U.S. Department of Energy

Portsmouth Site

Annual Environmental Report for 1994

Units of radiation measure

Current System	Système International	Conversion
curie (Ci)	becquerel (Bq)	1 Ci = 3.7×10^{10} Bq
rad (radiation absorbed dose)	gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	sievert (Sv)	1 rem = 0.01 Sv

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}	0.000000000000000001	atto-	a	E–18

On the cover: The purple fringeless orchid (*Platanthera peramoena*). (ORNL PHOTO 7546-90)

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U.S. DEPARTMENT OF ENERGY PORTSMOUTH SITE ANNUAL ENVIRONMENTAL REPORT FOR 1994

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Executive Summary

SCOPE AND PURPOSE

This report summarizes the 1994 environmental monitoring of U.S. Department of Energy (DOE) activities at the Portsmouth site and its environs. This report consists of three separate documents: a summary pamphlet for the general public; a more detailed discussion of compliance status, data, and environmental impacts (this document); and a volume of detailed data that is available on request. The objectives of this report are to

- report compliance status during 1994,
- provide information about the site and DOE operations,
- report 1994 monitoring data for the installation and its environs that may have been affected by DOE operations on the site,
- document information on input and assumptions used in calculations,
- provide trend analyses (where appropriate) to indicate increases and decreases in environmental impact, and
- provide general information on quality assurance for the environmental monitoring program for DOE operations.

Compliance Status

Several federal, state, and local agencies are responsible for enforcing environmental regulations at the Portsmouth site. As of July 1, 1993, responsibility for ensuring compliance was split between DOE, as site owner and operator of waste management and environmental restoration projects and nonleased facilities, and the United States Enrichment Corporation (USEC), a government-owned corporation formed by the National Energy Policy Act of 1992 to take over the nation's uranium enrichment business. The management and operating contractor for DOE is Lockheed Martin Energy Systems (formerly Martin Marietta Energy Systems); a new subsidiary, Lockheed Martin Utility Services (formerly Martin Marietta Utility Services), was formed to provide management and operation services for USEC. The Nuclear Regulatory Commission (NRC) is scheduled to assume direct oversight of USEC operations by the end of 1996. In the interim, DOE is providing oversight until the NRC assumes regulatory responsibility.

Although much progress has been made toward achieving full regulatory compliance at the Portsmouth site, much remains to be accomplished. Ongoing self-assessments of compliance status continue to identify environmental issues. These issues are discussed openly with regulatory agencies to ensure that appropriate actions are taken to achieve compliance.

In 1994, one notice of violation was issued to DOE by the Ohio Environmental Protection Agency (OEPA). The OEPA cited DOE for one violation identified in the annual Resource Conservation and Recovery Act (RCRA) compliance audit and reiterated five outstanding violations from previous audits. The new violation was failure to adequately maintain the condition of waste containers (one dented storage drum). This violation was corrected within 24 hours. The five outstanding violations were (1) failure to make hazardous waste determinations regarding depleted uranium fluoride cylinders and lithium hydroxide containers stored on the Portsmouth site; (2) storage of hazardous waste in the X-700 tank 7 for more than 90 days; (3) failure to conduct tank assessments on the X-700 tanks 6, 7, and 8 and the X-740 and X-750 tanks; (4) lack of secondary containment for the

five tanks listed in item 3; and (5) lack of a hazardous waste permit for the X-700 tank 7. Efforts are under way to negotiate an amended consent decree with the OEPA to address the five outstanding items. The X-700 tank 7 and X-750 tank have been closed.

RADIONUCLIDE AND CHEMICAL RELEASES

Environmental monitoring systems at Portsmouth include emission monitoring networks for air and surface water discharges. Specific emission monitoring networks include a network of three continuous vent samplers on the major radionuclide and fluoride emission sources and a network of nine sampling locations for plant discharges to local surface waters.

Airborne Releases

The release of pollutants into the atmosphere from numerous point and non-point sources at the Portsmouth site is regulated by permits from the state of Ohio and the U.S. Environmental Protection Agency (USEPA). These pollutants include standard industrial pollutants such as gaseous fluorides, gasoline and diesel fuel vapors, cleaning solvent vapors, and process coolants (chlorofluorocarbons), as well as small amounts of radionuclides. Airborne radionuclides are considered the main source of any radiation dose that might be received by the public from plant operations.

A total of 0.185 Ci (6.8×10^9 Bq) of radionuclides was released to the air in 1994, 75.1% of which was technetium-99 (^{99}Tc), a weak beta emitter, and 21.6% of which consisted of uranium isotopes, all alpha emitters. The remaining emissions consisted of the short-lived uranium daughters. The five-year trend for airborne radionuclide emissions is shown in Fig. 1.

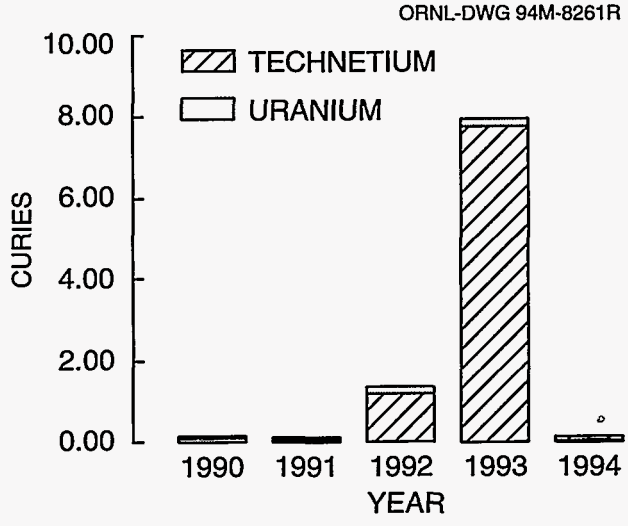

Fig. 1. Airborne radionuclides discharged at the Portsmouth site, 1990–1994.

Historically, uranium has accounted for 75 to almost 90% of the public dose from Portsmouth site emissions. Consequently, the emission control systems on the cascade are optimized to reduce uranium emissions first and technetium emissions second. For the future, it is expected that mass emissions (kilograms) of uranium will remain about the same as levels seen from 1990 through 1994 and that the activity emissions (curies) of uranium should decrease after 1994 because of the absence of highly enriched uranium in the emissions.

Waterborne Releases

Treated effluents discharge to surface streams that pass through the reservation to the Scioto River. All nonradiological plant-site liquid effluents related to DOE operations are regulated by the National Pollutant Discharge Elimination System (NPDES) and are

routinely monitored. Radiological analyses are also performed at NPDES sampling locations.

There are five radionuclides present in Portsmouth site releases 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 fifth is ^{99}Tc. In addition, the Portsmouth site also accounts for three short-lived uranium daughters (^{234}Th, ^{234m}Pa, and ^{231}Th), which are obviously 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 total of 0.28 Ci (1.0×10^{10} Bq) of radionuclides was released to surface water in 1994, 59% of which was ^{99}Tc and 40% of which consisted of uranium isotopes. The remaining emissions consisted of the short-lived uranium daughters. This represents a decrease in uranium and technetium emissions from 1993. The five-year trend for waterborne radionuclide releases is shown in Fig. 2. Total radiological releases to surface waters were well below all applicable USEPA and DOE standards.

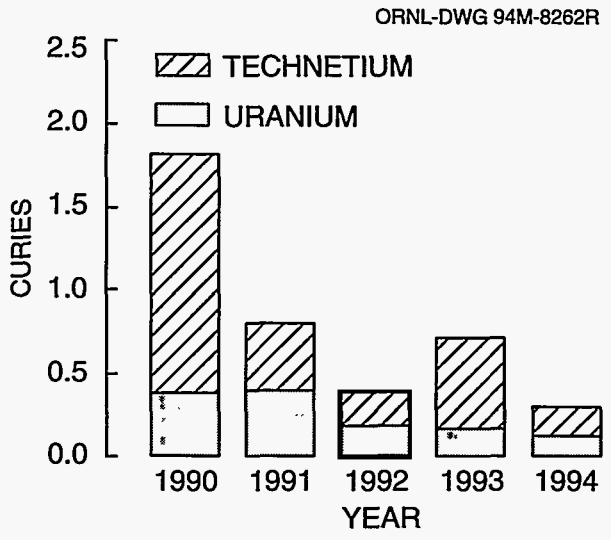

Fig. 2. Waterborne radionuclides discharged at the Portsmouth site, 1990–1994.

Nonradiological releases to surface waters are best summarized by the extent of compliance with the plant NPDES permit limits. The NPDES compliance rate for those outfalls that are DOE's responsibility was 99.0% for 1994.

AMBIENT MONITORING

Environmental monitoring systems at the Portsmouth site include ambient-sampling networks for direct monitoring of gamma radiation levels, air, surface water, and groundwater. Ambient monitoring results in 1994 indicated that DOE operations were not having a significant environmental impact outside the reservation boundaries.

Ambient-sampling networks are typically organized into three or four groups based on their distance from the plant:

- On-site stations in the Portsmouth site area. This group includes locations near Perimeter Road, an area of limited public access, and locations within the site's secured area, which is accessible only to employees and authorized visitors.
- Property-line stations on or near the DOE property line (the closest unrestricted public approach to the plant).
- Off-site stations at some distance from the Portsmouth site. These stations are located up to 16 km (10 miles) from the site and are sometimes divided into off-site and remote, or background, groups.

Individual (media-specific) networks include the following:

- 19 gamma radiation monitoring locations—9 on site, 8 at the property line, and 2 off site.
- 18 air sampling stations—6 on site and 12 off site.
- 573 groundwater monitoring wells on site. The majority of these wells were installed as part of the Groundwater Quality Assessment, RCRA facility investigations for Quadrants I through IV, solid waste landfill compliance activities, underground storage tank investigations, or other site characterizations.

External Gamma Radiation

External gamma levels at and around the Portsmouth site are not significantly different from average radiation levels throughout Ohio (115 mrem/year). Gamma levels measured around the Portsmouth site averaged 215 mrem/year at the edge of the active plant area and 214 mrem/year around the reservation boundary. The levels at more distant locations are from geological formations with higher concentrations of naturally occurring radioactive minerals that surround the Portsmouth reservation.

In 1993, the environmental external gamma monitoring system was combined with the health physics gamma monitoring system used for worker protection. The original environmental system was selected for maximum sensitivity at the expense of system reliability. The health physics system, although not as sensitive as the original environmental system, is still sensitive enough to make routine environmental measurements, does include cosmic radiation contributions, and is generally more reliable in operation. In addition, the health physics system is already accredited by the DOE Laboratory Accreditation Program and is expected to be accredited by the National Voluntary Laboratory Accreditation Program. The annual radiation dose for 1994 was 112 mrem/year, a 3.7% decrease from the 1993 radiation dose. The 3.7% difference is within the acceptable range for this configuration of thermoluminescent dosimeter (TLD) and TLD reader.

Ambient Air Monitoring

Gross alpha and beta activities and gaseous fluoride concentrations in the air on and around the Portsmouth site during 1994 were all well within applicable standards and were not significantly affected by Portsmouth site releases.

Annual average gross alpha activities at all monitoring locations accessible to the public (the USEPA definition of "ambient" includes public accessibility) were 0.005 pCi/m^3 (1.88×10^{-4} Bq/m^3) or less. The maximum alpha concentration measured at any of these locations was only 0.011 pCi/m^3 (4.07×10^{-4} Bq/m^3). No standard exists for gross alpha activities in air, but an airborne uranium concentration of 0.22 pCi/m^3 (8.1×10^{-3} Bq/m^3) would produce an "equivalent" annual gross alpha activity of 0.22 rem/year.

Annual average gross beta activities at all property-line and off-site monitoring locations were 0.030 pCi/m^3 (1.11×10^{-3} Bq/m^3) or less, with a maximum beta activity of 0.165 pCi/m^3 (6.11×10^{-3} Bq/m^3). On-site monitoring locations showed somewhat higher concentrations [up to 0.038 pCi/m^3 (1.41×10^{-3} Bq/m^3) annual average] to the northeast of the main plant area. No standard exists for gross beta activities in air, but an airborne ^{99}Tc concentration equivalent to the USEPA dose standard of 10 mrem/year would produce an annual gross beta activity of 2 pCi/m^3 (7.40×10^{-2} Bq/m^3).

Weekly average gaseous fluoride concentrations at all monitoring locations accessible to the public averaged 0.085 $\mu g/m^3$ or less, with a maximum weekly concentration of 0.26 $\mu g/m^3$. This concentration is well below the weekly standard for gaseous fluorides of 1.6 $\mu g/m^3$ adopted by most states that have set ambient air standards for gaseous fluorides.

RADIATION DOSE TO THE PUBLIC

The calculated maximum potential 50-year committed effective dose equivalent (EDE) to any individual from Portsmouth site activities during 1994 was 0.066 mrem/year, much lower than the applicable USEPA standard of 10 mrem/year and the DOE standard of 100 mrem/year. A comparison of maximum potential EDEs resulting from airborne emissions during the last five years is shown in Fig. 3. The calculated population dose (collective EDE) from airborne radionuclides was 0.02 person-rem/year to the nearest community and 0.6 person-rem/year to the total population within 80 km (50 miles) of the site. None of the potential doses calculated resulting from Portsmouth site operations is significant to public health.

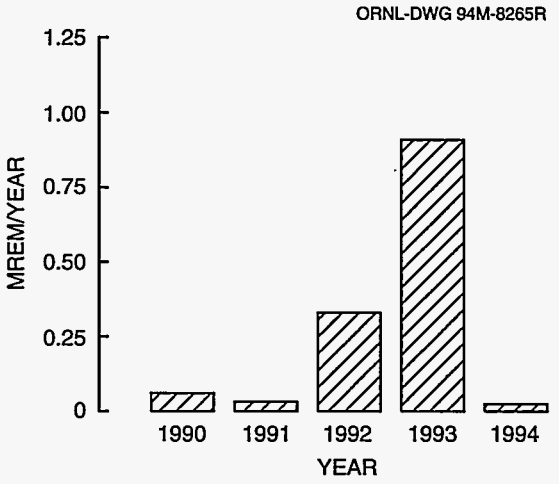

Fig. 3. Maximum predicted individual EDEs from airborne radionuclides discharged at the Portsmouth site, 1990–1994.

The calculated EDE for those drinking water and eating fish from the Scioto River throughout 1994 was only 0.006 mrem/year. This dose is well below the USEPA national standard of 4 mrem/year for radionuclides in drinking water as well as the DOE limit of 100 mrem/year for all exposure pathways. This calculated dose is hypothetical and should be considered very conservative. No public water supply or known private water supply is drawn from the Scioto River. Sport fishing is the only known activity taking place on the river downstream of the Portsmouth site. This hypothetical maximum waterborne dose is also calculated at a location on the opposite side of the plant (southwest) from the hypothetical maximum airborne dose (east-northeast), making it unlikely that one individual could be exposed to both doses. A comparison of maximum potential EDEs resulting from waterborne emissions during the past five years is shown in Fig. 4. Waterborne population doses are not calculated because the best estimate of the exposed population is zero.

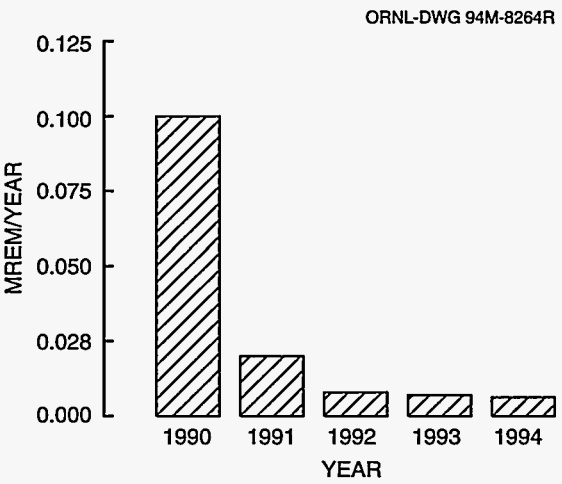

Fig. 4. Maximum predicted individual EDEs from waterborne radionuclides discharged at the Portsmouth site, 1990–1994.

GROUNDWATER MONITORING

The groundwater monitoring program includes assessment monitoring and surface water monitoring associated with three RCRA land disposal units, detection monitoring associated with a sanitary landfill and a neutralization pit, post-closure monitoring at a closed RCRA land disposal unit, 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 by Geraghty & Miller, Inc., in 1989 *(Groundwater Quality Assessment of Four RCRA Units)*. Quarterly monitoring for a list of approved analytes is accomplished by sampling wells installed in the Gallia sand and the Berea sandstone. Sampling locations include 26 wells at the X-701B surface impoundment, 26 wells at the X-749 landfill, and 15 wells at the X-231B land treatment area. 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, and the north holding pond.

Detection monitoring at the X-735 sanitary landfill is accomplished by sampling six groundwater monitoring wells on the perimeter of the landfill. In 1994, six additional point-of-compliance monitoring wells were installed. These wells were installed according to RCRA protocol to comply with changes in solid waste regulations. Detection monitoring is also conducted at three wells surrounding the X-701C neutralization pit.

Initially, quarterly assessment monitoring was conducted at 15 wells at the X-616 chromium sludge surface impoundments. However, this unit was certified closed in 1993, and these wells are now sampled semiannually under post-closure monitoring requirements. 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 Ohio Attorney General's Office on August 29, 1989, and with the RCRA, Section 3008(h), Administrative Consent Order issued by USEPA Region V in 1989 and updated on August 11, 1994. During the RCRA facility investigations, two new groundwater plumes contaminated with volatile organic compounds were delineated: the Quadrant I investigative area (near the X-710 laboratory) and the Quadrant II area (near the X-700 chemical cleaning facility and the X-705 decontamination buildings).

The primary groundwater contaminates and contaminates with the largest extent are trichloroethylene (TCE) and its breakdown compounds. The drinking water maximum contaminate level (MCL) for TCE is 5 µg/L; this MCL is exceeded at each of the plumes. The maximum TCE values for each plume are

- X-701B surface impoundment—449,000 µg/L,
- X-749 landfill—10,600 µg/L,
- X231B land treatment area—2,640 µg/L,
- Quadrant I investigative area—1,600 µg/L, and
- Quadrant II investigative area—3,700 µg/L.

OTHER ENVIRONMENTAL PROGRAMS AND ISSUES

Ecological Risk Assessment

In the summer and fall of 1993, DOE initiated the preparation of a baseline ecological risk assessment for the Portsmouth site, including a wetland survey, a threatened and

endangered plant survey, a threatened and endangered animal survey, and a bat survey. The wetland survey identified a number of areas considered to be wetland or emergent wetland; these areas were delineated and mapped in April 1994. The threatened and endangered plant survey and the bat survey were completed in the fall of 1994. Endangered animal survey results indicated the presence of several state-listed and possibly one federally listed threatened and endangered species within the reservation boundary. The final reports were submitted to DOE; the USEPA; and the OEPA.

REFERENCE

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

Acronyms and Abbreviations

AAQS	ambient air quality standard
ADI	acceptable daily intake
ANSI	American National Standards Institute
APG	Analytical Products Group, Inc.
Bq	becquerel
BUSTR	Bureau of Underground Storage Tank Regulations
°C	degrees Celcius
CAP-88	Clean Air Act Assessment Package-88
CDI	chronic daily intake
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Ci	curie
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
CMS	corrective measures study
DCA	dichloroethane
DCE	dichloroethylene
DCG	derived concentration guide
DLA	Defense Logistics Agency
DMR-QA	Discharge Monitoring Report Quality Assurance Study
DOE	U.S. Department of Energy
dpm	disintegrations per minute
EDE	effective dose equivalent
EML	Environmental Measurements Laboratory
EMP	environmental monitoring plan
EMSL-LV	Environmental Monitoring Systems Laboratory at Las Vegas
ENE	east-northeast
Energy Systems	Lockheed Martin Energy Systems
EPCRA	Emergency Planning and Community Right-To-Know Act
EPIP	environmental protection implementation plan
ER	environmental restoration
°F	degrees Fahrenheit
FFCA	federal facilities compliance agreement
Fm.	formation
ft	foot
ft^3	cubic foot

g	gram
gal	gallon
GCEP	Gas Centrifuge Enrichment Plant
GWPP	groundwater protection program
GWPPMP	groundwater protection program management plan
GWPS	groundwater protection standard
GWQA	groundwater quality assessment
HASA	high-assay sampling area
HEU	highly enriched uranium
HF	hydrogen fluoride
HSWA	Hazardous Solid Waste Amendment
in.	inch
kg	kilogram
km	kilometer
km^2	square kilometer
L	liter
lb	pound
LDR	land disposal restriction
LiF	lithium fluoride
LiOH	lithium hydroxide
LLW	low-level waste
m	meter
m^2	square meter
m^3	cubic meter
MCL	maximum contaminant level
mg	milligram
Mgd	million gallons per day
MLd	million liters per day
µCi	microcurie
µg	microgram
µm	micron
µrad	microrad
$mile^2$	square mile
mL	milliliter
mm	millimeter
MMES	Martin Marietta Energy Systems, Inc.
mrem	millirem
MSDS	material safety data sheet
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NGVD	national geodetic vertical datum of 1929
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute for Standards and Technology

NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
OANG	Ohio Army National Guard
OEPA	Ohio Environmental Protection Agency
Pa	protactinium
PCB	polychlorinated biphenyl
pCi	picrocurie
ppb	part per billion
ppm	part per million
QA	quality assurance
QC	quality control
qt	quart
RCRA	Resource Conservation and Recovery Act
RCW	recirculating cooling water
RFI	RCRA facility investigation
RQ	reportable quantity
RW	routine water
SARA	Superfund Amendments and Reauthorization Act
SWMU	solid waste management unit
Tc	technetium
TCA	trichloroethane
TCE	trichloroethylene
TCL/TAL	target compound list/target analyte list
Th	thorium
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
U	uranium
UF_6	uranium hexafluoride
USEC	United States Enrichment Corporation
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
Utility Services	Lockheed Martin Utility Services
VOC	volatile organic compound
WP	water pollution performance evaluation
WS	water supply

1. Site and Operations Overview

Abstract

The purpose of this document is to summarize the status of compliance with environmental laws, regulations, and orders; effluent monitoring data; and environmental surveillance results associated with U.S. Department of Energy (DOE) activities at the Portsmouth site. DOE requires that environmental monitoring be conducted and documented for all of its facilities under the purview of DOE Order 5400.1, *General Environmental Protection Program.* DOE activities at the Portsmouth site are environmental restoration and waste management. 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.

BACKGROUND

The Portsmouth site 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 (USEC), which was established by the National Energy Policy Act of 1992. Lockheed Martin Utility Services (Utility Services), formerly Martin Marietta Utility Services, manages and operates the leased facilities for USEC. Lockheed Martin Energy Systems (Energy Systems), formerly Martin Marietta Energy Systems, Inc. (MMES), remains the management and operating contractor for DOE responsibilities at the site, which are mainly environmental restoration, waste management, highly enriched uranium (HEU) removal, and operations of nonleased facilities.

This document contains a summary of DOE-related environmental monitoring activities at the Portsmouth site. 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 liquid and gaseous 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, assess radiation exposures of members of the public, demonstrate compliance with applicable standards and permit requirements, and detect and assess the effects (if any) of DOE activities on the local environment. Multiple samples are collected throughout the year and are analyzed for radioactivity, chemical content, and various physical attributes.

DESCRIPTION OF SITE LOCALE

The Portsmouth site is located in sparsely populated, rural Pike County, Ohio, on a 16.2-km^2 (6.3-mile^2) site (see Fig. 1.1). The site is 1.6 km (1 mile) east of the Scioto River valley in a small valley running parallel to and approximately 37 m (120 ft) above the Scioto River floodplain. Figure 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 kilometers of the plant. The county's largest community,

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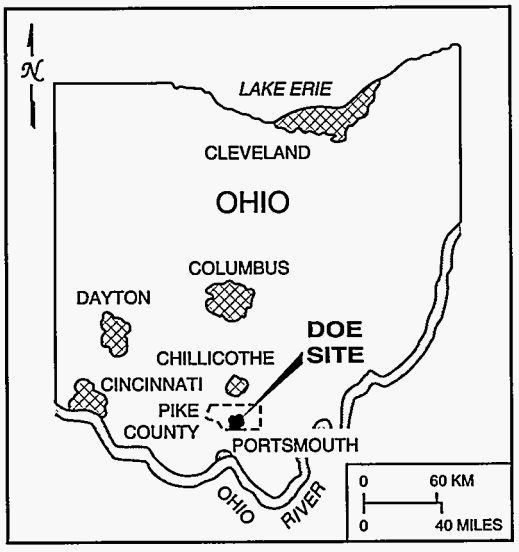

Fig. 1.1. Location of the Portsmouth site within the state of Ohio.

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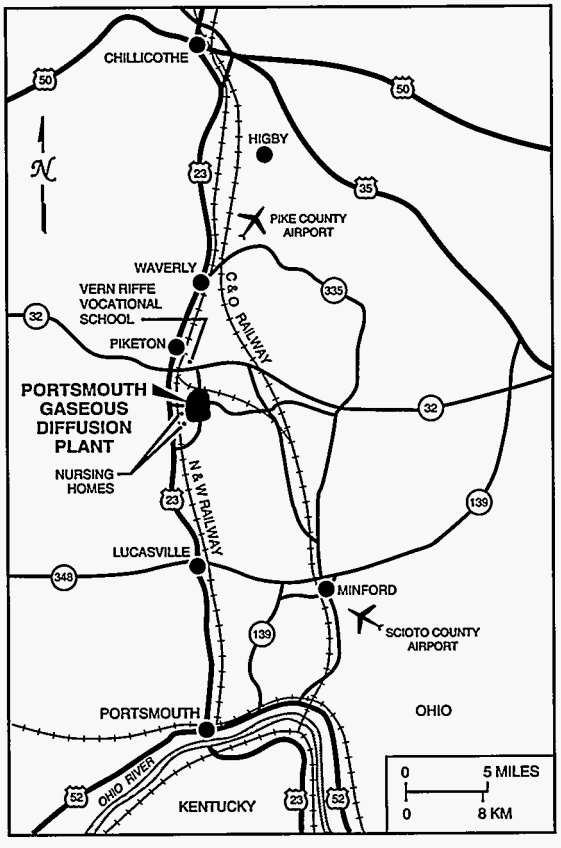

Fig. 1.2. Location of the Portsmouth site in relation to the geographic region.

Waverly, is about 19 km (12 miles) north of the plant site and has a population of about 4500 residents. The nearest residential center in this area is Piketon, which is about 8 km (5 miles) north of the plant on U.S. Route 23; its population is about 1700. 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. Two nursing homes, with a combined capacity of 60 persons, are located along Wakefield Mound Road.

Additional population centers within 80 km (50 miles) of the plant are Portsmouth (population 22,249), 43 km (27 miles) south; Chillicothe (population 21,923), 43 km (27 miles) north; and Jackson (population 6144), 29 km (18 miles) east. The total population of the area lying within an 80-km (50-mile) radius of the plant is approximately 900,000 (U.S. Department of Commerce 1991).

DESCRIPTION OF SITE OPERATIONS AND FACILITIES

DOE, through its operating contractor, Energy Systems, operates the Environmental Restoration, Waste Management, and Depleted Uranium Hexafluoride Cylinder programs at the plant. The Environmental Restoration staff performs remedial investigations to define the nature and extent of contamination, evaluates the risks to public health and the environment, and determines the available alternatives for a feasibility study 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 the Portsmouth site are thoroughly investigated and that appropriate remedial action is taken for the protection of human health and the environment.

DOE no longer enriches uranium at the Portsmouth site. The Portsmouth uranium enrichment production operation facilities are leased to USEC in accordance with the National Energy Policy Act of 1992. The enrichment production operations, the associated environmental impacts from enrichment production, and the monitoring performed by USEC are not reported in this document.

2. Environmental Compliance

Abstract

Ongoing self-assessments are conducted at the Portsmouth site to identify environmental issues. These issues are discussed openly with regulatory agencies to ensure that appropriate actions are taken to achieve compliance.

BACKGROUND AND OVERVIEW

The Portsmouth site 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 and settlement agreements. This section summarizes the plant's compliance status with regard to these various authorities.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at the Portsmouth site. As of July 1, 1993, responsibility for implementing environmental compliance was split between DOE, as site owner and operator of waste management and environmental remediation projects, and USEC, a government-owned corporation formed by the National Energy Policy Act of 1992 to take over the nation's uranium enrichment business. The management contractor for DOE is Lockheed Martin Energy Systems (Energy Systems), and a new subsidiary, Lockheed Martin Utility Services (Utility Services), was formed to provide management and operation services for USEC.

Under the terms of the lease between USEC and DOE, USEC assumed responsibility for compliance activities directly associated with uranium enrichment operations such as air emission permits for cascade vents and maintenance facilities, National Pollutant Discharge Elimination System (NPDES) compliance for the X-6619 sewage treatment plant and other leased facilities, and management of solid wastes generated by enrichment operations (with the exception of "legacy" wastes mentioned subsequently). DOE retains responsibility for the site Environmental Restoration Program; the bulk of the Waste Management Program, including waste inventories that predate July 1, 1993, wastes generated by current DOE activities, and wastes containing legacy constituents, such as asbestos, polychlorinated biphenyls (PCBs), and transuranics; and NPDES compliance at outfalls not leased to USEC and air emission sources not leased to USEC. DOE also retains responsibility for HEU removal and operation of all nonleased facilities on the Portsmouth site. The Nuclear Regulatory Commission (NRC) is scheduled to assume direct oversight of USEC operations in October 1995. In the interim, DOE is providing oversight until the NRC assumes regulatory authority.

Principal among other regulating agencies are the U.S. Environmental Protection Agency (USEPA) (both at Headquarters and Region V), the Ohio Environmental Protection Agency (OEPA), and the Ohio State Fire Marshal's Office. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

Although much progress has been made toward achieving full regulatory compliance at the Portsmouth site, much remains to be accomplished. Ongoing self-assessments of compliance status continue to identify environmental issues. These issues are discussed openly with the regulatory agencies to ensure that appropriate actions are taken to achieve compliance.

COMPLIANCE ACTIVITIES

Resource Conservation and Recovery Act

As of the end of 1994, negotiations for a Resource Conservation and Recovery Act (RCRA) Part B permit for the Portsmouth site were continuing between DOE and the state of Ohio. The Portsmouth site operates two RCRA container storage units (X-7725 and X-326L) under the OEPA Director's Findings and Orders issued July 15, 1991. In addition, several 90-day storage areas have been established for temporary storage of hazardous wastes.

Certification of closure has been received from the OEPA for five RCRA facilities. Five additional units have been closed and are awaiting OEPA certification. In July 1992, closure plans for the X-701C neutralization pit and the X-230J7 surface impoundment were submitted to the OEPA. Per OEPA request, closure plans for these two units were revised and resubmitted in late 1993 for OEPA review and approval. As of December 31, 1994, the OEPA had not taken any action. A closure plan was also submitted to the OEPA for the X-344A neutralization pit in 1993. Table 2.1 shows the current RCRA facility closure status.

Table 2.1. RCRA facility closure status at the Portsmouth site for 1994

Status	Facility
Certification of closure received from the OEPA	X-616 surface impoundments
	X-705A incinerator
	X-749 landfill (northern portion)
	X-750 tank
	X-752 container storage unit
Closed and awaiting certification	X-700 tank 7
	X-700 tank 6
	X-700 tank 8
	X-744G(R) container storage unit
	X-744G(U) container storage unit
Closure plans approved and closure under way	X-231B land treatment area
	X-735 landfill (cells 1–6)
	X-740 tank
	X-740 container storage unit
	X-744Y container storage yard
Revised closure plans submitted to the OEPA for review	X-701B holding pond
	X-701C neutralization pit
	X-230J7 surface impoundment
Initial closure plan submitted to the OEPA for review	X-344A neutralization pit

Ohio Consent Decree and USEPA Administrative Consent Order

A consent decree with the state of Ohio and an administrative consent order with the USEPA require the investigation and cleanup of releases to surface water and air; spills from past operations, including the elimination of groundwater contamination plumes; and solid waste management units (SWMUs), of which 74 have been identified. These 74 units are distributed over four areas (or quadrants) that are defined based on groundwater movement patterns. RCRA facility investigations (RFIs) for all quadrants have been completed, and reports have been submitted to the USEPA and the OEPA.

An amended consent decree is being negotiated to incorporate language addressing depleted uranium hexafluoride (UF_6) and lithium hydroxide (LiOH) stored at the

Portsmouth site. In addition, language addressing the settlement of long-standing enforcement action by the Ohio attorney general is being addressed. It is anticipated that the amended consent decree will be signed by all parties in 1995.

The administrative consent order with the USEPA was revised on August 11, 1994, to incorporate those actions resolving notices of violation (NOVs) issued by the USEPA in 1993 involving the Quadrant III RFI. DOE agreed to pay a $50,000 fine and conduct a supplemental environmental project costing $1M or more. The project chosen will address the sludge-drying beds of the X-6619 sewage treatment plant. Work will begin in 1995.

All air RFI fieldwork (ambient air sampling, vent and stack survey review, SWMU data review and sampling, and source modeling) was completed in 1994. The regulatory milestone for submittal of the air RFI report to the USEPA and OEPA on February 28, 1995, was met.

RCRA NOVs

One NOV, dated August 26, 1994, was issued by the OEPA. The OEPA cited DOE for one violation identified in the annual RCRA compliance audit and reiterated five outstanding violations from previous audits. The new violation was failure to adequately maintain the condition of waste containers (one dented storage drum). The five outstanding violations were (1) failure to make hazardous waste determinations regarding depleted UF_6 cylinders and LiOH; (2) storage of hazardous waste in the X-700 tank 7 for more than 90 days; (3) failure to conduct tank assessments on the X-700 tanks 6, 7, and 8 and the X-740 and X-750 tanks; (4) lack of secondary containment for the five tanks listed in item 3; and (5) lack of a hazardous waste permit for X-700 tank 7.

The new violation identified in the RCRA audit was corrected within 24 hours of being identified. Efforts are under way to negotiate an amended consent decree with the OEPA to address the five outstanding items. The X-700 tank 7 and X-750 tank have been closed.

Federal Facilities Compliance Act

The Federal Facilities Compliance Act was enacted by Congress in October 1992. Federal facilities are now required to develop and submit site treatment plans for treatment of mixed wastes. Approval authority has been delegated to the OEPA.

A conceptual site treatment plan was submitted in October 1993, and a draft site treatment plan was submitted in August 1994. The proposed site treatment plan was submitted by March 30, 1995.

Comprehensive Environmental Response, Compensation, and Liability Act

The Portsmouth site is not on the National Priorities List, and the USEPA and the OEPA have chosen to oversee environmental remediation activities at the Portsmouth site under the provisions of RCRA.

Reportable quantity (RQ) release reporting requirements for hazardous substances under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 103 require notification to the National Response Center in the event of an RQ release. There were no RQ releases reported during 1994.

Emergency Planning and Community Right-To-Know Act

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

EPCRA Section 304 requires reporting of off-site RQ releases to state and local authorities; Sections 311 and 312 require provision of material safety data sheets (MSDSs) or a list of hazardous chemicals for which the MSDSs are required and annual submittal of hazardous chemical inventories, respectively, to state and local authorities; and Section 313 requires annual reporting of releases of toxic chemicals to the USEPA and the state.

The Portsmouth site had no releases of hazardous chemicals subject to Section 304 notification requirements during 1994. The Section 311 MSDS lists are frequently updated and provided to appropriate officials. The Section 312 inventory report for 1994 included the identity, location, storage information, and hazards associated with 36 hazardous chemicals at the Portsmouth site. Of these 36 hazardous chemicals, 6 were stored on DOE-held properties not leased to other establishments within the Portsmouth facility. These six hazardous chemicals were diesel fuel, ethylene glycol, gasoline, lithium hydroxide, triuranium octaoxide, and uranium hexafluoride. Under EPCRA Section 313, releases of two toxic chemicals, hydrogen fluoride and zinc, were reported for 1994 from DOE-held properties not leased to other establishments within the Portsmouth facility and are summarized in Appendix C of this report.

Underground Storage Tanks

The underground storage tank (UST) program is managed in accordance with the regulations of DOE, the USEPA, OEPA, and the Ohio State Fire Marshal's Bureau of Underground Storage Tank Regulations (BUSTR), which are codified in the Ohio Administrative Code, Rule Chapter 1301:7–9. The Portsmouth site registered 25 tanks with BUSTR in June 1994, including 11 that were listed as temporarily out of service and are empty or contain water. DOE leases 11 of the USTs at the site to USEC, and 1 to the Ohio Army National Guard. DOE has retained responsibility for environmental compliance for 14 of the USTs, six of which are temporarily out of service.

Four of DOE's temporarily out-of-service tanks were removed in 1994, in accordance with BUSTR regulations, and included tanks located at the following facilities: X-1107DV in July; X-3346 in August; and X-3001N and X-3001S in September. Letters indicating that no further action was required at the X-1107DV site or the X-3346 site were received from BUSTR in December 1994. Letters are expected indicating no further action is required at the remaining three sites that underwent closure in 1994.

