plume, known as the Quadrant II groundwater investigative area plume, centered around the X-700 chemical cleaning facility and the X-705 decontamination building. The extent of the plume (Fig. 6.10), formerly referred to as the seven-unit plume, has been determined by monitoring several wells in the surrounding areas. The Ohio EPA directed DOE/PORTS to conduct detection monitoring to determine whether the X-701C neutralization pit has been releasing hazardous wastes or hazardous constituents into the groundwater. The detection monitoring plan is not typical because of the size of X-701C and its location in the seven-unit plume. If the X-701C is determined to be a source of contamination, the pit will be removed.

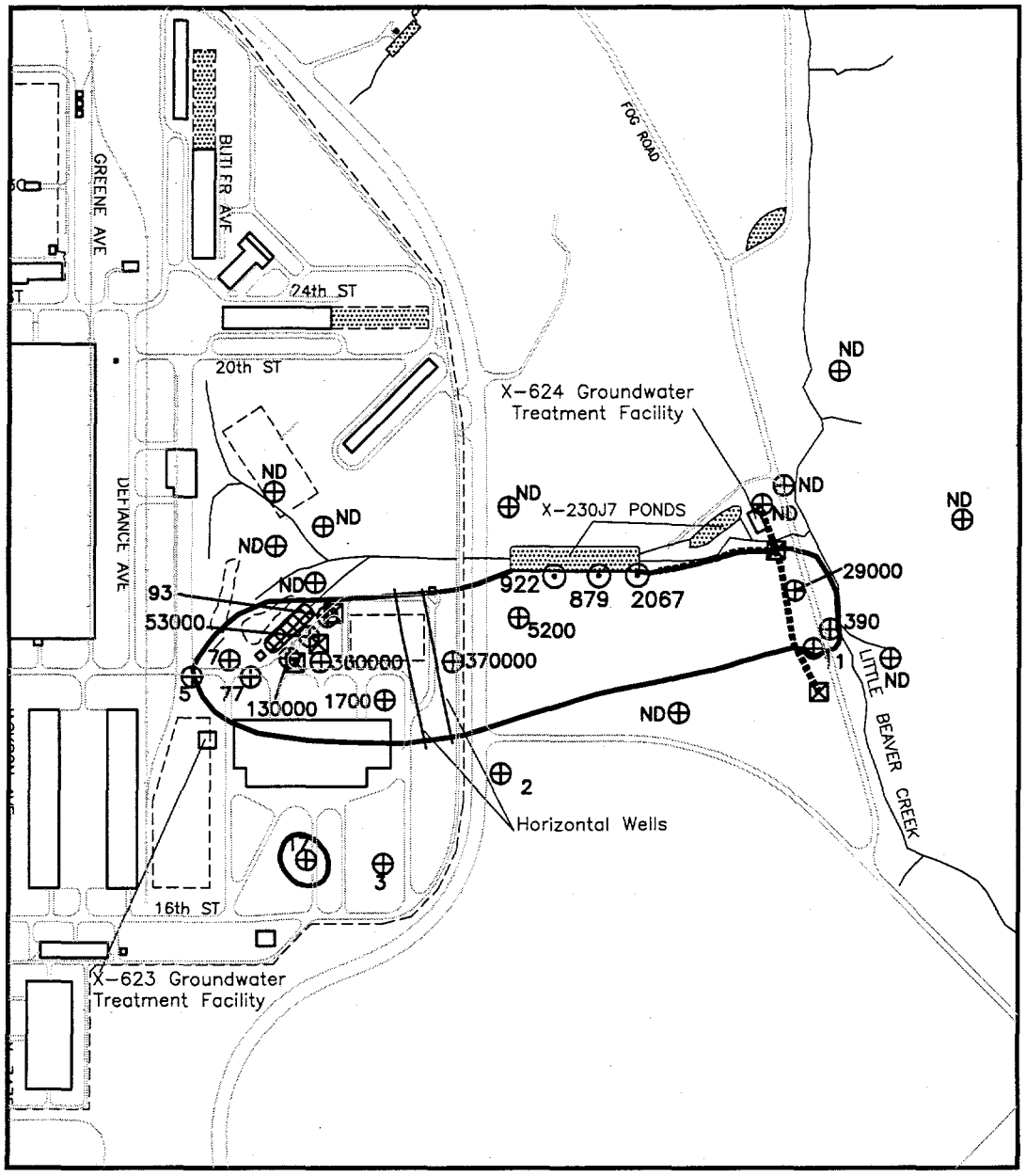



**Fig 6.8 X-701B holding pond Gallia groundwater trichloroethene plume fourth quarter, 1997**

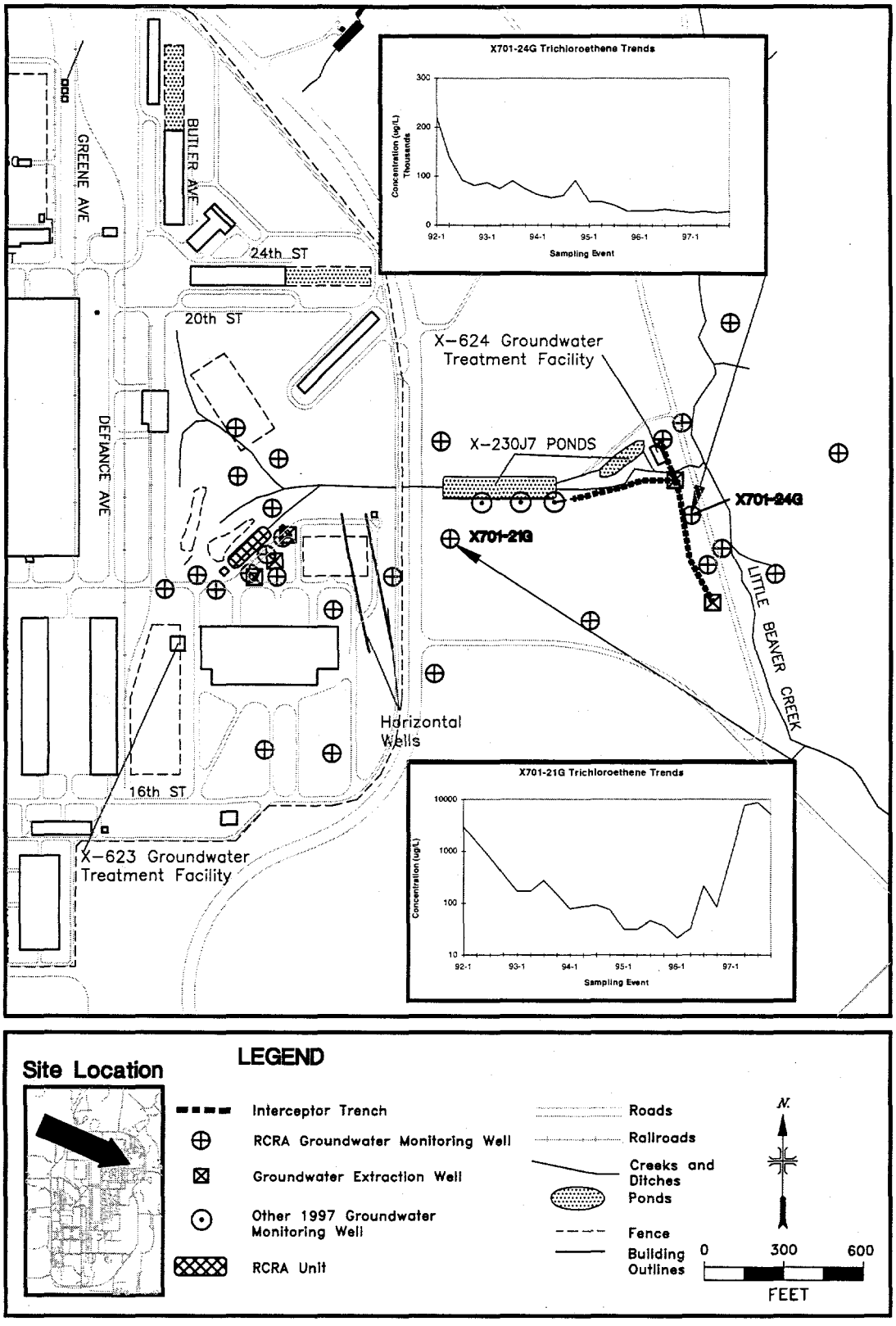



**Fig 6.9 X-701B holding pond trends in trichloroethene concentrations at selected wells.**

## X-735 RCRA Landfill (Northern Portion)

The X-735 landfill, located at the northern end of the Portsmouth reservation, began operation in September 1981. The unit was approved by the Ohio EPA and the Pike County Health Department for disposal of nonhazardous, nonradioactive solid wastes. In 1991, wipe rags potentially contaminated with solvents were inadvertently disposed in cells one through six at the northern end of the landfill. This portion of X-735 was subsequently closed as a RCRA (Subtitle C) landfill. The southern portion of X-735, which is the industrial solid waste facility (Fig. 6.3), ceased operations on December 31, 1997. Closure of the industrial solid waste landfill will commence under the solid waste regulations.

In the vicinity of the X-735, groundwater flow in the Gallia is generally east to west; however, the very low potentiometric surface gradient results in flow direction fluctuations. Little Beaver Creek to the south and a tributary of Little Beaver Creek to the west of X-735 locally influence the direction of groundwater flow in the northern and southern parts of the landfill area. In the northern portion, groundwater flow is toward the west and northwest. The representative east-west hydraulic gradient was 0.001 ft/ft for the sampling events in 1997. The hydraulic conductivity ranges from 1440 ft/day to 4.3 ft/day. The arithmetic mean hydraulic conductivity value of 430 ft/day is used in determining groundwater flow velocity for the Gallia. The effective porosity for the Gallia is assumed to be 25%. These values yield a groundwater flow rate range of 3.5 ft/day to 6.3 ft/day. The representative east-west hydraulic gradient for the Berea at X-735 ranged from 0.001 ft/ft to 0.002 ft/ft. The potentiometric head in the Gallia and Berea are about the same in the northern portion and eastern side of the landfill. However, a slight upward vertical gradient from the Berea sandstone into the Gallia sand is indicated in wells south of the X-735 RCRA landfill.