All DOE tanks are in compliance with current BUSTR regulations with respect to general operating and leak-detection requirements and methods. Plans are being made to remove DOE's six remaining out-of-service tanks. Additionally, according to current regulations, by December 22, 1998, the remaining four USTs will either (1) require upgrades to meet current regulatory standards, or (2) be required to be removed and replaced.

Toxic Substances Control Act

The electrical power system at the Portsmouth site uses PCB transformers and large, high-voltage PCB capacitors to supply electricity to the enrichment cascade. At the end of 1994, the site inventory of PCBs in electrical equipment (including spare equipment) was approximately 900,000 kg (1,984,127 lb).

PCBs that are not totally enclosed are in service at the Portsmouth site in duct gaskets and some large lube-oil systems. These two uses of PCBs are addressed in a federal facilities compliance agreement (FFCA) between DOE and the USEPA. The agreement requires that troughs be installed under all motor exhaust duct gaskets to collect leaks of PCB oils. The troughing of the motor exhaust ducts was certified as complete by the March 30, 1994, deadline specified in the agreement. The agreement also requires that all PCB-contaminated lube-oil systems be drained. The PCB-contaminated systems were drained and retrofilled by the end of March 1993. By the end of June 1993, all the lube systems were successfully reclassified as either detectable PCB or non-PCB and were returned to service.

The Portsmouth site operates several storage areas for PCB wastes. The main storage areas meet all applicable requirements of 40 CFR 761.65. Some storage areas for uranium-contaminated PCB waste meet modified requirements regarding curb height and container specification to allow for nuclear criticality safety requirements. Virtually all Portsmouth site PCB wastes are in long-term storage because of the lack of disposal facilities authorized to dispose of wastes containing both PCBs and radionuclides.

Other sections of the Toxic Substances Control Act (TSCA) have little or no impact on the Portsmouth site. Although friable asbestos is regulated under TSCA, the specific regulations applicable to the site are duplications of other state and federal regulations, specifically, the National Emission Standards for Hazardous Air Pollutants (NESHAP) and Occupational Safety and Health Administration regulations. The Portsmouth site 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 invariably simple negatives.

Federal Facilities Compliance Agreement

In February 1992, an FFCA between DOE and USEPA Headquarters that addresses PCB issues common to all three DOE uranium enrichment plants became effective. Several compliance issues were resolved. These issues included the use of PCBs in nontotally enclosed systems, storage of PCB-radioactive waste in accordance with nuclear criticality safety requirements, and storage of PCB-radioactive waste for longer than one year. As of the end of 1994, the Portsmouth site is in full compliance with the requirements and milestones of this FFCA.

A quarterly status report is compiled and submitted to DOE regarding progress toward the milestones specified in the FFCA. An annual compilation of the quarterly reports is submitted to the USEPA. In addition, DOE and USEPA representatives meet to resolve any unanticipated issues or uncertainties regarding the terms of the agreement. One such meeting was held on January 27, 1994. Discussion included clarification of issues concerning PCB laboratory practices, PCB waste storage requirements, PCB disposal requirements, use of PCBs in electrical cable and wiring insulation, and PCB spill cleanup. In a January 19, 1995, letter, the USEPA formally approved 11 of the 12 proposals submitted.

Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides are used by Portsmouth site personnel. When application of a restricted-use pesticide is required, a certified contractor is used. Application of general-use pesticides by plant personnel is conducted according to product labeling; all product warnings and cautions are strictly obeyed. Application of pesticides by plant and contractor personnel must be approved by the plant pesticide coordinator.

Clean Air Act and NESHAP

Ohio Permits To Operate

Under OAC 3745-35, any air contaminant source emitting more than 4.5 kg/day (10 lb/day) that is not permanently exempt requires the submission of a permit-to-operate application. As of the end of 1994, the Portsmouth site had 3 state air permits (permits to operate), 17 registered sources ("registered" sources are listed by the OEPA in lieu of receiving a formal permit), and 4 exempt sources. An additional 16 permit applications were awaiting action by the OEPA. No violations of air permit limits occurred during 1994.

Clean Air Act, Title V, Permitting Program

After an initial ruling that its submission was incomplete, the state of Ohio submitted a complete Title V program application to the USEPA on July 22, 1994. The USEPA has not yet acted on the application. The state proposes to implement the Title V program in essentially the same manner outlined in 40 CFR 70.

Ohio plans to segregate regulated sources into three groups by zip code. Permit applications will be due from the first, second, and third groups within 60, 120, and 180 days, respectively. Ohio will merge its major new source review program with the Title V program but will leave its minor new source review process separate. The USEPA's maximum achievable control technology rules will be adopted unchanged.

The applicability of Title V permitting to DOE operations has not yet been determined. DOE sources alone are not significant enough to be considered major; however, because DOE operations are subject to NESHAP, this provision alone may trigger Title V permitting.

In 1994, the OEPA began reviewing all DOE permit applications for the Portsmouth site. Many of these applications are now in the process of being withdrawn because of a new *de minimis* level for air contaminants.

Clean Air Act, Title VI, Stratospheric Ozone Protection

Several activities are proceeding to enable compliance with Title VI of the Clean Air Act amendments. As part of the Stratospheric Ozone Protection Plan, Energy Systems at the Portsmouth site 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 (e.g., the cascade, refrigeration shop, and the garage). The appliance service record and retrofit or retirement plan forms apply to those units with a capacity of more than 23 kg (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 Energy Systems

control have been identified. Maintenance and service of these units is conducted by Utility Services personnel under contract to Energy Systems. The Utility Services technicians who service the equipment have been properly trained in accordance with USEPA requirements. Additionally, Energy Systems has verified that the technicians servicing the units have purchased approved recovery/recycling equipment and have submitted the equipment certifications to the USEPA.

NESHAP

DOE gaseous emissions were monitored at 6 active sources during 1994:

- X-326 top- and side-purge cascades,
- X-744G sampling facility (inactive),
- X-345 sampling facility (inactive),
- X-345 high-assay sampling area (HASA),
- X-344 evacuation vent, and
- X-326 (Areas 4, 5, and 6) seal exhaust vents.

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 and are presumed to be in equilibrium with their parent isotopes. In general, the ^{238}U daughters (^{234}Th and ^{234m}Pa) dominate the ^{235}U daughter (^{231}Th). Technetium is a beta emitter that originally entered the process as a contaminant from reprocessed reactor fuel.

Gaseous radionuclide emissions are monitored and released continuously from the X-326 top- and side-purge cascades and the seal exhaust vents. Emissions from the X-345 HASA vent are intermittent.

The Portsmouth site is in compliance with the 10 mrem/year radiological emission limit established by the USEPA; 1994 emissions from DOE activities were 0.016 mrem. The 5 most significant radionuclide emission sources are monitored by continuous vent samplers for radionuclides and fluorides. Stack tests for radionuclide emissions have been conducted on six minor sources. Emissions from other minor sources are estimated based on process knowledge and the emission factors in Appendix D of 40 CFR 61, "NESHAP."

On July 11–15, 1994, the USEPA conducted a follow-up inspection of the Portsmouth site for compliance with 40 CFR 61, Subpart H, "National Emission Standards for Emission of Radionuclides Other than Radon from Department of Energy Facilities." No actions were required as no violations were noted.

Clean Water Act

As of the end of 1994, Portsmouth had a single NDPES permit covering the entire site. This permit encompasses 21 monitored outfalls, 14 of which are classified as point-source discharges to waters of the state. The remaining seven outfalls are classified as internal outfalls, effluents from which go through another monitored outfall before reaching waters of the state. DOE and USEC work together as copermittees to maintain compliance with the terms of the permit. DOE completes a monthly operating report for 10 of the 21 outfalls; USEC completes a monthly operating report for the remaining 11 outfalls.

Compliance rates (by individual parameter) at DOE outfalls ranged from 92 to 100%. The overall site-wide compliance rate for 1994 was 99%. (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.)

High rainfall runoff and excessive algae growth have routinely resulted in total-suspended-solid and elevated-pH exceedences. Draining ponds to reduce algae growth and lower pH values, adding carbon dioxide to ponds to control pH values, and dredging ponds to increase settling time are among the measures implemented to eliminate these occurrences. As a result of these efforts, exceedences at DOE outfalls decreased to five in 1994. Fourteen additional exceedences at USEC outfalls were attributed to DOE operations. All exceedences consisted of either total suspended solids, pH, or, in one case, 1,2-*trans*-dichloroethene.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires evaluation of the environmental impacts of activities at federal facilities and of activities funded with federal dollars. NEPA 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 those 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 class I groundwater, sole-source aquifers, wellhead protection areas, and other water sources that are vital to a region).

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

The Portsmouth site has a formal program dedicated to compliance with NEPA pursuant to DOE Order 451.1, *National Environmental Policy Act Compliance Program.* Remedial actions and waste management activities are evaluated to determine the appropriate level of NEPA documentation. NEPA documents are produced by NEPA compliance program personnel and are submitted to DOE for evaluation and approval. (Note: environmental impact statements must be produced by an independent organization.) Routine operations and maintenance activities are evaluated to assess potential environmental impacts. Most activities performed on site qualify for categorical exclusion as defined in 10 CFR 1021, "NEPA Implementing Procedures," and listed in Subpart D, Appendixes (a) and (b). These activities are considered to have no significant individual or cumulative environmental impacts. In 1994, six generic categorical exclusions were in effect for Portsmouth site actions. Of the 55 individual categorical exclusions, 52 were

approved. Two revised environmental assessments, "Construction and Operation of a Non-hazardous Solid Waste Landfill at Portsmouth Gaseous Diffusion Plant" and "Modification and Expansion of the X-7725A Waste Accountability Facility for Polychlorinated Biphenyl (PCB) Wastes at the Portsmouth Gaseous Diffusion Plant (PORTS)," were submitted to DOE–Oak Ridge Operations for review and comment in 1994. These assessments are awaiting approval. An environmental impact statement for the Portsmouth area was completed in 1977.

On July 1, 1993, USEC formally began operation of facilities leased from DOE to enrich uranium for commercial purposes. In accordance with the USEC Environmental Review Policy published in the *Federal Register* (Vol. 58, No. 233, Dec. 7, 1993), USEC also continues to evaluate routine operations, waste management, maintenance, and engineering project activities for environmental impacts.

Other Environmental Acts and Federal Regulations

Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of rare and threatened wildlife and plants. The act also serves to protect ecosystems on which such species depend. Field surveys are performed, and mitigating measures are designed as needed. When appropriate, formal consultations with the U.S. Fish and Wildlife Service and the Ohio Department of Natural Resources are made through DOE. A threatened and endangered species habitat survey was completed in October 1994. A bat survey was completed in September 1994.

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 through DOE as required by Section 106 of the act. No reviews were conducted in 1994.

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 through DOE. No prime farmland surveys were conducted at the Portsmouth site in 1994.

Title 10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements"

Title 10 CFR 1022 establishes policy and procedures for compliance with Executive Order 11988, "Floodplain Management," and Executive Order 11990, "Protection of Wetlands." 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.* A floodplain or wetland assessment must then be prepared and

submitted to DOE for approval. These assessments must discuss the effects of the proposed project on the floodplain or wetland and any alternatives or mitigating measures that would lessen adverse impacts. For floodplains, a floodplain statement of findings summarizing the floodplain assessment must also be approved by DOE and be published in the *Federal Register* for public comment at least 15 days prior to beginning the project. A wetland survey relating to the Portsmouth site was completed in March 1994. The wetland survey identified a number of areas considered wetland or emergent wetland; these areas were delineated and mapped in April 1994.

Ecological Risk Assessment

In the summer and fall of 1993, DOE began preparing a baseline ecological risk assessment for the Portsmouth site. 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, a water toxicity testing task, sediment toxicity testing, soil toxicity testing, and fish tissue analyses. The wetland survey identified a number of areas considered wetland or emergent wetland; these areas were delineated and mapped in April 1994. The threatened and endangered species habitat survey was completed in October 1994. Results from this survey indicated the presence of several state-listed and possibly one federally listed threatened and endangered species within the Portsmouth reservation boundary. The bat survey, which was completed in September 1994, did not indicate the presence of the endangered Indiana Bat (*Myotis sodalis*). The fish community surveys were performed on the fish communities in all receiving streams associated with the Portsmouth facility. The benthic macroinvertebrate community studies, which evaluate the ecological well-being or health of an aquatic ecosystem, were conducted on streams on the Portsmouth reservation. The toxicity testing task was performed to assess the impact that releases from the Portsmouth site have, have had, or may have on the ecology of surrounding streams. Sediment toxicity testing was conducted to determine the ecological condition of various stream and creek sediments within and surrounding the Portsmouth site. The soil toxicity testing was performed to estimate bioavailable concentrations of chemicals of concern in soil from analytical soil chemistry data. Fish tissue analyses [consisting of whole body analyses of individual fish for various metals, PCBs/pesticides, fluoride, and radionuclides (gross alpha and beta activity and ^{99}Tc activity)] were conducted from forage fish collected from streams draining the Portsmouth site.

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, the Mound Plant, and the Portsmouth Gaseous Diffusion Site). The agreement provides approximately $11M 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 OEPA is the lead state agency for the agreement. The Ohio Department of Health and the Ohio Emergency Management Agency are also involved.

DOE Order Compliance

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. The Portsmouth site maintains compliance with federal, state, and local statutes through implementation of requirements found in the Clean Air Act, Clean Water Act, RCRA, TSCA, the Safe Drinking Water Act, and other appropriate statutes.

The Portsmouth site environmental protection programs mandate the creation of several environmental reports. These reports include the radioactive effluent and on-site discharge data report submitted annually to the Waste Information Systems Branch at Idaho National Engineering Laboratory; 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 5000.3B, *Occurrence Reporting and Processing of Operations Information.* An environmental protection implementation plan (EPIP) is required to be prepared and updated annually. The EPIP defines specific environmental objectives, including the means and schedules for accomplishing those objectives. The EPIP was reviewed and red-lined for updating in 1994. An environmental monitoring plan (EMP) is to be prepared, reviewed annually, and updated every three years. The EMP defines a comprehensive system to provide effluent monitoring and environmental surveillance of effluents from the Portsmouth site. The monitoring program includes all environmental media—surface water, groundwater, air, earth, and biological media. The EMP is designed to meet federal and state regulatory requirements as well as those internal to the Portsmouth site and DOE. The final draft of the EMP was issued in June 1994.

Quality assurance and data evaluation are primary considerations for Portsmouth site monitoring, surveillance, sampling, and analytical activities. Independent data verification is conducted. This aspect of monitoring is targeted for increased attention in the future. Audits of monitoring and sampling activities by state and federal regulatory agencies have been positive, and no significant findings have been issued.

Pollution Prevention and Waste Minimization

Pollution prevention activities are administered at the Portsmouth site through the 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, the last resort in the pollution prevention hierarchy, as referenced in the Pollution Prevention Act of 1990. DOE participates in the voluntary "Ohio Prevention First" program, an initiative sponsored by the state of Ohio that promotes pollution prevention programs. The goal of the program is to incorporate pollution prevention into the decision-making process at every level throughout the organization. The 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.

The Pollution Prevention Awareness Program consists of (1) pollution prevention awareness through newsletters, bulletins, and memorandums; (2) awards, recognition, 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.*

Radioactive waste minimization efforts include segregation of radioactive and nonradioactive wastes and reduction of controlled radiation areas, with an associated reduction in use of disposable and washable personal protective equipment. Mixed waste (hazardous waste mixed with radionuclides) minimization efforts include segregating hazardous wastes from radioactive contaminated wastes, reduction of absorbent cloth use in PCB spill cleanup, and material substitution. A procedure has been issued that requires all waste generators to issue and have approved before starting work a waste management plan that states how wastes are to be minimized for the course of a project. Nonhazardous waste minimization efforts include a sanitary waste recycling program that includes recycling aluminum cans, corrugated cardboard, and office waste paper.

Proposed waste minimization projects include recycling spent fluorescent light bulbs, toner cartridges, lead acid batteries, and scrap metal. The development of a site waste minimization team, continuation of waste minimization training for employees, and performing pollution prevention opportunity assessments on selected waste streams and activities are expected to identify additional waste minimization opportunities.

Environmental Training

Environmental training is a continuous process at the Portsmouth site. During 1994, training included environmental compliance, hazardous waste operations, and RCRA-generator training. Hazardous waste operations training is conducted at three levels, including a 24-hour course, a 40-hour course, and an 8-hour refresher course. This training satisfies occupational safety and health requirements specified in 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response." RCRA training courses are specific, dealing with hazardous waste generators and treatment, storage, and disposal operations. This training satisfies RCRA requirements specified in 40 CFR 265.16, "Personnel Training," and OAC-3745-55-16(D), "Survey Plat."

Groundwater Protection Program

Scope of the Groundwater Protection Program

DOE Order 5400.1 outlines requirements for groundwater monitoring at all DOE facilities and specifies the development of three individual documents relating to groundwater monitoring: an EMP, a groundwater protection program management plan (GWPPMP), and a groundwater monitoring plan. The GWPPMP formalizes and structures the Portsmouth site groundwater protection program (GWPP) by identifying and assigning specific roles and responsibilities to the various staff within the plant who are matrixed to the program. The Portsmouth site plan meets the requirements for a GWPPMP as described in DOE Order 5400.1. The contents of this plan have been updated and assembled to reflect the following scope:

- Define the purpose, policies, objectives, and history of the GWPPMP.
- Define regulations, requirements, and guidance applicable to groundwater monitoring at the Portsmouth site.
- Provide a brief description of the hydrogeologic conditions and known groundwater contamination at the Portsmouth site.
- Describe the groundwater monitoring strategies used at the Portsmouth site to meet the applicable regulations and requirements.
- Define the organizational roles and responsibilities of the GWPP, including interfaces with other programs.

- Define the documentation required for GWPP projects.
- Provide the most effective overall management possible for the GWPP.

The Portsmouth site GWPPMP is a dynamic document that will be updated and revised routinely. The format allows updating of individual sections independent of the rest of the document. The plan as a whole will be reviewed annually and will be revised and reissued every three years. Sections that are revised between reissue dates will be numbered and dated. Where appropriate, the GWPPMP incorporates material by reference; all referenced materials are subject to annual review, revision, and reissue.

Purpose, Policies, and Objectives of the Portsmouth GWPP

The purpose of the Portsmouth site GWPP is to characterize the hydrogeology and monitor the groundwater quality at the Portsmouth site and its environs. Related tasks are conducted primarily in support of (1) environmental surveillance activities conducted by Environmental Management and Enrichment Facilities, (2) land disposal units requiring groundwater monitoring under RCRA, (3) the Remedial Action Program, (4) UST monitoring, and (5) land disposal units requiring groundwater monitoring under state solid waste regulations (OAC-3745-27). 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.

Groundwater Investigations at the Portsmouth Site

In 1994, the Portsmouth site revised and issued the four quadrant RFI reports, completed field activities and issued a draft report for an off-site soil and groundwater background study, and initiated the corrective measures study (CMS) process. Seven draft CMS reports (Quadrant I, Quadrant II, X-701B, Peter Kiewett landfill, X-749/X-120, X-611A, and X-705 A and B) were submitted to the OEPA and USEPA. After addressing regulatory comments, two draft CMS reports (X-611A and X-705 A and B) were issued as final drafts.

In addition, construction activities for the X-749 and Peter Kiewett landfill interim remedial measures were completed. At the southern boundary of the Portsmouth reservation, the installation of a subsurface barrier [in the unconsolidated soil and into the top 1.2 m (4 ft) of bedrock] was completed. This barrier will preclude continued southward migration of contaminated groundwater from the X-749 landfill. At the Peter Kiewett landfill, a seep collection system was installed and Big Run Creek was relocated to prevent volatile organic contaminants (primarily vinyl chloride) from entering Big Run Creek.

A geologic and hydrogeologic reconnaissance was completed for property adjoining the Portsmouth southern boundary. A cone penetrometer was used to collect geologic data (four borings) and seven groundwater samples. In addition, six small-diameter piezometers [less than 5.1 cm (2 in.)] were installed on the property. Analytical results for the groundwater samples did not show volatile organic contamination on the property.

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 risk from operations of DOE and DOE contractors. The order requires that off-site radiation doses not exceed 100 mrem/year. In 1994, the total off-site dose from the Portsmouth site

was 0.066 mrem/year, including airborne emissions, consumption of locally produced foodstuffs (including fish caught in the Scioto River), and consumption of drinking water from the Scioto River.

The Portsmouth site 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 (DCGs) for specific nuclides in wastewater and storm water discharges (6.7% of the USEPA limit and 0.67% of the DOE limit). The Portsmouth site conducts various modeling and dose assessment activities from samples and other information collected to address the potential for multiple-pathway exposures of the public. The Portsmouth site is in compliance with the requirements of this order.

DOE Order 5820.2A, *Radioactive Waste Management*

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

All radioactive wastes generated at the Portsmouth site are classified as low-level waste (LLW) 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 of at DOE facilities. Facilities have been identified for this purpose (e.g., Hanford and the Nevada test site), and procedures and protocols are being established to provide proper access to these facilities. The Portsmouth site has initiated shipments to Hanford and is in the process of qualifying itself as an "approved Hanford generator" with a certification program.

Commercial facilities are becoming available for these activities (i.e., treatment, storage, and disposal), and DOE has provided a method of approving use of these facilities for small quantities of waste. Volume reduction of LLW is provided by a commercial facility in Tennessee, and disposal of LLW and mixed waste is provided by a commercial facility in Utah. The Portsmouth site is proceeding to ship wastes under the recently negotiated nationwide contract between DOE and Envirocare of Utah, Inc., for disposal of mixed waste.

LLW 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-LLW and PCB-LLW). Storage requirements for each of these waste types diminish the potential for environmental release. The Portsmouth site is in compliance with the requirements of this order.

Occurrences Reported to Regulatory Agencies

Because the potential exists to generate reportable-quantity releases from several Portsmouth site operations, the Portsmouth site is required to evaluate spills and unanticipated releases to determine if such incidents are reportable as prescribed in 40 CFR 302.6, "Notification requirements," and 40 CFR 355.40, "Emergency release notification." These releases include fluorine associated with the uranium enrichment cascade, stack emissions from the coal-fired steam plant, and a variety of substances from contaminated groundwater associated with RCRA units. Estimates of potential releases from each of these sources were calculated and determined to be insufficient to constitute reportable-quantity releases. In 1994, the Portsmouth site had no releases from these sources or other potential sources (e.g., spills of maintenance materials such as antifreeze) that exceeded quantities reportable under the Comprehensive Environmental Response, Compensation, and Liability Act.

Compliance Audits of Environmental Programs

During 1994, 8 audits, appraisals, or inspections of the Portsmouth environmental restoration and waste management site environmental programs were conducted. The most important are summarized as follows; a complete listing is in Table 2.2.

Table 2.2. Environmental audits and inspections at the Portsmouth site during 1994

Date	Auditor	Type
April 7	DOE/Federal Energy Regulatory Commission	Annual dam and dike inspection
June 21	USEPA and OEPA	NPDES outfall and laboratory inspection
July 11–15	USEPA	Annual NESHAP compliance inspection
July 12–15	OEPA	Plant-wide RCRA inspection
August 15–24	DOE	Regulatory oversight agreement audit
September 27–29	USEPA	RCRA and TSCA compliance inspection
October 13	OEPA	Annual air emission source inspection
December 15	Defense Nuclear Facility Safety Board	Depleted uranium cylinder yard and procedure inspection

The OEPA conducted the annual RCRA compliance audit in July. All areas of compliance, including record keeping and compliance self-inspections required by RCRA regulations, were reviewed. The OEPA issued an NOV to DOE based on its findings (see the "RCRA NOVs" section for details). DOE corrected the deficiency identified during the audit within 24 hours.

USEPA Region V conducted a NESHAP compliance inspection in July, and the OEPA conducted an inspection of state-permitted air emission sources on October 13. The USEPA and OEPA conducted a joint inspection of the plant NPDES outfalls and the plant laboratory on June 21. None of these inspections resulted in any NOVs.

ENVIRONMENTAL PERMITS

Table 2.3 lists the current environmental permit status for the Portsmouth site.

Clean Air Act Permit Status

At the end of 1994, DOE had 3 permits to operate, 17 registered sources, 4 exempt sources, and 16 pending permit applications associated with air emission sources.

Clean Water Act Permit Status

A new NPDES permit was issued on September 23, 1991, and was modified on December 12, 1991, and June 1, 1993. The permit was also amended on September 3, 1993, to add USEC as a copermittee with DOE. The permit was again modified on April 1, 1994, and was scheduled to expire on July 29, 1994. In January 1994, DOE and USEC submitted applications for separate permits to the OEPA. Although the OEPA did not issue new permits in 1994, they did authorize continued use of the existing permit and plan on issuing new permits in 1995.

Table 2.3. Portsmouth site environmental permits

Permits	No. permits applied for	No. permits received
Air (Clean Air Act)	16	3 (17)[a]
NPDES (Clean Water Act)	1	1
RCRA	1	
X-735 sanitary landfill license	1	1

[a]Air sources registered by the OEPA in lieu of formal permits to operate.

RCRA Permit Status

In March 1993, the OEPA submitted the RCRA Part B permit application to the Ohio Hazardous Waste Facility Board, which is reviewing the permit. This is a formal, legal process, and subsequent hearings will be held before the permit is issued.

In 1994, one NOV was issued by the OEPA. The NOV was issued for one violation found during the annual RCRA inspection and for five ongoing issues. A more detailed description of the NOVs is provided in the RCRA section under "RCRA NOVs."

Land Disposal Restriction Waste

The Portsmouth site is currently storing RCRA hazardous waste and low-level radioactive RCRA hazardous waste. This waste is subject to RCRA land ban provisions, which permit storage only to attain sufficient quantities to facilitate proper treatment, recycling, or disposal. Because the nation's treatment capacity for radioactive mixed waste is inadequate, a national capacity variance was obtained that extended the effective date of land disposal restriction (LDR) prohibitions until May 8, 1992. The national capacity variance did not extend to radioactive mixed waste containing solvents, dioxins, or California-listed wastes. USEPA Region V informed the Portsmouth site in a letter dated March 30, 1992, that any LDR compliance issues involving mixed wastes should be discussed with the OEPA. The OEPA issued a Director's Findings and Orders to the Portsmouth site allowing the storage of LDR wastes for periods longer than one year while negotiations for long-term resolution are being conducted.

X-735 Sanitary Landfill Permit Status

The X-735 sanitary landfill is the only permitted solid waste facility at the Portsmouth site. The Portsmouth site is in compliance with its permit for disposal of sanitary waste. A license to operate the landfill is obtained annually from Pike County, Ohio. Wastes permitted in the X-735 landfill include cafeteria wastes, industrial wastes, disinfected medical wastes (except drugs), construction and demolition debris, and asbestos (in designated locations). No hazardous wastes, TSCA wastes, or radioactive wastes are permitted in this facility. Asbestos disposal is conducted in accordance with NESHAP and OAC 3745-20, "Asbestos Handling—Demolition, Renovation, Disposal."

The Portsmouth site construction spoils area (X-736), located immediately west of the X-735 sanitary landfill, is an operating landfill for materials not regulated as solid wastes by the state of Ohio. Materials of this type include certain construction and demolition debris that do not contain hazardous or toxic substances.

3. Environmental Program Information

Abstract

The goal of the environmental programs at the Portsmouth site is to assess the effects of DOE operations at the site on the environment and public health and to maintain the quality of the surrounding environment. DOE has an extensive environmental monitoring program that consists of radiological and nonradiological monitoring of liquid and gaseous discharges, ambient air, and groundwater. Monitoring is based on environmental regulations, critical pathways analyses, public concerns, and measurement capabilities. Other environmental programs at the Portsmouth site include waste management, environmental restoration, waste minimization and pollution prevention, training, information exchanges, and public and employee awareness.

ENVIRONMENTAL MONITORING PROGRAM

Because the primary mission of DOE at the Portsmouth plant is remediation, the environmental monitoring effort is directed toward collecting samples and analyzing them for compliance with regulatory requirements. 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 sampling medium, such as water, soil, or vegetation. For this reason, mathematical models are used to estimate the transport and dispersion of radionuclides into the environment. Basically, this involves monitoring the source of the contamination (i.e., 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.

These models are also used to help optimize the effectiveness of the existing radiological monitoring program. For example, predictions based on models can be very beneficial in choosing the best locations for measuring devices and in identifying important pathways and contaminants. 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 atmospheric and liquid discharges comply with state and federal standards. Monitoring of atmospheric releases is designed to ensure compliance with permits issued by the OEPA. 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. In addition to monitoring liquid effluents, the Portsmouth site collects and analyzes samples from site streams and the Scioto River. This surveillance is designed to provide verification of outfall sampling and to ensure that materials that could adversely affect the environment are detected and properly characterized.

Goals

The environmental monitoring program is designed for the assessment of DOE site operations on the environment and public health. This is accomplished through the collection and analysis of samples. The results are compared with defined standards. These results are used to gauge the environmental impact of DOE operations and to set priorities for further environmental improvements.

Rationale

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 Portsmouth site environmental monitoring program is found in the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (MMES 1994).

Environmental Regulations

Numerous state and federal regulations that encompass radiological and nonradiological programs are drivers for much of the monitoring conducted at the Portsmouth site. These regulations include NESHAP, NPDES, RCRA, and NEPA. Compliance with these regulations requires a number of regulators, including the USEPA and the OEPA, 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 of this report, "Environmental Compliance."

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. As discussed in Section 6, "Dose," the Portsmouth site uses USEPA-approved mathematical models to estimate the dispersion of radioactive contaminants in the environment and resulting exposures to the off-site population.

Critical Pathways Analyses

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 were 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, is a good indicator for determining which radionuclides and pathways at a particular site deserve the most attention. Critical pathways analyses have been used historically at the Portsmouth site as input for the environmental monitoring program.

The following sections summarize the results of a critical pathways analysis of DOE site 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.

Air

Air provides a potential exposure pathway to humans for radionuclides released into the atmosphere. Therefore, air sampling is conducted to evaluate the potential dose to local populations. Monitors measure radiological and nonradiological air emissions from individual buildings, specific facility locations, and surrounding communities. This information is used to help protect the health and safety of Portsmouth site workers and the general public and to demonstrate compliance with state and federal air quality regulations. Both effluent air (air that flows from a specific source into the environment) and ambient air (existing air in the surrounding environment) are monitored.

Surface Water

Surface waters at the Portsmouth site are analyzed to ensure compliance with water quality standards, establish background water quality, evaluate the potential for contaminant releases, and to comply with monitoring regulations and permits.

Summary of Radionuclides

The three natural uranium isotopes (^{234}U, ^{235}U, and ^{238}U), ^{99}Tc, and daughter products are potentially significant when calculating the radiation dose received by the public around the Portsmouth site. 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 radiations 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.

Important Pathways for Radionuclides from the Portsmouth Site

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 burial areas) located within plant and reservation boundaries. Doses are estimated for all potentially significant exposure pathways relevant to the exposure modes just described.

Implications of Pathway Analysis for Environmental Monitoring

Models used to assess any environmental impact relating to the transport of and human exposures to substances released from the Portsmouth site must be appropriate for the situation encountered. Measurements are used when available to ensure that any assessment is as accurate and realistic as possible. All significant potential human exposure pathways are considered in assessing radiological and chemical exposure. Those pathways of exposure to the most exposed individual and to the entire population residing within 80 km (50 miles) of the Portsmouth site 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 complete 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.

Public Concerns

Although the actual amount of a substance released is of great concern to the public, its effect on the environment and public health is of even greater concern. Such concern can arise when 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.

Measurement Capabilities

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 Program Changes in 1994

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. Environmental monitoring program changes in 1994 included the following:

- Portsmouth site plans to upgrade the ambient air monitoring stations to comply with USEPA criteria for sampling particulate matter, which specify use of a high-volume sampler. The high-volume design is the recognized standard for particulate sampling. High-volume samplers have already been installed at three stations along the plant perimeter and at the background station near Otway. High-volume samplers were installed at two additional perimeter locations in early 1994, and four more are scheduled for upgrading in 1995.
- DOE does not monitor the environmental impact of USEC activities.

A comprehensive review of the environmental monitoring program began in 1991, and the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* was formulated. The plan, required by DOE Order 5400.1, was under review in 1993 and was submitted for approval in July 1994; no formal DOE acceptance has yet been received. The plan documents effluent monitoring and environmental surveillance activities conducted at the Portsmouth site. 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.

ENVIRONMENTAL QUALITY

Maintaining the quality of the environment at the Portsmouth site and in the surrounding communities requires programs that involve several site departments and organizations. These programs are extensive and varied, involving not only site personnel but also members of the general public. Activities include waste management,

environmental restoration (ER), waste minimization and pollution prevention, environmental training, and information exchange and public awareness programs.

Waste Management Program

The Portsmouth Waste Management Program directs the safe storage, treatment, and disposal of waste generated by past and present operations and from current ER projects. The primary objective is to ensure that waste materials do not migrate into the environment. Waste managed under the program is divided into six categories: low-level radioactive, hazardous, mixed, PCB and PCB-radioactive, asbestos, and conventional sanitary waste:

- *Low-level radioactive waste*—radioactive waste not classified as high level or transuranic and that does not contain any components regulated by RCRA or TSCA.
- *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.
- *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.
- *PCB and PCB-radioactive wastes*—waste containing PCBs, a class of synthetic organic chemicals including 209 known isomers, each with from 1 to 10 chlorine atoms on a biphenyl ring. Under TSCA regulations, PCB manufacturing was prohibited after 1978. However, continued use of PCBs is allowed provided that the use does not pose a risk to human health or the environment. Disposal of all PCB materials is regulated.
- *Asbestos waste*—friable asbestos materials from renovation and demolition activities.
- *Sanitary waste*—waste that is neither radioactive nor hazardous. Solid sanitary waste is basically refuse and is disposed of in landfills. Liquid sanitary waste includes sewage and industrial waste treated at the Portsmouth site sewage treatment plant.

Waste management requirements are varied and are sometimes complex because of the variety of waste streams generated by Portsmouth site activities. DOE orders and USEPA and Ohio Department of Health regulations must be satisfied to ensure compliance for waste management activities. Supplemental policies have been implemented for management of radioactive, hazardous, and mixed wastes. These policies include

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

Environmental Restoration Program

DOE established the ER Program to find, analyze, and correct site contamination problems as quickly and cost-effectively as possible. The ER Program encompasses both inactive sites (remedial action) and active facilities (decontamination and decommissioning). Options for correcting or mitigating the contaminated sites and facilities include removal, stabilization, and treatment of contaminants.

The Portsmouth ER Program is designed to ensure that activities meet federal and state requirements (primarily RCRA) and DOE orders. The OEPA and USEPA oversee the Portsmouth ER Program through their respective agreements with DOE. The Ohio Consent Decree became effective August 29, 1989. The Administrative Consent Order, between the USEPA and DOE, became effective in 1989 and was revised on August 11, 1994. These agreements establish a program of corrective actions to be taken and a schedule for their completion.

As required in these agreements, Portsmouth ER Program activities are conducted in accordance with the RCRA corrective action process, which consists of the following:

- *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 in advance of permanent action.

Because of the size of the facility and the nature of groundwater flow, the Portsmouth site was divided into four quadrants for investigation and cleanup.

The Portsmouth ER Program was developed in 1989 and was granted an initial budget of $13.8M. Since then, annual program expenditures have grown to $50–60M. RFIs have been completed for all quadrants, and corrective-measures studies are being initiated. As a result of potential threats to human health and the environment, several interim remedial measures were initiated; of these, two have been completed and two others are being planned to address migration of contaminated groundwater.

Waste Minimization and Pollution Prevention Program

The Portsmouth site has combined its waste minimization and pollution prevention efforts to consolidate related activities. Objectives of the Portsmouth Waste Minimization and Pollution Prevention Program include

- 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 closed-loop recycling; and
- complying with federal and state regulations and USEC–DOE policies and requirements for waste minimization.

The Portsmouth Waste Minimization and Pollution Prevention Program continues activities to achieve the waste minimization objectives. Typical projects include

- 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.

Environmental Training Program

The Portsmouth site 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 the Portsmouth site includes

- hazardous waste site training for workers;
- hazardous waste site 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, the Portsmouth site exchanges information within the site and with other DOE facilities and other sources of information.

Technical Information Exchange

Portsmouth site representatives attend both DOE-sponsored and independent technical information exchange workshops such as the annual DOE Model Conference, quarterly multiplant task team meetings, and professional conferences.

Public Awareness Program

A comprehensive community relations and public participation program on the ER and Waste Management programs has been established 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 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 opened a public Environmental Information Center in February 1993 in an effort to provide public access to all documents used to drive decisions on remedial actions being taken at the plant. The information center has a full-time staff and is located about 16 km (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 (614-947-5093).

A group of about 45 key stakeholders, composed of elected officials, community leaders, environmentalists, and other individuals who have expressed an interest in the ER 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, and semiannual newsletters are printed and distributed to more than 4000 recipients, including the community relations mailing list, neighbors within 3 km (2 miles) of the plant, and all plant employees and retirees.

Points of contact have been established for the public to obtain information or direct questions regarding the ER and Waste Management programs. The ER Program manager for DOE is the primary point of contact (614-897-5512). The Energy Systems site manager and the community relations manager also provide information on the program.