Ten wells, two of which are also included in the monitoring program for the industrial solid waste landfill, are sampled quarterly for detection monitoring at the X-735 RCRA landfill and are analyzed for the parameters listed in Table 6.1. Dedicated bladder pumps and low-flow sampling techniques were used to collect samples in 1997. Trichloroethene was detected in one well for the third-quarter sampling event; however, trichloroethene was not detected in the fourth-quarter sampling event for this well. This was the only sampling event within the past five years in which trichloroethene was detected. Trichloroethene was the only volatile organic compound detected at any X-735 well in 1997. Samples containing rock- and soil-forming elements such as iron, manganese, and zinc exceeded the secondary maximum contaminant level or maximum contaminant levels most frequently in three wells. Background upper-tolerance limits defined in the X-735 Closure/Post-closure Plan for arsenic, barium, cadmium, chromium, and lead were not exceeded in any of the X-735 wells. Background upper tolerance limits for mercury, selenium, and silver were not determined because the results for these analytes were typically below detection limits.

## X-749 Contaminated Materials Storage Yard (Northern Portion)

The X-749 contaminated materials storage yard is located in the south central area of the site. This landfill, covering approximately 7.5 acres, was built in an area of highest elevation within the southern half of the facility. During operation of the landfill from 1955 through 1990, buried wastes were generally contained in metal drums or other compatible containers. The landfill was divided into northern and southern portions. The northern portion, measuring approximately 200,000 square ft, contains waste contaminated with industrial solvents, waste oils from plant compressors and pumps, and hazardous and low-level radioactive sludges. The northern portion was closed in accordance with RCRA Subtitle C requirements. The southern portion is approximately 130,000 square ft and contains nonhazardous, low-level fixed, and possibly transferable radioactive scrap materials. Because a groundwater contaminant plume (Fig. 6.11) underlies both portions, which are adjacent and were closed simultaneously, the X-749 is considered a single unit for the purposes of groundwater monitoring.

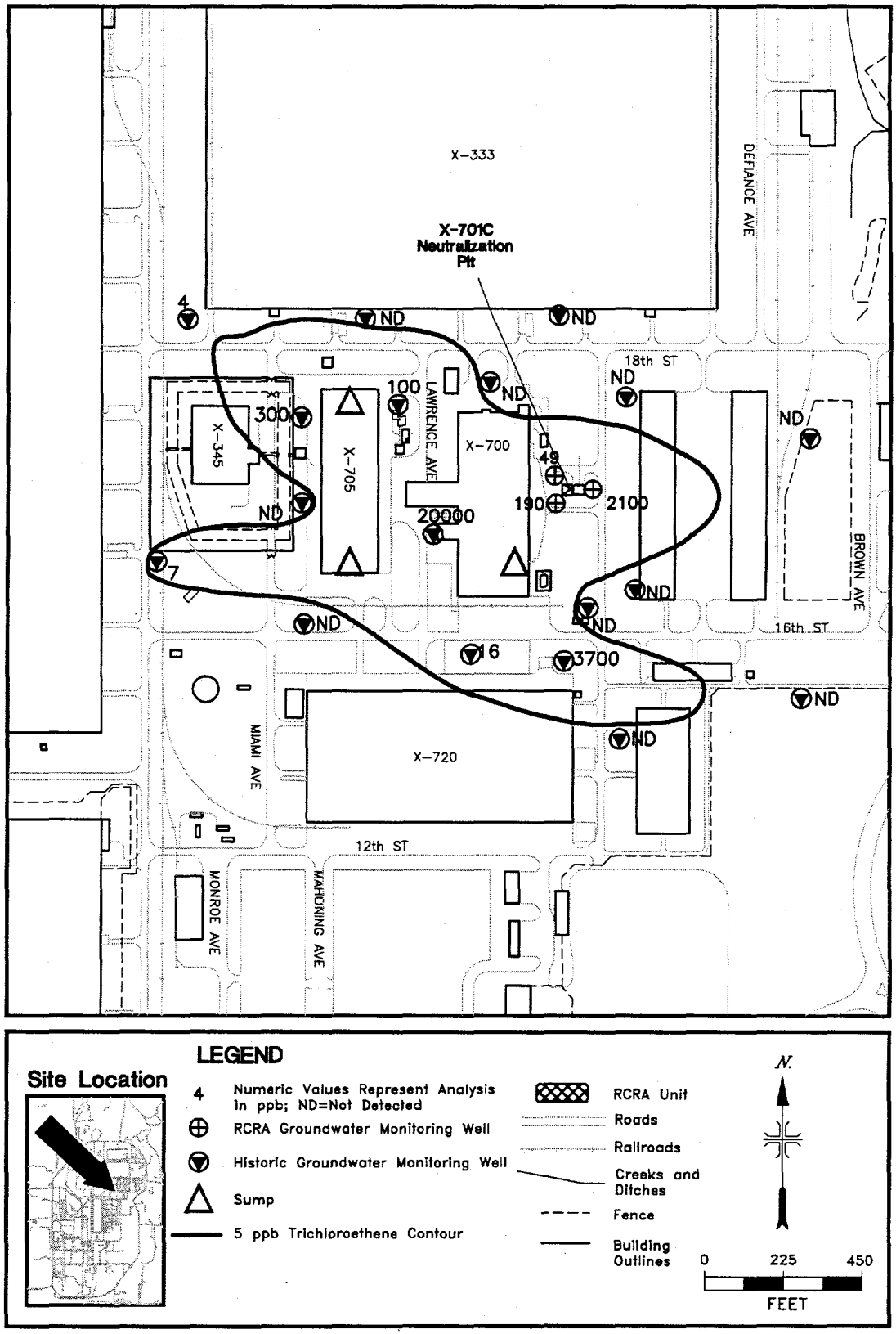



**FIG 6.10 X-701C neutralization pit Gallia groundwater trichloroethene plume second semester, 1997.**

The X-749 area contains three groundwater flow zones with three distinct hydraulic gradients: a steeper gradient to the east and more gradual gradients to the south and west. Hydraulic conductivities of 5.0 ft/day (east), 4.13 ft/day (west) and 6.0 ft/day (south) for these areas were used to calculate average linear velocities. The effective porosity is 30%. Eastern velocity values have increased from previous values. This increase may be related to a more accurate groundwater analysis using numerical modeling and/or the upgrading of the Peter Kiewit interceptor trenches during 1997. There are two distinct hydraulic gradients in the Berea; a steeper gradient to the east near Big Run Creek, and a more gradual gradient to the south and west. The hydraulic conductivity value is 1.0 ft/day for the Berea. The effective porosity is 10%. As expected, groundwater flow velocities in the Berea are lower than those recorded for the Gallia.

Three wells are being monitored quarterly according to the closure plan, and an additional 26 wells are being monitored semiannually to delineate the plume. A total of 61 wells have been installed in the area. The most extensive and most concentrated constituents at X-749 were volatile organic compounds, particularly trichloroethene and trichloroethane and their degradation products 1,2-DCA, 1,1-DCE, cis-1, 2-DCE, 1,2-DCA, and vinyl chloride. The recent five-year trend in trichloroethene concentrations at two X-749 wells is depicted in Fig. 6.12. Other volatile organic compounds detected were Freon-113 and chloroform. Chloride was detected at concentrations exceeding the secondary maximum contaminant level in one Berea well. Metals detected at concentrations exceeding maximum contaminant levels or secondary maximum contaminant levels included cadmium, chromium, and iron. Total chromium concentrations only exceeded the maximum contaminant levels at three wells. Uranium was detected at levels well below the comparison value, and no technetium activity measurements exceeded the proposed action level for PORTS groundwater.

The facility was closed in 1992 in accordance with RCRA requirements. Closure consisted of the installation of a multimedia cap, a slurry wall along the north side and northwest corner of the unit, subsurface groundwater drains on the northern half of the east side and southwest corner of the unit, and one groundwater extraction well within each of the drains. The groundwater collected by the extraction wells is pumped to the X-622 south groundwater treatment facility, which is an activated carbon filtration system. Field investigations in conjunction with the closure included 75 Geoprobe™ borings, 21 piezometer installations, two synoptic water level measurements, 27 slug tests, contiguous water level recording at three well clusters, 12 test pits, and two pumping tests. In 1994, an interim remedial measure subsurface diversion wall was completed across a portion of the facility's southern boundary to prevent plume migration off plant property prior to implementation of a final remedial measure.

## Groundwater Surveillance Monitoring

The surveillance monitoring program at DOE/PORTS consists of perimeter exit pathway monitoring, off-site water supply sampling, and baseline monitoring. Perimeter monitoring assesses the effect of the facility on regional groundwater quality and quantity. Off-site sampling and the PORTS water supply well field sampling provide information about any impact DOE/PORTS operations may have on the quality of the drinking water supply. Baseline monitoring is conducted to establish baseline data.