Ohio Agreement in Principle

The Ohio Agreement in Principle is a program originated by DOE in which DOE contributes funding to state agencies for resident state personnel to oversee environmental compliance at the three DOE facilities within the state of Ohio (the Fernald Environmental Management Project near Cincinnati; the Mound Plant, Miamisburg; and the Portsmouth Gaseous Diffusion Plant, Piketon). The lead state agency is the OEPA.

4. Effluent Monitoring

Abstract

The release of airborne pollutants from the Portsmouth site is regulated by permits from the state of Ohio and the U.S. Environmental Protection Agency. The majority of liquid effluents from the Portsmouth site are regulated by the National Pollutant Discharge Elimination System (NPDES). A total of 0.20 Ci (7.40×10^9 Bq) of radioactivity was released to surface water from DOE outfalls. This total represents a decrease in uranium and technetium emissions. For nonradiological releases, overall compliance with the NPDES permit limits was 99.4%.

INTRODUCTION

The Portsmouth site 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 pollution abatement technology followed by continual review of treatment facility performance to meet current regulations regarding airborne and liquid effluents in the most cost-effective manner.

AIRBORNE DISCHARGES

This section briefly describes major radiological and nonradiological air emission sources and associated emission control and emission monitoring systems at the DOE Portsmouth site, followed by a summary of the total annual emission data and a discussion of its significance.

Radiological Airborne Discharges

As a result of the formation of USEC, DOE leased the enrichment operations facilities at the Portsmouth site to USEC. Under the terms of the lease, USEC assumed responsibility for most of the existing radionuclide point-source discharges. The primary source of DOE radiological discharges to the air at the Portsmouth site is the uranium enrichment cascade itself, which could release radionuclides through process vents one and three during DOE decontamination and cleaning activities. In addition, the monitoring system covers the supporting system (X-345 HASA and X-344 evacuation vent), a potentially significant contributor to total site releases.

Regulatory Requirements

Airborne discharges of radionuclides from DOE facilities are regulated by the USEPA under the Clean Air Act and NESHAP. These regulations set (1) an annual dose limit of 10 mrem/year to any member of the public as a result of airborne releases from DOE facilities 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 regulations. However, Ohio does not yet have

any standards governing radionuclide emission limits and defers to the federal NESHAP program instead of acting on permit applications filed by the Portsmouth site.

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 NESHAP limit, the DOE limit includes the impacts of radioactivity releases from a facility through all pathways.

Radiological Airborne Sample Collection and Analytical Procedure

Gaseous radionuclide and fluoride emissions from the purge cascade vents, the cold recovery and wet-air evacuation vents, the X-345 HASA vent, and X-344 evacuation vent are sampled continuously by systems developed and built by the Portsmouth plant laboratory. The continuous vent samplers draw a flow-proportional sample of the vent stream through two small alumina traps in series by way of an isokinetic probe. The primary sample traps are replaced weekly, and the secondary traps are replaced quarterly.

A waste stream analysis was performed to determine what 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 ^{99}Tc; and equilibrium concentrations of short-lived uranium daughters. 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. The uranium daughters included in the equilibrium calculations are the thorium and protactinium isotopes ^{234}Th, ^{231}Th, and ^{234m}Pa.

Radiological Airborne Results

Radionuclide emissions from DOE activities at the Portsmouth site (Table 4.1) had no significant impact on public health or the environment. Total radionuclide emissions from the site increased in 1994 because of increased technetium emissions from decontamination activities. There were no unplanned releases during 1994. Portsmouth site emissions 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 NRC, and the International Committee on Radiation Protection.

Table 4.1. Radionuclide releases from DOE activities at the Portsmouth site to air in 1994

Radionuclide	kg/year	Ci/year[a]
^{234}U	0.0039	0.0243
^{235}U	0.357	0.000769
^{236}U	0.00097	7.46^{-6}
^{238}U	1.41	0.000464
Total uranium	1.79	0.033
^{99}Tc	0.007	0.122
Uranium daughters	3.0×10^{-11}[b]	0.002

[a] 1 Ci = 3.7×10^{10} Bq.
[b] 0.00000000003.

Historically, uranium has accounted for 75 to almost 90% of the public dose from Portsmouth site emissions. Consequently, the emission control systems on the cascade are optimized to reduce uranium emissions first and technetium emissions second. Figures 4.1 through 4.3 show the Portsmouth facility emission levels for uranium and technetium over the last five years. Figures 4.1 and 4.2 show uranium emissions in curies (a measure of radioactivity) and kilograms (a measure of mass), respectively. Both figures are included because uranium is a mixture of three different isotopes (^{236}U is a trace contaminant) with widely varying specific activities, producing varying levels of curies per kilogram. Because of this, 1 Ci (3.70×10^{10} Bq) of uranium can weigh from 9 kg (19.8 lb) to 3 metric tons (6600 lb), depending on the proportions of isotopes present. For the future, it is expected that mass emissions (kilograms) of uranium will remain about the same as levels seen from 1989 through 1993 and that the activity emissions (curies) of uranium should decrease after 1993 because of the absence of highly enriched uranium in the emissions.

Figure 4.3 shows technetium emissions in curies. Because only one isotope of technetium is present at the Portsmouth site, a figure showing mass emissions would provide no information not found in Fig. 4.3. Mass emissions of technetium from the Portsmouth site in 1994 were 0.46 kg (1.01 lb).

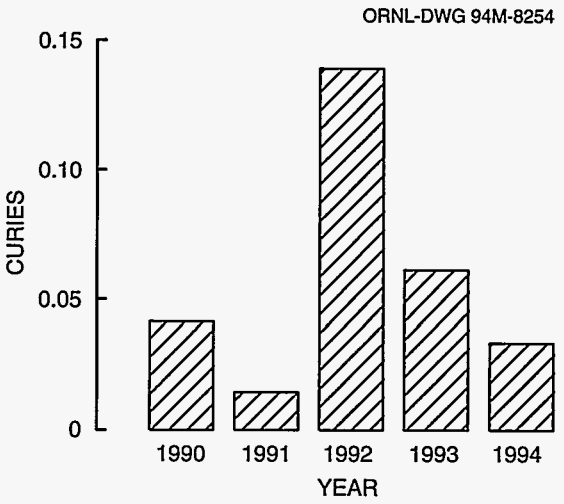

Fig. 4.1. Total curies of uranium discharged to air from DOE sources, 1990–1994 (1 Ci = 3.7×10^{10} Bq).

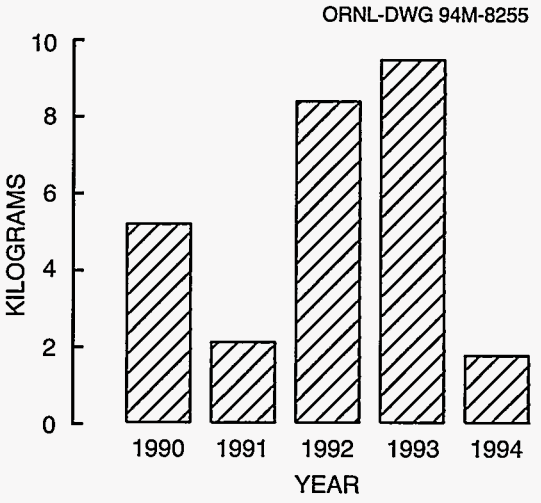

Fig. 4.2. Total kilograms of uranium discharged to air from DOE sources, 1990–1994.

Emissions of uranium daughters have ranged from 0.002 to 0.028 Ci/year (7.40×10^7 to 1.04×10^9 Bq/year) since 1986 and have never had a significant impact on the environment or public health. Emissions during 1994 were 0.002 Ci/year (7.40×10^7 Bq/year).

Nonradiological Airborne Discharges

Portsmouth site operations also release various nonradiological substances to the atmosphere. Fluorides are present in the cascade vents as various reactive fluoride gases, including UF_6 and hydrogen fluoride (HF). These emissions are monitored directly with the continuous vent samplers. In addition, several types of airborne emissions are calculated from process data or from purchasing records. All of these emissions are now the responsibility of USEC.

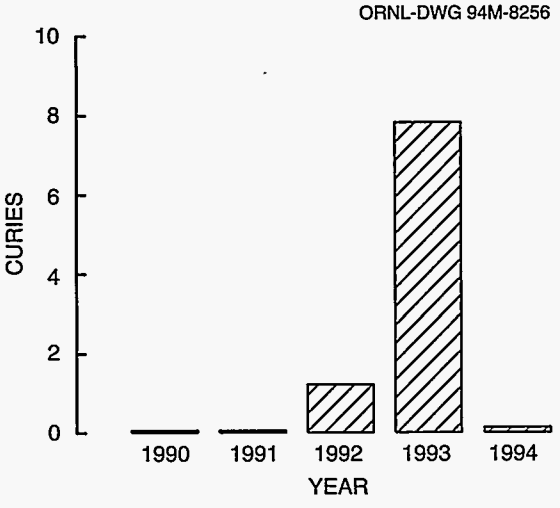

Fig. 4.3. Total curies of technetium discharged to air from DOE sources, 1990–1994 (1 Ci = 3.7×10^{10} Bq).

Regulatory Requirements

Discharges to the atmosphere are regulated under the Ohio permit-to-operate regulations. Under Ohio regulations, the OEPA can "register" small emission sources rather than issue a formal permit. Permits to operate must be renewed every three years and 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 OEPA and presumes that the registered source is too small to have a significant environmental impact. Most of the nonradiological sources at the Portsmouth site are either registered or are expected to be registered when the OEPA acts on them.

Background

DOE Portsmouth operates numerous small sources of criteria (or conventional) air pollutants. Air pollutants emitted from DOE Portsmouth include chlorine, HF, methanol, assorted solvents, and coolants. The amounts of these chemicals emitted are estimated for annual reports to the USEPA as required under Section 313 of SARA and are incorporated in this report.

Another air pollutant present at the Portsmouth site is asbestos released by renovation or demolition of plant facilities. Asbestos emissions are not included under Section 313 of SARA, and no quantified emission level is available. Asbestos emissions are controlled by a system of work practices supervised by the Industrial Hygiene Department. The amount of asbestos removed and disposed of is reported quarterly to the OEPA.

LIQUID DISCHARGES

This section briefly describes major water discharge sources and associated control and monitoring systems at the Portsmouth site that are DOE responsibilities. A summary of total annual radiological and nonradiological discharges and a discussion of the significance of the data and of any anomalies follow.

Existing Portsmouth site collection and treatment facilities are discussed in this section together with facility improvements, new treatment facilities, and studies to improve performance. Varieties of hazardous liquid wastes—uranium contaminated as well as noncontaminated—result from operations associated with uranium recovery and decontamination activities. In addition, various conventional wastes exist such as domestic sewage and once-through cooling water. Major wastewater sources and systems are shown in Fig. 4.4.

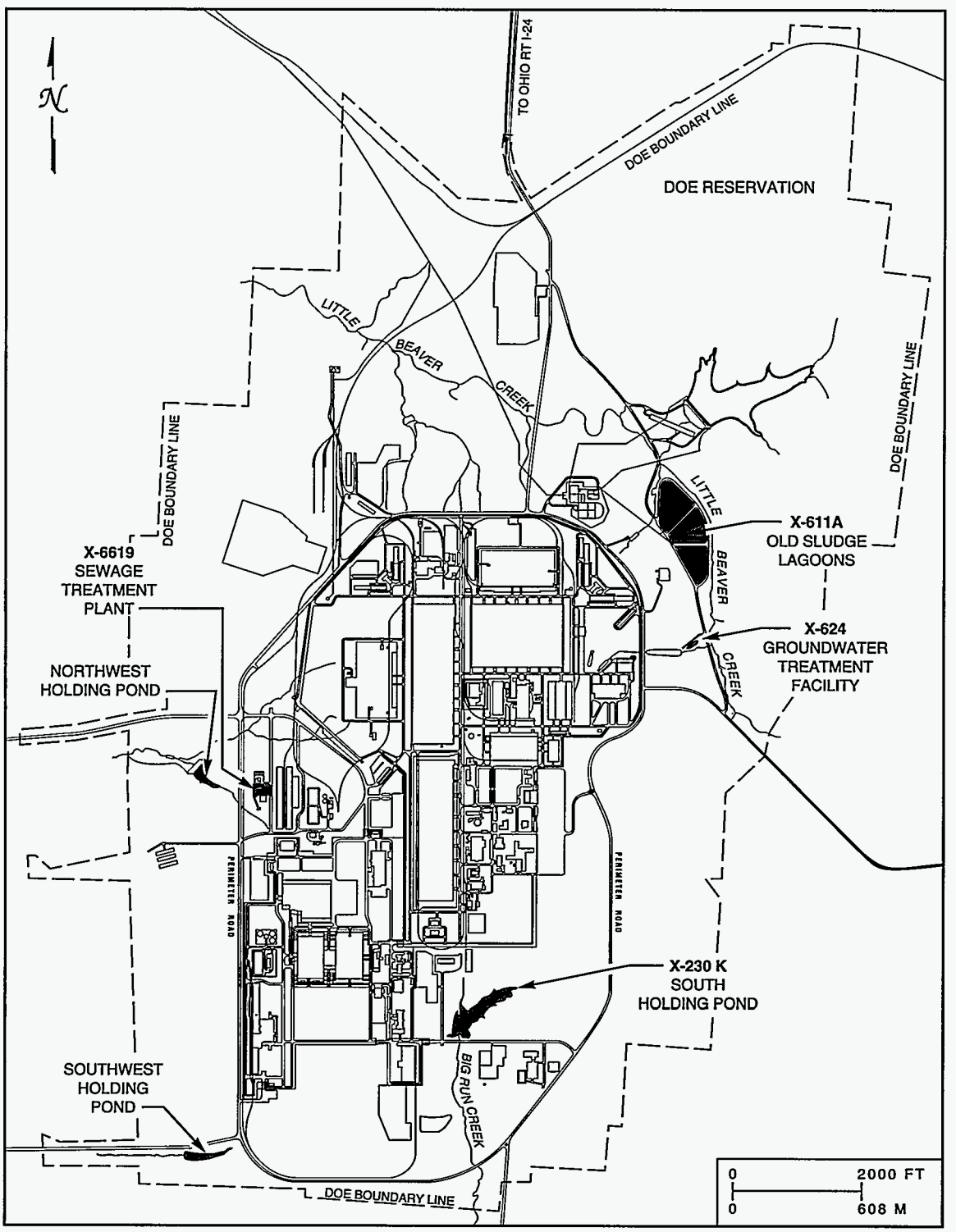

Fig. 4.4. Major wastewater sources and systems at the Portsmouth site.

Background

The quality of surface waters on the Portsmouth site 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 were collected and analyzed at various intervals (weekly, monthly, etc.) for radiological and nonradiological parameters.

Liquid plant effluents are regulated by the NPDES permit and discharge to surface streams that pass through the reservation to the Scioto River. A brief description of these discharge points, or outfalls, is provided in the following paragraphs. The locations of the NPDES-permitted outfalls that are the responsibility of DOE are shown in Fig. 4.5.

NPDES 609 (X-624 carbon filtration facility)—This facility provides for removal of volatile organic compounds (VOCs) from contaminated groundwater originating from the X-701B plume interceptor trenches. These groundwater interceptor trenches were constructed to control the migration of VOC-contaminated groundwater toward Little Beaver Creek. A flow diagram for outfall 609 is shown in Fig. 4.6.

NPDES 606 (X-701E/X-623 carbon filtration facility)—These facilities (X-623 replaced the X-701E in June 1994) provide for removal of VOCs 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 outfall 003.

NPDES 607 (X-700 air stripper)—The X-700 air stripper was constructed to remove VOCs from contaminated groundwater originating from the X-701B site remediation activities. Discharge of treated water is to the sanitary sewer and then to outfall 003. This facility operates infrequently because of stringent air discharge limitations.

NPDES 608 (X-622 groundwater treatment facility)—This facility provides for removal of VOCs from contaminated groundwater originating from X-231B, X-749, and Peter Kiewit landfill site remediation activities.

NPDES 006 (X-611A north sludge lagoon), NPDES 007 (X-611A middle sludge lagoon), and NPDES 008 (X-611A south sludge lagoon)—These lagoons once received lime sludge from the plant water-softening process and are filled to capacity. The lagoons now receive water from rainfall. Discharges from these facilities are rare and occur only during periods of excessive rainfall. Flow diagrams for outfalls 006, 007, and 008 are shown in Fig. 4.7.

NPDES 012 [X-2230M holding pond, formerly Gas Centrifuge Enrichment Plant (GCEP) 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. This outfall was renamed outfall 012 by the OEPA on September 23, 1991.

NPDES 013 (X-2230N holding pond, formerly GCEP 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. This outfall was renamed outfall 013 by the OEPA on September 23, 1991.

NPDES 014 (holding pond not constructed, formerly GCEP 003)—A holding pond originally planned and designated as outfall 003 was not constructed because of significant changes in area topography. The Portsmouth NPDES permit issued September 23, 1991, limits discharges to this outfall to storm water only and requires no routine monitoring. This outfall was renamed outfall 014 by the OEPA on September 23, 1991.

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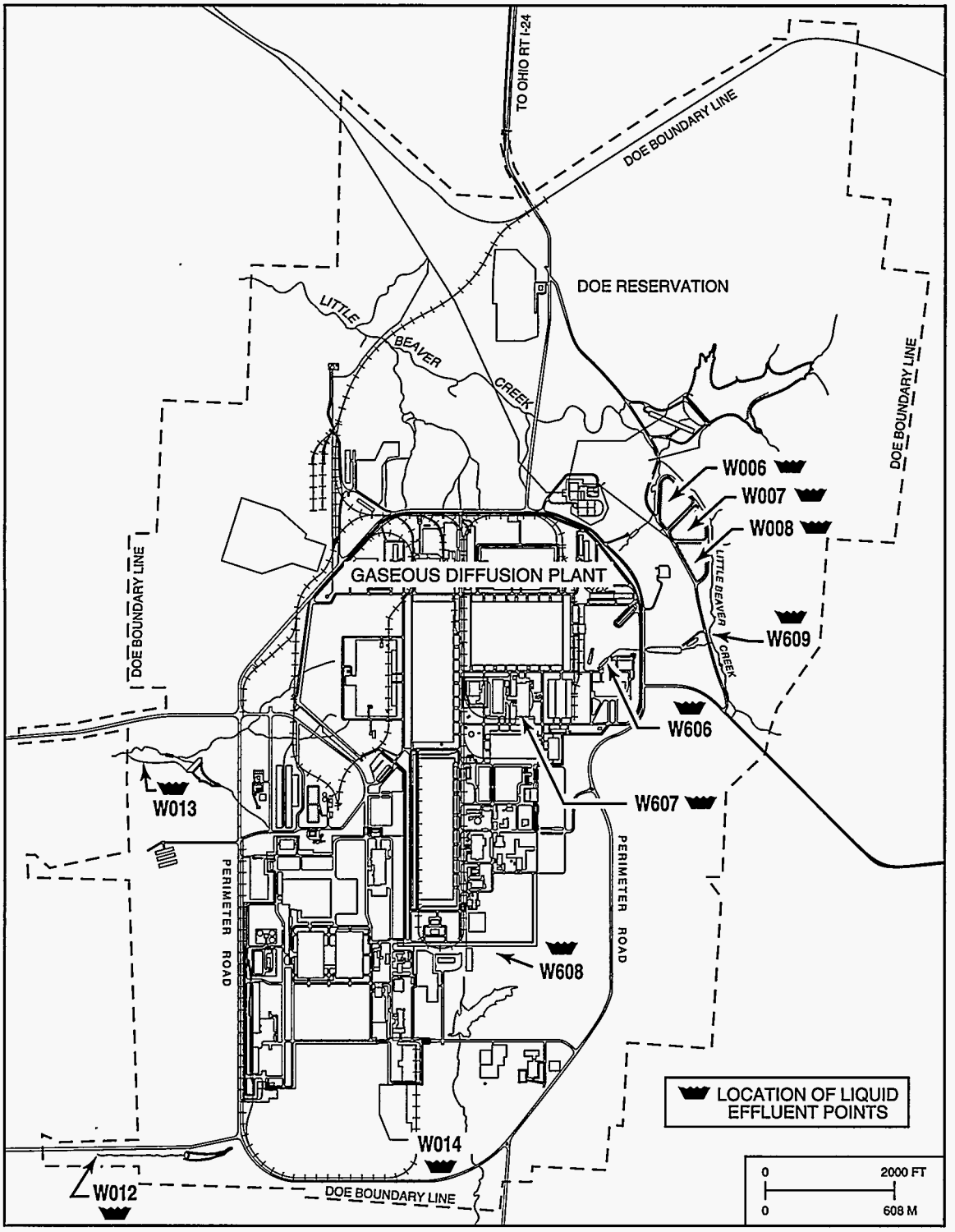

Fig. 4.5. DOE's NPDES water sampling locations at the Portsmouth site.

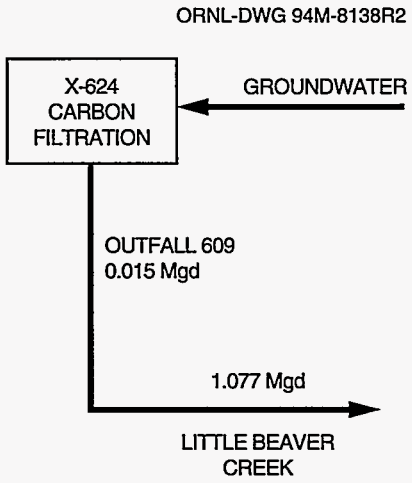

Fig. 4.6. Flow diagram for outfall 609 (X-624 carbon filtration facility).

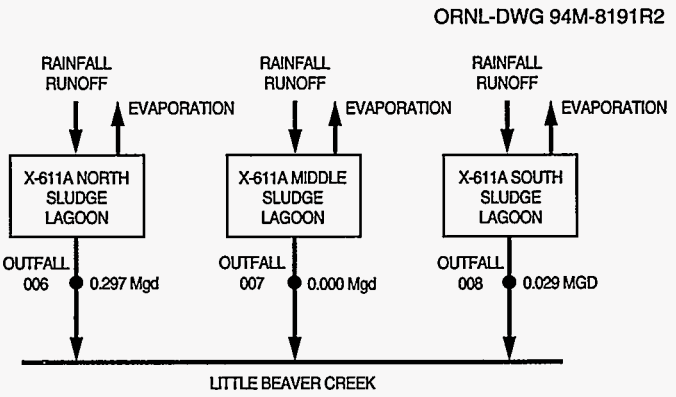

Fig. 4.7. Flow diagram for outfalls 006, 007, and 008 (X-611A north, middle, and south sludge lagoons).

A flow diagram for NPDES outfalls 012, 013, and 014 is shown in Fig. 4.8.

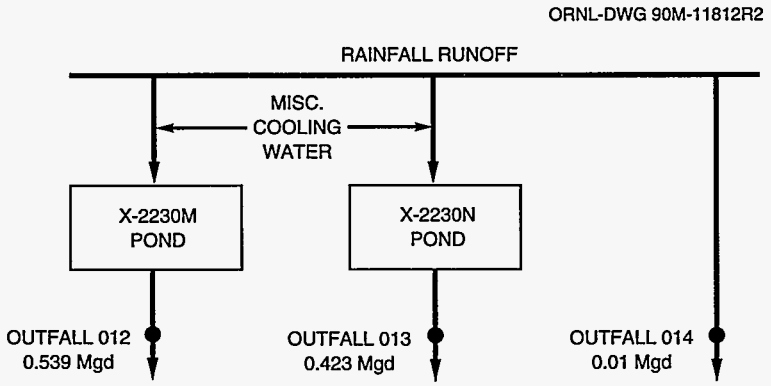

Fig. 4.8. Flow diagram for outfalls 012 and 013 (X-2230M holding pond and X-2230N holding pond) and the drainage sector designated as outfall 014.

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 the Portsmouth site and may be discharged from any of the NPDES outfalls.

Radiological Liquid Sample Collection and Analytical Procedure

All DOE external outfalls (012 and 013) are monitored by taking grab samples in compliance with NPDES. Aliquots from these samples are analyzed for total uranium concentrations, gross alpha, gross beta, and ^{99}Tc-beta radioactivity. The ratio of alpha activity to total uranium is used along with process data to calculate the proportions of the individual uranium isotopes. The short-lived uranium daughters ^{231}Th, ^{234}Th, and ^{234m}Pa are presumed to be present in equilibrium with their parent nuclides based on the laws of physics.

Radiological Liquid Results

Liquid radiological discharges from the Portsmouth site (Table 4.2) had no significant impact on public health or the environment. Total radionuclide discharges from the site decreased in 1994 because of decreased levels of technetium resulting from decontamination activities. Mass and activity emissions of uranium also decreased [from 28 to 24 kg and from 0.12 to 0.109 Ci (4.44×10^9 to 4.03×10^9 Bq)]. Discharges of uranium daughters also decreased. No unplanned releases to surface water occurred during 1994.

Table 4.2. Radionuclide releases from DOE activities at the Portsmouth site to surface water in 1994

Radionuclide	kg/year	Ci/year[a]
^{234}U	0.016	0.1058
^{235}U	1.694	0.0036
^{236}U	0.00018	0.0000114
^{238}U	0.030	0.00001
Total uranium	24.343	0.109
^{99}Tc	0.010	0.167
Uranium daughters	6.66×10^{-11}[b]	0.0036

[a] 1 Ci = 3.7×10^{10} Bq.
[b] 0.0000000000666.

The secondary standard for multiple nuclides is that the sum of the fractional DCG values shall not exceed 1.0. Portsmouth site 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 NRC, and the International Committee on Radiation Protection (5 rem/year). Figures 4.9 through 4.12 show the five-year trends for uranium (in curies and kilograms of uranium), ^{99}Tc, and uranium daughters discharged to surface waters through NPDES outfalls.

As shown in Table 4.2 and Fig. 4.9, a total of 0.109 Ci (4.03×10^9 Bq) of uranium was discharged in 1994. This was equivalent to 24 kg of uranium (Fig. 4.10). Almost half of the uranium—49%—was discharged through outfall 003 to the Scioto River, and another 41% was discharged though outfall 001. All other outfalls contributed between 0.2 and 4% of the total. Note that most of the gross alpha concentrations listed for these other outfalls (and fully half of the concentrations listed for outfall 001) are actually below the limit of detection. Consequently, uranium discharges from these outfalls are actually lower than reported.

As shown in Table 4.2 and Fig. 4.11, a total of 0.167 Ci (6.18×10^9 Bq) of technetium was discharged in 1994; this value is consistent with average technetium releases over the past four years. Of the total technetium released, 42% was discharged through outfall 003 to the Scioto River, 17% through outfall 001 to Little Beaver Creek, and less than 1% through outfall 004 to the Scioto River.

As shown in Table 4.2 and Fig. 4.12, a total of 0.0036 Ci (1.33×10^8 Bq) of uranium daughter products was discharged in 1994. Uranium daughter products are generated by the natural radioactive decay of uranium and therefore roughly follow uranium emissions. Because ^{235}U generates the bulk of the detectable uranium daughters, the proportion of

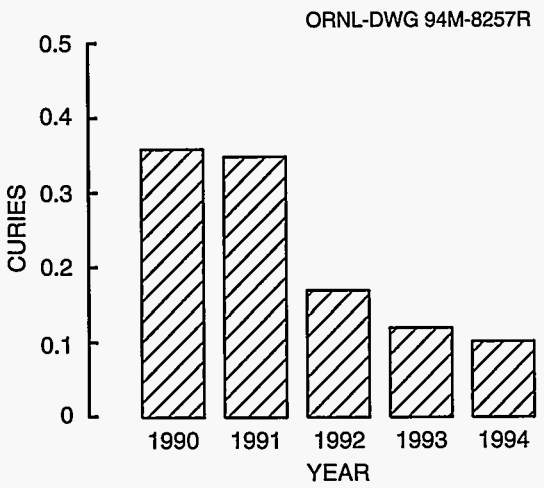

Fig. 4.9. Total curies of uranium discharged to surface water, 1990–1994 (1 Ci = 3.7 × 10^{10} Bq).

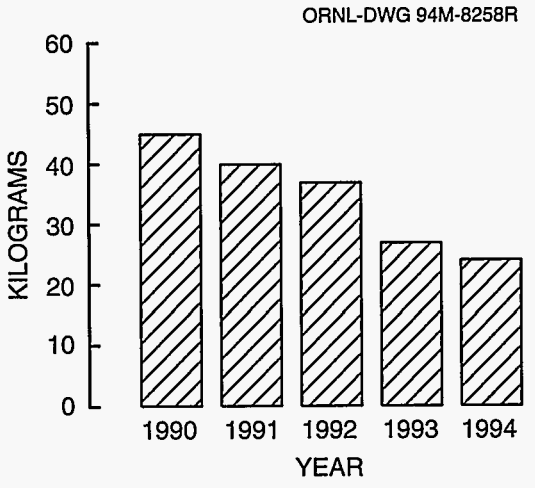

Fig. 4.10. Total kilograms of uranium discharged to surface water, 1990–1994.

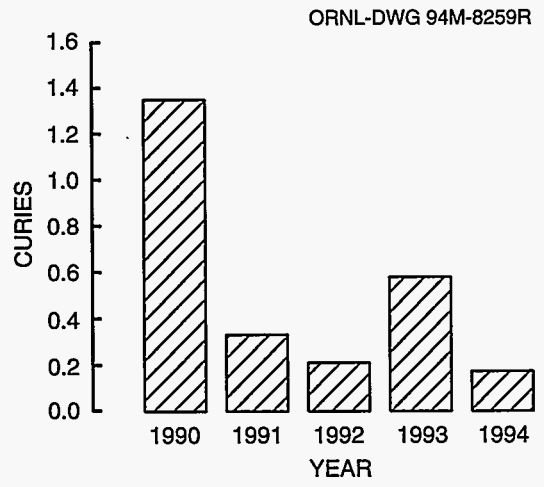

Fig. 4.11. Total curies of technetium discharged to surface water, 1990–1994 (1 Ci = 3.7 × 10^{10} Bq).

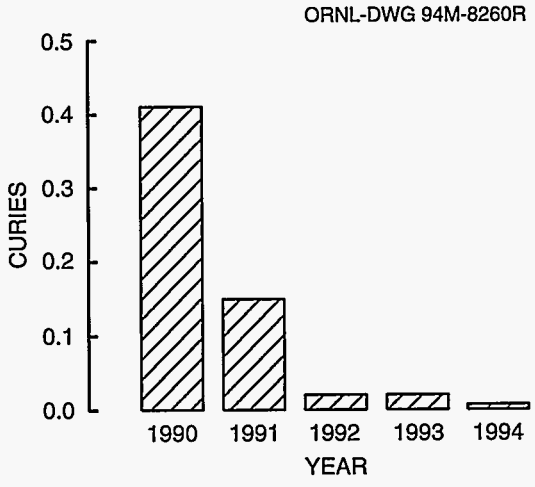

Fig. 4.12. Total curies of uranium daughters (^{231}Th, ^{234}Th, and ^{234m}Pa) discharged to surface water, 1990–1994 (1 Ci = 3.7 × 10^{10} Bq).

uranium daughter products to total uranium will vary with the uranium assay. The uranium daughters make no significant contribution to the radiation dose to the public.

Nonradiological Liquid Discharges

Portsmouth site operations also release various nonradiological substances to surface waters. In addition, a shallow groundwater aquifer under the Portsmouth site discharges to local surface waters on all four sides of the plant, although not always within the reservation boundary.

Regulatory Requirements

Nonradiological discharges to surface waters are regulated by the Portsmouth NPDES permit issued under the authority of the Clean Water Act. The OEPA has regulatory authority for the Clean Water Act at the Portsmouth site; however, the OEPA did not become active in administering NPDES permits to federal facilities until early 1983. In a letter dated May 25, 1983, from the OEPA, the Portsmouth site was advised to begin sending monthly self-monitoring NPDES reports directly to the OEPA beginning with the August 1983 report. The most recent revision of the Portsmouth NPDES permit was issued on September 23, 1991, and additional modifications were issued on December 12, 1991; June 1, 1993; September 3, 1993; and April 1, 1994. This permit expired on July 29, 1994. In January 1994, DOE submitted an application for a new permit to the OEPA. Although the OEPA did not issue the new permit in 1994, they authorized continued effluent-stream sampling in accordance with the existing NPDES permit.

Nonradiological Liquid Sample Collection and Analytical Procedure

Sampling of nonradioactive constituents is regulated under the Portsmouth NPDES permit. Analysis is in accordance with 40 CFR 136.

Nonradiological Liquid Results

The 1994 NPDES compliance rate for DOE outfalls was 99%. Compliance rates for individual parameters ranged from a low of 92% to a high of 100%.

Data from the three discharge points from the X-611A lime sludge lagoons (NPDES 006, 007, and 008) indicated that there were no exceedences of the measured parameters, although the flow at these outfalls is too infrequent to calculate a useful compliance rate. In 1994, only 23 samples were obtained for all three outfalls.

At the X-2230M holding pond (NPDES 012), one exceedence of the total suspended solids (TSS) daily limit resulted in a compliance rate of 96%. The TSS monthly average concentration limit was also exceeded once, which resulted in a compliance rate of 92%. Exceedences were determined to be caused by heavy rainfall/snowmelt and high ambient temperatures and algae growth. The compliance rate for all other parameters was 100%.

One pH exceedence and one TSS exceedence at the X-2230N holding pond (NPDES 013) resulted in compliance rates of 97 and 96%, respectively. The exceedences were attributed to heavy rainfall/snowmelt and high ambient temperatures and algae growth. The compliance rate for all other parameters was 100%.

The X-701E/X-623 carbon filtration facility (NPDES 606) did not have any exceedences of effluent limits; however, the X-623 facility (which replaced the X-701E facility in June 1994) was operational only until July 1994, at which time operations were suspended indefinitely.

The X-700 air stripper (NPDES 607) was not used during 1994 and subsequently had no discharges to sample.

At the X-622 groundwater treatment facility (NPDES 608), one exceedence of the monthly average concentration of 1,2-*trans*-dichloroethene resulted in a compliance rate of 92% for this parameter.

At the X-624 carbon filtration facility (NPDES 609), the compliance rate for all parameters was 100%.

5. Environmental Surveillance

Abstract

Environmental surveillance at the Portsmouth site is conducted to assess the impact of plant operations on the surrounding environment. Surveillance includes direct monitoring of gamma radiation levels, air, surface water, groundwater (see Section 7), creek and river sediments, soil, vegetation, food crops, fish, and terrestrial wildlife. Samples are analyzed for radiological contaminants as well as potentially harmful nonradiological pollutants. Monitoring is conducted within the plant boundaries, on or near the property line, and up to 16 km (10 miles) from the plant site. Results for 1994 indicate that Portsmouth site operations did not have a significant environmental impact outside the reservation boundaries.

INTRODUCTION

The Portsmouth plant has maintained an environmental surveillance network since 1964. Environmental surveillance involves monitoring and sampling the surrounding environment, as distinct from the more common monitoring of effluents. Both programs provide distinct advantages. Effluent monitoring allows the sources of the effluents to be identified and controlled, thus minimizing environmental impacts. However, effluent monitoring cannot be used to reliably quantify an environmental impact but can only be used to drive a model that tries to predict the nature and extent of the associated impacts. Consequently, an environmental surveillance program is necessary both to validate environmental models and to verify that no unexpected impacts are occurring.

Applicable Regulations

DOE Order 5400.1, *General Environmental Protection Program,* requires DOE facilities to establish, in addition to effluent monitoring programs, environmental surveillance programs sufficient to ensure that no unrecognized environmental impact is occurring as a result of DOE operations. The details of the Portsmouth site environmental monitoring program are documented in the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (MMES 1994), which is discussed in detail in Section 2, "Environmental Compliance."

EXTERNAL GAMMA RADIATION MONITORING

External gamma radiation measurements confirm that direct radiation and radioactive effluents from the Portsmouth site are not significantly different from natural background levels. This section describes the external gamma radiation monitoring network at the Portsmouth site and presents a summary of the data collected by the network. A brief summary of the radiation doses that can be estimated from these data is also presented. A more extensive discussion of radiation dose calculations is in Section 6, "Dose."

External Gamma Sample Collection and Analytical Procedure

Portsmouth uses thermoluminescent dosimeters (TLDs) to measure gamma radiation exposure. When exposed to penetrating radiation (such as X-ray, gamma, or cosmic radiation), thermoluminescent materials absorb and store a portion of the radiation energy. If the material is later heated, this energy will be released as light. Although thermoluminescent materials (such as clay) are fairly common, only a handful are sufficiently accurate for use in radiation measuring devices (dosimeters).

In the past, the Portsmouth site used TLDs containing calcium fluoride:dysprosium (CaF_2:Dy) chips for environmental surveillance. In late 1992, these TLDs were replaced with ones containing four lithium fluoride (LiF) chips. These are the same type of TLDs used by the Portsmouth site Health Physics Department to monitor worker exposure. The older TLDs had been selected for extreme sensitivity at the expense of other parameters. As a result, readings were not easily compared with more standardized systems. Experience with both types of TLDs shows that the LiF-based TLDs, although less sensitive, are adequate for monitoring radiation levels around the Portsmouth site.