### Perimeter Exit Pathway Monitoring

Groundwater investigations have determined that the Gallia sand is the primary hydrogeologic unit for contaminant migration at DOE/PORTS. The Gallia sand is not a regionally persistent unit because of the topography on which it was deposited, as well as its depositional environment. Selected locations on local streams and drainage channels near the reservation boundary are sampling points of the surveillance monitoring program because groundwater discharges to these surface waters. Monitoring wells near the reservation

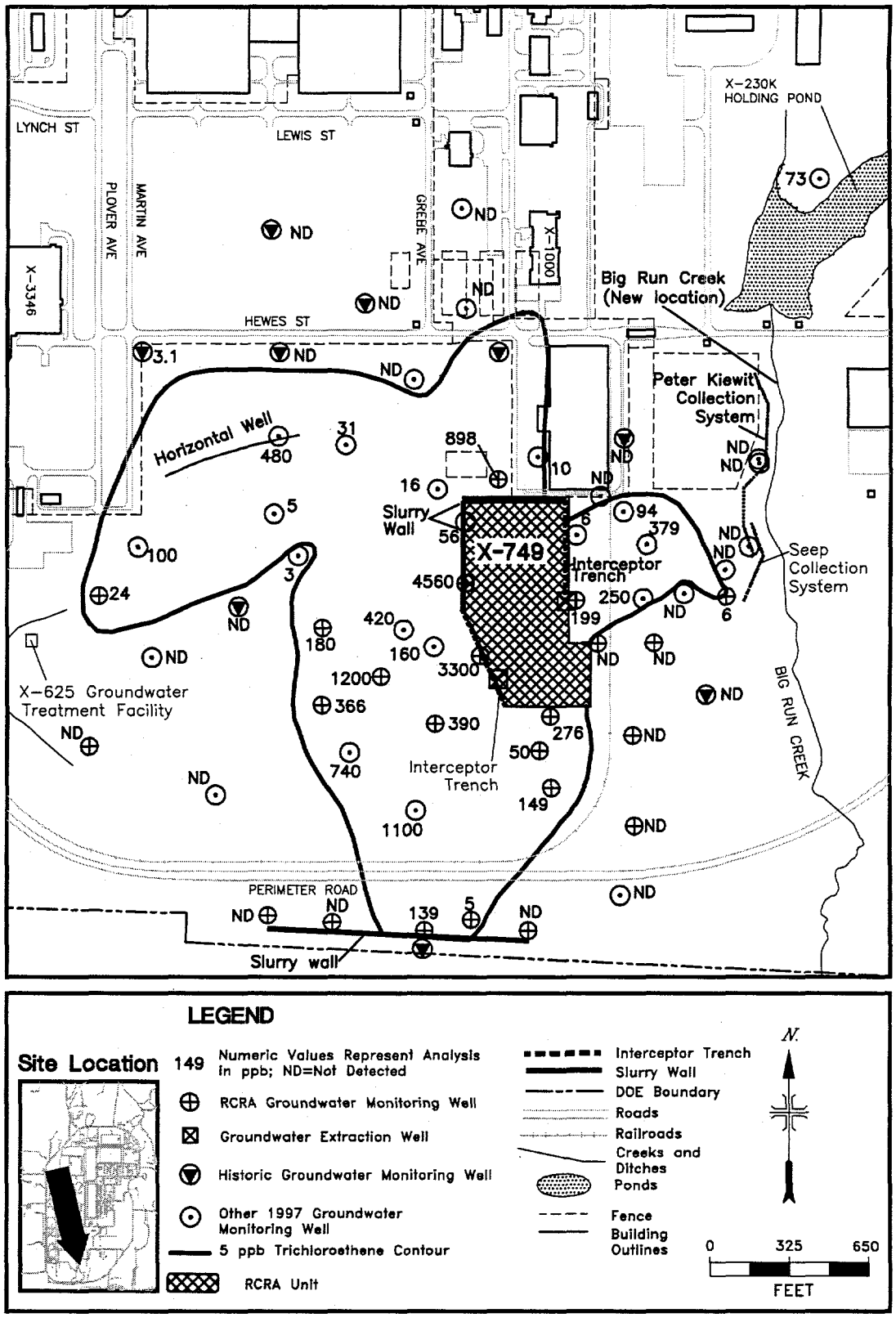



**Fig. 6.11 X-749 contaminated materials storage yard Gallia groundwater trichloroethene plume second semester, 1997**

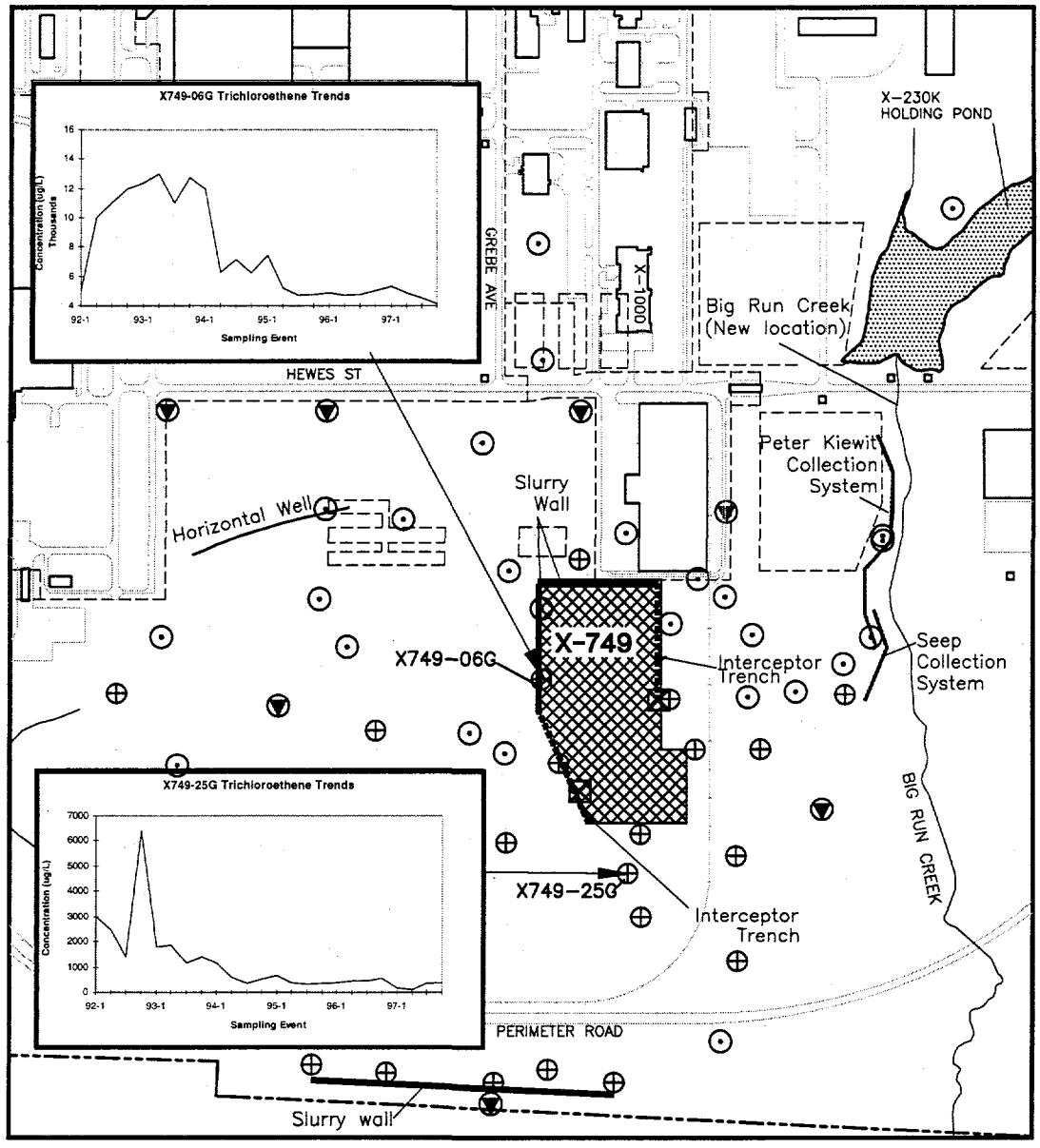



**Fig. 6.12 X-749 contaminated materials storage yard trends in trichloroethene concentrations at selected wells.**

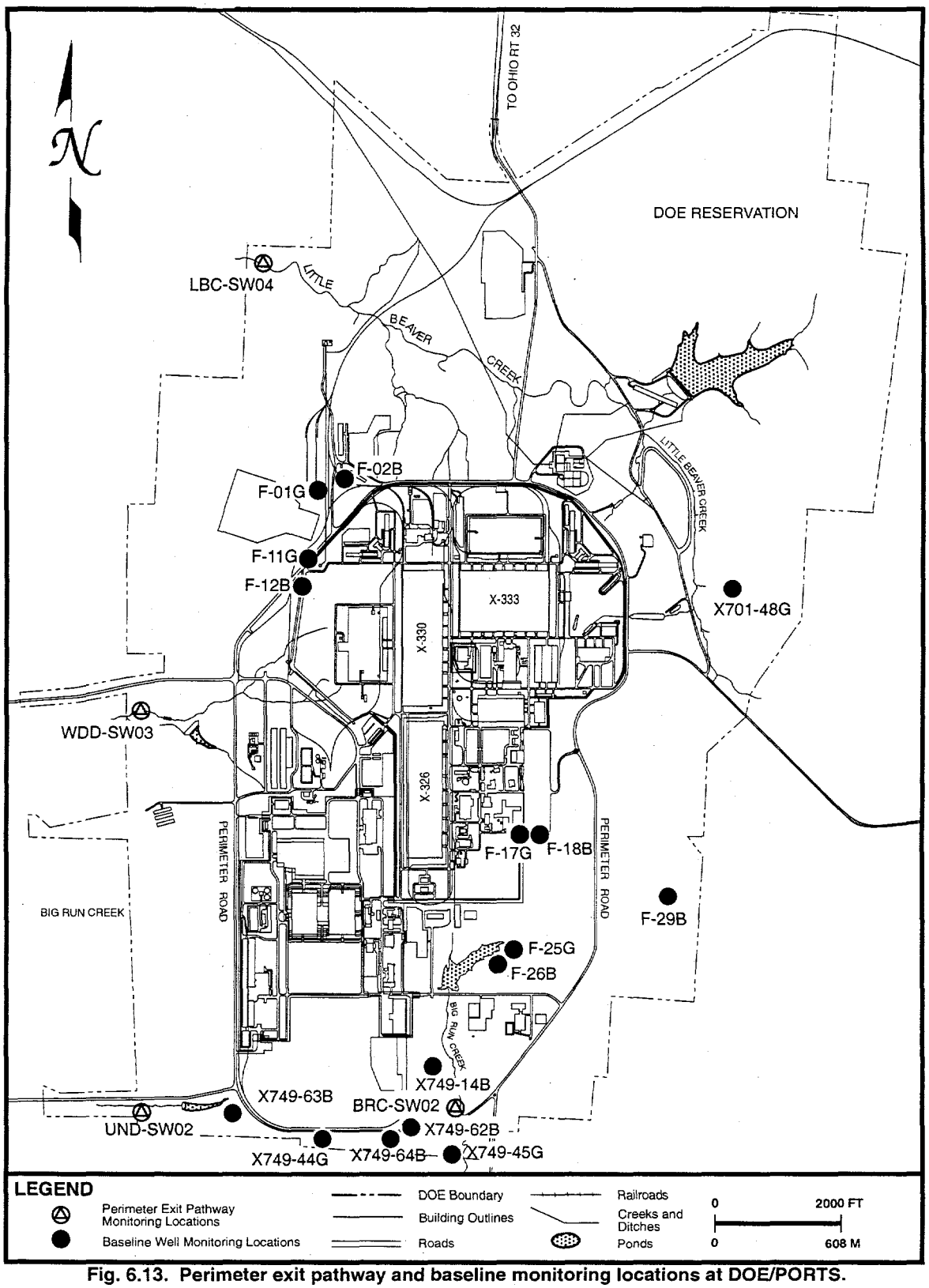



**Fig. 6.13. Perimeter exit pathway and baseline monitoring locations at DOE/PORTS.**

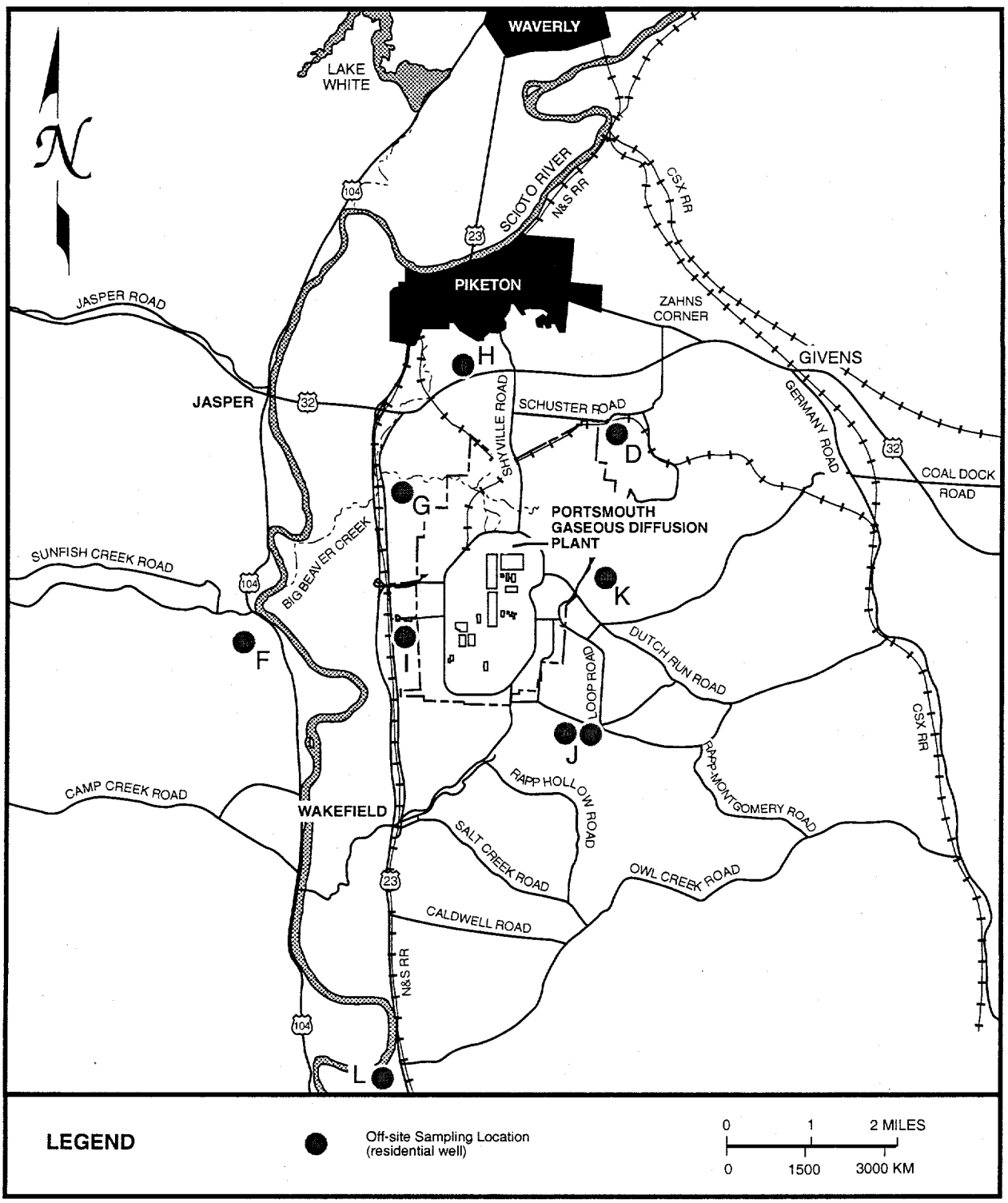



**Fig. 6.14. Portsmouth off-site sampling locations.**

boundary are also used in the surveillance monitoring program. Fig. 6.13 shows the sampling locations for exit pathway monitoring.

### Off-Site Sampling

The purpose of the off-site sampling program is to ensure that drinking water sources have not been adversely affected by DOE/PORTS 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 detecting contaminants and determining the rate and extent of contaminant movement. Because little is known about how residential wells were constructed and about the pumps used in residential wells, data from this program will not be used in hydrogeologic or geochemical investigations.

In 1997, six residents participated in the program (see Fig. 6.14 for sampling locations and Table 6.1 for the analytical parameters). All sampling for the residential program is conducted semiannually. Sampling locations are added or deleted at residents' requests and as program requirements dictate. Typically, sampling locations are deleted when a resident obtains access to the public water supply. Sampling locations are added on request and if there is a probable hydrogeologic connection between DOE/PORTS and a resident's water supply. Residential sampling to date indicates that DOE/PORTS is not affecting residential water supplies.