The usual concern about the accuracy of a TLD network is whether it correctly determines the level of ambient or external gamma radiation around the Portsmouth site. The term "external" is used because the source of the radiation is external to the body. In contrast, internal sources that have been inhaled or swallowed may involve nonpenetrating alpha and beta radiation. The only significant sources of gamma radiation at the Portsmouth site are ^{235}U and the short-lived uranium daughters ^{231}Th, ^{234}Th, and ^{234m}Pa.

External gamma measurements are collected in the relatively small area of the Portsmouth site accessible to the public, around the edge of the site, and at the ambient air sampling stations in Piketon, location 6, and at Camp Creek, location 28 (see Fig. 5.1). The two off-site TLDs provide a general indication of background levels. Eight TLDs (Site Group II) are used in conjunction with the fence-post air monitoring stations discussed in the section on ambient air. Nine on-site field TLDs (Site Group I) are located on or near Perimeter Road, which surrounds the secured area of the facility (see Fig. 5.2). The TLDs are calibrated and analyzed according to current Health Physics Department procedures.

The external gamma radiation levels for Site Groups I and II are reported as quarterly site-group averages, with one exception in Site Group I. TLD location 874 is at the corner of a uranium storage yard where gamma levels are sharply higher than those on the rest of Perimeter Road. This location is reported separately to emphasize that a single "hot spot" exists and that Perimeter Road in general is not an area of elevated gamma levels. This procedure is particularly important when estimating radiation doses from radiation levels. For Site Group II and for off-site locations, this calculation is made by multiplying the annual average gamma levels by the potential time exposed (i.e., 24 hours/day, 365 days/year) because a continuous exposure in those areas is a reasonable assumption.

Public exposure to Site Group I gamma levels is limited to actual travel on Perimeter Road and is much lower than the 24 hours/day, 365 days/year assumed for the other site groups. Because it is impossible to reliably estimate how low this public exposure is and because the average gamma level for the group is not significantly higher than background, a conservative worst-case continuous exposure is assumed for the group average. However, this would not be a reasonable assumption for location 874. Because location 874 is located away from access roads and security fence gates, it is possible to estimate an annual exposure to members of the general public for this area. Public traffic is not allowed to stop in this area. Tests performed by environmental personnel have shown that a car traveling slightly under the posted speed limit passes through the hot spot in 20 to 30 seconds. Therefore, the average exposure is calculated for an individual driving to and from work.

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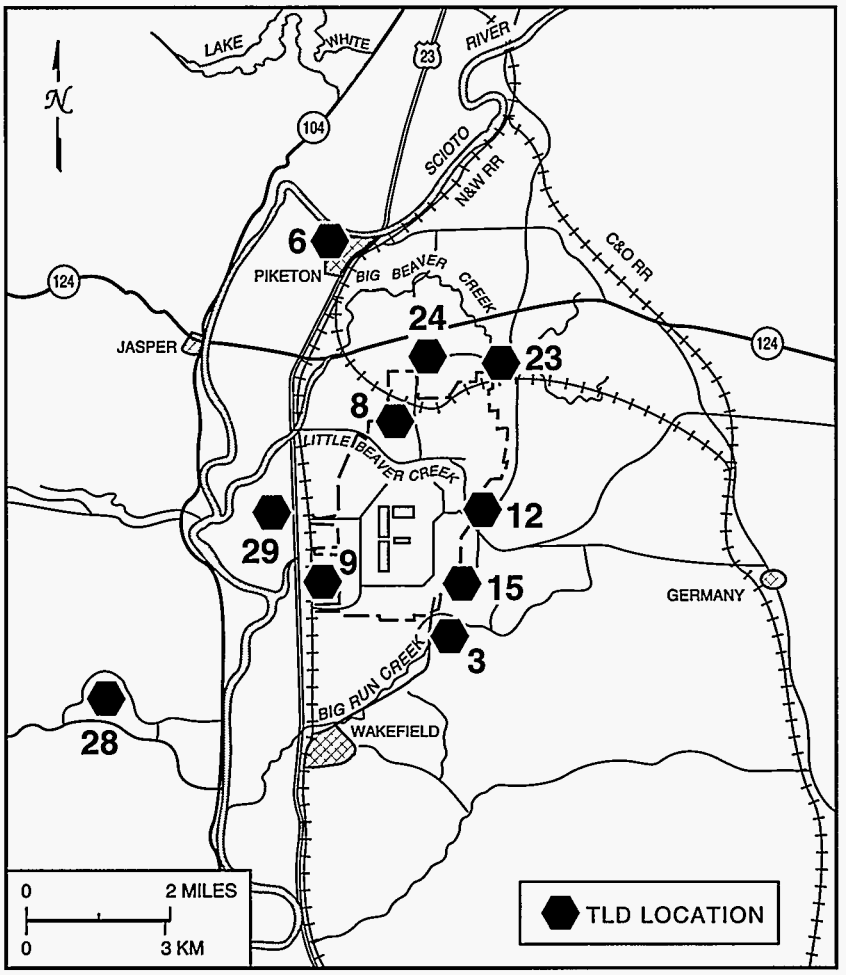

Fig. 5.1. Off-site TLD locations (Site Group II) for the Portsmouth site.

An average of 1 minute in this hot spot is considered conservative. Total exposure can then be estimated as equal to the average gamma levels within the hot spot (e.g., half the measured peak gamma level at location 874) times 1 minute per trip times 2 trips per day times 5 workdays per week times 52 weeks per year, or 8.7 hours/year times ½ the measured radiation level at location 874.

External Gamma Monitoring Results

Except for TLD location 874, external gamma levels around the Portsmouth site are not significantly different from natural background levels. Table 5.1 shows the average external gamma level (in microrads per hour), plus or minus twice the standard deviation, by site group and calendar quarter. Quarterly average gamma levels at location 874 are shown below the data for the rest of Site Group I. The last two columns show the estimated gross annual external gamma dose within each of the site groups. For Site Group I, the annual dosage is estimated assuming continuous exposure to the group average radiation levels. The additional dose resulting from the 8.7 hours/year exposure to location 874 is also listed.

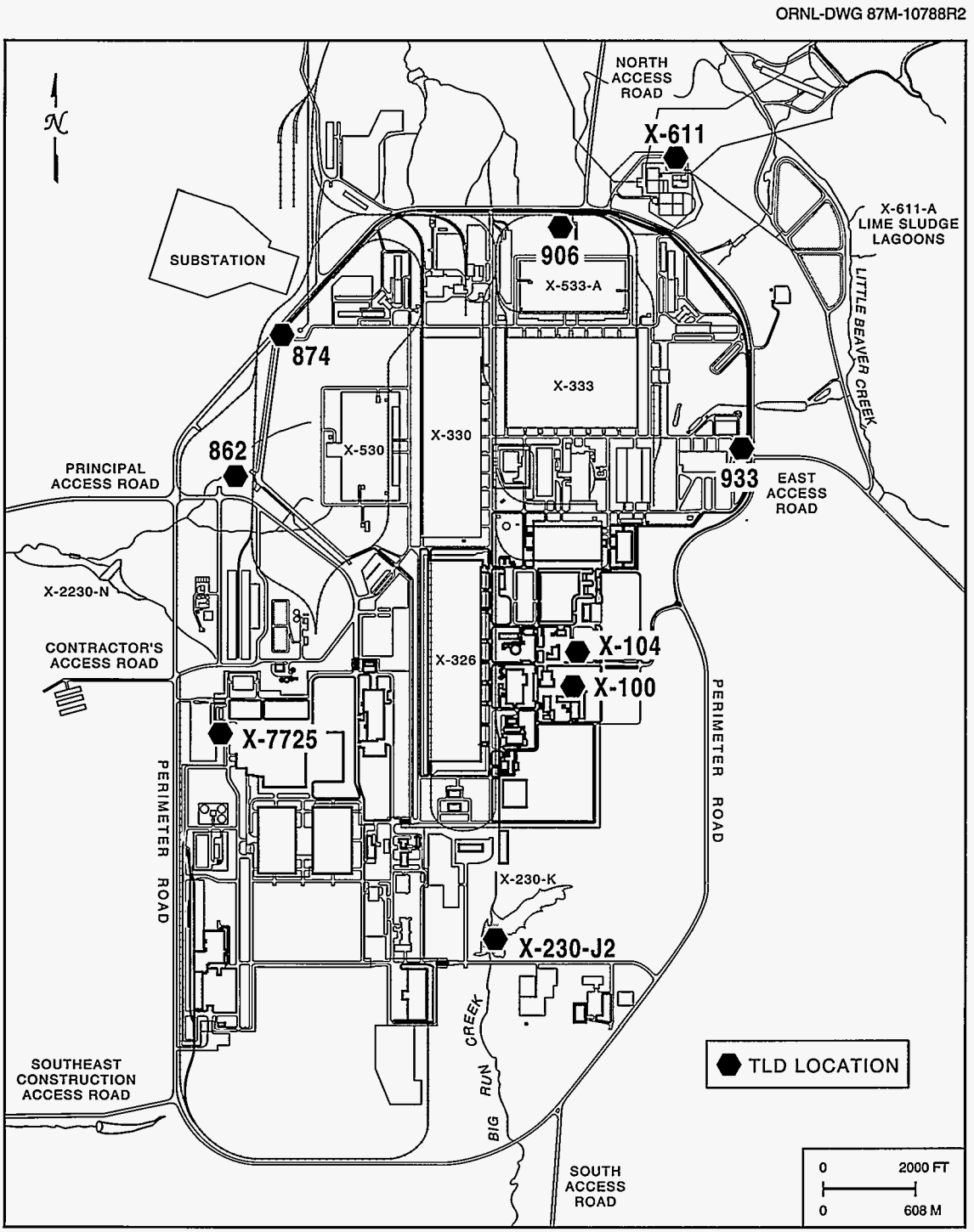

Fig. 5.2. On-site TLD locations (Site Group I) at the Portsmouth site.

Table 5.1. Average external gamma radiation levels and doses at the Portsmouth site for 1994

Location	Ambient gamma levels (μrad/hour)				Annual dose (μrad/hour)	Annual dose (mrem/year)
	First quarter	Second quarter	Third quarter	Fourth quarter		
Site Group I (on site)	26.04±4.13	26.16 ±11.36	26.33±6.63	20.26±4.43	24.6	215
Location 874[a]	106.4	121.7	158.6	157.2	137.5	0.60[b]
Site Group II (off site)	30.4±11.1	20.6±2.7	26.0±4.5	21.4±2.1	24.4	214
Piketon (6)[c]	21.6	19.9	24.6	19.4	21.6	189
Camp Creek (28)[c]	25.7	15.9	23.0	17.4	20.4	179

[a]Not included in Site Group I averages or standard deviations.
[b]Dose was calculated for 8.7 hours/year exposure.
[c]See Fig. 5.1.

The numbers in Table 5.1 represent gross gamma levels and doses, including gamma radiation from Portsmouth site activities and effluents, local natural sources (i.e., terrestrial gamma radiation), and cosmic radiation. No effort has been made to separate natural radiation from the Portsmouth site contribution. In theory, this could be done by subtracting the external gamma level at a background location from external gamma levels at all the other locations. Historically, TLDs at most of the off-site locations (now discontinued) around the Portsmouth site have recorded higher gamma levels than the potentially more exposed TLDs on and within the site boundary. The cause of this phenomenon lies in the geology of the Portsmouth site. The Portsmouth site is located within an ancient river bed that was filled with clay and silt during the glacial period. The surrounding hills and ridges, on the other hand, are composed largely of much older shale that is significantly richer in natural radioactive minerals. Most of the now discontinued off-site TLDs were located near these hills and ridges, where they were exposed to a higher level of radiation than the on-site TLDs. Consequently, no legitimate background level of radiation could be designated. However, plant emissions that are consistently lower than the local variation in natural background radiation can hardly be called significant.

Piketon, the off-site location of another TLD, is located in the Scioto River valley (which is within the older Newark River valley). The geographic setting is comparable to the Site Group II TLDs. If Piketon were not the nearest population center to the plant site, this might well be a usable background location. On the other hand, ambient radiation levels at a Camp Creek location have historically been consistently lower than any other location monitored by the Portsmouth site; this includes locations farther from the plant. Apparently, the geography at Camp Creek is unusual, and this location cannot be used to establish a background standard for Portsmouth site ambient radiation levels. However, radiation levels do remain consistent at this location. The low levels recorded are compared with levels at other areas. For comparison, Fig. 5.3 shows the annual gross external radiation dose for each of the two site groups, the two off-site TLDs (Piketon and Camp Creek), and the published average annual doses for the state of Ohio and the United States as a whole. For a more general comparison refer to Fig. 5.4, which shows the average annual doses from terrestrial gamma, cosmic, and total radiation for several states and the United States.

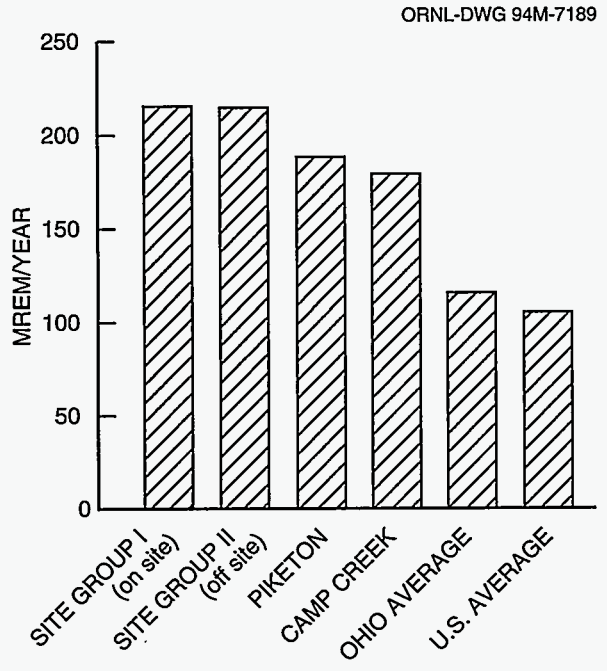

Fig. 5.3. Average external gamma exposure on and around the Portsmouth site, for the state of Ohio, and for the United States as a whole for 1994.

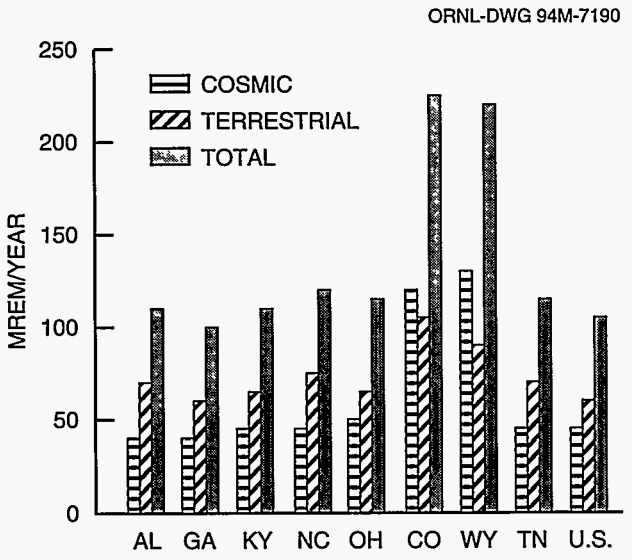

Fig. 5.4. Average external cosmic, terrestrial, and total gamma exposure for several states and the United States as a whole for 1994.

AMBIENT AIR SAMPLING

This section describes the ambient air monitoring network maintained by the Portsmouth site and includes a summary of the ambient air data at each of the air monitoring stations.

Ambient Air Sample Collection and Analytical Procedure

In 1964, the Portsmouth facility established a network of on-site and off-site permanent stations to collect continuous ambient air samples. Figures 5.5 and 5.6 show the station locations in the current network. Strictly speaking, the locations in Fig. 5.5 are not "ambient" as the USEPA defines it. The USEPA definition requires "unrestricted access by members of the public." Air is monitored at these six locations because the public does have some access to these areas and because any problems resulting from airborne emissions would be detected at these locations long before they would become evident at the more distant locations shown in Fig. 5.6.

Each monitoring station consists of a Teflon particulate filter for monitoring radioactivity, a chemically treated filter for gaseous fluorides, a flow controller, a gas meter, and a vacuum pump. The particulate filters and the gaseous fluoride filters are mounted in separate Teflon filter holders to prevent cross-contamination and to simplify handling. The particulate filters are collected monthly and subjected to gross alpha and beta-gamma counts. If the gross counts exceed plant-established limits (100 dpm alpha or 200 dpm beta-gamma), the filters are analyzed for specific radionuclides. To date, air samples have never exceeded the plant-established limits. All filters indicating positive counts are retained for an annual composite analysis (for specific radionuclides to verify that no unexpected radionuclides are being discharged

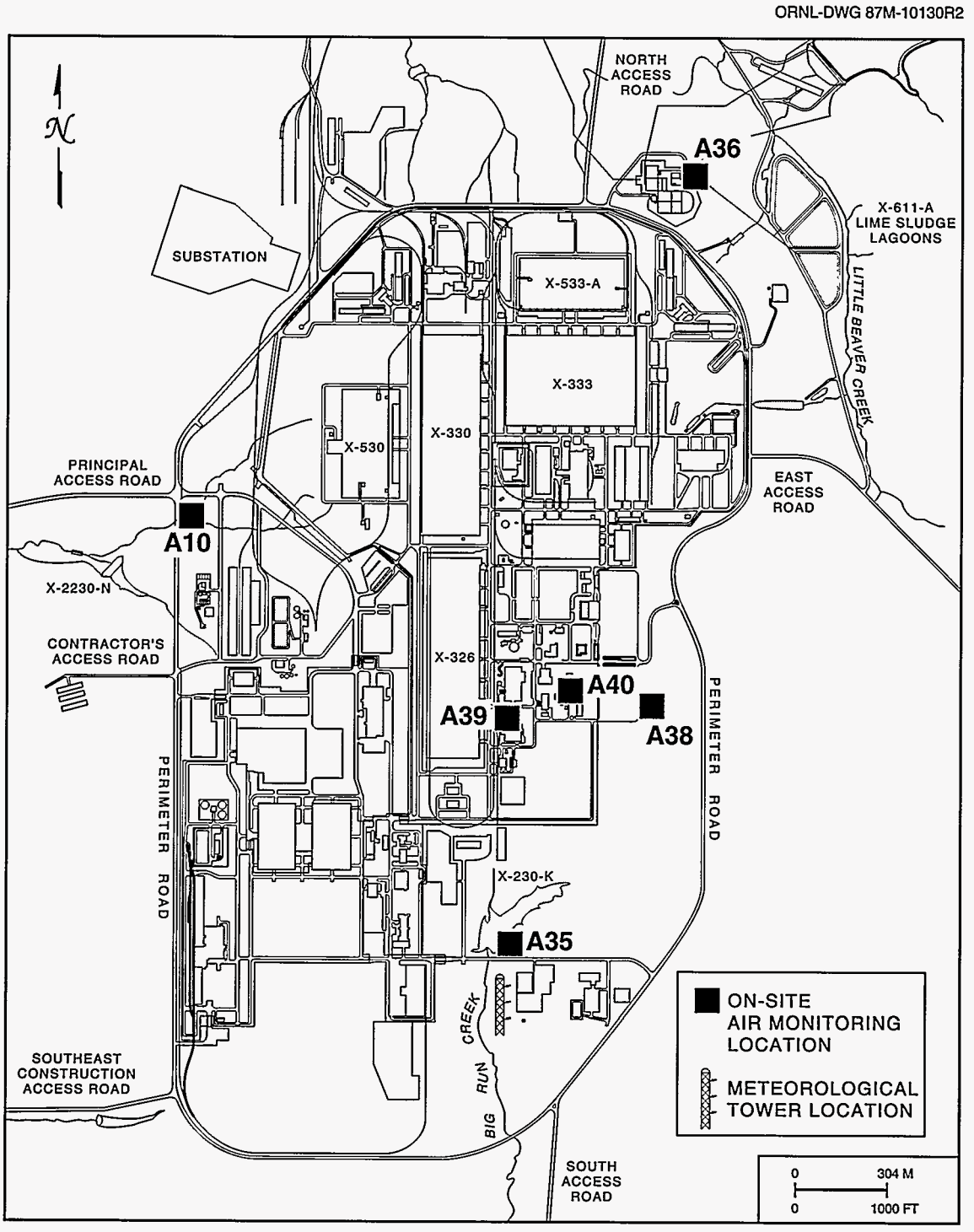

Fig. 5.5. On-site ambient air monitoring and meteorological tower locations at the Portsmouth site.

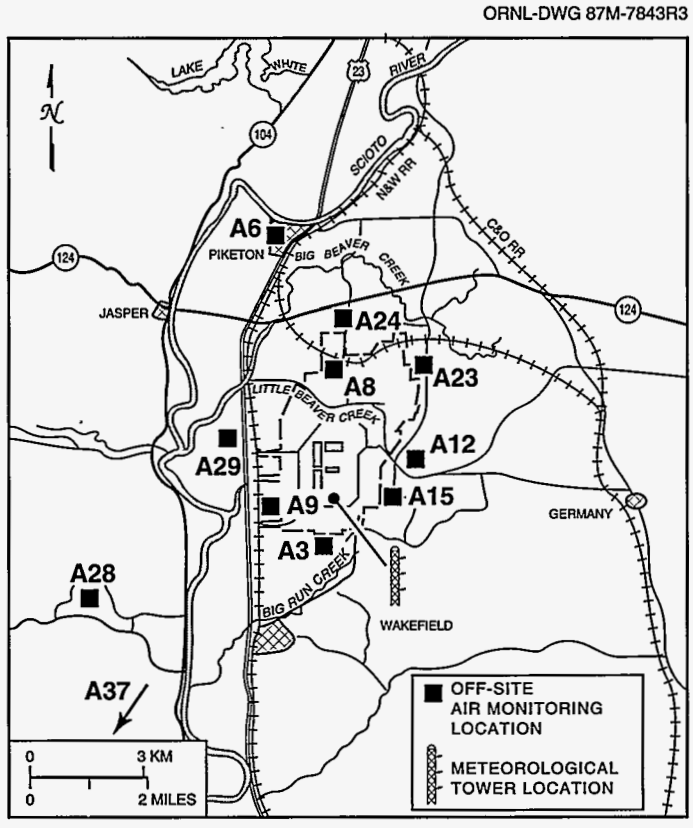

Fig. 5.6. Off-site ambient air monitoring locations for the Portsmouth site.

to the air). The chemically treated filters are collected weekly and analyzed for total fluorides.

Ambient Air Sampling Results

Tables 5,2 and 5.3 contain summaries of the airborne gross alpha and beta-gamma radiation concentrations in and around the Portsmouth site for 1994. The tables include the number of samples collected; the maximum, minimum, and average concentrations in the samples; and the standard deviation of the concentrations at each air station. Note that the standard deviations are on the same order of magnitude as the average concentrations. The deviations are greater than the differences noted among most of the average concentrations, indicating large variations at each station. This indicates that small differences in the average concentrations are probably not significant.

The highest monthly ambient concentration of alpha was recorded near Perimeter Road at A10. The highest monthly beta-gamma was recorded at two locations, one on site (A36) and the other at the property line (A29). The highest annual average beta-gamma levels recorded in 1994 were found at station A6. None of the concentrations was statistically significant as evidenced by the magnitude of the standard deviations.

Annual average alpha concentrations of 0.003 to 0.004 pCi/m^3 (1.11×10^{-4} to 1.48×10^{-4} Bq/m^3) were detected at all property-line and off-site stations. The detection limit is 0.001 pCi/m^3 (3.70×10^{-5} Bq/m^3). The maximum monthly reading detected for these stations was 0.008 pCi/m^3 (2.96×10^{-4} Bq/m^3) at stations A10 and A37. Annual average

Table 5.2. Gross alpha concentrations in ambient air at the Portsmouth site for 1994

Location	No. of samples	Concentration (pCi/m^3)[a]			Standard deviation
		Max	Min	Av	
		On site			
A10	12 (10)[b]	0.008	<0.002	<0.004	0.001
A36	12 (11)	0.006	<0.001	<0.004	0.001
A40	12 (9)	0.006	<0.002	<0.003	0.001
		Property line			
A3	12 (10)	0.006	<0.001	<0.003	0.001
A8	12 (10)	<0.005	<0.001	<0.003	0.001
A9	12 (11)	0.004	<0.002	<0.003	0.001
A12	12 (10)	<0.004	<0.002	<0.003	0.001
A15	12 (11)	<0.005	<0.001	<0.004	0.001
A23	12 (8)	<0.006	<0.002	<0.004	0.001
A24	12 (9)	0.005	<0.002	<0.003	0.001
A29	12 (8)	0.004	0.002	<0.003	0.001
		Off site			
A6	12 (8)	0.005	<0.001	<0.004	0.001
A28	12 (9)	0.003	<0.002	<0.003	0.000
A37	12 (9)	0.008	<0.001	<0.003	0.002

[a]1 Ci = 3.7×10^{10} Bq.
[b]Parentheses denote the number of samples below the lower limit of detection.

Table 5.3. Gross beta-gamma concentrations in ambient air at the Portsmouth site for 1994

Location	No. of samples	Concentration (pCi/m^3)[a]			Standard deviation
		Max	Min	Av	
		On site			
A10	12 (1)[b]	0.060	<0.004	0.031	0.016
A36	12 (0)	0.061	0.021	0.038	0.010
A40	12 (2)	0.039	<0.005	0.024	0.009
		Property line			
A3	12 (0)	0.056	0.017	0.031	0.012
A8	12 (0)	0.049	0.009	0.029	0.010
A9	12 (0)	0.044	0.019	0.031	0.009
A12	12 (0)	0.036	0.018	0.027	0.006
A15	12 (0)	0.054	0.022	0.034	0.010
A23	12 (0)	0.060	0.018	0.037	0.014
A24	12 (0)	0.045	0.014	0.026	0.008
A29	12 (0)	0.061	0.008	0.026	0.014
		Off site			
A6	12 (0)	0.057	0.027	0.039	0.009
A28	12 (2)	0.053	<0.006	<0.025	0.014
A37	12 (0)	0.059	0.015	0.028	0.013

[a]1 Ci = 3.7×10^{10} Bq.
[b]Parentheses denote the number of samples below the lower limit of detection.

beta-gamma concentrations at the reservation boundary ranged from 0.026 to 0.037 pCi/m^3 (9.62×10^{-4} to 1.37×10^{-3} Bq), with an annual average background concentration of 0.028 pCi/m^3 (1.04×10^{-3} Bq/m^3) and a maximum monthly concentration of 0.061 pCi/m^3 (2.26×10^{-3} Bq/m^3) at two locations (A29 and A36). The background concentrations are measured at station A37, which is located approximately 21 km (13 miles) from the plant, near the community of Otway.

The data in Tables 5.2 and 5.3 are "gross" concentrations. Included are all alpha and beta-gamma emitters present around the Portsmouth site, such as emissions from Portsmouth site operations, emissions from other facilities (coal, for instance, includes radioactive constituents that are released from coal-fired power plants in considerable quantities), and naturally occurring radionuclides from the local soil. The Portsmouth site also estimates "net" concentrations resulting from its emissions only. The average background measured near Otway is subtracted from the highest annual average concentration measured around the Portsmouth reservation boundary. In 1994, the highest net average alpha concentration around the Portsmouth reservation boundary was 0.001 pCi/m^3 (3.70×10^{-5} Bq/m^3). The highest net average beta-gamma concentration was 0.037 pCi/m^3 (1.37×10^{-3} Bq/m^3). Low ambient air concentrations confirm that emissions from the Portsmouth site are indeed well below the allowable limit and further substantiate the data collected from the continuous stack samplers. The ambient data also confirm that no significant amounts of radionuclides are being released from unmonitored minor sources. One disadvantage of low ambient concentrations is that it is difficult to analyze for specific radionuclides (e.g., uranium and technetium). The Portsmouth site therefore assumes that all the net alpha concentration is from uranium emissions relating to plant operations. Another assumption is that all of the net beta-gamma concentration is from technetium and uranium daughters in the same proportion as the measured emissions.

Table 5.4 provides results of the weekly ambient fluoride samples collected in 1994. Ambient air quality standards from Kentucky and Tennessee are used for comparison because standards for ambient gaseous fluorides have not been issued in the state of Ohio. Kentucky regulations include a primary (i.e., public health) standard of 400 µg/m^3 (annual average) and a secondary (i.e., public welfare) standard of 1.6 µg/m^3 (7-day average). Tennessee regulations include both primary and secondary standards of 1.6 µg/m^3 (7-day average). All of the 7-day fluoride concentrations, both on and off site, were well below the 1.6 µg/m^3 standard. The highest 7-day average recorded on site was 0.20 µg/m^3 at station A40, which is downwind of the largest fluoride source. The highest 7-day average recorded off site, 0.11 µg/m^3, was documented at station A15, southeast of the plant. The second-highest 7-day average calculated was 0.10 µg/m^3, which was recorded at stations A12 and A23, east and northeast of the plant, respectively.

Meteorological Monitoring

The Portsmouth site maintains two meteorological towers about 40 ft apart (see Fig. 5.5). The X-120A is equipped with instrument packages at the 10- and 40-m levels, the X-120H at the 10-, 30-, and 60-m levels. Air temperature, relative humidity, and wind speed and direction are measured at both the 10- and 40-m levels. In addition, ground-level instrumentation measures solar radiation, barometric pressure, precipitation, and soil temperature at 0.30- and 0.61-m (~1- and 2-ft) depths.

Two microprocessors at the foot of the X-120A tower convert analog data from the instruments to digital data. The microprocessors calculate both 15- and 60-minute summary

Table 5.4. Total gaseous fluoride concentrations (as hydrogen fluoride) in ambient air at the Portsmouth site for 1994

Location	No. of samples	Concentration ($\mu g/m^3$)			Standard deviation
		Max	Min	Av	
		On site			
A10	51 (25)[a]	0.16	0.05	<0.09	0.023
A36	51 (14)	0.62	<0.06	<0.18	0.121
A40	44 (7)	0.58	<0.05	<0.20	0.144
		Property line			
A3	51 (33)	0.20	<0.05	<0.09	0.033
A8	51 (30)	0.15	<0.05	<0.08	0.025
A9	47 (34)	0.11	<0.04	<0.07	0.019
A12	51 (14)	0.26	<0.05	<0.10	0.034
A15	51 (31)	0.24	<0.06	<0.11	0.049
A23	51 (28)	0.23	0.04	<0.10	0.034
A24	51 (31)	0.17	<0.05	<0.08	0.024
A29	45 (27)	0.12	<0.05	<0.08	0.016
		Off site			
A6	51 (40)	0.14	0.05	<0.09	0.020
A28	49 (38)	0.16	0.04	<0.08	0.022
A37	51 (38)	<0.10	<0.05	<0.06	0.011

[a]Parentheses indicate the number of samples below the lower limit of detection.

data. These data are transmitted by radio to the X-1020 emergency operations center and then to an IBM PC–compatible computer. The data are stored on the PC hard disk and are backed up to floppy diskettes. Each midnight, hourly data, daily averages, and totals are printed on a console for archival purposes. The 15-minute data are transmitted to video terminals in the X-300 process control building and to the Air and Water Policy Department of Utility Services. The X-120H is a new meteorological tower that became operational in February 1995. This tower will eventually replace the X-120A tower.

Figures 5.7 and 5.8 are standard graphic presentations of wind speed and direction data called "wind roses." Each wind rose has 16 arms (representing the standard 16 wind directions), each of which is divided into 6 segments (representing 6 wind speed classes). The length of each segment represents the fraction of time that wind was blowing from that direction at an average speed within that class. The key at the bottom of the figure includes the maximum speed of each wind speed class except the last, which includes all wind speeds above the first five classes. The primary use of a wind rose is to provide an easily understood picture of the prevailing wind patterns at a site. The relative length of the arms gives a quick indication of which wind directions predominate and to what extent.

A joint frequency distribution is defined as a set of tables that lists the fraction of time in each of 576 wind classes (16 directions × 6 wind speeds × 6 atmospheric stability classes) instead of the 96 classes of a wind rose (16 directions × 6 wind speeds only). Atmospheric stability can be described roughly as the tendency of wind to mix with and dilute a pollutant as opposed to merely transporting it downwind. The stability classes range from A (extremely unstable, maximum mixing), through D (neutral), to F (moderately stable, minimum mixing). Because of their complexity, joint frequency

distributions are more useful as input for computer models than for data presentation. Such computer models (known as "air dispersion models") are used to predict the downwind spread of pollutants. The USEPA requires that one such model, AIRDOS-USEPA, be produced to demonstrate compliance with the radiation dose limits from NESHAP (see Section 2, "Environmental Compliance").

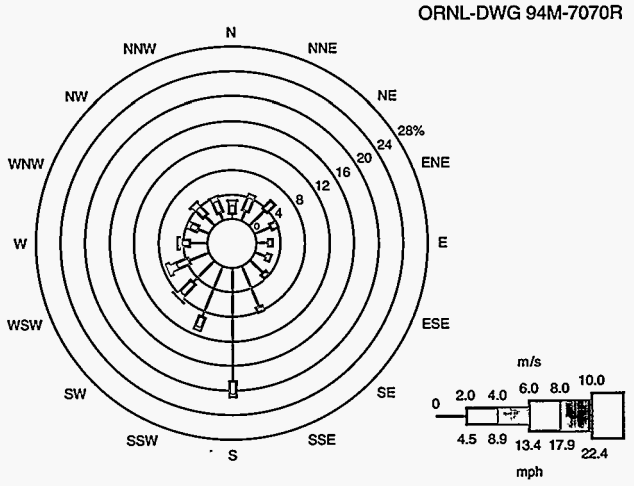

Fig. 5.7. Wind rose (10-m level) showing wind speed frequency distribution data (with 96.2% of possible data) used for 1994 estimates.

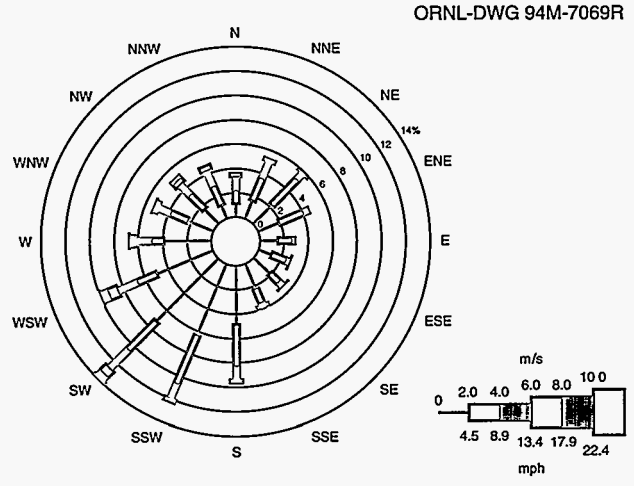

Fig. 5.8. Wind rose (40-m level) showing wind speed frequency distribution data (with 96.2% of possible data) used for 1994 estimates.

6. Dose

Abstract

Potential impacts on human health from Portsmouth site operations are calculated based on environmental monitoring and surveillance data. The maximum potential effective dose equivalent that a person living off site could receive from radiological releases from the Portsmouth site is 0.066 mrem. This potential dose is less than the 1993 effective dose equivalent for the Portsmouth site and 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

Previous sections of this report characterize and quantify radiological and chemical releases from Portsmouth site operations during 1994 (Section 4) and the direct impacts on the surrounding environment (Section 5). This section evaluates the potential impacts (i.e., dose) on human health based on the data presented in Sections 4 and 5.

APPLICABLE REGULATIONS

Radiological Regulations

Airborne releases of radionuclides from DOE facilities are regulated by the USEPA under the Clean Air Act and NESHAP. These regulations set an annual dose limit of 10 mrem/year to any member of the public as a result of airborne releases from DOE nuclear facilities, as well as setting 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 regulations. However, Ohio does not yet have standards governing radionuclide emission limits and therefore defers to the federal NESHAP regulations.

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. The DOE limit includes all radionuclide releases from a facility, unlike the NESHAP limit. In addition, DOE Order 5400.5 limits the absorbed dose to aquatic biota from liquid discharges to less than 1 rad/day.

Chemical Regulations

Airborne discharges of chemical agents are regulated under the Ohio permit-to-operate regulations 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

Small quantities of radionuclides were released to the environment from Portsmouth site operations during 1994. 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.

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 (EDE)*—a risk-equivalent dose equivalent that can be used to estimate health-effect risks to exposed persons; it is a weighted sum of dose equivalents to specified organs. The weighing factors and identification of these specific organs have been published by the International Commission on Radiological Protection (ICRP 1977, ICRP 1978).
- *Committed (effective) dose equivalent (CEDE)*—the total (effective) dose equivalent that will be received over a specified time period (in this document calculations are based on a 50-year period) because of radionuclides taken into the body during the current year.

- *Collective committed (effective) 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).