### Baseline Monitoring

Four well clusters, each composed of one well completed in the Gallia sand and one well completed in the Berea sandstone, are sampled semiannually to determine baseline water quality (Fig. 6.13). Sampling is conducted to support the RCRA permit applications and to provide a comparison between on-site wells and off-site background water. In 1997, no contaminants were detected in the baseline monitoring wells.

## RCRA Facility Investigations for Quadrants I-IV

The DOE/PORTS Consent Decree issued by the Ohio Attorney General's Office on August 29, 1989, and the Administrative Consent Order issued by USEPA Region V on September 29, 1989, outline requirements and schedules for the RCRA facility investigation.

Groundwater investigative activity is based on guidelines for a RCRA corrective action plan. However, because DOE/PORTS is large, complex, and resource-intensive, the plan was implemented in four parts called "quadrants." The quadrants divide the plant site into four geographic areas based roughly on groundwater divides and drainage patterns. These quadrants (QI, QII, QIII, and QIV) are identified in Fig. 6.15. Parallel efforts to provide comprehensive definitions of geology and the hydrologic flow systems provide cohesiveness to this four-part approach.

During the Quadrant I and Quadrant II RCRA facility investigations, 103 monitoring wells were installed, and 149 soil borings were drilled. A total of 34 solid waste management units was investigated, and the following units were identified as sources to the contaminated groundwater plumes: (1) the X-120 Goodyear training center (Figs. 6.11 and 6.12); (2) the X-231A southeast oil biodegradation plot (Figs. 6.5 and 6.6); (3) the X-710 neutralization pit, X-710 hot pit, and X-760 neutralization pit; and (4) the X-700 chemical cleaning facility, X-705 decontamination building, and X-720 maintenance and stores building (Fig. 6.10). The final Quadrant I and Quadrant II RCRA facility investigation reports were approved by the Ohio EPA and USEPA in September 1997.

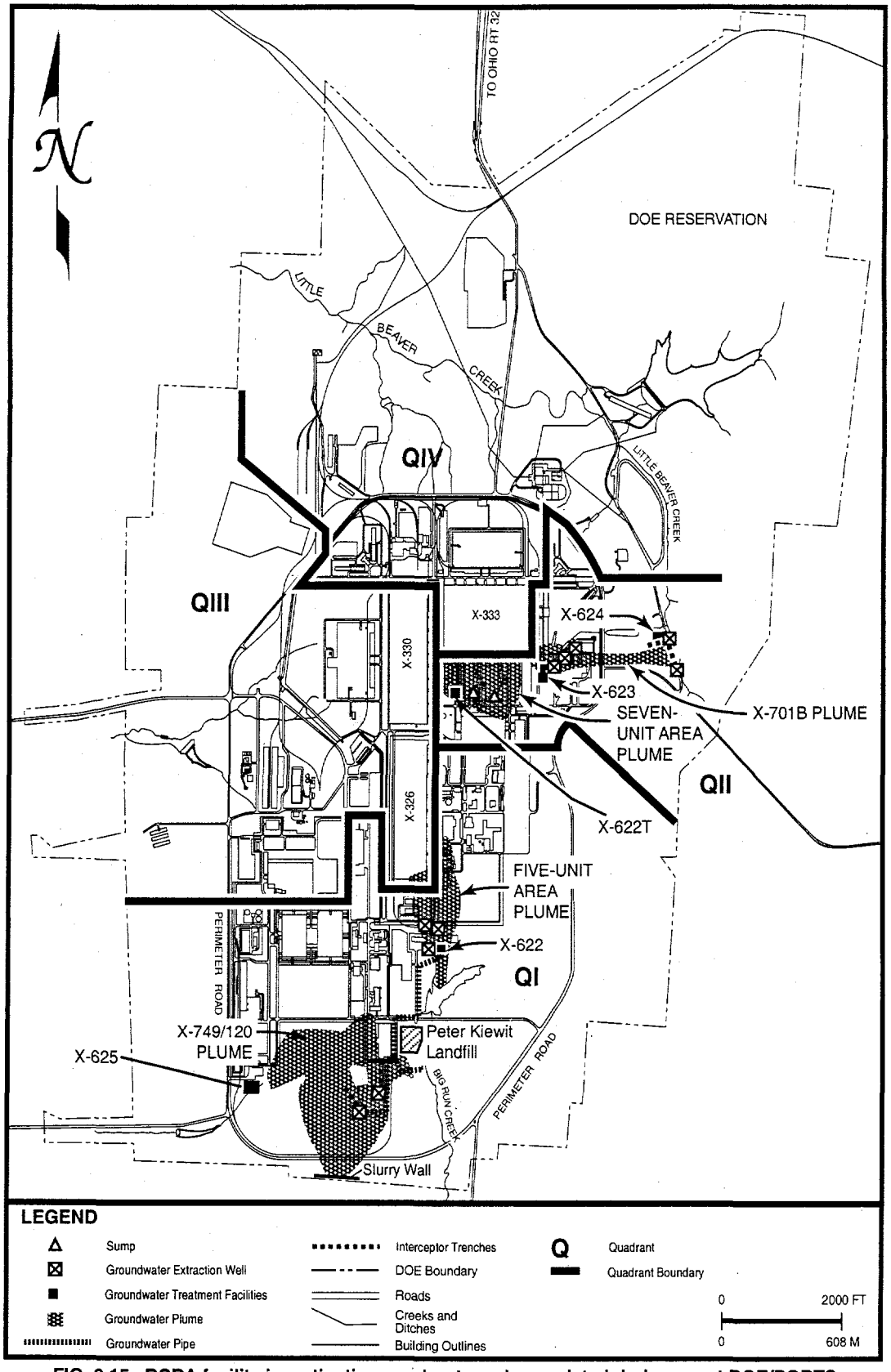



**FIG. 6.15. RCRA facility investigation quadrants and associated drainages at DOE/PORTS.**

A total of 18 solid waste management units was investigated in the Quadrant III RCRA facility investigation. As part of the investigation, 14 wells were installed, 44 soil borings and 93 hand augers were completed, 36 sediment samples were taken, and two surface water sampling sites were monitored. Additional sampling was completed in 1994 to support the RCRA facility investigation and the corrective measures study. The final Quadrant III RCRA facility investigation report was approved by the Ohio EPA and USEPA in September 1997.

A total of 24 solid waste management units was investigated in the Quadrant IV RCRA facility investigation. As part of this investigation, 49 wells were installed, 80 soil borings and 85 hand augers were completed, and 85 sediment samples were collected. Additional sampling was completed in 1994 to support the RCRA facility investigation and the corrective measures study. The final Quadrant IV RCRA facility investigation report was approved by the Ohio EPA and USEPA in September 1997.

## X-120 Goodyear Training Center

The X-120 Goodyear training center consisted of several utility and storage buildings that were used during construction of PORTS in the 1950s and were subsequently removed. The plume associated with the X-120 Goodyear training center consists of trichloroethene. Initially, this contamination was presumed to be associated with the X-749 contaminated materials disposal facility; however, results from the Quadrant I RCRA facility investigation indicated that the contamination is independent of the X-749 facility. The X-120 Goodyear training center contaminant plume is co-mingled with the X-749 contaminated materials disposal facility plume, and they are collectively referred to as the X-749/X-120 contaminated groundwater plume. The long and narrow trichloroethene contaminant plume associated with the X-120 facility originates south of Hewes Street and extends approximately 1,400 ft to the southwest (Fig. 6.11).

## X-231A Southeast Oil Biodegradation Plot

The plume associated with the X-231A southeast oil biodegradation area is composed of trichloroethene, trichloroethane, dichloroethene, and dichloroethane. All other contaminants are contained within the trichloroethene plume. The trichloroethene plume, which has a semicircular shape extending from the south side of X-231A area, is called the Quadrant I groundwater investigative area and is often referred to as the five-unit plume (Fig. 6.5).

## X-710 Neutralization Pit, X-710 Hot Pit, and X-760 Neutralization Pit

The plume associated with the X-710 neutralization pit, the X-710 hot pit, and the X-760 neutralization pit is composed mainly of trichloroethene, with minor amounts of trichloroethane and dichloroethene. Contaminants from these two units combine to form a single indistinguishable plume situated almost due south of the X-710 technical services building, under the X-600A coal pile yard, X-621 coal pile runoff treatment facility, and the X-749A classified materials disposal facility. The plume associated with these units is referred to as the Quadrant I groundwater investigative area, also known as the five-unit plume. The X-710 neutralization pit and the X-710 hot pit are both located just north of well X231B-36G. Volatile organic compound contamination was not detected in any Berea sandstone monitoring wells in this area.

### X-700 Facilities and Tanks, X-705 Decontamination Building, and X-720 Neutralization Pit

The plume associated with the X-700 chemical cleaning facility, X-700 chemical and petroleum storage containment tanks, X-700 trichloroethene/trichloroethane outside storage tank, X-705 decontamination building, and the X-720 neutralization pit is composed primarily of trichloroethene. Secondary volatile organic compound contaminants are trichloroethane, dichloroethene, chloroform, and methylene chloride. All volatile organic compound contaminant plumes are contained within the boundaries of the trichloroethene plume. These facilities are sources to the Quadrant II groundwater investigative area plume (Fig. 6.10), also referred to as the seven-unit plume.

## GROUNDWATER TREATMENT UNITS

In 1997, a combined total of approximately 23.1 million gal of contaminated groundwater was treated at the X-622 (Fig. 6.6), X-622T (Fig. 6.4), X-623 (Fig. 6.7), X-624 (Fig. 6.7), and X-625 groundwater treatment facilities. Approximately 151 gallons of trichloroethene were removed from the groundwater. All processed water is discharged through NPDES outfalls before exiting PORTS.

### X-622 Groundwater Treatment Facility

The groundwater treatment method used at the X-622 groundwater treatment facility is activated carbon and green sand filtration of the contaminated groundwater. Trichloroethene-contaminated groundwater from the X-231B southwest oil biodegradation plot, the X-749 contaminated materials disposal facility, and the Peter Kiewit groundwater collection system are processed at this treatment unit. In 1997, the unit processed approximately 7.4 million gallons of groundwater, and about one gallon of trichloroethene was removed.

### X-622T Groundwater Treatment Facility

At the X-622T treatment facility, activated carbon is used to treat contaminated groundwater from the X-700 chemical cleaning facility and the X-705 decontamination building. The X-700 and X-705 buildings are located above a volatile organic compound contaminant groundwater plume, and contaminated groundwater is extracted from sumps located in the basement of each building. In 1997, approximately 9.8 million gallons of groundwater were processed, and about 16 gallons of trichloroethene were removed.

### 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 provides treatment for trichloroethene-contaminated groundwater from the X-701B holding pond and three groundwater extraction wells in the X-701B plume area. The facility treated approximately 2.0 million gallons of water in 1997, and about 80 gallons of trichloroethene were removed.

### X-624 Groundwater Treatment Facility

At the X-624 groundwater treatment facility, groundwater is treated via an air stripper with offgas activated carbon filtration plus carbon filtration of the effluent water. This facility processes trichloroethene-

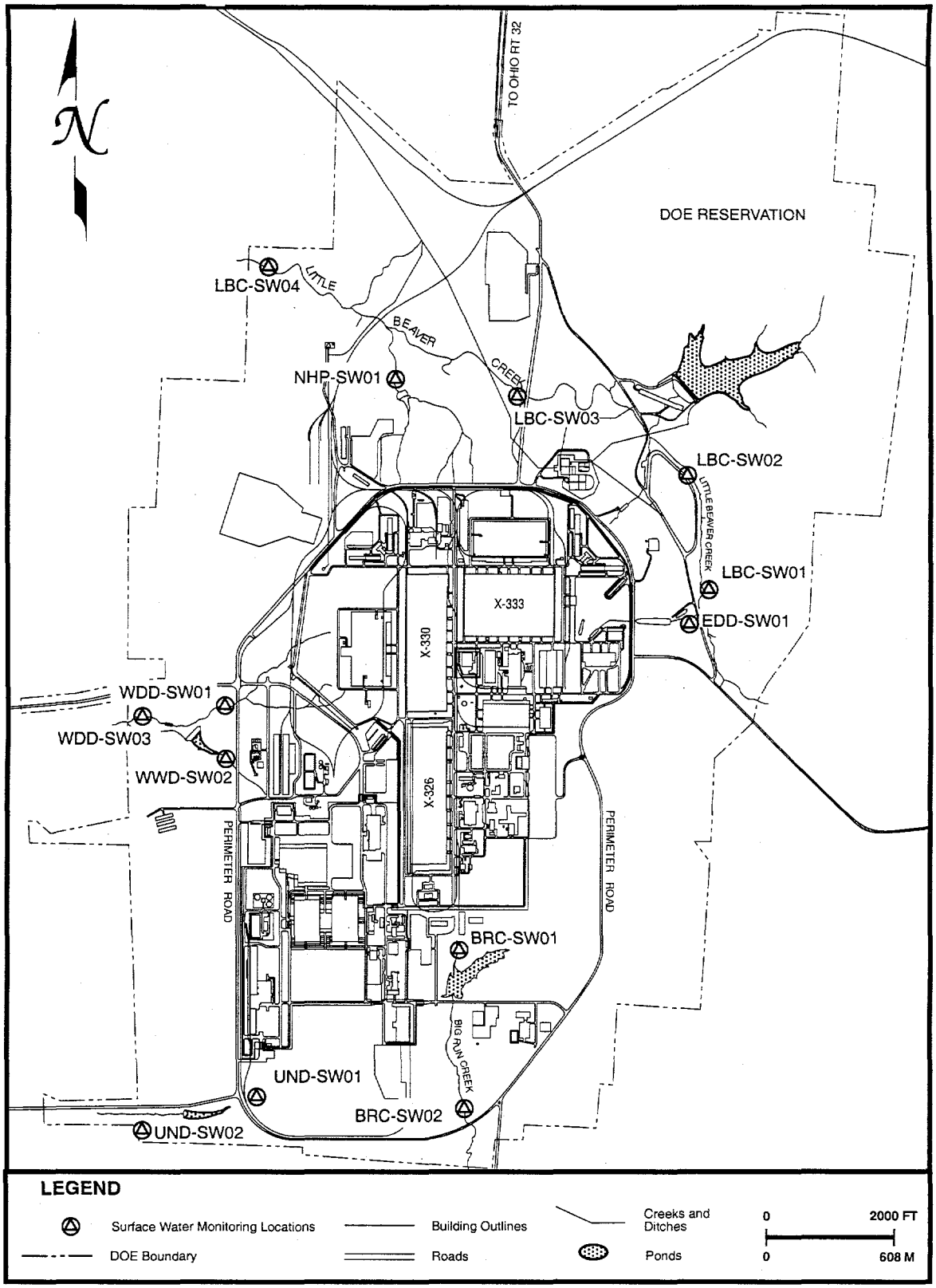



**Fig. 6.16. Surface water monitoring locations.**

contaminated groundwater from the X-237 interceptor trench associated with the X-701B plume. In 1997, about 3.6 million gallons of groundwater were treated, and about 54 gallons of trichloroethene were removed.