Dose Calculation for Airborne Radionuclides

Characterizing the consequences of radionuclides released to the atmosphere by site activities during 1994 was accomplished by calculating EDEs 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 918,506) residing within 80 km (50 miles) of the plant. Dose calculations were made using the Clean Air Act Assessment Package-88 (CAP-88) of computer codes (Beres 1990), which was developed under sponsorship of the USEPA for use in demonstrating compliance with NESHAP concerning radionuclides (40 CFR 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 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 EDEs 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, "Effluent 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 1994 at the 40-m station on the Portsmouth site meteorological tower. Rainfall during 1994 was 110.5 cm (43.5 in.), the average air temperature was 11.8°C (52°F), and the average mixing layer height was 2000 m (6562 ft).

The dose calculations assumed that each person remained unprotected, at home (actually outside the house) during the entire year and obtained food according to the rural pattern defined in the NESHAP 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 80 km (50 miles) of the Portsmouth site. For collective EDE estimates, production of beef, milk, and crops within 80 km (50 miles) of the Portsmouth site was calculated using the state-specific production rates provided with CAP-88.

Dose Calculation for Waterborne Radionuclides

Water is sampled at all plant outfalls and in the receiving streams. Sample results for the Scioto River show no significant difference in radionuclide concentrations between upstream and downstream locations (see Section 4, "Effluent Monitoring").

Dose Calculation for Radionuclides in Other Environmental Media

The CAP-88 computer codes calculate doses from ingestion of meat, milk, and vegetables containing radionuclides that were released to the atmosphere. Using the conservative food consumption pattern described in the previous sections, about 62% of the maximum individual EDE and 81% of the collective EDE result from ingestion of foodstuffs.

Calculation of Radiological Dose to Aquatic Biota

DOE Order 5400.5, Chapter II, sets an absorbed dose rate limit of 1 rad/day to native aquatic organisms. To demonstrate compliance with this limit, absorbed dose rates to crustacea, mollusks, and fish were calculated using the CRITR2 computer code and measured (annual average) radionuclide concentrations in the Scioto River. CRITR2 estimates dose rates from internally deposited radionuclides, from immersion in water, and from sediment irradiation (Baker and Soldat 1993).

Chemical Dose Calculation

Varying amounts of chemicals were released to the environment from Portsmouth site operations during 1994. 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 (ADI)*—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. ADIs are calculated from several different federal standards and regulations.
- *Ambient air quality standard (AAQS)*—national or state standard for maximum concentration of an airborne pollutant that is not expected to adversely affect the public health (primary AAQS) or the public welfare (secondary AAQS).
- *Chronic daily intake (CDI)*—intake of a chemical (expressed in milligrams per day) from drinking 2 L (2 qt) of surface water per day.
- *Maximum contaminant level*—maximum concentration legally allowable in drinking water under 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. USEPA national secondary drinking water regulations that apply to public water systems.
- *NPDES*—permit program that includes effluent standards, monitoring requirements, and conditions for discharge.

- *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 Airborne Chemicals

Since the early 1980s, the Portsmouth site has voluntarily monitored and tracked ambient concentrations of gaseous fluorides in the atmosphere for comparison to the AAQS. Because neither the USEPA nor the OEPA have established an AAQS for gaseous fluorides, the AAQSs set by the states of Tennessee and Kentucky are used.

Dose Calculation for Waterborne Chemicals

The USEPA has set ADI standards for some chemicals in the form of maximum contaminant levels and maximum-contaminant-level goals (in milligrams per liter), which were converted to ADI 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, ADIs 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 milligrams per kilograms per day) should result in no adverse effect over a lifetime. ADIs were calculated from reference doses by multiplying by 70 kg, 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 the Portsmouth site and the Scioto River and are classified as unsuitable for use as potable water sources because of agricultural runoff. Consequently, the first realistic location for a member of the public to be routinely exposed to liquid discharges is the Scioto River. In fact, there are no identified drinking water intakes in the Scioto River downstream of the Portsmouth site either.

Sampling data for eight metals and two organic chemicals are available for NPDES outfall stations. (Not all chemicals were measured at each outfall.) Annual average values of the sampling data (in micrograms per liter) 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 CDIs are also reported as less-than values. The CDIs were compared with the ADIs to establish whether ingestion of water could result in an exposure above the ADI. CDI/ADI ratios of less than 1 indicate an acceptable level of risk; CDI/ADI 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 the Portsmouth site. 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 is highly unlikely.

DOSE CALCULATION RESULTS

Radiological Dose Results

Airborne Radionuclide Results

The maximum potential EDE to an off-site individual from 1994 radiological releases from the Portsmouth site is 0.016 mrem (Table 6.1), which is well below the 10-mrem NESHAP limit applicable to the Portsmouth site and the approximate 300-mrem dose per 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 EDE to the entire population around the Portsmouth site was 0.6 person-rem, which is a minute fraction of the approximately 276,000 person-rem that this population received from natural sources of radiation during 1994. The collective EDE to the nearest community, Piketon, was calculated to be approximately 0.02 person-rem.

Table 6.1. Summary of estimated CEDEs to an adult at locations of maximum exposure

Emission pathway	Location	CEDE (mrem)
Airborne releases	1770 m ENE	0.016
Waterborne releases	Scioto River	0.006

Waterborne Radionuclide Results

If the Scioto River were used for drinking water, fishing, and recreation, an annual EDE of 0.006 mrem could have been received from radionuclides released to surface water.

In the Scioto River, potential dose rates to aquatic biota were 6.9×10^{-8} rad/day to fish, 3.4×10^{-7} rad/day to crustacea, and 2.6×10^{-7} rad/day to muskrats. These results indicate that the aquatic biota did not receive an absorbed dose of greater than 1 rad/day during 1994.

Chemical Dose Results

Airborne Chemical Results

During 1994, all of the measured gaseous fluoride concentrations in ambient air were within applicable Tennessee and Kentucky AAQSs.

7. Groundwater

Abstract

The purpose of groundwater monitoring at the Portsmouth site is to characterize the hydrogeology and monitor groundwater quality at the site and its environs. More than 500 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 Portsmouth operations on nearby public and residential water supplies.

INTRODUCTION

The purpose of the groundwater monitoring program at the Portsmouth site is to characterize the hydrogeology and monitor the groundwater quality at the site and its environs. Groundwater monitoring activities conducted by Energy Systems Environmental Management and Enrichment Facilities include surveillance monitoring and monitoring of (1) RCRA units, (2) solid waste disposal units, (3) special investigations or monitoring units, (4) groundwater treatment units, and (5) RFI quadrant location units.

GROUNDWATER HYDROLOGY

A portion of rain accumulates as groundwater by soaking into the ground, infiltrating soil and rock. The accumulation of groundwater in pore spaces of sediments creates sources of usable water, which flows in response to external forces. Groundwater eventually reappears at the surface in springs, swamps, stream and river beds, or pumped wells. Thus, the primary input to groundwater is recharge from rainwater, and the output of groundwater is discharge to springs, swamps, rivers, streams, and wells.

Surface water percolates downward into soil through the pore spaces between sediment grains. The smaller the pore spaces, the slower the flow of water through pore spaces; the slower the flow of water through pore spaces, the slower the flow of water through sediment. Permeability is the ease with which water moves through the pore spaces and cracks in a given material and is largely determined by the volume and size of the pore spaces and how well connected the pore spaces are.

As water infiltrates the earth, it travels down through the vadose, or unsaturated, zone. Here the pore spaces are filled partly with water and partly with air. Water moving down through the unsaturated zone will eventually reach the saturated zone, where the pore spaces are completely filled with water. The boundary between unsaturated and saturated zones is known as the water table, the elevation of which generally follows, in subtle form, the contour of the surface topography. Springs, swamps, and beds of streams and rivers are outcrops of the water table.

The unit of measurement for permeability most commonly used in the study of hydrology or hydrogeology is hydraulic conductivity, which indicates the speed at which groundwater flows through a particular kind of rock or soil. The water pressure at a particular location, called the hydraulic head, is for the most part a result of the elevation

of the water table at that location. The hydraulic head varies from location to location because the elevation of the water table is not level but normally mimics the surface of the ground, although in a subdued fashion. Variations in the hydraulic head create a hydraulic gradient and are the driving force for movement of groundwater through the saturated zone. In addition to hydraulic conductivity, the actual groundwater velocity at a particular location depends on the hydraulic gradient and the porosity of the earth materials at that location.

The flow of groundwater and the position of the water table may be complicated by variations in the hydraulic conductivity. Because the earth is composed of materials that have greatly varying permeability, groundwater flowing through subsurface strata does not travel at a constant rate or without impediment. Strata that transmit water easily (such as those composed primarily of sand) are called aquifers, and strata that restrict water movement (such as clay and shale layers) are called aquitards. An aquifer with an aquitard lying above and below it is a confined aquifer.

Groundwater moves through aquifers in a downgradient direction. Because hydraulic head is not solely a function of elevation, downgradient is not necessarily synonymous with downhill. The downgradient direction has a horizontal and a vertical component, just as a household drain moves wastewater both horizontally and vertically, seeking the lowest point of exit. Aquitards deflect groundwater movement just as drainpipe walls control the direction of wastewater movement. In an aquifer constrained by aquitards, such as horizontal clay layers, the downgradient direction tends to be more horizontal than vertical.

Water infiltrating surficial soils is the primary pathway for potentially hazardous substances to enter an aquifer. Substances placed in the soil may be dissolved in rainwater, which moves them downward through the unsaturated zone to the water table. The water then flows downgradient toward a discharge point.

Monitoring wells are used extensively to assess the effect of operations on groundwater quality, generally to determine the effect of a specific site on nearby groundwater quality. Wells positioned to intercept groundwater flowing away from a site are called downgradient wells, and wells placed to intercept groundwater before it flows under a site are called upgradient wells. Any contamination of downgradient wells not present in upgradient wells at a site may be assumed to be a product of that site. Wells are drilled to various depths in the saturated zone downgradient of the area to be monitored. At the screen zone, the well casing is perforated to allow water to enter the well. Thus, the screen zone refers to the zone of subsurface strata where water is being sampled by the well. Figure 7.1 illustrates the construction of a monitoring well and the relationship between the screen zone and water elevation for wells screened below the water table. Water rises in the well casing to equilibrate with the hydraulic head of the water surrounding the screen zone of the well. The elevation of the water in the well is measured to determine the hydraulic head of the water in the monitored zone. By comparing water levels in adjacent wells screened in the same zone, the hydraulic gradient can be determined and thus the horizontal direction of groundwater flow can be predicted. Only wells screened in the same zones are considered when determining the horizontal gradient; wells screened above and below an aquitard can have different hydraulic heads, defining a vertical gradient.

Vertical groundwater movement is controlled by the hydraulic conductivity of the aquitards and the relative difference in hydraulic head of the water on either side of an aquitard. Vertical gradients can be determined by comparing the water levels between adjacent wells screened on either side of an aquitard. If the water levels in deeper wells are higher than those in shallower wells, the vertical component of flow is upward. Conversely,

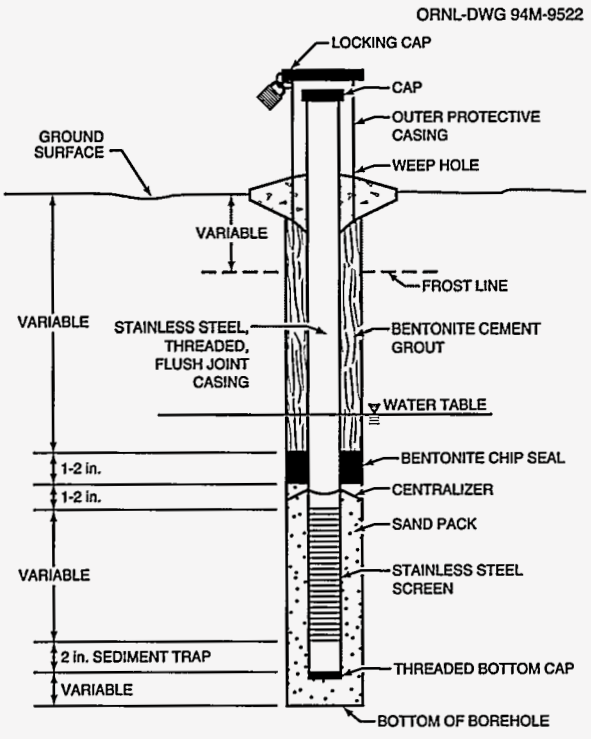

Fig. 7.1. Typical monitoring well construction.

if the water levels in deeper wells are lower than those in shallower wells, the vertical component of flow is downward.

Vertical and horizontal groundwater flow directions are determined in part by the permeability and continuity of geologic strata. To effectively monitor the movement of groundwater and any hazardous constituents it may contain, hydrogeologists at the Portsmouth site have undertaken many detailed studies of the geology of the strata beneath the site.

GEOLOGICAL AND HYDROGEOLOGICAL SETTING

The Portsmouth site is located near the northwestern boundary of the Appalachian Plateau physiographic province. The uppermost rock units in this region were deposited in an inland sea during the Paleozoic era. At the end of the Paleozoic era (approximately 230 million years ago), the region was uplifted and gently folded to form a shallow basin that parallels the Appalachian Mountains. Subsequent erosion of the uplifted sediments produced the deeply dissected, knobby terrain that characterizes the region. Glaciation during the Pleistocene era (2 million to 25,000 years ago) affected this region by changing the directions of streams, which caused lakes to form and filled in valleys with lake and river sediments.

Topography

The Portsmouth site occupies an upland area of southern Ohio with an average land surface elevation of 204 m (670 ft) above mean sea level. The site sits in a mile-wide abandoned river valley 40 m (130 ft) above the Scioto River to the west (see Fig. 7.2).

The predominant landform in the site area is the relatively level, broad, filled valley, which is oriented north to south and is bounded on the east and west by deeply dissected ridges or low-lying hills. Another significant landform is the small valley formed by Little Beaver Creek; this creek flows in a northwesterly direction across the middle of the site, just north and east of the main industrialized area.

Other significant landforms consist of several small valleys formed by streams that have cut into the relatively level unconsolidated deposits under the Portsmouth site. One of these valleys is that of a northwestwardly flowing stream, the west drainage ditch, which is near the west-central area of the plant. Two more streams are located in the southern portion of the industrialized area. In the southeast portion of the site, a southerly flowing stream, Big Run Creek, is situated in a relatively broad, gently sloping valley. An unnamed southwesterly flowing stream in the southwest portion of the site has formed a narrow, steep-walled valley.

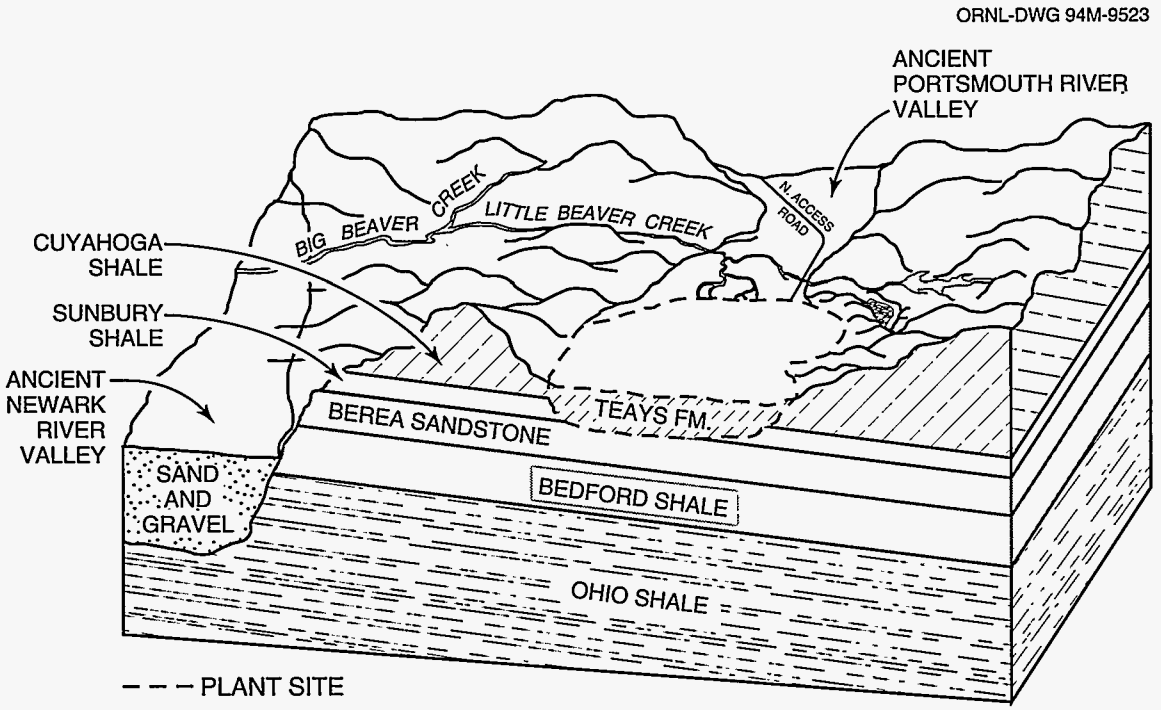

Fig. 7.2. Schematic cross section of the Portsmouth site.

In much of the industrialized area of the Portsmouth site, the original topography was modified for construction of buildings and other facility components.

Stratigraphy

The surficial material over much of the industrialized area of the Portsmouth site is fill material removed from the higher elevations of the site. The material is composed of varying proportions of the unconsolidated geologic materials that are described in the following paragraphs (see Table 7.1).

The geologic materials of the Portsmouth site consist of unconsolidated lacustrine (lake) and fluvial (river) deposits that overlie the regional consolidated bedrock. The unconsolidated deposits were deposited during the recent glaciation. Rather than being deposited directly by the glaciers, the deposits were formed in dammed, preexisting river valleys and in valleys created by glacial runoff, features peripheral to the glaciers themselves. The unconsolidated deposits beneath the Portsmouth site are not continuous with the unconsolidated deposits in the Scioto River valley to the west. A bedrock ridge forms the western valley wall that separates the two groups of unconsolidated deposits. The consolidated bedrock deposits formed in a broad, continental sea about 400 million years ago.

The unconsolidated Teays Formation (Fm.) consists of two members: the Minford clay and silt and the Gallia sand. The consolidated bedrock is composed of the Cuyahoga, Sunbury, Berea, and Bedford Fms. In the vicinity of the Portsmouth site, the Cuyahoga, Sunbury, and Bedford Fms. are predominantly shales, whereas the Berea Fm. is predominantly sandstone.

Table 7.1. Stratigraphy in the vicinity of the Portsmouth site

Geologic unit	Predominant lithology
Unconsolidated	
Teays Formation	
Minford member	upper: clay lower: silty clay and silt
Gallia member	silty sand, clay, sand, and gravel
Bedrock	
Cuyahoga Formation	shale
Sunbury Formation	shale
Berea Formation	sandstone
Bedford Formation	shale
Ohio Formation	shale

The Minford member of the Teays Fm. is a lacustrine deposit consisting of two distinct units: an upper clay unit with silt and sand and a lower silt unit composed of silty clay and very fine to fine-grained sand. Both units are continuous across the Portsmouth site. Across much of the facility, only the basal part of the clay unit is saturated, whereas the lower silt unit is usually completely saturated.

The Gallia member of the Teays Fm., commonly referred to as the Gallia sand, is a fluvial deposit underlying the Minford member at approximately 8 m (25 ft) below ground surface. The Gallia sand is discontinuous across the site and typically consists of red-brown, clayey, medium to coarse sand and gravel; it overlies bedrock and has a mean thickness of about 1 m (3 ft). The Gallia sand is usually poorly sorted, often containing silt and clay as well as numerous pebble-sized rock fragments. The Gallia sand is commonly absent near bedrock highs, such as the bedrock valley walls. The coarser sands and gravels usually occur near the base of the unit and were deposited as point bar and/or channel lag deposits. Contact between the Minford and Gallia members varies from gradational to sharp.

The Cuyahoga Fm., commonly referred to as the Cuyahoga shale, is the uppermost bedrock formation in the geographic area and is a moderately hard, thinly laminated shale with numerous sandstone laminations. The Fm. is not found beneath the industrial portion of the Portsmouth site but does form hills surrounding the site.

The Sunbury Fm., commonly referred to as the Sunbury shale, is the uppermost bedrock formation (where present) beneath the industrial portion of the Portsmouth site. The unit is composed of a competent, black, carbonaceous, fissile shale that is approximately 6 m (20 ft) thick on the eastern portion of the facility and is absent on the western portion.

The Berea Fm., commonly referred to as the Berea sandstone, is continuous beneath the industrial portion of the Portsmouth site. The Berea sandstone underlies the Sunbury shale on the eastern portion of the facility and underlies the unconsolidated Minford and Gallia members of the Teays Fm. on the western portion of the facility. The Berea sandstone is approximately 9 m (30 ft) thick. A thin zone [3 to 8 cm (1 to 3 in.)] of sulfide mineralization occurs at the interface between the Sunbury shale and the Berea sandstone. The upper portion of the Berea Fm., approximately 6 m (20 ft) thick, is composed of a light-gray, hard, thickly bedded, fine-grained sandstone; the lower portion, approximately

3 m (10 ft) thick, has numerous interlayered shale laminations and is similar to the underlying Bedford Fm.

The Bedford Fm., commonly referred to as the Bedford shale, is continuous beneath the Portsmouth site and is also found everywhere beneath the Berea sandstone. The formation averages 30 m (100 ft) in thickness and consists of thinly bedded shale with interbeds and laminations of hard, gray, fine-grained sandstone and siltstone. In three boreholes that penetrated the Bedford, the sandstone interbeds at 174 m (570 ft) above the national geodetic vertical datum of 1929 (NGVD) were saturated with naturally occurring petroleum hydrocarbons.

Geologic History

Prior to glaciation, the major drainage system in southern Ohio was the Teays River system. The Teays flowed northwest and passed about 4.8 km (3 miles) north of the area now occupied by the Portsmouth site. Immediately north of the plant site, Big Beaver Creek occupies a portion of the valley of the extinct Teays River.

The Portsmouth River, a tributary of the Teays, flowed north across the area that is now occupied by the Portsmouth site. In that same area, the Portsmouth River eroded a valley through the Cuyahoga shale and the Sunbury shale and in localized areas may have eroded into the Berea sandstone. The Sunbury was eroded into a wedge that diminishes to the west and exposes the Berea bedrock on the western half of the site. As the Portsmouth River meandered through the valley, sand and gravel were deposited; these fluvial deposits formed the Gallia member of the Teays Fm. Subsequently, an advancing glacier blocked the northwestward flow of the Teays River, and a glacial lake, Lake Tight, filled the valleys of the Teays River and its tributaries. The Minford member of the Teays Fm. was formed at this time as lacustrine silts and clays accumulated in the lake bed. These deposits are in two distinct stratigraphic units. The deepest unit is composed of relatively clean silts, indicative of shallow lake levels or overbank deposits; the upper unit is composed of a series of laminated clays that probably were deposited as Lake Tight increased in size and depth.

Eventually, Lake Tight overflowed its banks and initiated the "deep stage drainage"; the most significant deep stage stream in southern Ohio was the south-flowing Newark River. The Newark occupied the course of the present day Scioto River from Chillicothe to Portsmouth. As the glacier retreated, meltwater moved through the Newark River valley and partially backfilled it with outwash. The current drainage for the region, the Scioto River, is situated on a thick layer of outwash in the valley formed by the Newark River.

The geologic structure of the area is simple; the Mississippian strata dips gently to the east at approximately 9 m/km (30 ft/mile) or 0.3°. A schematic cross section of the Portsmouth reservation and adjacent areas is presented in Fig. 7.2. No known major or minor faults are in the area; however, two distinct joint sets (i.e., fractures) are present in outcrops of the Sunbury and Berea. Azimuths for joint sets are N65°E and N25°W. Bedding plane fractures also have been identified.

Surface soils at the Portsmouth site are composed of loess, colluvium, and more recently deposited alluvium. During the initial grading of the site prior to plant construction, elevated areas were removed and used to fill depressions. In most cases, the fill is indistinguishable from undisturbed Minford deposits.

Groundwater Hydrogeology

The unconsolidated and bedrock systems at the Portsmouth site each include a low- and high-permeability unit. The Gallia sand and the Berea sandstone are the transmissive units at the Portsmouth site. The Gallia sand has the highest hydraulic conductivity and is the primary groundwater migration pathway. The hydraulic conductivity of the Minford silt member is somewhat lower than that of the Gallia sand but is much higher than that of the Minford clay member. The Gallia sand and the saturated portion of the Minford silt member act as a single hydrogeologic unit. The Berea sandstone is a regional geologic unit, and its relatively high hydraulic conductivity makes it the second lithologic unit with transmissive properties. The Minford clay member and the Sunbury shale exhibit lower hydraulic conductivities. The Minford clay member forms a semiconfining layer for the Gallia sand. The Sunbury shale, where more than 1.2 m (4 ft) thick, forms a confining layer for the Minford silt member and the Berea sandstone. The Bedford shale is the lowest confining layer in the groundwater flow system because of its massive thickness and shale composition.

Based on numerous laboratory tests, the average hydraulic conductivity for the Minford clay is 2.3×10^{-4} ft/day and for the Minford silt is 4.3×10^{-3} ft/day. The vertical hydraulic conductivities of Minford clay and Minford silt are approximately an order of magnitude lower than their horizontal hydraulic conductivities. The hydraulic conductivity determined by single-well tests of the Gallia sand ranged from 0.11 to 150 ft/day, with a mean value of 3.4 ft/day. The hydraulic conductivity of the Sunbury shale, based on modeling, ranges from 1.6×10^{-4} ft/day to 9.6×10^{-4} ft/day. The vertical hydraulic conductivity of the Sunbury shale is an order of magnitude lower than its horizontal hydraulic conductivity. The hydraulic conductivity determined by single-well tests of the Berea sandstone ranges from 4.5×10^{-3} to 15 ft/day with a mean value of 0.16 ft/day. The higher hydraulic conductive results are from areas where the Sunbury shale is absent.

The Minford silt member, the Gallia sand, and the Berea sandstone make up the uppermost aquifer. The Gallia sand is the primary aquifer, or water-bearing zone, because it has the highest hydraulic conductivity, but it is not present everywhere. The Minford silt member and the Berea sandstone have somewhat lower hydraulic conductivities than the Gallia sand. Because it is regionally present, the Gallia sand is a regional water-bearing unit.

Based on water-level measurements from August 1993, the average elevation of the Gallia sand potentiometric surface at the Portsmouth site ranges from more than 201 m (660 ft) above NGVD at the center of the facility to 189 m (620 ft) below NGVD on the south, east, and west and to 183 m (600 ft) below NGVD on the north. This results in a site-wide average water table depth of approximately 3 to 5 m (10 to 15 ft). Many factors can affect water table depth at a particular location, including seasonal variations resulting from increased or decreased precipitation, topography, land use, thickness of the upper clay portion of the Minford member, presence of storm drains, and operation of groundwater remediation processes. Future construction activities or additional groundwater treatment facilities will affect water table depth.

As discussed previously, the Portsmouth site is located in a valley. The industrialized portion of the site is located in the central portion of the valley. Four creeks or drainage channels drain the facility: Little Beaver Creek drains the eastern and northern portion; Big Run Creek and the unnamed drainage channel drain the southern, southwestern, and western portion; and the west drainage ditch drains the western portion (see Fig. 7.3). All ultimately discharge to the Scioto River. All four creeks and drainage ditches dissect the

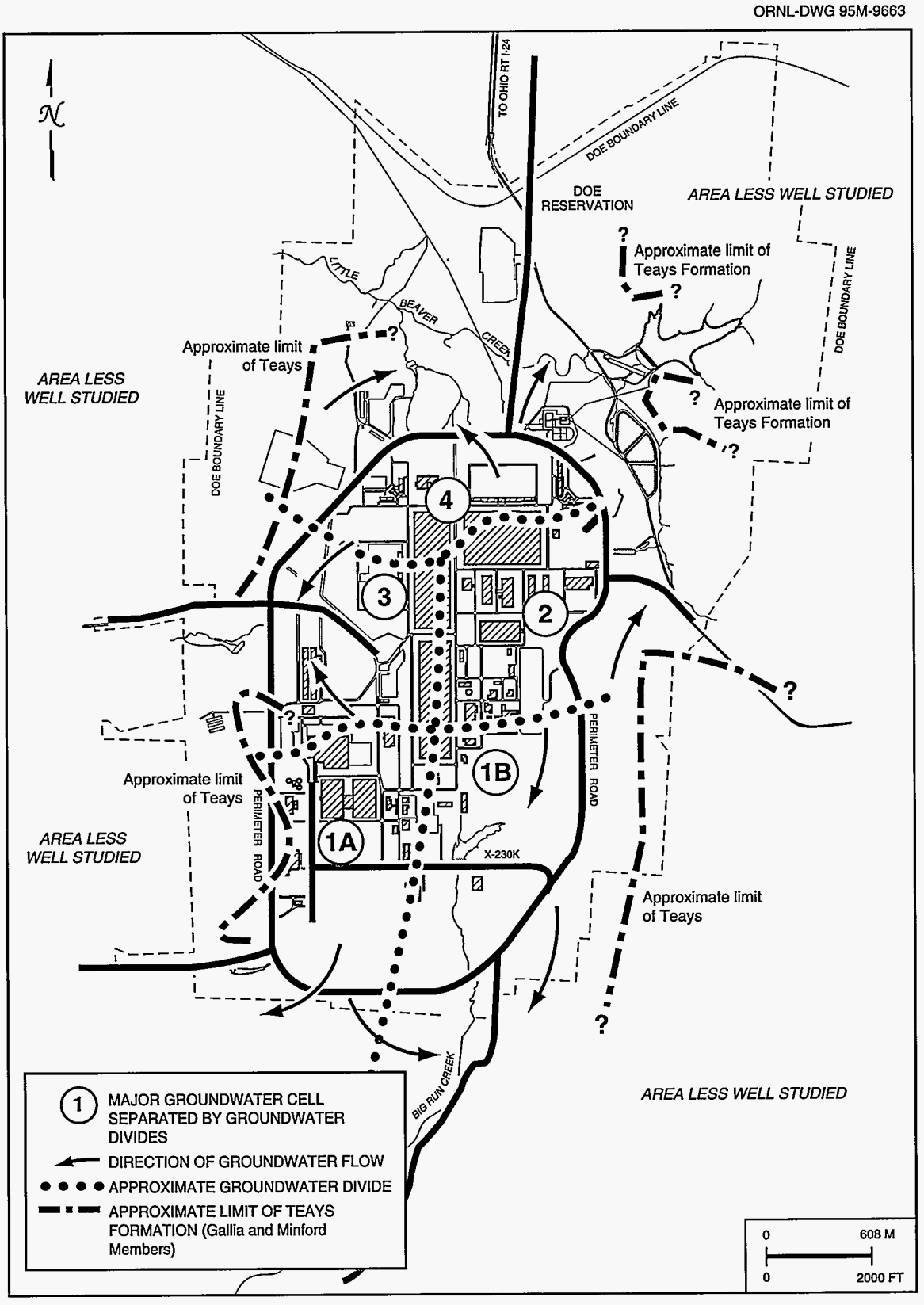

Fig. 7.3. Groundwater divides and major directions of flow in the Gallia.

unconsolidated Minford silt and clay and Gallia sand, the bedrock-forming Sunbury shale (where present), and the Berea sandstone before exiting the site. Because the elevation of the water table is above the elevations of the creeks and drainage ditches, groundwater discharges to them.

Groundwater flow divides exist beneath the Portsmouth site where the groundwater flows toward one or another of these discharge locations. The groundwater divides in the Gallia sand and the Berea sandstone are located in approximately the same place. The locations vary throughout the year because of climatic conditions. Generally, the Berea sandstone and Gallia sand groundwater divides coincide (see Fig. 7.4). Migration of the groundwater divides in the Berea sandstone shows less seasonal variation than that of the Gallia sand.

USES OF GROUNDWATER IN THE VICINITY

Groundwater is used as a domestic, municipal, and industrial water supply in the vicinity of the Portsmouth site. Most municipal and industrial water supplies in Pike County are developed from the Scioto Valley river aquifer, which is where the largest towns and virtually all industry are located. Domestic water supplies are obtained from either unconsolidated deposits in preglacial valleys, major tributaries to the Scioto River, or from fractured bedrock encountered during drilling.

The Portsmouth facility is the largest industrial user of water in the vicinity and obtains its water from the X-608 water supply well field, which is next to the Scioto River just southwest of Piketon. The wells tap the Scioto Valley river aquifer. Total groundwater production averages 49 MLd (13 Mgd).

APPLICABLE MONITORING STANDARDS

A myriad of state and federal laws and regulations, as well as DOE orders, establish standards and requirements governing groundwater monitoring activities at the Portsmouth site. State and federal regulations, DOE orders, and guidance documents relevant to groundwater monitoring at the site are described in the following.

State and Federal Laws and Regulations

RCRA, with its accompanying regulations, is the primary federal law establishing groundwater monitoring requirements, although CERCLA also contains certain requirements. The USEPA promulgates and enforces federal groundwater monitoring regulations. The Portsmouth site is located in USEPA Region V, which is headquartered in Chicago and encompasses the midwestern states.

The OEPA promulgates and enforces state groundwater monitoring regulations, which must be consistent with federal regulations. The Portsmouth site is located within the jurisdiction of the OEPA Southeast District Office in Logan, Ohio. The OEPA is authorized to manage the RCRA and Hazardous Solid Waste Amendment (HSWA) program in Ohio, excluding the authority to issue interim-status corrective orders. The OEPA has primary enforcement authority for RCRA requirements within its authorization.

State and federal regulations governing groundwater monitoring at the Portsmouth site are briefly described in the following sections.

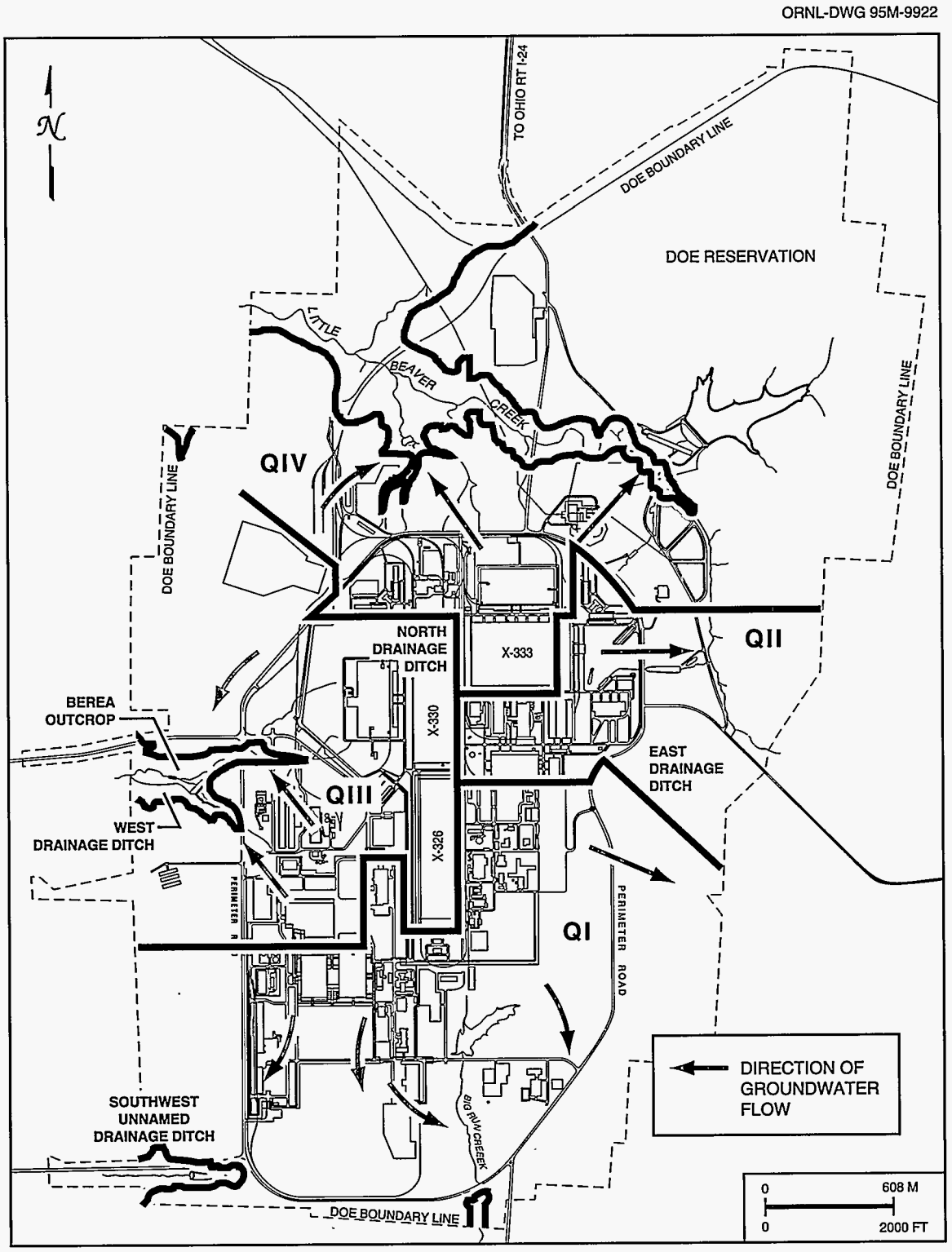

Fig. 7.4. Major groundwater flow direction in the Berea and Berea outcrops.