### X-625 Groundwater Treatment Facility

At the X-625 treatment facility, groundwater is gravity-fed from a horizontal well associated with the X-749/X-120 groundwater plume (Fig. 6.15). As part of an ongoing technology demonstration, water is treated with various passive media, such as iron filings. (See Section 3, "Environmental Programs," for details.) In 1997, approximately 200,000 gallons of groundwater were successfully treated.

## SURFACE WATER MONITORING

Surface water monitoring is conducted in conjunction with groundwater assessment monitoring to help determine whether groundwater contaminants are seeping into streams. Note that dilution of groundwater inflow by the streams may make the contaminants undetectable in surface water samples. Surface water is collected quarterly from the following 13 locations at PORTS, identified in Fig. 6.16:

- 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 serves in assessing potential contamination from the X-611A lime sludge lagoons;
- Big Run Creek sample locations BRC-SW01 and BRC-SW02 monitor groundwater discharges related to the X-231B southwest oil biodegradation plot, the greater 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 regulate potential contaminated 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 additional contaminated groundwater discharges from any unknown Quadrant IV sources; and
- The West Drainage Ditch sample locations WDD-SW01, WDD-SW02, and WDD-SW03 appraise contaminated groundwater discharges from the X-616 area to the West Drainage Ditch and the X-2230N holding pond.

### Surface Water Monitoring Results

Surface water monitoring of the Big Run Creek, East Drainage Ditch, Little Beaver Creek, North Holding Pond, unnamed southwestern drainage ditch, and West Drainage Ditch is conducted quarterly to assess the effect of the discharge of groundwater to streams (as base flow) at PORTS. This monitoring helps to support assessment monitoring at X-231B and X-701B and post-closure monitoring at X-616, X-735, and X-749. These surface monitoring locations are part of the Groundwater Monitoring Program and are not considered part of the PORTS NPDES sampling program.

No volatile organic compounds were detected at the surface water sampling locations in Big Run Creek, Little Beaver Creek, East Drainage Ditch, North Holding Pond, or West Drainage Ditch during 1997, with the exception of small amounts of chloroform detected at BRC-SW01 during the first and second

quarters. Trichloroethene has been detected at UND-SW01 (inside the perimeter road) at low levels; however, no volatile organic compounds were detected in the downstream location UND-SW02.

At East Drainage Ditch sampling location EDD-SW01, low levels of technetium have been detected only during the first quarter of every year since 1993. No levels of uranium or gross alpha and beta activity were detected at the East Drainage Ditch or Little Beaver Creek during 1997 above the comparison values. Naturally occurring Sunbury shale chips and fines in the stream sediment contain trace concentrations of uranium, and these chips might account for the low uranium concentrations that were detected during the first through third quarters of 1997. Uranium was detected at levels below the comparison value at the North Holding Pond and the West Drainage Ditch; however, technetium was not detected at either of those locations. No elevated levels of uranium or technetium were detected at Big Run Creek and the unnamed southwestern drainage ditch.

# 7. Quality Assurance

***Abstract***

Quality assurance and quality control are essential components of environmental surveillance activities at U.S. Department of Energy/Portsmouth Gaseous Diffusion Plant (DOE/PORTS). Quality is integrated into sample preservation, field data and sample collection, and sample transport. Numerous program assessment activities in the field and within the facilities are conducted at regular intervals to ensure that quality is built into and maintained in all DOE/PORTS programs.

## INTRODUCTION

Quality assurance, an integral part of the environmental surveillance effort, requires systematic control of the processes involved in sampling the environment and in analyzing the samples. To ensure accurate results, DOE/PORTS uses the following major types of 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 ensure 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 continually 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 USEPA, 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 supports the quality standards established at DOE/PORTS.

## 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 exercising authority over DOE/PORTS activities. These procedures specify sampling protocol, sampling devices, and containers and preser-

vatives 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.

## Basic Concepts and Practices

Data generated from field sampling can be greatly influenced by the methods used to collect and transport the samples. It is thus imperative that a quality assurance program be in place to ensure that the samples are collected properly and 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, using clean sampling devices and containers, employing approved sample preservation techniques, and submitting field blanks, trip blanks, and duplicate samples. Chain-of-custody procedures are strictly followed to ensure that sample integrity is maintained. Samples are delivered to the laboratory as soon as practicable after collection to ensure sample integrity.

# 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 programs.

# Appendix A: Radiation

This appendix gives basic facts about radiation. This 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.

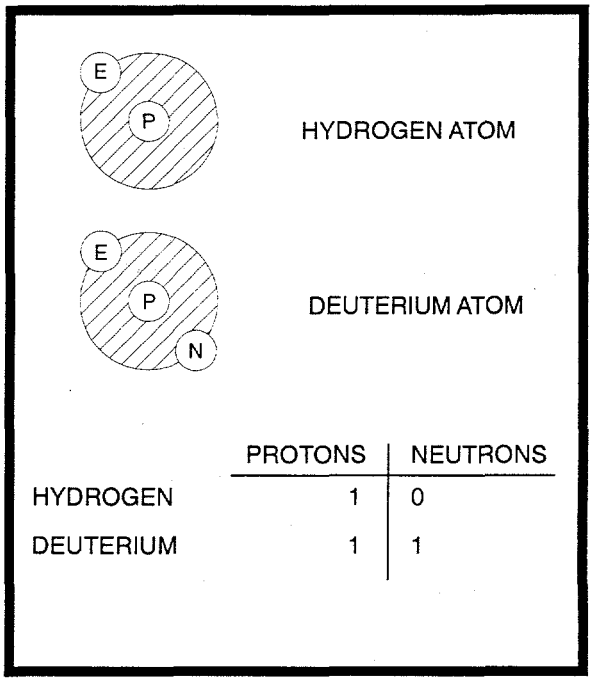
*radiation*—1. The emission and propagation of waves transmitting energy through space or through some medium; for example, the emission and propagation of electromagnetic, sound, or elastic waves. 2. The energy transmitted through space or some medium; when unqualified, usually refers to electromagnetic 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.

## ATOMS AND ISOTOPES

All matter is made up of atoms. An atom is "a unit of matter consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (American Nuclear Society 1986). The number of protons in the nucleus determines an element's atomic number, or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the number of neutrons may vary among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element with a different number of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights. Figure 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-239 has 92 protons and 147 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.

## 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.

### 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 forms 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.

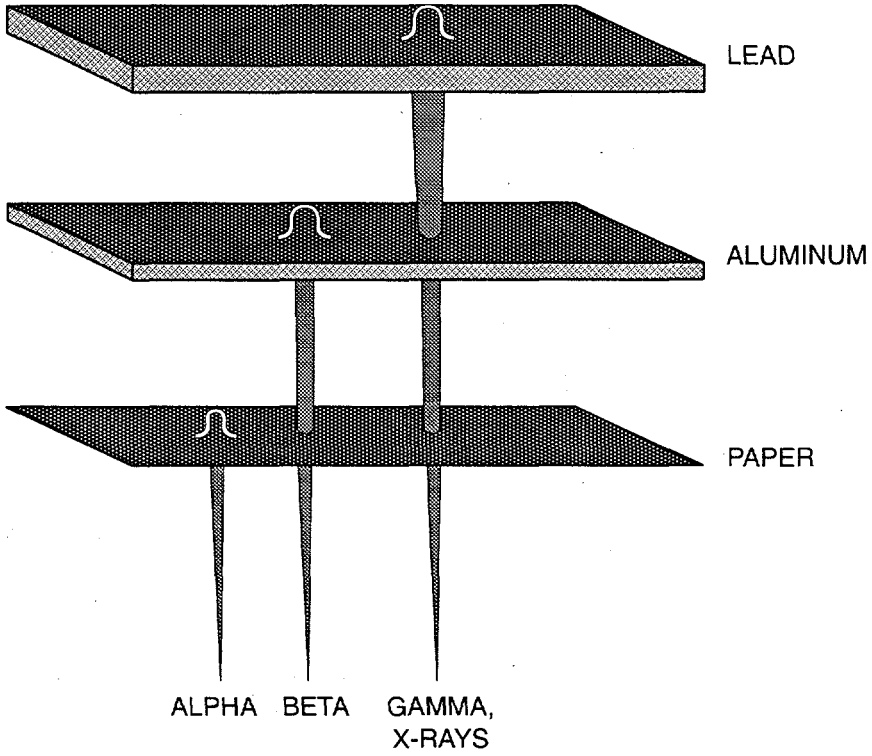



**Fig. A.2. Penetrating power of radiation.**

### Nonionizing Radiation

Nonionizing radiation bounces off of 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.

# SOURCES OF RADIATION

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

## Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Though 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.

### 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.

### 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.

### 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).

## Human-Made Radiation

In addition to background radiation, there are human-made sources of radiation to which most people are exposed. 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.

### 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 televisions and tobacco products, the radiation occurs incidentally to the product function.

### 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 radioactive materials are also used in a wide variety of pharmaceuticals and in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Nuclear medicine examinations and treatment involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body.

### 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.

## PATHWAYS OF RADIATION

Radiation and radioactive material 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).

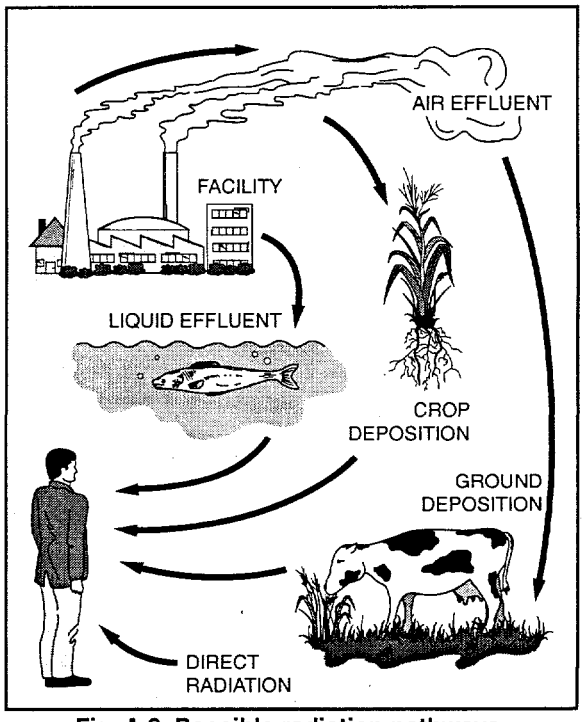



**Fig. A.3. Possible radiation pathways.**

## MEASURING RADIATION

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

## Activity

When measuring the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radioisotopes. For that reason, 1 g 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 = 3.7E+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 measure.**

| Current System | Systeme International | 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 |

## 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). However, in terms of human health, it is the effect of the absorbed energy that is important, not the actual amount.

## 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).

## 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.

**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 by the USEPA, 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) | USEPA protective action guidelines state that public officials should 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, caused by the radiation, of 0.8% (Biological Effects of Ionizing Radiations 1990) |
| 25 rem (0.25 Sv) | USEPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency |
| 75 rem (0.75 Sv) | USEPA 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.

## 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 help the reader become familiar with the type of doses individuals may receive.

### 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).

### 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.

### 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).

### 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).

### 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. However, the radionuclides used in specific tests 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).

## Dose 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 USEPA 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).

# Appendix B: Environmental Permits

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

| Permit/Registered Source | Source No. | Issue Date | Expiration Date | Status |
|---|---|---|---|---|
| *Clean Air Act Permits* [a] | | | | |
| Permit to Operate X-326 glovebox | P022 | 5/5/95 | 5/5/98 | Active |
| Registered Source X-345 emergency generator | B005 | | None | Active |
| Permit to Operate X-345 lab fume hood | P006 | | Permit Appealed | Active |
| Permit to Operate X-345 high assay sampling area | P008 | | Permit Appealed | Active |
| Permit to Operate X-345 sampling glovebox vent | P009 | | Permit Appealed | Active |
| Registered Source X-345 security fuel oil tank | T005 | | None | Active |
| Registered Source X-623 groundwater treatment facility | P018 | | None | Active |
| Permit to Operate X-624 groundwater treatment facility | P019 | | Permit Appealed | Active |
| Permit to Operate X-735 landfill refuse and asbestos handling | F001 | 2/8/93 | 2/8/96 | Renewal permit to operate applied for. Awaiting action by Ohio EPA. |
| Permit to Operate X-735 landfill roads and parking areas (southern portion) | F002 | 2/8/93 | 2/8/96 | Renewal permit to operate applied for. Awaiting action by Ohio EPA. |
| Permit to Operate X-735 landfill roads and parking areas (northern portion) | F005 | 5/26/95 | None | Active |
| Registered Source X-735 landfill storage piles | F006 | | None | Active |
| Permit to Install Peter Kiewit landfill roadways for cap construction | F008 | | 11/21/98 | Active |
| Permit to Operate X-735 landfill cap and venting system (northern portion) | P023 | 5/26/95 | 5/26/98 | Active |
| Registered Source X-744G oil-fired furnace | B006 | | None | Active |
| Permit to Operate X-744G glovebox | P007 | | Permit Appealed | Active |
| Registered Source X-744G fuel oil tank (south) | T008 | | None | Active |
| Registered Source X-744G alumina melter | P020 | | None | Active |
| Registered Source X-749 contaminated materials disposal facility | P027 | | None | Active |
| Permit to Operate X-7725 drum dumper | P024 | | Permit Appealed | Active |
| Registered Source X-7725 fluorescent bulb crusher | P028 | | None | Active |
| Permit to Operate chrome sludge repackaging | P025 | | Permit Appealed | Active |
| Permit to Operate mobile drum dumper | P026 | | Permit Appealed | Active |

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

| Permit/Registered Source | Source No. | Issue Date | Expiration Date | Status |
|---|---|---|---|---|
| | | *Clean Water Act permits* | | |
| NPDES[b] Permit (DOE) | OIO00000*GD | 9/2/99 | 3/31/99 | Active |
| NPDES[b] General Permit for stormwater (Peter Kiewit Landfill) | | 11/7/96 | 8/7/97 | Inactive |
| NPDES[b] General permit for stormwater (X-611A) | OHR104429 | 8/28/97 | 12/31/97 | Inactive |
| 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 InstallX-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 and remediation expected completion of work | | 4/30/97 | | |
| | | *Hazardous waste permits* | | |
| RCRA[c] Part B Permit | RCRA-LQG/TSDF OH7890008983/ 04-57-0680 | 8/25/95 | 8/25/00 | Active |
| | | *National Environmental Policy Act permits* | | |
| Federal fish and wildlife permit | | | 9/30/97 | Inactive |
| | | *Registrations* | | |
| Underground storage tank registration | 6651067 | | 7/1/98 | Active |

[a] Eight Clean Air Act permits are being appealed by DOE/PORTS to correct inconsistencies in the permit requirements.

[b] National Pollutant Discharge Elimination System.

[c] Resource Conservation and Recovery Act.

# Appendix C: Radionuclide and Chemical Nomenclature

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

| Radionuclide | Symbol | Half-life |
|---|---|---|
| Bismuth-210 | $^{210}Bi$ | 5.01 days |
| Bismuth-214 | $^{214}Bi$ | 19.7 minutes |
| Lead-206 | $^{206}Pb$ | Stable |
| Lead-210 | $^{210}Pb$ | 21 years |
| Lead-214 | $^{214}Pb$ | 26.8 minutes |
| 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-234m | $^{234m}Pa$ | 1.17 minutes |
| Radium-226 | $^{226}Ra$ | 1,602 years |
| Radon-222 | $^{222}Rn$ | 3.821 days |
| Technetium-99 | $^{99}Tc$ | 212,000 years |
| Thorium-230 | $^{230}Th$ | 80,000 years |
| Thorium-231 | $^{231}Th$ | 25.5 hours |
| 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 |
| Chromium, hexavalent | $Cr_{6+}$ |
| 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 |
| Uranium | U |
| Zinc | Zn |

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# Glossary

**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."

**aliquot**—The quantity of sample being used for analysis that is representative of a larger quantity (e.g., 5 aliquots of 15 in the sample).

**alluvium**—Soil material, such as clay or gravel, deposited by running water.

**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.

**alumina**—The oxide of aluminum, occurring in nature as the mineral corundum (a hard material used as an abrasive) and in bauxite (a clayish substance that is the chief ore of aluminum).

**ambient air**—The atmosphere around people, plants, and structures.

**analytical detection limit**—The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

**analyte**—A constituent or parameter being analyzed.

**aquifer**—A saturated, permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

**ash**—Inorganic residue remaining after ignition of combustible substances.

**assimilate**—To take up or absorb.

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

**background radiation**—Radiation that occurs naturally in the surrounding environment.

**baffling**—A device, such as a wall or screen, used to deflect, check, or regulate the flow of liquid.

**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.

**benthic**—A form of aquatic plant or animal life found near the bottom of a lake, stream, or ocean.

**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.

**bioassay**—Using living organisms to measure the effect of a substance, factor, or condition by comparing "before" and "after" data.

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

**bladder pump**—A specialized pump that uses the low-flow sampling technique to collect water samples.

**Bq**—See "Becquerel."

**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, analysis, and disposal.

**Ci**—See "curie."

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

**compliance**—Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

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

**conductivity**—A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

**cone of depression**—The depression, roughly conical in shape, produced in a water table or piezometric surface by pumping.

**confluence**—The point at which two or more streams meet; the point where a tributary joins the main stream.

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

**contiguous**—Touching without fusion.

**control limits**—A statistical tool used to define the bounds of virtually all values produced by a system in statistical control.

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

**coulomb**—A unit of electrical charge equal to the electricity transferred by a current of one ampere in one second.

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

**critical pathway**—The route through which individuals can be exposed to airborne and liquid releases of radioactive and chemical materials.

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

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

**daughter**—A nuclide formed by the radioactive 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.

**dense nonaqueous phase liquid**—The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds, such as tetrachloroethene and trichloroethene.

**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 given in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

**detector**—Material or device (instrument) that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

**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.

**dosimeter**—A portable detection device for measuring the total accumulated exposure to ionizing radiation.

**dosimetry**—The theory and application of principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with using various types of radiation instruments to make measurements.

**downgradient**—In the direction of decreasing hydrostatic head.

**downgradient well**—A well that is installed hydraulically downgradient of a site and that may be capable of detecting migration of contaminants from a site.

**drinking water standards**—Federal primary drinking water standards, both proposed and final, as set forth by the U.S. Environmental Protection Agency.

**effluent**—A liquid or gaseous waste discharge to the environment.

**effluent monitoring**—The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures of members of the public, and demonstrating 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 incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that 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.