Title 40, Code of Federal Regulations, Part 265, Subpart F; Part 264, Subpart F; and Corresponding State Regulations

RCRA groundwater monitoring requirements have been established in phases. Initial requirements, or interim-status requirements, are prescribed by 40 CFR 265 or OAC 3745-65-90 through -94. Interim-status groundwater monitoring requirements are applied to all authorized interim-status hazardous waste management units. Basically, the 40 CFR 265 standards require that a facility (1) monitor for detection of contaminants in groundwater; (2) prepare a groundwater quality assessment (GWQA) plan to be implemented in the event contaminants are discovered; and (3) monitor to assess the extent of contamination, as required by the GWQA plan. Groundwater monitoring requirements are to continue through the post-closure period of the facility.

In 40 CFR 264, Subpart F, and OAC 3745-54-90 through -99 are prescribed the more stringent standards facilities must meet upon receipt of their final administrative permit, issued pursuant to a RCRA permit application. Until 1984, Part 264, Subpart F, standards applied only to regulated units, as specifically defined in RCRA. Under Part 264, facilities are required to set up a groundwater monitoring program for each regulated unit consisting of at least one of three stages (detection monitoring, compliance monitoring, or corrective action). Detection monitoring is conducted to detect contamination. Once detected, a groundwater protection standard (GWPS), in the form of a maximum contaminant level or alternate concentration limit, is formulated for each hazardous constituent of concern. Compliance monitoring is conducted to verify that the GWPS is not exceeded. If the GWPS is exceeded, the facility must institute corrective action to clean up the contaminant(s) to the GWPS level. During the corrective action stage, the facility must conduct groundwater monitoring to demonstrate the effectiveness of the corrective action program. Monitoring in the corrective action stage must be at least as effective as groundwater monitoring in the compliance stage and is to continue through the post-closure period of the facility.

RCRA, Sections 3004(u) and 3008(h), and 40 CFR 264, Proposed Subpart S

In 1984, RCRA was amended by the HSWAs, which contain two important provisions. First, the amendments extend the number of units subject to corrective action requirements by creating an SWMU and subjecting all SWMUs to corrective action at the time the facility submits its RCRA permit application [RCRA, Section 3004(u), "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities"]. RCRA, Section 3004(u), is implemented through 40 CFR 264.101 (Subpart F) and the corresponding state rule, OAC 3745-55-011. Thus, groundwater monitoring under corrective action is conducted according to 40 CFR 264, Subpart F, rather than the less stringent 40 CFR 265 interim status regulations.

In July 1990, the USEPA proposed a major rulemaking to implement RCRA, Section 3004(u). In establishing a complete regulatory scheme for corrective action, a new Subpart S in CFR 264 was created as a result of the proposal. Among other changes, the proposal would delete 40 CFR 264.101 and repromulgate it as the new 40 CFR 264.500, Subpart S. This change is still in proposed form, as is most of the July 1990 rulemaking.

In the second HSWA provision, the HSWAs create a vehicle to apply 40 CFR 264, Subpart F, groundwater monitoring requirements to RCRA-regulated units before the regulated units receive their final administrative permits by use of a Section 3008(h) interim status corrective action order. As another provision of these amendments, RCRA, Section 3004(v), requires corrective action for hazardous waste or hazardous constituent releases beyond the facility boundary.

Closure and Post-Closure Care Requirements

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

Part B Permit Application Requirements

Title 40 CFR 270, Subpart B, and OAC 3745-50-44(B) specify that groundwater monitoring information and plan requirements are to be submitted as part of the facility's RCRA permit application.

Final Administrative Permit Conditions

Title 40 CFR 270, Subpart C, and OAC 3745-50-58(J) specify that record keeping and reporting requirements for groundwater monitoring data are to be collected under the appropriate permit.

Underground Storage Tank Requirements

Groundwater monitoring is required in certain instances for USTs. Technical standards and corrective action requirements for owners and operators of USTs can be found in 40 CFR 280, Subparts D, E, F, and G. Corresponding state regulations can be found in OAC 1301:7-9-07, 7-9-12, 7-9-13, and 7-9-14.

CERCLA Requirements

Title 40 CFR 300, Subpart F, requires evaluation of groundwater contamination and hydrogeological conditions when considering remedial alternatives for CERCLA sites.

Solid Waste Requirements

OAC 3745-27 requires groundwater monitoring for releases at solid waste disposal sites. The code includes detailed sampling and analysis plan requirements and monitoring well construction and installation requirements. State solid waste groundwater monitoring requirements parallel those for hazardous waste.

DOE Orders

DOE orders contain basic legal requirements for DOE programs and operations. Several DOE orders contain references to groundwater protection or monitoring and require that contaminated groundwater shall be managed or decontaminated under the procedures and requirements of DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards,* and the 5400 series. A list of the orders and a summary of these requirements follow.

5400.1, *General Environmental Protection Program*

This order 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" (Intro., 5a). 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" (Intro., 6b).

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. A groundwater protection program management plan must be reviewed annually and updated every three years. The plan should include

- documentation of the groundwater regime with respect to quantity and quality;
- design and implementation of a groundwater monitoring program to support resource management and comply with applicable environmental laws and regulations;
- a management program for groundwater protection and remediation, including specific Safe Drinking Water Act, RCRA, and CERCLA action;
- a summary and identification of areas that may be contaminated with hazardous substances;
- strategies for controlling sources of these contaminants;
- a remedial action program that is part of the site CERCLA program required by DOE Order 5400.4; and
- decontamination and decommissioning and other remedial programs contained in DOE directives.

A groundwater monitoring program is to be developed as part of any environmental monitoring plan and for the groundwater protection management program. The groundwater monitoring program shall conform with RCRA standards, where appropriate. Monitoring for radionuclides is to be conducted in accordance with DOE orders. In addition to these general requirements, DOE Order 5400.1 also requires the development of a groundwater monitoring plan regarding monitoring location, groundwater sampling frequency, sampling and analytical methods, sample sizes, and methods of sample preservation.

5400.2A, *Environmental Compliance Issue Coordination*

This order requires coordination of environmental issues that are of significance to DOE, including groundwater protection.

5400.3, *Hazardous and Radioactive Mixed Waste Program*

Under this order, DOE must manage hazardous and radioactive mixed waste according to RCRA requirements, including those of 40 CFR 264 and 265: "RCRA applies to the extent it is not inconsistent with the AEA [Atomic Energy Act]. The radioactive component of radioactive mixed waste is subject to the requirements of DOE 5820.2A" (Intro., 6a).

5400.4, *Comprehensive Environmental Response, Compensation, and Liability Act Program*

This order requires that corrective actions under RCRA or state laws be performed in a manner that satisfies CERCLA requirements, where appropriate.

5400.5, *Radiation Protection of the Public and the Environment*

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 CFR 141. DCGs, 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. Finally, the order states that long-term management of groundwater shall be in accordance with legally applicable federal and state standards.

5480.4, *Environmental Protection, Safety, and Health Protection Standards*

This order specifies statutory and regulatory provisions that apply to DOE programs and operations.

5820.2A, *Radioactive Waste Management*

This order 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

- operational effluent releases,
- migration of radionuclides,
- disposal unit subsidence, and
- changes in parameters for disposal facilities and disposal sites that may affect long-term site performance.

Moreover, the monitoring program must be 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 that discusses, among other items, the environmental monitoring programs at individual waste management facilities.

Ohio Consent Decree and USEPA Administrative Consent Order

The Ohio Consent Decree entered into on August 29, 1989, and the RCRA, Section 3008(h), Administrative Consent Order entered into with USEPA Region V in 1989 and revised on August 11, 1994, outline requirements and schedules for the RFI at the Portsmouth site. These documents include specific dates and deliverables that must be complied with throughout the RFI, the corrective measures study, and corrective measures implementation. In addition, these documents include (1) specific interim remedial measures: a site-wide environmental audit, trichloroethylene (TCE) removal from groundwater at X-701B, and runoff sampling at X-749; (2) changes in environmental management practices, development of a PCB spill cleanup plan, and modifications of the site contingency plan and waste tracking system; (3) completion of GWQAs at X-701B,

X-749, X-231B, and X-616; and (4) development of an interim remedial measures plan for off-site contamination.

Under the USEPA Administrative Consent Order, the Portsmouth site is to conduct a groundwater investigation to characterize any plumes of contamination at the facility. The language of the order parallels language of 40 CFR 264, Subpart F, and OAC 3745-54-90 through -99, requiring that groundwater protection standards be established for any groundwater contaminants found. The order also lists the four RCRA interim-status units as hazardous waste disposal and storage areas. In addition, it identifies the X-231B, X-616, and X-749 facilities as SWMUs.

The Ohio Consent Decree acknowledges receipt of the GWQA, as required under 40 CFR 265, Subpart F, and OAC 3745-55-90 through -65-94, and requires that a hydrogeologic investigation be conducted as part of the site investigation to determine the present and potential extent of groundwater contamination. Long-term disposition of contaminants will be evaluated when the investigation is complete. The decree labels the four RCRA interim-status units as hazardous waste treatment, storage, and disposal areas but includes only X-701B in its list of waste units.

Both of these documents will serve as major sources of information and guidance throughout the RFI, corrective measures study, and corrective measures implementation. At this time, directives stipulated by both documents are consistent with groundwater investigations conducted at the Portsmouth site in response to federal and state regulations and DOE orders. Hence, the monitoring strategies presented in the following section are limited to specific regulations and/or DOE orders.

Guidance Documents

The *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (USEPA 1989a) is the applicable guidance document actively used by the Portsmouth site groundwater protection program.

GROUNDWATER MONITORING AT THE PORTSMOUTH SITE

More than 500 monitoring wells and piezometers (an instrument used to measure fluid pressure) are installed at the Portsmouth site. Approximately 100 monitoring wells and 13 surface water monitoring locations are sampled routinely.

The Portsmouth site has six RCRA interim-status units (see Fig. 7.5) for which groundwater monitoring is specified in 40 CFR 265.93, Subpart F, and OAC 3745-65. Under these regulations, detection monitoring is performed at units where there has been no statistically significant exceedence of threshold levels of groundwater indicator parameters at downgradient wells. These parameters are listed in Table 7.2. In the event of a statistically significant exceedence of these parameters at downgradient wells, the groundwater contaminant plume associated with the unit is characterized during a GWQA and assessment monitoring is performed on a quarterly basis. After a unit has been certified closed, post-closure monitoring may be conducted semiannually.

Detection monitoring is being performed at two units: (1) the X-735 landfill and (2) the X-701C neutralization pit. Assessment monitoring is performed at three units: (1) the X-701B holding pond, (2) X-749 south contaminated materials storage yard, and (3) the X-231B southwest oil biodegradation plot. Post-closure monitoring is being performed at the X-616 chromium sludge surface impoundments.

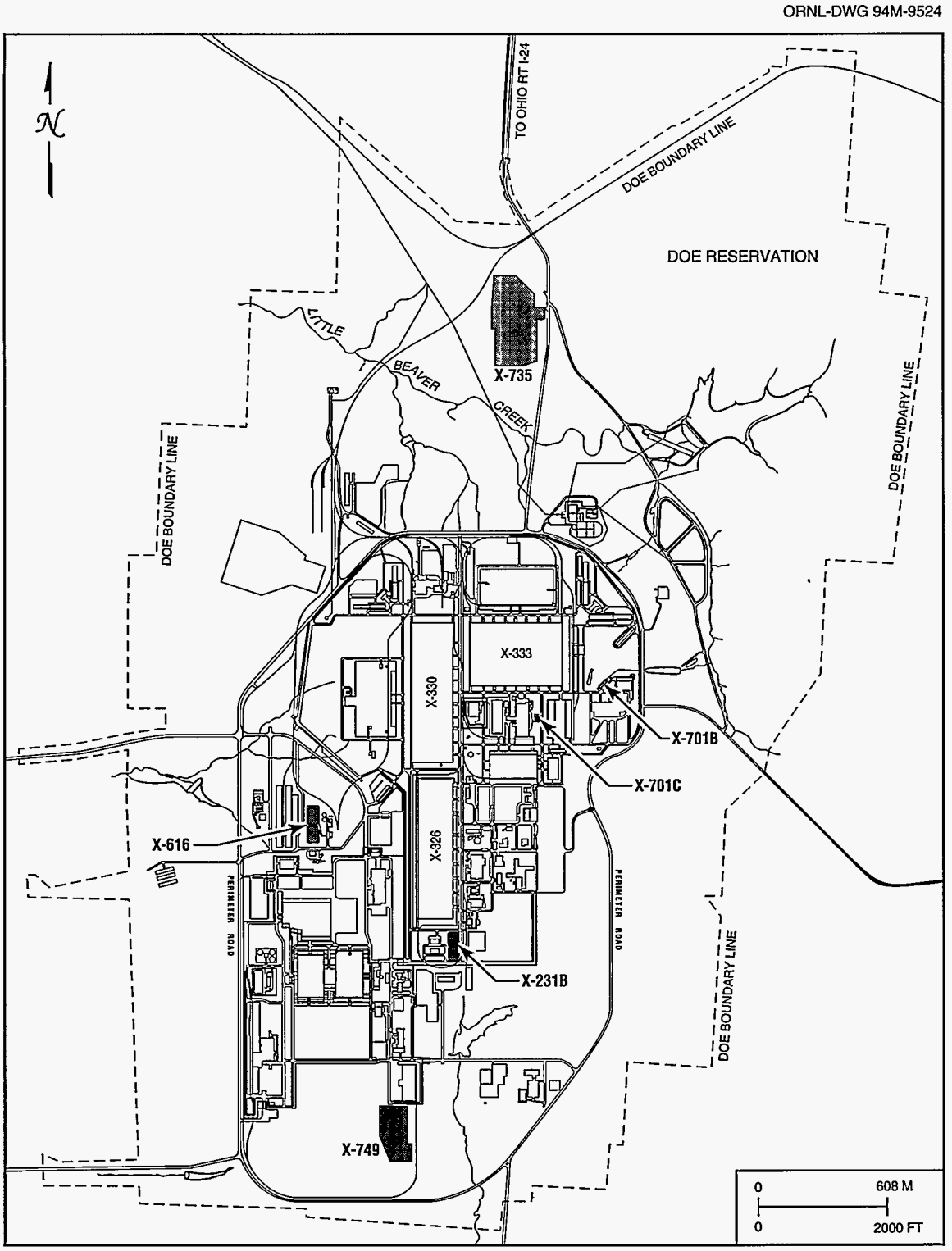

Fig. 7.5. RCRA interim-status land disposal unit locations at the Portsmouth site.

Table 7.2. Analyte analyses required for groundwater monitoring at RCRA units, the sanitary landfill, surface water locations, off-site locations, and the X-701C neutralization pit at the Portsmouth site

Analyte	Monitoring location							
	X-701B[a]	X-749[a]	X-231B[a]	X-616[a]	X-735[b]	Surface water	Off site	701C
			Volatile organic halogens (Method 8010)					
Vinyl chloride	√	√	√	√	√	√	√	√
Trichlorofluoromethane	√	√	√	√	√	√	√	√
Freon-113	√	√	√	√	√	√	√	√
1,1-dichloroethene	√	√	√	√	√	√	√	√
Methylene chloride	√	√	√	√	√	√	√	√
Trans-1,2-dichloroethene	√	√	√	√	√	√	√	√
1,1-dichloroethane	√	√	√	√	√	√	√	√
Cis-1,2-dichloroethene	√	√	√	√	√	√	√	√
Chloroform	√	√	√	√	√	√	√	√
1,1,1-trichloroethane	√	√	√	√	√	√	√	√
Carbon tetrachloride	√	√	√	√	√	√	√	√
1,2-dichloroethane	√	√	√	√	√	√	√	√
Trichloroethene	√	√	√	√	√	√	√	√
Bromodichloromethane	√	√	√	√	√	√	√	√
1,1,2-trichloroethane	√	√	√	√	√	√	√	√
Tetrachloroethene	√	√	√	√	√	√	√	√
Dibromochloromethane	√	√	√	√	√	√	√	√
Bromoform	√	√	√	√	√	√	√	√
			Volatile organic compounds (Method 8240)					
Acetone	√	√	√	√	√	√	√	√
Benzene	√	√	√	√	√	√	√	√
Bromodichloromethane	√	√	√	√	√	√	√	√
Bromoform	√	√	√	√	√	√	√	√
Bromomethane	√	√	√	√	√	√	√	√
2-butanene	√	√	√	√	√	√	√	√
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-pentanene	√	√	√	√	√	√	√	√
1,1,2,2-tetrachloroethane	√	√	√	√	√	√	√	√
Tetrachloroethene	√	√	√	√	√	√	√	√
Toluene	√	√	√	√	√	√	√	√
1,1,1-trichloroethane	√	c	√	√	√	√	√	√
1,1,2-trichloroethane	√	√	√	√	√	√	√	√
Trichloroethylene	c	c	c	c	c	c	√	c
Trichlorofluoromethane	√	√	√	√	√	√	√	√
Vinyl chloride	√	√	√	√	√	√	√	√
Xylenes	√	√	√	√	√	√	√	√

Table 7.2 (continued)

Analyte	Monitoring location							
	X-701B[a]	X-749[a]	X-231B[a]	X-616[a]	X-735[b]	Surface water	Off site	701C
Radionuclide parameters								
Gross alpha	√	√	√	√	√	√	√	√
Gross beta	√	√	√	√	√	√	√	√
Total uranium	√	√	√	√	√	√	√	√
Technetium beta	√	√	√	√	√	√	√	√
Transuranics	√	√	√		√	√		
Isotopic uranium	√	√	√		√	√		
Metals								
Arsenic					√			
Barium			√	√	√			
Cadmium	√	√		√	√			√
Copper					√			
Chromium	√	√	√	√	√			√
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]Sanitary landfill.
[c]Primary volatile organic compound of concern.

The surveillance monitoring program at the Portsmouth site consists of perimeter exit-pathway monitoring, off-site sampling, and baseline monitoring. The purpose of perimeter exit pathway monitoring is to assess the effect of Portsmouth site operations on regional groundwater quality and quantity. The off-site sampling addresses public concerns about the effect of Portsmouth site operations on nearby residential and public water supplies. Baseline monitoring is conducted to establish baseline data, which is used to support various efforts including permit applications.

In 1994, field work was completed for Phase II of the RFI for Quadrants III and IV. These quadrants are located in the northern and western portions of the Portsmouth site. In addition, construction activities for the X-749 and Peter Kiewit landfill interim remedial measures were completed. The X-749 interim remedial measure consisted of a subsurface barrier completed along the southern boundary of the Portsmouth reservation. This barrier (diversion wall) was installed to preclude the off-site migration of the X-749 groundwater contaminant plume prior to a final remedial measure. At the Peter Kiewit landfill, Big Run Creek was relocated and a seep collection system was installed to prevent organic contaminants (primarily vinyl chloride) from entering Big Run Creek.

Also in 1994, a geologic and hydrogeologic reconnaissance was completed for a property adjoining the southern boundary of the plant. A cone penetrometer (hydraulic punch) was used to collect geologic data. Groundwater samples were collected, and the analytical results showed no volatile organic contamination on the property.

Detection Monitoring

Detection monitoring is being performed at two units: (1) the X-735 landfill and (2) the X-701C neutralization pit.

X-735 Landfill

The X-735 landfill is located on the northern part of the Portsmouth site (see Fig 7.6). Initially, a total of 7.2 ha (17.9 acres) was approved for landfill use by the OEPA and the Pike County Department of Health for the disposal of sanitary solid waste. An investigation conducted by Portsmouth site staff indicated that wipe rags contaminated with solvents had inadvertently been disposed of in cells 1 through 6 of the landfill. The OEPA has determined that these cells must be closed as a RCRA hazardous waste landfill. The remaining three cells are regulated by solid waste regulations. The cells containing hazardous waste occupy the northern part of the landfill, and the cells that contain only sanitary solid waste occupy the southern part. There is an undisturbed buffer between the two sections. Construction of a RCRA cap for X-735 began in 1994 and is scheduled for completion in 1995.

X-735 Groundwater Investigations

Seven wells are used for monitoring. Currently, these wells surround the perimeter of the entire landfill (both RCRA and sanitary solid waste sections). In 1994, six additional point-of-compliance monitoring wells were installed. Post-closure monitoring will begin once the RCRA cap is constructed and the unit is certified closed.

X-735 Groundwater Flow

The calculated hydraulic conductivity (K) ranges from a high of 439 m/day (1440 ft/day) to a low of 1.3 m/day (4.3 ft/day). The arithmetic mean hydraulic

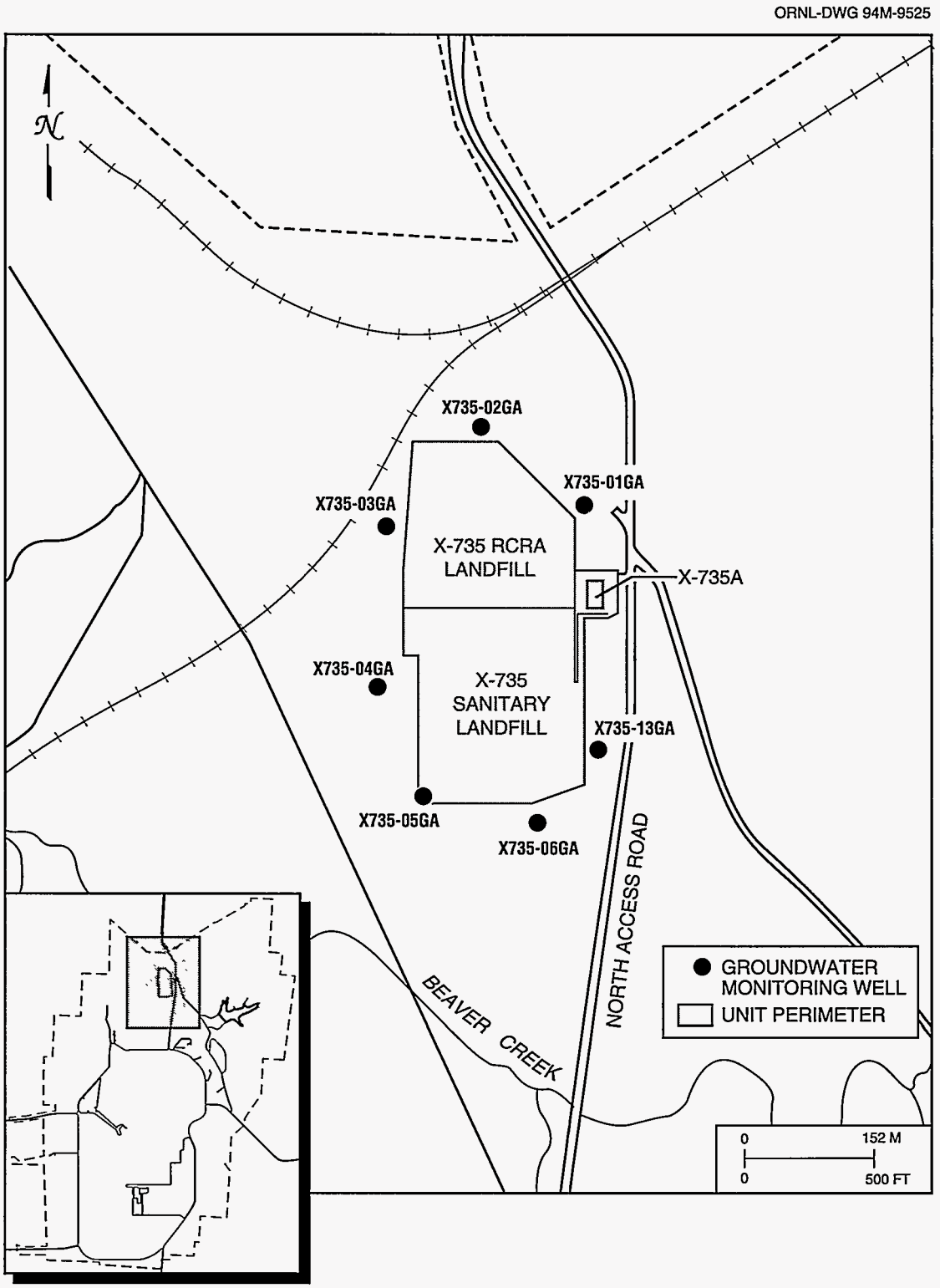

Fig. 7.6. X-735 landfill monitoring well locations.

conductivity value of 131 m/day (430 ft/day) is used in determining groundwater flow velocity for the Gallia sand. The calculated groundwater flow rates range from 0.6 to 1.0 m/day (1.7 to 3.4 ft/day).

X-735 Extent of Contamination

Statistical analysis of the indicator parameters revealed that no contamination exists downgradient of the X-735 sanitary landfill. No VOCs have been detected consistently. The VOC carbon disulfide has been detected occasionally but is believed to be the result of sampling- or laboratory-induced contamination.

X-701C Neutralization Pit

The X-701C neutralization pit consists of a neutralization pit and a pump pit (see Fig. 7.7). The dimensions of the neutralization pit are 7.6 × 7.6 m (25 × 25 ft), with a depth of 5.5 m (18 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 drains into the adjacent pump pit. The pump pit, which is constructed of concrete, has an area of about 7.5 m^2 (81 ft^2) and is 2.7 m (9 ft) deep. Two feeder lines enter the X-701C pit: a 20-cm (8-in.) line from the X-700 chemical cleaning facility and a 10-cm (4-in.) line from the X-701A lime house.

X-701C Groundwater Investigations

The vicinity of the X-701C neutralization pit was included in the seven-unit investigative area of the Quadrant II RFI conducted in 1991 and 1994.

X-701C Groundwater Flow

Groundwater flow in the vicinity of the X-701C neutralization pit is to the west toward the X-700 building (see Fig. 7.7). Groundwater flow in this direction is caused by the pumping of sumps in the X-700 and X-705 buildings, which has also caused a cone of depression centered under these buildings. This is a local reversal of direction of groundwater flow. Without the pumping of these sumps, groundwater flow would be to the east toward Little Beaver Creek. With the induced groundwater flow direction, the upgradient well is X701-69G and downgradient wells are X701-68G and X701-70G.

The hydraulic conductivity of the Gallia sand in the vicinity of the X-701C neutralization pit is about 11.3 m/day (37 ft/day). Calculated groundwater flow velocities range from 0.6 to 0.7 m/day (2.0 to 2.4 ft/day).

X-701C Extent of Contamination

Results of the Quadrant II RFI indicate that the X-701C neutralization pit is located within a TCE groundwater plume centered under the X-700 chemical cleaning facility and the X-705 decontamination building. The extent of the plume's contamination near X-701C is shown in Fig. 7.7. This plume is discussed later in the text as the X-700 chemical cleaning facility, X-705 decontamination building, and X-720 neutralization pit containment plume under the section "RCRA Facility Investigation for Quadrants I-IV."

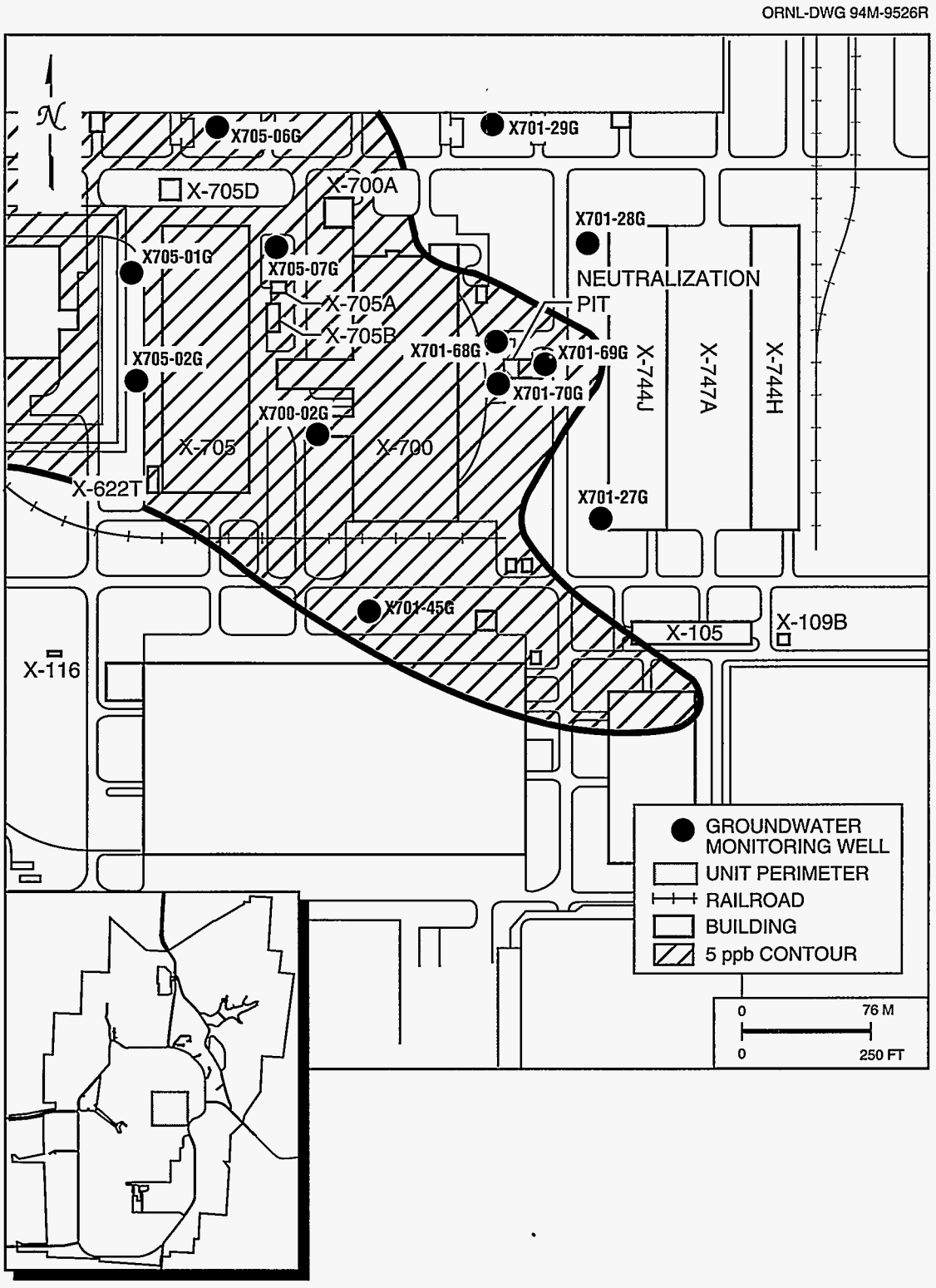

Fig. 7.7. X-701C neutralization pit monitoring well locations.

Assessment Monitoring

Because contaminants have been detected in the groundwater, groundwater assessment monitoring is being performed on three RCRA units, the X-701B holding pond, X-749 south contaminated materials storage yard, and the X-231B southwest oil biodegradation plot (see Fig. 7.5). The contaminants are mainly VOCs [1,1,1-trichloroethane (TCA) and TCE] and low-energy beta emitters (^{99}Tc). Assessment monitoring was also previously performed at the X-616 liquid effluent control facility because indicator parameters had exceeded threshold levels. This unit was certified closed in 1993 and was monitored semiannually in 1994 under post-closure requirements.

GWQAs for all four units were performed from 1988 to 1989. The GWQAs characterized the extent, rate of migration, and concentration of hazardous waste and hazardous waste constituents released from each unit. The investigation results indicated that several factors controlled groundwater flow and contaminant migration at the units: the thickness and hydraulic conductivity of the Gallia sand and Minford silt, the thickness and low vertical conductivity of the Sunbury shale, the presence of storm drains, and the low hydraulic conductivity of the Minford clay. Based on the results of the GWQAs, quarterly assessment monitoring was initiated for the X-701B holding pond, X-749 south contaminated materials storage yard, and the X-231B southwest oil biodegradation plot. Although the GWQA for the X-616 liquid effluent control facility did not indicate the presence of contamination, contamination was detected in subsequent sampling; therefore, quarterly monitoring was also initiated for that facility.

Groundwater assessment networks for these units are designed to evaluate contaminant concentrations and movement of indicator parameters. The networks consist of monitoring wells with well screens located in either the Gallia sand or Berea sandstone. Monitoring wells screened in the Gallia sand were installed in the centers of plumes, at the edges of plumes, and downgradient of plumes. Monitoring wells screened in the Berea sandstone were installed below plumes. Results obtained from chemical analyses of samples from these wells (1) indicate maximum concentrations of contaminants, (2) detect contaminants or quantify changes over time of the concentration of contaminants at the edges of plumes, (3) detect lateral migration of contaminants in the Gallia sand, and (4) detect downward migration of contaminants through the Sunbury shale and into the Berea sandstone.

Surface water monitoring is conducted in conjunction with groundwater monitoring to determine if the contaminated groundwater has reached surface water. The following are surface water monitoring sites and their associated discharge points (see Fig. 7.8):

- Little Beaver Creek sample locations (LBC-SW01 to LBC-SW04), which assess X-701B groundwater discharges.
- The unnamed southwest drainage ditch at the southwest corner of the Portsmouth site (UND-SW01 and UND-SW02) and Big Run Creek (BRC-SW01 and BRC-SW02) sample locations, which assess the X-749 groundwater discharges. Big Run Creek sample locations also provide assessment for the X-231B southwest oil biodegradation plot.
- West drainage ditch sample locations (WDD-SW01 to WDD-SW03), which assess X-616 groundwater discharges.
- The north holding pond sample location (NHP-SW01), which assesses additional groundwater discharges.

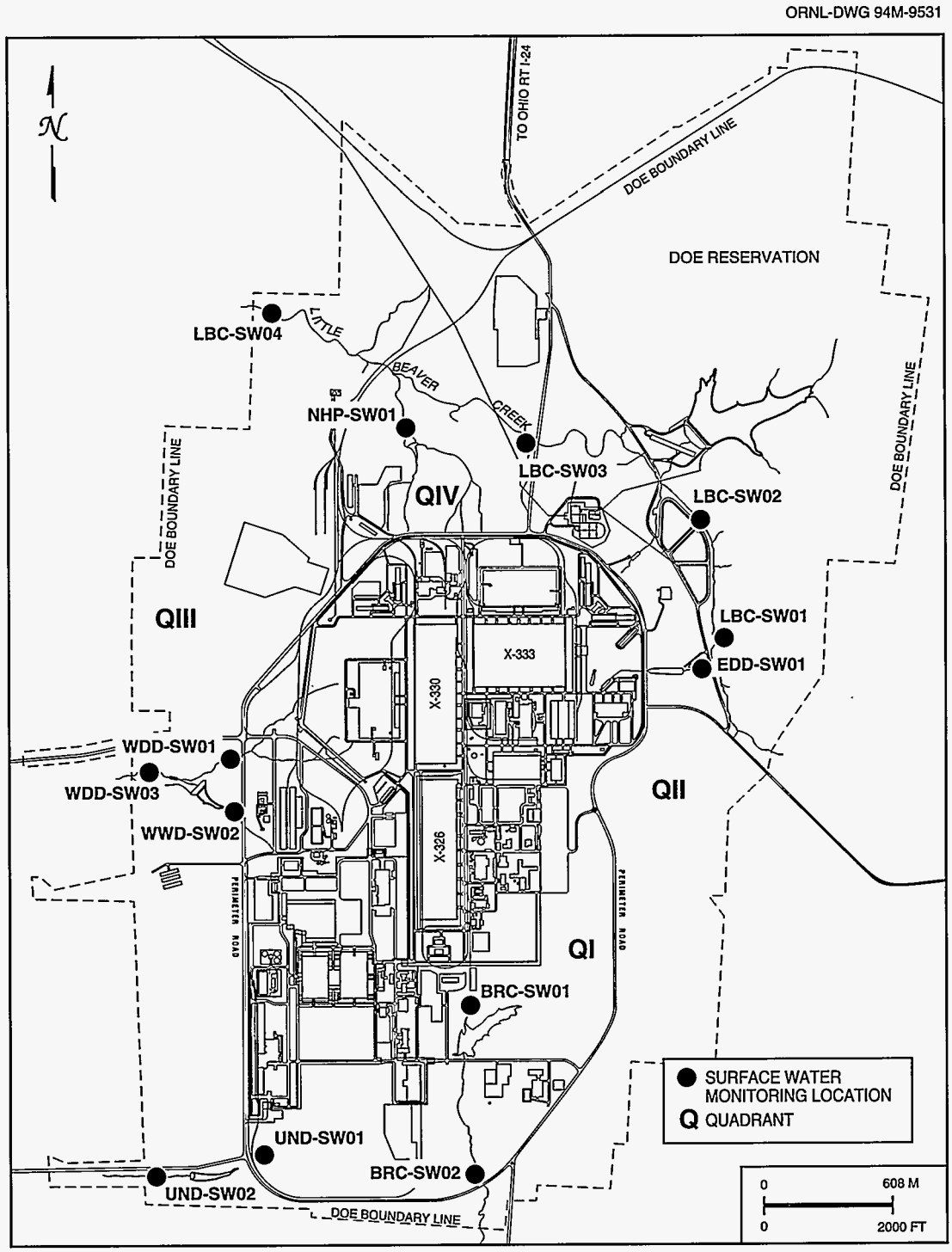

Fig. 7.8. Site-wide surface water monitoring locations at the Portsmouth site.