**fauna**—The population of animals at a given area, environment, formation, or time span.

**fecal coliform**—Aerobic, non-spore-forming, rod-shaped bacteria normally present in the intestinal tracts of humans and other warm-blooded animals.

**flora**—The population of plants at a given area, environment, formation, or time span.

**formation**—A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

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

**fusion**—The union or blending together of materials.

**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.

**gamma spectrometry**—A system consisting of a detector, associated electronics, and a multichannel analyzer that is used to analyze samples for gamma-emitting radionuclides.

**Gaussian puff/plume model**—A computer-simulated atmospheric dispersion of a release using a Gaussian (normal) statistical distribution to determine concentrations in air.

**Geiger-Mueller counter**—A highly sensitive, gas-filled radiation detector that operates at voltages sufficiently high to produce ionization. The counter is used primarily in the detection of gamma radiation and beta emission. It is named for Hans Geiger and W. Mueller, who invented it in 1928.

**geochemical**—Broadly defined as relating to all parts of geology that involve chemical changes, or narrowly defined as the distribution of the elements.

**grab sample**—A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface water samples (also called dip samples).

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

**groundwater, unconfined**—Groundwater exposed to the unsaturated zone.

**Gy**—See "gray."

**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.

**hydraulic conductivity**—The rate at which water can move through a permeable medium.

**hydraulic fracturing**—The fracturing of soil or rock accomplished by pumping a fluid into a well in order to produce artificial openings in the media, thereby increasing permeability.

**hydraulic gradient**—The direction of groundwater flow due to changes in the depth of the water table.

**hydrocarbon**—A chemical compound that consists entirely of carbon and hydrogen.

**hydrology**—The science dealing with the properties, distribution, and circulation of natural water systems.

**hydrogeology**—Hydraulic aspects of site geology.

**hydrophytic**—The ability of a plant to grow in and adapt to a very wet environment.

**hydrostatic head**—The height of a vertical column of water, the height of which is equal to the hydrostatic pressure of the water at that point.

**hydrostatic pressure**—The pressure exerted by the water at any given point in a body of water at rest.

**industrial solid waste landfill**—A type of sanitary landfill facility 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 dose factor**—A factor used to convert intakes of radionuclides to dose equivalents.

**internal radiation**—Occurs when natural radionuclides enter the body by ingestion of foods, milk, 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.

**isokinetic**—Sampling of a pollutant-carrying gas stream so that the same velocity is maintained in the probe tip as exists in the adjacent gas stream.

**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 quantity of it 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).

**joule**—A unit of work or energy equal to the work done by a force of one newton acting through a distance of one meter.

**jurisdictional wetland**—An area that is periodically or permanently inundated by surface or ground water, supports hydrophytic vegetation, and has hydric soils, 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.

**lithology**—The overall, general characteristics of a rock.

**low-flow pump**—A pump used in a sampling collection technique that minimizes turbidity in groundwater samples.

**lower limit of detection**—The smallest concentration or amount of analyte that can be reliably detected in a sample at a 95% confidence level.

**macroinvertebrate**—An invertebrate animal (animal without a back bone) large enough to be seen without magnification.

**manifest**—A form required by RCRA that is used to document and track waste during transport and disposal.

**mass-balance calculation**—A calculation used to demonstrate that the amount of pollutants entering a system is equal to the amount that exits the system.

**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.

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

**minimum detectable concentration**—The smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

**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 hydrophytic vegetation, has hydric soils, and is associated with an active holding pond.

**nuclide**—An atom specified by its 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.

**palladized**—Coated with palladium.

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

**part per billion (ppb)**—A unit measure of concentration equivalent to the weight/volume ratio expressed as g/L or ng/mL.

**part per million (ppm)**—A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

**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.

**photocatalytic**—The acceleration of a chemical reaction by radiant energy acting either directly or by charging a substance that in turn catalyzes the main reaction.

**piezometer**—An instrument used to measure the potentiometric surface of the groundwater; also, a well designed for this purpose.

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

**potentiometric**—In relation to an aquifer, the potentiometric surface is defined by the levels to which water will rise in tightly cased wells.

**ppb**—See "part per billion."

**ppm**—See "part per million."

**process water**—Water used within a system process.

**process sewer**—Pipe or drain, generally located underground, used to carry off process water or waste matter.

**purge**—To remove water before sampling, generally by pumping or bailing.

**quality assurance**—Any action in environmental monitoring to ensure 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.

**quality factor**—The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. A quality factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

**quiescent**—Marked by a state of inactivity; being at rest; latent, dormant, potential.

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

**radiation detection instruments**—Devices that detect and record the characteristics of ionizing radiation.

**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 accompanied by the emission of photons or particles.

**RCRA**—See "Resource Conservation and Recovery Act."

**RCRA facility investigation program**—USEPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

**reference material**—A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

**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 times 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)**—Federal 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 $2.58 \times 10^{-4}$ coulombs per kg of air.

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

**screen zone**—In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

**semiconductor**—A substance whose electrical conductivity is between that of a conductor and insulator and which increases with temperature increase.

**sidegradient well**—A well that intercepts groundwater flowing next to a site; a sidegradient well is located neither upgradient nor downgradient to the monitored site.

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

**slaked**—Crumbled (lime) due to mixture with water.

**slurry**—A suspension of solid particles (sludge) in water.

**solubilization**—The dissolving of a substance in a fluid; the state of being able to pass into solution.

**source**—A point or object from which radiation or contamination emanates.

**sparger**—A device that injects air below the water table to strip dissolved volatile organic compounds and/or oxygenated groundwater to facilitate aerobic biodegradation of organic compounds.

**stable**—Not radioactive or not easily decomposed or otherwise modified chemically.

**stack**—A vertical pipe or flue designed to exhaust airborne gases and suspended particulate matter.

**standard deviation**—An indication of the dispersion of a set of results around their average.

**storm water runoff**—Surface streams that appear after precipitation.

**strata**—Beds, layers, or zones of rocks.

**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 Environmental Protection Agency solid waste emergency and long-term removal and remedial actions.

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

**surfactant**—A surface-active agent used in detergents to cause lathering.

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

**Sv**—See "sievert."

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

**thermoluminescent dosimeter**—A device used to measure external gamma radiation.

**total activity**—The total quantity of radioactive decay particles that are emitted from a sample.

**total solids**—The sum of total dissolved solids and suspended solids.

**total suspended particulates**—Refers to the concentration of particulates in suspension in the air regardless of the nature, source, or size of the particulates.

**tracer test**—A test in which an identifiable chemical is injected into groundwater to monitor flow-rate.

**trivalent**—A compound that has three valence electrons.

**troughing system**—A system designed to collect leaking polychlorinated biphenyls in the process buildings.

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

**upgradient**—In the direction of increasing hydrostatic head.

**vadose zone**—Soil zone located above the water table.

**volatile organic compounds**—Chemicals of an organic nature (containing hydrogen, oxygen, and carbon) which readily volatilize, or travel from water into the air. Most such substances are industrial chemicals and solvents. They include light alcohol, acetone, trichloroethene, dichloroethene, benzene, vinyl chloride, toluene, and methylene chloride. Because they easily evaporate into the air, there exists an increased potential for exposure to humans. Due to their low water solubility and widespread industrial use, they are commonly found in soil and water.

**watershed**—The region draining into a river, river system, or body of water.

**wetland**—A lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support hydrophytic vegetation typically adapted to life in saturated soils.

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## Conversions

| Multiply | by | to obtain |
|---|---|---|
| inches (in.) | 2.54 | centimeters (cm) |
| cm | 0.394 | in. |
| feet (ft) | 0.305 | meters (m) |
| square feet ($ft^2$) | 0.093 | square meters ($m^2$) |
| cubic feet ($ft^3$) | 0.028 | cubic meters ($m^3$) |
| miles (mi) | 1.61 | kilometers (km) |
| square miles ($mi^2$) | 2.59 | square kilometers ($km^2$) |
| m | 3.28 | ft |
| $m^2$ | 10.764 | $ft^2$ |
| $m^3$ | 35.31 | $ft^3$ |
| km | 0.621 | mi |
| $km^2$ | 0.386 | $mi^2$ |
| pounds (lb) | 0.4536 | kilograms (kg) |
| kg | 2.205 | lb |
| liquid quarts (liq qt) (U.S.) | 0.944 | liters (L) |
| L | 1.057 | liq qt (U.S.) |
| picocuries (pCi) | $10^{-6}$ | curies (Ci) |
| pCi | 0.037 | disintegrations per second (dps) |
| dps | 2.7 | pCi |
| picocuries per liter (pCi/L) (water) | $10^{-9}$ | curies per milliliter (Ci/mL) (water) |
| picocuries per cubic meter ($pCi/m^3$) (air) | $10^{-12}$ | Ci/mL (air) |
| millicureis (mCi) | $10^{6}$ | pCi |
| millicureis per milliliter (mCi/mL) (water) | $10^{9}$ | pCi/L (water) |
| mCi/mL (air) | $10^{12}$ | $pCi/m^3$ (air) |

## Fractions and multiples of units

| Multiple | Decimal Equivalent | Prefix | Symbol | Report Format |
|---|---|---|---|---|
| $10^{6}$ | 1,000,000 | mega- | M | E+06 |
| $10^{3}$ | 1,000 | kilo- | k | E+03 |
| $10^{2}$ | 100 | hecto- | h | E+02 |
| 10 | 10 | deka- | da | E+01 |
| $10^{-1}$ | 0.1 | deci- | d | E-01 |
| $10^{-2}$ | 0.01 | centi- | c | E-02 |
| $10^{-3}$ | 0.001 | milli- | m | E-03 |
| $10^{-6}$ | 0.000001 | micro- | μ | E-06 |
| $10^{-9}$ | 0.000000001 | nano- | n | E-09 |
| $10^{-12}$ | 0.000000000001 | pico- | p | E-12 |
| $10^{-15}$ | 0.000000000000001 | femto- | f | E-15 |
| $10^{-18}$ | 0.00000000000000000 | atto- | a | E-18 |