X-701B Holding Pond

The X-701B holding pond (see Fig. 7.9) is a group of unlined ponds consisting of a holding pond and the east and west retention basins. The holding pond was used from the beginning of plant operation in 1954 until November 1988. The pond was designed for neutralization and settlement of acid waste from several sources, including the X-701C neutralization pit (which receives waste from the X-700 chemical cleaning building), the X-705 decontamination building, and the X-720 maintenance building (Fig. 7.7). Most wastes discharged to the X-701B holding pond were acid wastes, although degreasing solvents, including TCA and TCE, were also discharged to the pond.

In 1974, slake lime was added to the waste streams to neutralize the acid and induce precipitation of radionuclides. The accumulated sludge was dredged annually and placed in the east retention basin from 1974 to 1980. After 1980, the sludge was placed in the west retention basin. Like the holding pond, these retention basins were unlined and did not have a leachate collection system.

X-701B Groundwater Investigations

Several groundwater investigations have been conducted at this unit as well as installation of 74 groundwater monitoring wells: 8 wells are screened in the Minford clay/silt, 57 in the Gallia sand, 1 in the Sunbury shale, and 8 in the Berea sandstone. Twenty-six wells have been selected for quarterly assessment sampling. The samples are analyzed for parameters shown in Table 7.2.

X-701B Groundwater Flow

The primary pattern of groundwater movement in the Minford clay/silt is vertically downward. Approximately 80% of the water entering the Minford clay/silt moves downward to the Gallia sand. The primary pattern of groundwater movement in the Gallia sand is horizontal. Groundwater in the Gallia sand near X-701B holding pond flows radially from a groundwater mound located about 366 m (1200 ft) north of the holding pond. Groundwater flows from the mound southward under the X-701B holding pond and then turns eastward toward Little Beaver Creek. A groundwater divide is located just west of the holding pond, indicating that all groundwater in the X-701B holding pond area discharges either to Little Beaver Creek, the X-230J7 east holding pond, or the east drainage ditch (see Fig. 7.9).

Calculated groundwater flow velocity ranges from 0.2 to 0.5 m/day (0.8 to 1.6 ft/day). The hydraulic conductivity of the Gallia sand is higher near the X-701B holding pond and decreases toward Little Beaver Creek. The hydraulic gradient is lowest near the X-701B holding pond but increases in the same direction that the hydraulic conductivity decreases so that the groundwater velocity remains nearly constant.

Practically all inflow to the Sunbury shale migrates vertically downward to the Berea sandstone, although this is only 2.4% of the water that enters the Gallia sand. Groundwater flow velocities calculated for the Sunbury shale are much lower than those for the Gallia sand or Berea sandstone. This is consistent with field observation of thick, competent shale in the vicinity of the X-701B holding pond.

The groundwater flow direction in the Berea sandstone, toward Little Beaver Creek, is the same as it is for the other geologic units in the vicinity of the X-701B holding pond. However, groundwater in the Berea sandstone does not discharge to Little Beaver Creek because the Sunbury shale is an upper confining bed for the Berea sandstone and the Berea sandstone is not exposed at the creek.

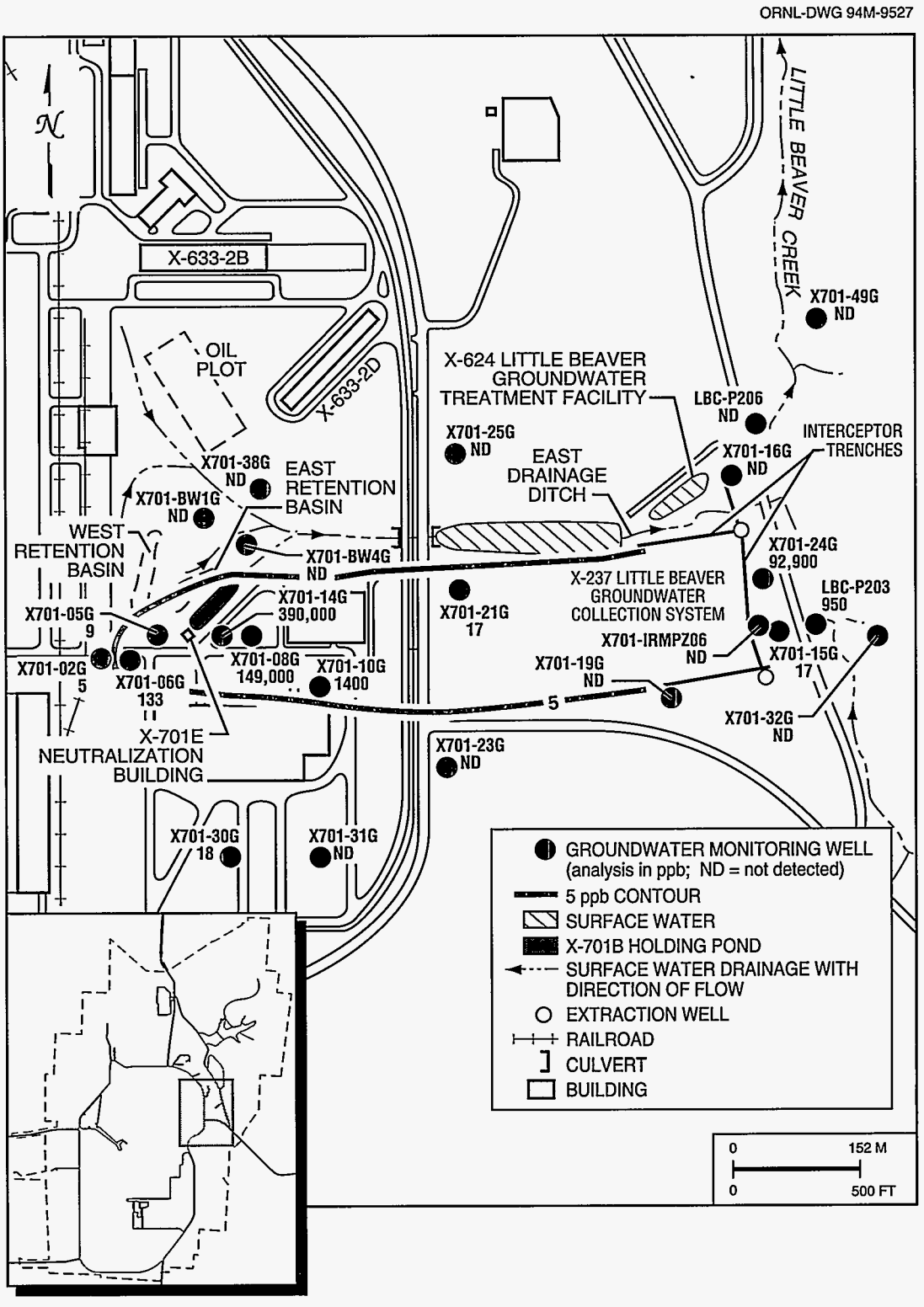

Fig. 7.9. X-701B holding pond—extent of TCE concentration, 4th quarter 1994.

X-701B Extent of Contamination

Groundwater contamination in the Gallia sand is characterized by a long, narrow plume of mixed organic and radioactive constituents; the plume extends from the X-701B holding pond to Little Beaver Creek (Fig. 7.9).

TCE has migrated farther than any other contaminant and defines the extent of contamination. Contaminant plumes for other constituents have a pattern similar to that for TCE. Other VOCs of concern at the X-701B holding pond include 1,1,1-TCA and 1,1-dichloroethene (DCE). The following is a summary of contaminant plume information:

- Contaminant migration is initially to the southeast and then shifts to the east (toward Little Beaver Creek), corresponding to the location of thick but narrow deposits of Gallia sand.
- Groundwater flow converges from both the north and south, forcing a narrowing of flow.
- Contamination has been detected in samples from Little Beaver Creek and the east drainage ditch.
- No contamination has been detected east of Little Beaver Creek.
- No TCE has been detected in the Berea sandstone.

A qualitative evaluation of benthic fauna, conducted in 1991, indicated that species of pollution-sensitive macroinvertebrates (e.g., *Ephemeroptera*, *Trichoptera*, and *Plecoptera*) were absent and that pollution-tolerant taxa (e.g., *Diptera* and *Chironomidae*) were abundant. The benthic fauna were reevaluated in 1992, and results were similar to those for 1991. Subsequent surface water sampling in the east drainage ditch revealed that the TCE plume from the X-701B holding pond was discharging into the east drainage ditch below the X-230J7 east monitoring facility holding pond embankment. As a result, further analysis of the groundwater flow regimes was conducted and an improved groundwater flow model was developed.

X-701B Remediation

Interceptor trenches (french drains) and extraction wells in the interceptor trenches were installed near Little Beaver Creek and the east drainage ditch to capture contaminated groundwater. The primary interceptor trench is situated parallel to the west bank of Little Beaver Creek and intercepts the TCE plume that could possibly enter Little Beaver Creek. The secondary interceptor trench is situated parallel to the south bank of the east drainage ditch and intercepts the TCE plume that could possibly enter the east drainage ditch. Interceptor trench locations and the extent of the TCE contamination plume are shown in Fig. 7.9. The lower parts of the interceptor trenches are backfilled with gravel to facilitate flow, while the upper parts are backfilled with clean soil. The primary trench is 201 m (660 ft) long and has two extraction wells completed in the backfill; the secondary trench is 134 m (440 ft) long and intersects the primary trench.

In 1994, about 24.6 million L (6.5 million gal) of groundwater was extracted from the trenches. The extracted water is treated using activated carbon filters and an air stripper at the X-624 groundwater treatment facility. Approximately 477 L (126 gal) of TCE was removed. The operation of this system stops migration of the contaminant plume toward Little Beaver Creek and the east drainage ditch.

X-749 South Contaminated Materials Storage Yard

Operation of the X-749 south contaminated materials storage yard began in the 1950s. No detailed records of wastes deposited in the landfill were kept until after 1976. Records

kept from 1976 to 1990 indicate that deposited wastes consisted of 85% scrap materials and 15% containerized solids. Typically, wastes were placed in trenches approximately 3.7 to 4.6 m (12 to 15 ft) deep and were then covered with earth.

X-749 Groundwater Investigations

Several groundwater investigations that included installation of groundwater monitoring wells have been conducted at this unit. A total of 61 wells have been installed: 5 wells are screened in the Minford clay/silt, 44 in the Gallia sand, 1 in the Sunbury shale, and 11 in the Berea sandstone (Fig. 7.10).

In addition to quarterly assessment monitoring, field investigations were conducted in 1992 and 1993. The work included 75 Geoprobe borings, 21 piezometer or monitoring well installations, 2 synoptic water level measurements, 27 slug tests, continuous water level recording at 3 well clusters, groundwater sampling and analysis at 15 wells, digging of 12 test pits, and 2 pumping tests. This six-month long investigation defined the nature and extent of groundwater contamination and the hydrogeologic characteristics of the shallow water-bearing zone and provided data to support the evaluation and selection process for the interim-measure alternative.

X-749 Groundwater Flow

The primary pattern of groundwater movement in the Minford clay/silt is vertically downward. Approximately 80% of the surface water entering the Minford clay/silt travels downward to the Gallia sand.

East of the X-749 south contaminated materials storage yard, near Big Run Creek, approximately 76% of the groundwater entering the Gallia sand flows horizontally; the remainder migrates vertically downward. The vertical component predominantly migrates directly to the Berea sandstone because the Sunbury shale is either thin or absent in this area and has been completely eroded by Big Run Creek.

The direction of horizontal flow is affected by the presence of groundwater divides. North-south trending groundwater flow divides are present in both the Gallia sand and the Berea sandstone. The divide in the Gallia sand is situated near the western boundary of the unit: groundwater flowing east from the divide migrates toward Big Run Creek; groundwater flowing to the west migrates toward the unnamed southwest drainage ditch and to the south toward the Portsmouth boundary.

Two pumping tests in the Gallia sand have been conducted at the X-749 south contaminated materials storage yard. Hydraulic conductivity values determined from pumping test data range from 1.2 to 1.9 m/day (4 to 6 ft/day). Groundwater velocities calculated from using these hydraulic conductivity values range from 0.02 m/day (0.06 ft/day) to less than 0.2 m/day (0.6 ft/day). Groundwater flow velocity is relatively constant in the Gallia sand throughout the area of this unit. A decrease in the hydraulic conductivity from the X-749 south materials storage yard toward Big Run Creek is compensated by a rapid drop in elevation over this same distance; this results in higher hydraulic gradients towards the east. Gallia sand potentiometric surface elevations average 2.4 to 4.6 m/day (8 to 15 ft) higher than those of the Berea sandstone. Hydraulic conductivity values for the Sunbury shale, when present, are significantly lower than those for the Gallia sand and Berea sandstone.

The direction of groundwater flow in the Berea sandstone is very similar to that observed for the Gallia sand, except that the north-south trending divide in the Berea sandstone is farther west than the Gallia sand divide. Flow east of the divide migrates

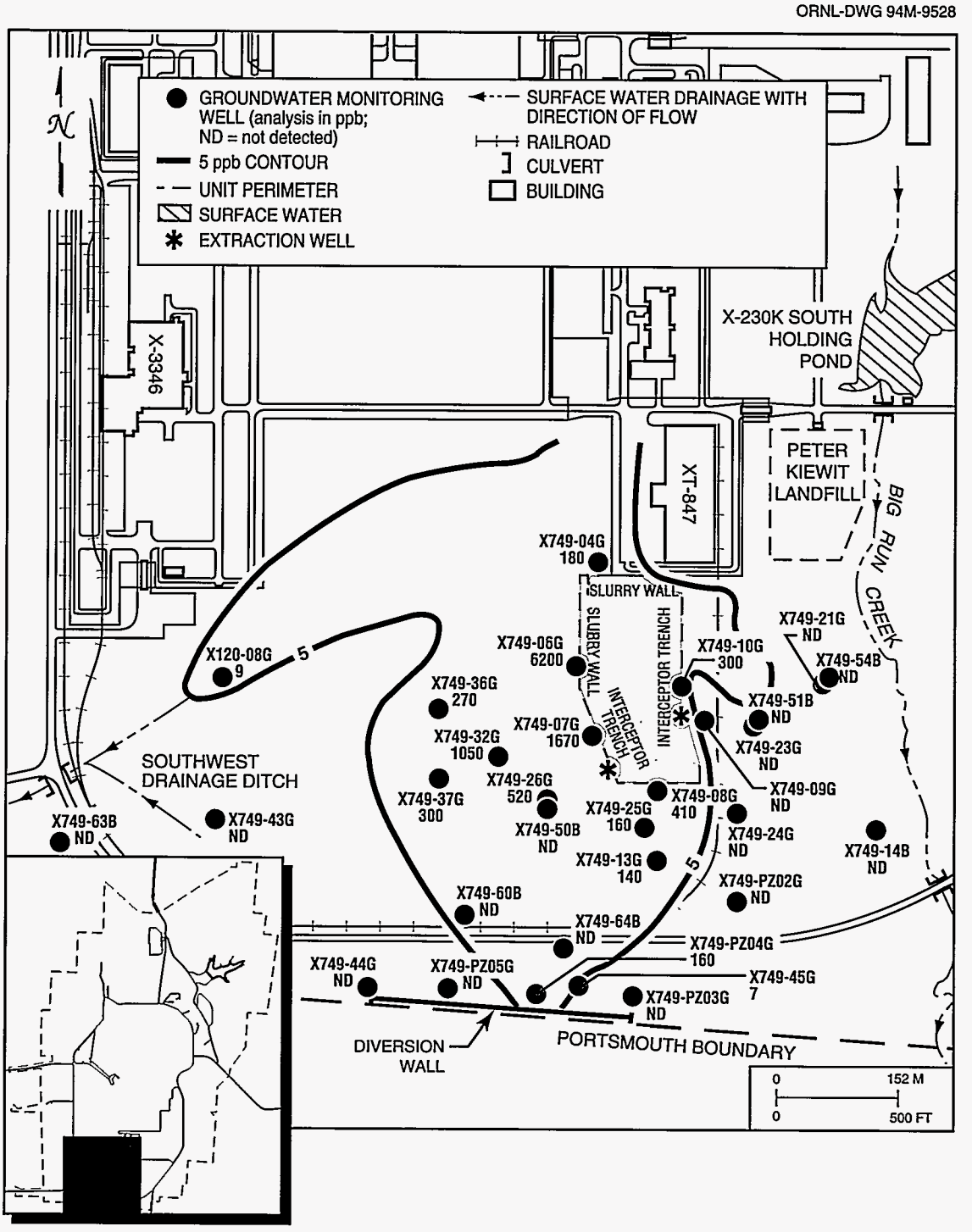

Fig. 7.10. X-749 south contaminated materials storage yard—extent of TCE concentration, 4th quarter 1994.

toward Big Run Creek; flow west of the divide migrates toward the unnamed southwest drainage ditch. The average groundwater linear velocity in the Berea sandstone is 0.005 m/day (0.015 ft/day). The area of higher Berea sandstone groundwater velocity is east of the X-749 south contaminated materials storage yard, where the Sunbury shale has been eroded.

X-749 Extent of Contamination

Although 18 wells were originally selected for quarterly assessment sampling, 29 wells were monitored for all four quarters of 1994 because of apparent contaminant plume migration. Samples were analyzed for the parameters listed in Table 7.2. The most extensive and most concentrated VOCs at the X-749 south contaminated materials storage yard were TCE and TCA. Other VOCs detected were 1,1-dichloroethane (DCA), DCE, 1,2-DCE, chloroform, and Freon-113. All contaminants were generally lower in concentration than, and contained within the extent of, the TCE plume.

X-749 Remediation

The X-749 south contaminated materials storage yard has been closed according to RCRA requirements. Elements of the closure included

- installation of a multimedia cap,
- installation of a slurry wall along the north side and northwest corner of the unit,
- installation of subsurface groundwater drains on the northern half of the east side and the southwest corner of the unit, and
- one groundwater extraction well within each of the groundwater drains.

The slurry wall and subsurface drains extend down to bedrock. After collection, groundwater is pumped from the subsurface drains to an activated carbon filtration system at the X-622 groundwater treatment building (Fig. 7.11), where the groundwater is treated. The decontaminated water is discharged through the 003 NPDES-permitted outfall.

Field work in 1992 and 1993 indicated that the TCE plume is closer to the Portsmouth site boundary than was anticipated. The Gallia sand contamination (see Fig. 7.10) plume at the X-749 south contaminated materials storage yard extends about 457 m (1500 ft) to the south-southwest, about 305 m (1000 ft) to the south, and about 61 m (200 ft) to the southeast of the unit. The largest area of contamination extending to the south corresponds to the area where the Gallia sand deposits are thickest. In 1993, the X-749 interim remedial measure investigation was completed and the location of the southern edge of the VOC contamination plume was refined. TCE was detected within 17 m (55 ft) of the Portsmouth site boundary. A subsurface barrier was selected as the regulatory-approved interim remedial measure.

In 1994, an interim-measure subsurface diversion wall was completed across a portion of the facility's southern boundary. The diversion wall, which extends from the surface into the Sunbury shale, will preclude plume migration off plant property before implementation of a final remedial measure.

In addition, groundwater samples were collected in November and December 1994 on the private property located just south of the Portsmouth site, confirming that groundwater contamination has not moved off site. Groundwater samples were collected from seven locations (Fig. 7.12). Also, surface water samples were collected from a nearby pond. Groundwater samples were analyzed for VOCs, including TCE and several breakdown

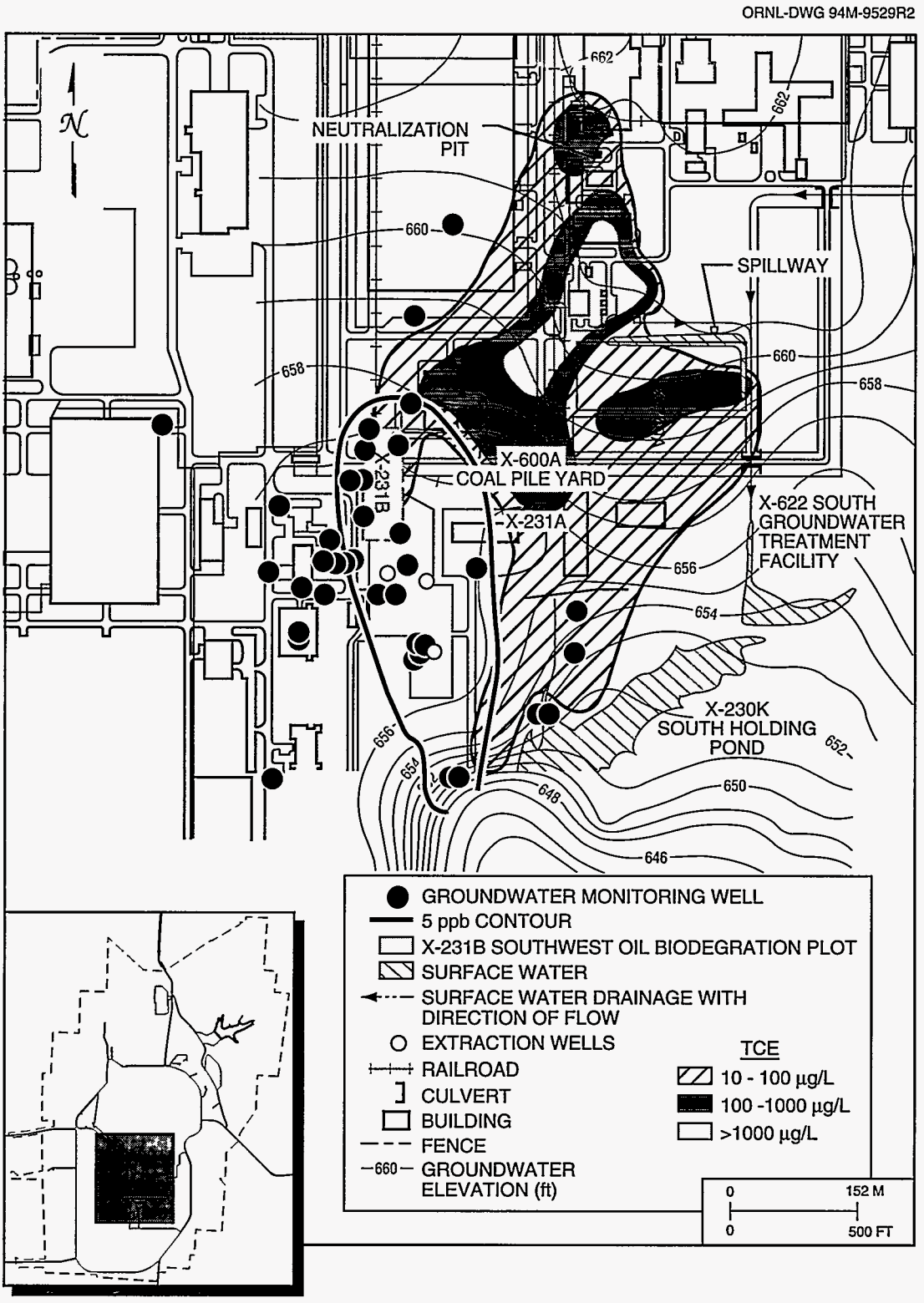

Fig. 7.11. X-231B southwest oil biodegradation plot monitoring well locations and TCE contaminant plume location.

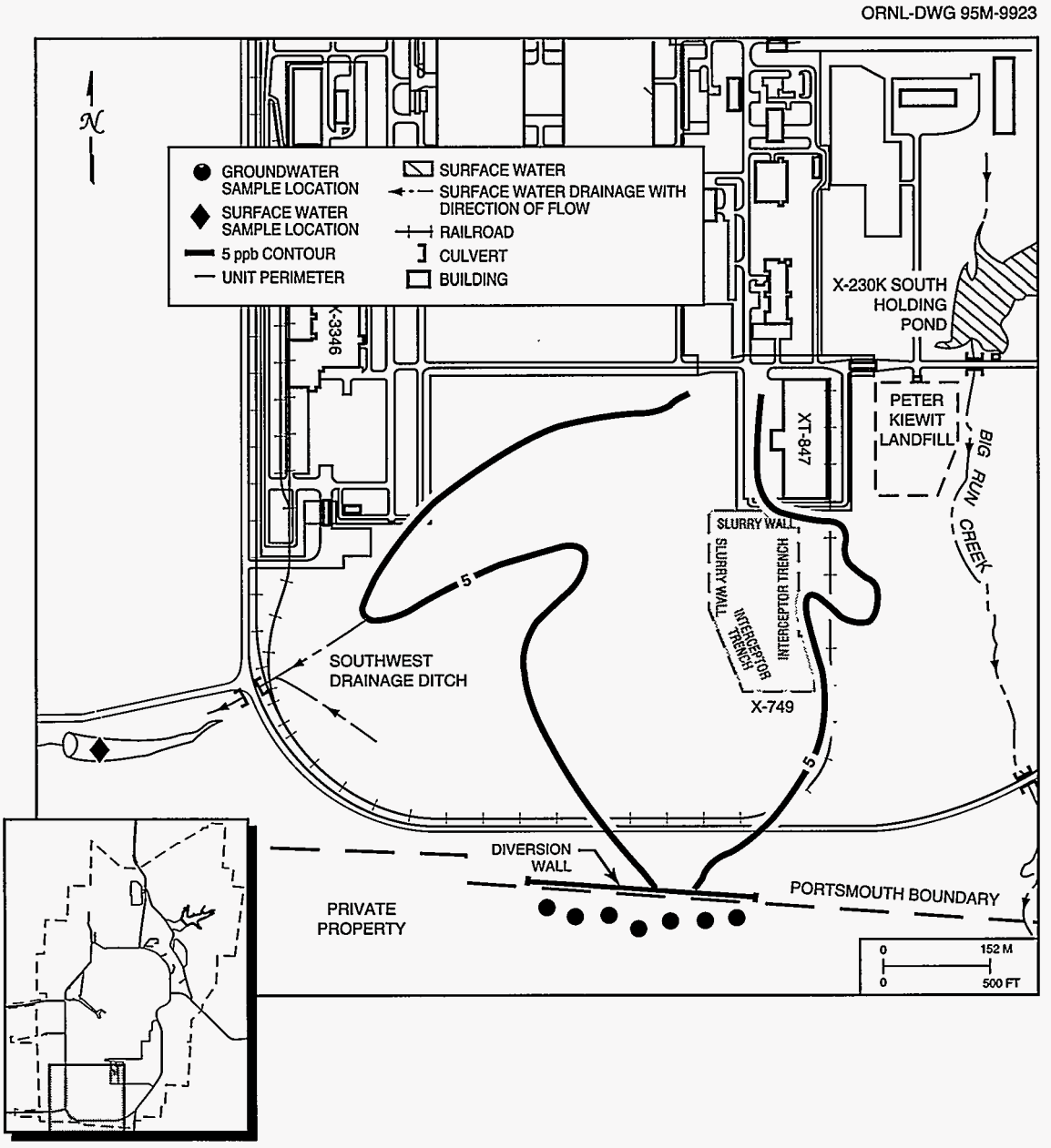

Fig. 7.12. Locations where groundwater and surface water samples were collected during the X-749 plume investigation to determine if contamination had moved off site.

products of TCE. Additionally, samples were tested for total uranium, gross alpha, gross beta, and ^{99}Tc. Results from the study showed no detectable levels of VOCs or radiological contamination beyond the southern boundary line.

X-231B Southwest Oil Biodegradation Plot

The X-231B southwest oil biodegradation plot was used from 1976 to 1983 for land application of waste oils and degreasing solvents and consists of two disposal plots, each surrounded by an elevated soil berm. The plots were periodically fertilized and disced to enhance aeration and promote natural biological degradation of waste oil. This unit has

been capped with a temporary synthetic cover. In late 1993, vadose zone remediation was initiated.

X-231B Groundwater Investigations

Since 1985, several groundwater investigations and installations of monitoring wells have occurred. At the completion of the GWQA investigation, 35 monitoring wells were installed in the vicinity of this unit (see Fig. 7.11): 3 wells were screened in the Minford clay/silt, 25 in the Gallia sand, 1 in the Sunbury shale, and 6 in the Berea sandstone. Thirteen wells have been selected for quarterly assessment monitoring. Samples are analyzed for the chemical parameters listed in Table 7.2.

X-231B Groundwater Flow

The primary pattern of groundwater movement in the Minford clay/silt is vertically downward to the Gallia sand. Groundwater entering the Gallia sand at the X-231B southwest oil biodegradation plot flows laterally, primarily to the southeast toward the X-230K south holding pond. Most groundwater remains in the Gallia sand and does not migrate downward into the Berea sandstone. The hydraulic gradient is very low because the X-231B southwest oil biodegradation plot is located in an area where the bedrock is relatively flat; thick, permeable Gallia sand deposits are present; and the area is close to the east-west groundwater divide that runs through the Portsmouth site. The vertical hydraulic gradient from the Gallia sand to the Berea sandstone is steep and has an average potentiometric difference of 2.4 to 3.0 m (8 to 10 ft); approximately 1% of the water entering the Gallia sand migrates to the Berea sandstone.

The hydraulic conductivity of the Gallia sand is 12.5 m/day (41.0 ft/day), and the average flow velocity is 0.4 m/day (1.2 ft/day). The Gallia sand is thin, generally less than 0.37 m (1.2 ft) thick, below the X-231 southwest oil biodegradation plot. More extensive Gallia sand deposits occur to the southeast and east of the unit. The average groundwater velocity for the Gallia sand is approximately 0.6 m/day (2.0 ft/day).

The hydraulic conductivity of the Sunbury shale is significantly lower than the hydraulic conductivity of the Gallia sand. Therefore, the downward vertical migration of groundwater from the Gallia sand to the Berea sandstone is impeded.

Groundwater in the Berea sandstone flows to the southeast. The flow system is not similar to that in the Gallia sand because of the presence of relatively thick [2.4 m (8 ft) or more] Sunbury shale. Surface drainage influences the direction of groundwater flow in the Gallia sand but not in the Berea sandstone. The calculated average linear groundwater velocity for the Berea sandstone is 0.03 m/day (0.1 ft/day).

Groundwater flow modeling predicts that groundwater movement from the X-231B southwest oil biodegradation plot is slow and may eventually discharge to the X-230K south holding pond (Fig. 7.11).

X-231B Extent of Contamination

The VOC plumes at the X-231B southwest oil biodegradation plot are smaller in extent than those at the X-701B holding pond and X-749 south contaminated materials storage yard. The plumes are narrow and elongated in the north-south direction. The Gallia sand contamination plume at the X-231B southwest oil biodegradation plot extends about 305 m (1000 ft) to the south toward the X-230K holding pond. The northern boundary of the TCE plume is near the south end of the X-326 building. The areal extent of the TCE plume

encompasses the areal extent of all other VOC plumes associated with X-231B oil biodegradation plot, and the levels of TCE are also higher than any other VOC.

X-231B Remediation

As part of closure on this unit, three groundwater extraction wells were installed in the Gallia sand. These wells are located south of the unit and are aligned across the central portion of the TCE contaminant plume (shown in Fig. 7.11). This configuration prevents TCE dispersion.

X-616 Liquid Effluent Control Facility

The X-616 liquid effluent control facility (Fig. 7.13) consists of two unlined surface impoundments that were used from 1976 to 1985 for storage of sludge generated by treatment of recirculating cooling water blowdown from the Portsmouth plant 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 pumped to the X-616 impoundments, where it was stored.

From February to May 1987, treated process effluent from the X-700 chemical cleaning facility, via the X-701C neutralization pit, was diverted to the X-616 liquid effluent control facility to reduce the high concentration of suspended solids discharged from the X-701B holding pond. In addition, chlorinated organic solvents were discovered in the X-700 chemical cleaning facility basement sump that discharges to the X-701C neutralization pit.

X-616 Groundwater Investigations

Since 1978, groundwater investigations have been conducted and monitoring wells have been installed at the X-616 liquid effluent control facility. During the GWQA study for the X-616 liquid effluent control facility, 22 groundwater monitoring wells were sampled. Some VOCs were found in isolated wells at concentrations below 10 ppb. In November 1989, four wells were sampled for RCRA Appendix IX analytes and elevated levels of total chromium were detected. In 1990, quarterly sampling for chromium was conducted at 12 wells. The results indicated that some total chromium results exceeded regulatory limits. Upon completion of the GWQA, 28 monitoring wells were installed in the vicinity: 3 in the Minford clay/silt, 20 in the Gallia sand, and 5 in the Berea sandstone (Fig. 7.13).

During this time, the X-616 liquid effluent control facility was undergoing a clean closure according to RCRA requirements. A review of all groundwater data showed that TCE had been detected at low levels (less than 30 ppb) in monitoring wells not included in the 12-well monitoring network; therefore, a clean closure could not be certified. Two wells at which TCE had been detected were added to the monitoring well network. When TCE was detected in these two wells, an adjacent well was added to the monitoring well network.

In 1991, groundwater samples were monitored for VOCs, radiological parameters, and five unfiltered metals. In 1992, the five metals were analyzed for in both filtered and unfiltered samples. In 1993, common anions and cations were added to the list of analytes (see Table 7.2). Portsmouth is currently investigating statistical methods for determining background concentrations for metals. Once background values are determined,

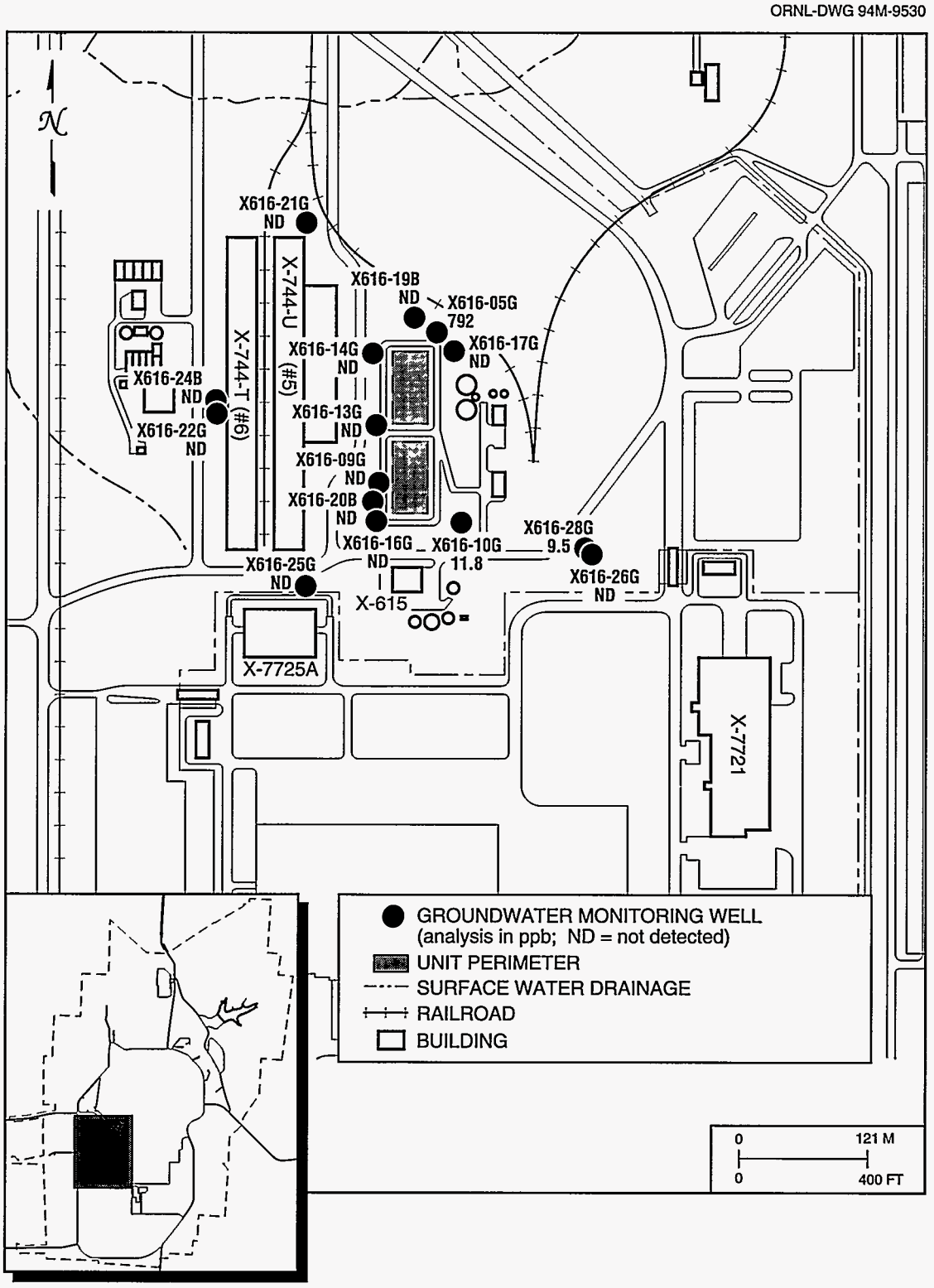

Fig. 7.13. X-616 liquid effluent control facility and chromium sludge surface impoundments—extent of chromium (SW846/Diss.) concentration, 1st quarter 1994.

concentrations of chromium at X-616 will be compared with background levels of chromium.

X-616 Groundwater Flow

At the X-616 liquid effluent control facility, the Gallia sand is 1.2 to 1.4 m (4 to 6 ft) thick and thins in all directions away from the surface impoundments. The Sunbury shale is absent under the X-616 liquid effluent control facility, so the Gallia sand overlies the Berea sandstone. Hydraulic conductivity in the Gallia sand is about 1.4 m/day (4.6 ft/day), and groundwater velocity ranges from 0.05 to 0.09 m/day (0.17 to 0.28 ft/day). Before closure, groundwater flow from the site was reported as being radial. Since closure, groundwater flow in the Gallia sand has changed to a predominantly west-northwest direction toward local drainage channels of the west drainage ditch.

Groundwater flow in the Berea sandstone is primarily to the northwest. Groundwater in both the Gallia sand and the Berea sandstone flows away from the X-616 liquid effluent control facility through two forks of the west drainage ditch to the X-230J5 holding pond. The average Berea sandstone hydraulic conductivity in the vicinity of the X-616 liquid effluent control facility is 0.11 m/day (0.35 ft/day), which is higher than that measured at the other assessment monitoring units. Because the Sunbury shale is absent, the Gallia and Berea are in direct hydrologic communication. Groundwater flow modeling predicts that groundwater from both the Gallia sand and the Berea sandstone discharges to the west discharge ditch, with an estimated groundwater travel time in excess of 30 years for both.

X-616 Closure Activities

Closure activities at the X-616 liquid effluent control facility in 1991 included dewatering, removing the chromium sludge, and backfilling the ponds with clean fill. This unit was certified closed in 1993, and post-closure monitoring of this unit began in 1994.

Groundwater Surveillance Monitoring

The surveillance monitoring program at the Portsmouth site consists of perimeter exit-pathway monitoring, off-site well sampling, and Portsmouth site water supply well field sampling. Perimeter monitoring assesses the effect of the facility on regional groundwater quality and quantity. Off-site well sampling and Portsmouth site water supply well field sampling address concerns about the impact of Portsmouth site operations on the quality of the drinking water supply. Baseline monitoring is also conducted.

Perimeter Exit-Pathway Monitoring

Groundwater investigations have determined that the Gallia sand is the primary hydrogeologic unit for contaminant migration at the Portsmouth site. 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 boundary are also used in the surveillance monitoring program. Figure 7.14 shows the sampling locations for exit-pathway monitoring.

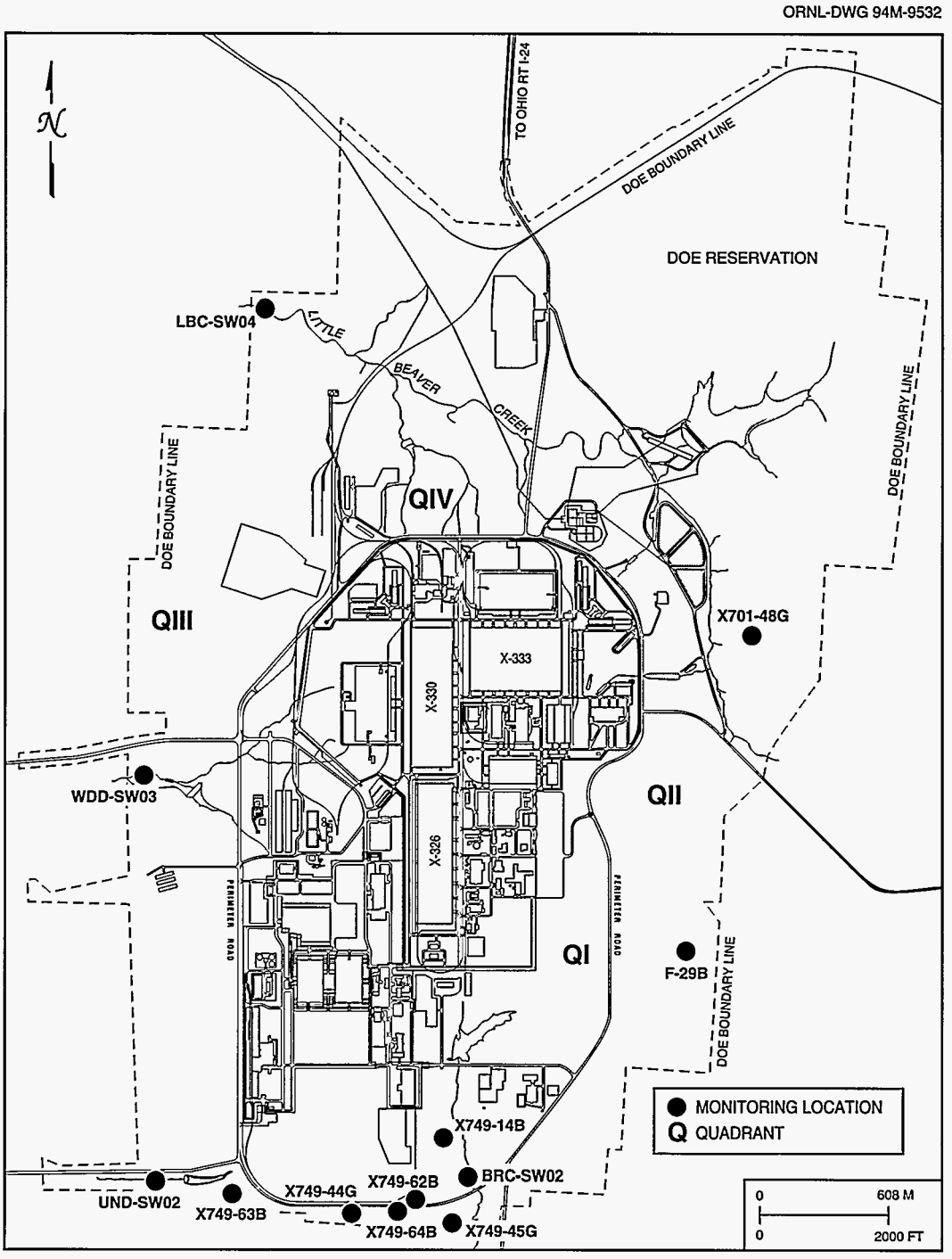

Fig. 7.14. Exit-pathway monitoring locations at the Portsmouth site.

Off-Site Well Sampling

The purpose of the off-site well sampling program is to ensure that drinking water sources have not been adversely affected by Portsmouth site 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 is not used in hydrogeologic or geochemical investigations.

Currently, nine residents are participating in the program (see Fig. 7.15 for sampling locations and Table 7.2 for the analytical parameters). All sampling for the residential program is conducted semiannually. Sampling locations are added or deleted as residents' requests and 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 the Portsmouth site and a resident's water supply. Sampling results indicate that residential water supplies have not been affected by site operations.

Portsmouth Water Supply Well Field Sampling

The water supply for the Portsmouth site is provided by the X-605G, X-608B, and X-6609 well fields located along the east side of the Scioto River about 1.45 to 7.2 km (0.9 to 4.5 miles) west of the site (Fig. 7.16). At any given time, approximately 25% of the wells are out of service because of scheduled or unscheduled maintenance; when this occurs, water demands are met by pumping the remaining in-service wells from all three well fields.

Selected Portsmouth site water supply wells are sampled semiannually. If the wells to be sampled are out of service during the sampling period, designated alternates are sampled. Sampling results indicate that the Portsmouth site water supply has not been affected by site operations.

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. 7.17). Sampling is conducted to support the next RCRA permit application and to provide a comparison between on-site wells and off-site background water.

Other Investigations

Two other groundwater or groundwater-related investigations occurred in 1994: (1) Peter Kiewit landfill seep sampling and (2) the X-737 proposed sanitary landfill hydrogeology investigation.

Peter Kiewit Landfill

The Peter Kiewit landfill is located west of Big Run Creek just south of the X-230K holding pond (Fig. 7.10). The landfill, opened in 1952, was used as the salvage yard, burn pit, and trash area during construction of the Portsmouth facility. 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 that characterize the material in the landfill. In addition, construction details and operation records are not available.

Groundwater seeps have been identified along the southeast corner of the landfill. The approximate flow rate ranges from 1136 to 2157 L/day (300 to 570 gal/day). Environmental

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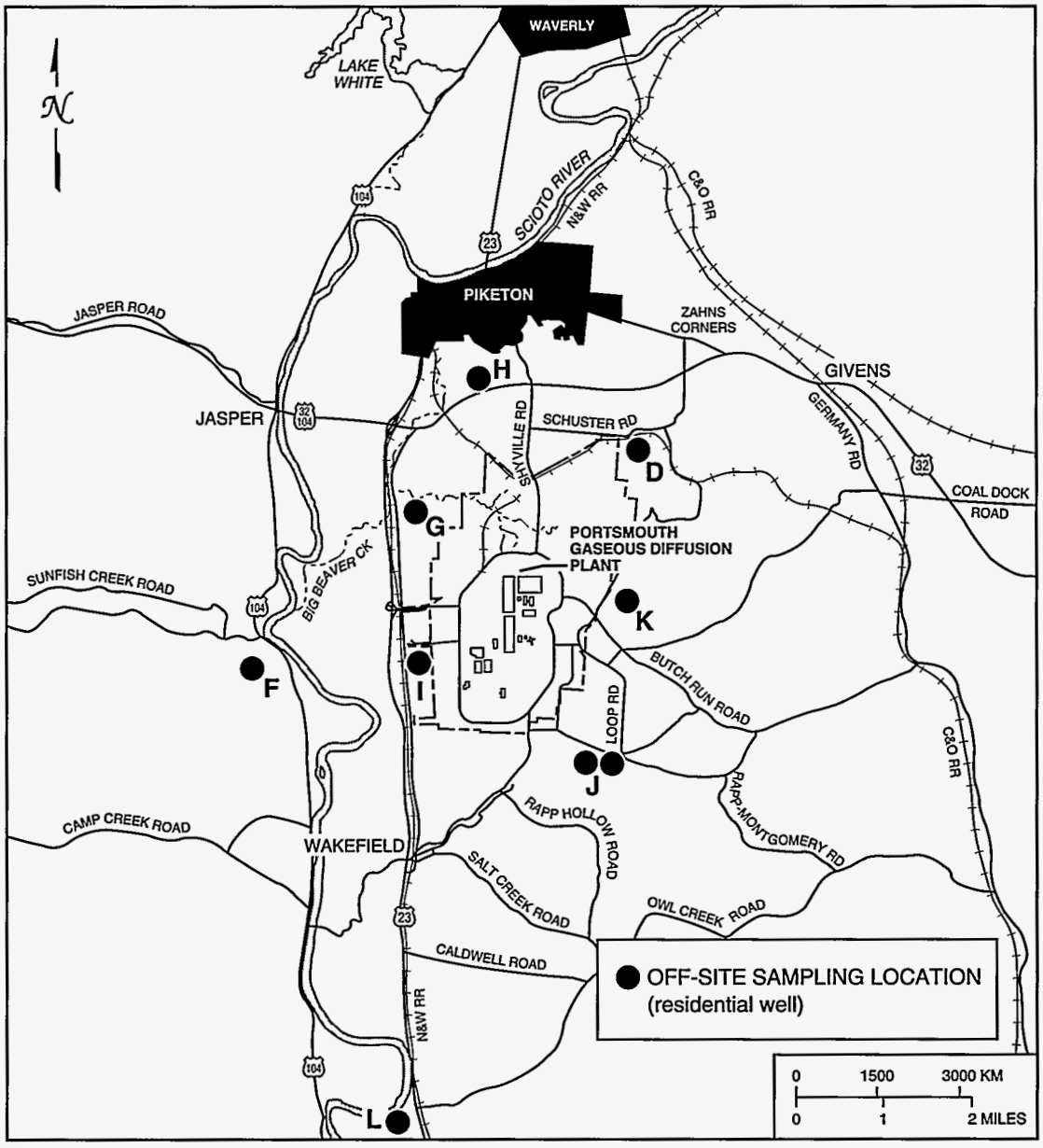


Fig. 7.15. Off-site well sampling locations near the Portsmouth site.

sampling is conducted at three of the seeps and at Big Run Creek, about 12 m (40 ft) downstream of the seeps. The primary contaminant of concern is vinyl chloride, which was first during Quadrant I RFI sampling. The most recent laboratory analyses indicate that the level of vinyl chloride in the seep samples is above the values reported in the draft of the Quadrant I final RFI report.

The vinyl chloride concentration of the seeps ranges from 20 to 104 ppb. However, the vinyl chloride concentration in the sample from Big Run Creek just downstream from the seeps is less than the detection limit of 1 ppb. After confirmation of contaminants in the seeps, sampling was conducted weekly for eight weeks and then quarterly.

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 old

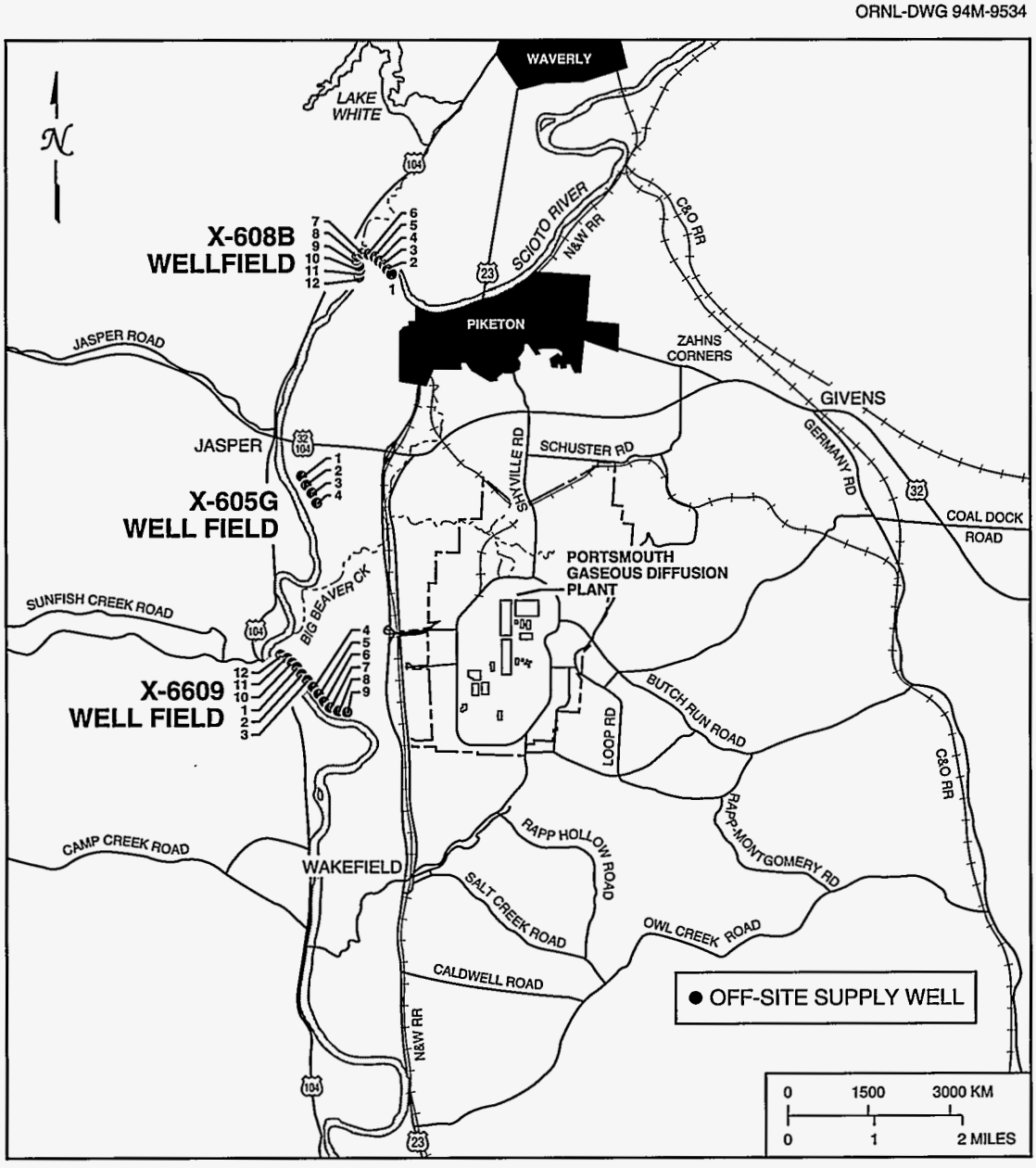


Fig. 7.16. Portsmouth site water supply well field sampling locations.

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.

X-737 Landfill Investigation

The X-737 landfill is the proposed location of a new sanitary landfill at the north end of the Portsmouth site (Fig. 7.18). The proposed landfill is approximately 16 ha (40 acres).

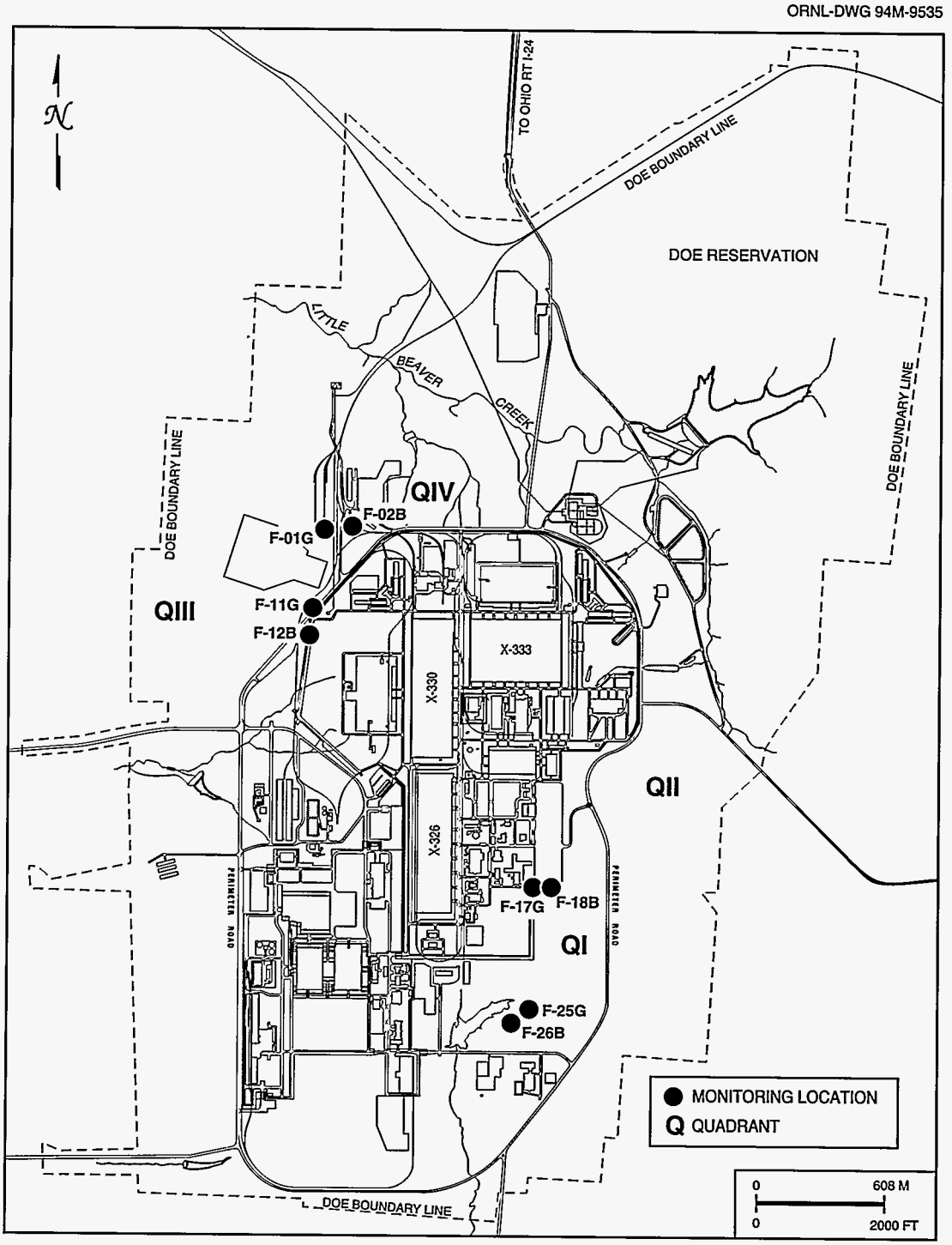


Fig. 7.17. Baseline well monitoring locations at the Portsmouth site.

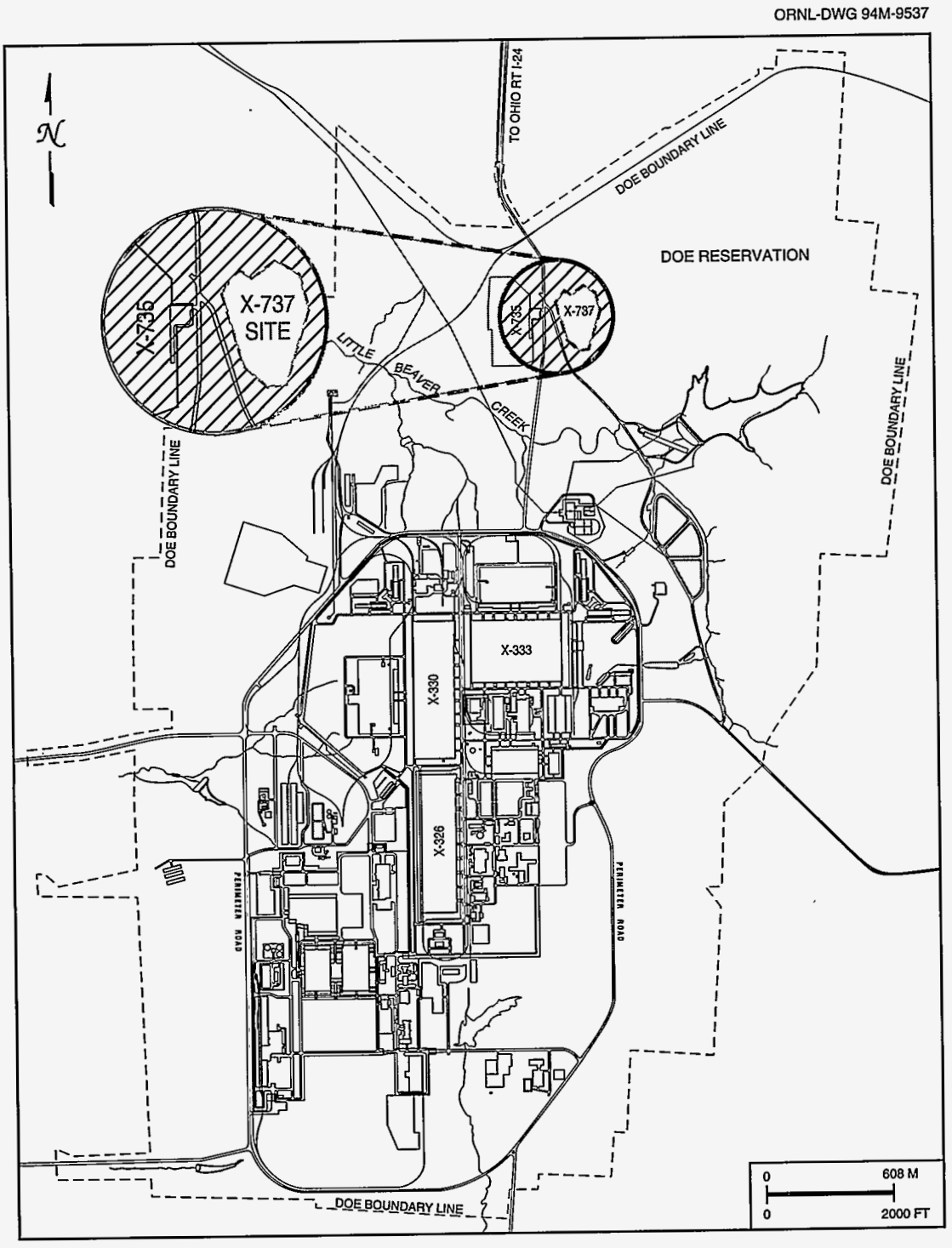


Fig. 7.18. X-737 proposed landfill.

X-737 Groundwater Investigations

A hydrogeologic site investigation was conducted in 1993. Work conducted during this investigation fulfilled requirements specified in OAC 3745-27-06(C)(2). The *X-737 Hydrogeologic Site Characterization Report* and the *Groundwater Monitoring Plan* were completed in 1994.

At this location, the combined thickness of the unconsolidated sediments composed of the Minford clay/silt and the Gallia sand is up to 13.4 m (43.8 ft). The Sunbury shale is absent, and the Berea sandstone forms the bedrock. Seven monitoring wells were installed in the unconsolidated sediments, and four monitoring wells were installed in the Berea sandstone. Eleven samples of unconsolidated sediments and four samples of the Berea sandstone were analyzed for parameters on the target compound list/target analyte list (TCL/TAL) and for radiological parameters. Geotechnical analyses were performed on three samples from the Berea sandstone. Slug tests were performed on seven of the groundwater monitoring wells: four in the unconsolidated sediments and three in bedrock. Groundwater samples were analyzed for TCL/TAL and radiological parameters.

X-737 Groundwater Flow

Groundwater flow in the unconsolidated deposits is located in the lower Teays Fm., which is composed of the Minford silt and Gallia sand. The change from the Minford silt to the Gallia sand is gradational, and the lithologic contact for the two cannot be distinguished. Therefore, for discussion of hydraulic conductivity, the Minford silt and Gallia sand are considered as one hydrologic unit. Based on slug-test results, the hydraulic conductivity values for the lower Teays Fm. range from 1.2 to 27 m/day (4 to 88 ft/day). Groundwater flow is to the west toward Little Beaver Creek and its tributary.

The Berea sandstone exhibits two hydraulic conductivities. The first is for unfractured Berea sandstone where groundwater flow is in the pore space of the formation. The unfractured rock hydraulic conductivity ranges from 0.03 to 0.7 m/day (0.09 to 2.3 ft/day). The second conductivity is where fractures are encountered and groundwater flow is in the fractures. In these cases, the Berea has the same 6.7 m/day (22 ft/day) hydraulic conductivity as the unconsolidated deposits. Groundwater flow in the Berea is to the west toward Little Beaver Creek and its tributary.

RCRA Facility Investigations for Quadrants I–IV

The Ohio Consent Decree issued by the Ohio Attorney General's Office on August 29, 1989, and the RCRA, 3008(h), Administrative Consent Order issued by USEPA Region V on September 29, 1989, outline requirements and schedules for the RFI. These documents include specific dates and specifications for deliverables that must be complied with throughout the RFI, the corrective measures study, and corrective measures implementation.

Groundwater investigative activity is based on guidelines for a RCRA corrective action plan. However, because the Portsmouth site is large, complex, and resource intensive, the plan has been 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) and associated drainages are indicated in Fig. 7.19. Parallel efforts to provide comprehensive definitions of geology and the hydrologic flow systems provide cohesiveness to this four-part approach.

Field work for each of the quadrants was divided into two phases. Phase I field activities were completed in 1991 for QI and QII, in 1992 for QIII, and in 1993 for QIV.

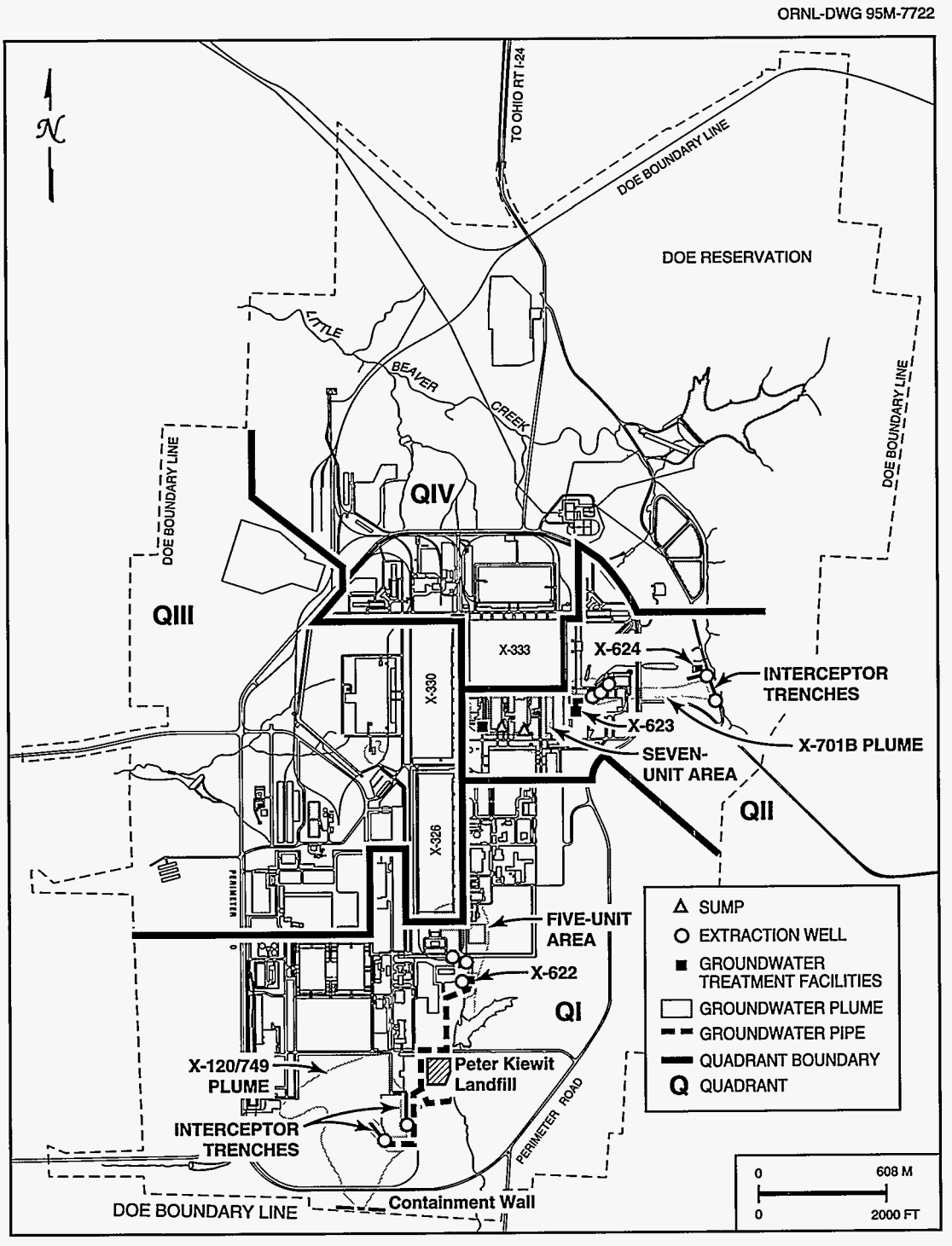


Fig. 7.19. RFI quadrants and associated drainages at the Portsmouth site.

Phase II field activities for each of the quadrants were completed in 1994. Site wide, more than 200 monitoring wells and 350 soil borings were installed as part of the RFI. Each of the newly installed wells and a select number of existing wells were sampled during the RFI. In addition, over 760 surface samples and 193 geoprobe samples were collected.

A total of 21 SWMUs were investigated in the QI RFI. As part of this investigation, 79 wells were installed. Contaminated groundwater plumes were discovered emanating from the following units: (1) the X-120 Goodyear Training Center (Fig. 7.10); (2) X-231A southeast oil biodegradation plot (Fig. 7.11); and (3) X-710 neutralization pit (Fig. 7.7), X-710 "hot pit," and X-760 neutralization pit (Fig. 7.11). The results and conclusions of the report are included in the QI RFI draft final report dated June 20, 1994.

A total of 22 SWMUs were investigated in the QII RFI. As part of this investigation, 51 wells were installed. Contaminated groundwater plumes were discovered emanating from the following units: the X-700 chemical cleaning facility (Fig. 7.7), X-705 decontamination building (Fig. 7.7), and X-720 maintenance and stores building (Fig. 7.7). The results and conclusions of the report are included in the QII RFI draft final report dated June 20, 1994.

A total of 18 SWMUs were investigated in the QIII RFI. As part of the investigation, 32 wells were installed. The results and conclusions of the report are included in the QIII draft final report dated November 4, 1994.

A total of 27 SWMUs were investigated in the QIV RFI. As part of this investigation, 57 wells were installed. The results and conclusions of the report are included in the QIV draft final report dated November 4, 1994.

X-120 Goodyear Training Center Contaminant Plume

The X-120 Goodyear Training Center consists of several utility and storage buildings used during construction of the Portsmouth facility in the 1950s. The plume associated with the X-120 Goodyear Training Center consists of TCE; 1200 ppb was the highest concentration detected. In 1989, TCE concentrations of 800 and 100 ppb were detected in two groundwater wells at this location. Initially, this contamination was presumed to be associated with the X-749 south contaminated materials storage yard; however, results from the QI RFI indicated that the contamination is independent of the X-749 facility.

During the QI RFI, TCE was detected in four wells at concentrations ranging from 18 to 1200 ppb. The long, narrow TCE contaminant plume associated with the X-120 facility originates south of Hewes Street and extends approximately 427 m (1400 ft) to the southwest (Fig. 7.10); the southeastern edge of the plume nearly converges with the plume emanating from the X-749 south contaminated materials storage yard.

X-231A Southeast Oil Degradation Area Contaminant Plume

The plume associated with the X-231A southeast oil degradation area is composed of TCE, TCA, DCE, and DCA. The highest VOC concentration is TCE at 120 ppb. All non-TCE contaminants are contained within the TCE plume. The TCE plume has a semicircular shape extending from the south side of X-231A area (Fig. 7.11).

X-710 Neutralization Pit, X-710 Hot Pit, and X-760 Neutralization Pit Contaminant Plume

The plume associated with the X-710 neutralization pit, X-710 hot pit, and the X-760 neutralization pit is composed mainly of TCE, with minor amounts of TCA and DCE. The

highest level of TCE was 1600 ppb, the highest level of DCE was 21 ppb, and the highest level of TCA was 5 ppb. 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 material burial grounds. This plume coalesces with the X-231B southeast oil biodegradation area plume shown in Fig. 7.11. The X-710 neutralization pit and the X-710 hot pit are both located just north of well X231B-36G. VOC contamination was not detected in any Berea sandstone monitoring wells in this area.

X-700 Chemical Cleaning Facility, X-705 Decontamination Building, and X-720 Neutralization Pit Contaminant Plume

The plume associated with the X-700 chemical cleaning facility, X-700 chemical and petroleum storage containment tanks, X-700 TCE/TCA outside storage tank, X-705 decontamination building, and the X-720 neutralization pit is composed primarily of TCE, with a maximum concentration of 19,000 ppb. Secondary VOC contaminants are TCA, DCE, chloroform, and methylene chloride. All VOC contaminant plumes are contained within the boundaries of the TCE plume. This plume has also been called the Quadrant II investigative area plume or the seven unit (or seven SWMU) area. The plume is contained by sumps in the X-700 and X-705 buildings, from which groundwater is pumped to the X-622T groundwater treatment facility.

Groundwater Treatment Units

In 1994, a combined total of approximately 88.9 million L (23.5 million gal) of contaminated groundwater was treated at the X-622 south groundwater treatment facility (Fig. 7.11), X-622T treatment trailer (Fig. 7.7), and the X-624 Little Beaver groundwater treatment facility (Fig. 7.9). Approximately 587 L (155 gal) of TCE was removed from the groundwater. All processed water is discharged through an NPDES outfall before exiting the Portsmouth site.

X-622 South Groundwater Treatment Facility

The groundwater treatment used at the X-622 south groundwater treatment facility is activated carbon filtration of contaminated groundwater. TCE-contaminated groundwater from the X-231B southwest oil biodegradation plot, the X-749 south contaminated materials storage yard, and the Peter Kiewit groundwater collection system are processed at this treatment unit. In 1994, the unit processed approximately 29.1 million L (7.7 million gal) of groundwater and approximately 19 L (5 gal) of TCE was removed.

X-622T Groundwater Treatment Trailer

At the X-622T treatment trailer, 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 VOC contaminant groundwater plume, and contaminated groundwater is extracted from the sumps in each building. In 1994, approximately 35.2 million L (9.3 million gal) of groundwater was processed and about 34 L (9 gal) of TCE was removed.

X-624 Little Beaver Groundwater Treatment Facility

At the X-624 Little Beaver groundwater treatment facility, groundwater is treated via an air stripper with off-gas activated carbon filtration plus carbon filtration of the effluent water. This facility processes TCE-contaminated groundwater from the X-701B holding pond. In 1994, about 24.6 million L (6.5 million gal) of groundwater was treated and about 477 L (126 gal) of TCE removed.

Background Sampling

The USEPA and the OEPA have requested that background metal concentrations be determined from a statistically significant number of samples taken in off-site geologic and hydrogeologic settings similar to those existing on site. The off-site background sampling was conducted in 1994. The Portsmouth site is investigating statistical methods for determining background concentrations for metals.

GROUNDWATER MONITORING RESULTS

The results for groundwater monitoring activities at the Portsmouth site are discussed briefly under "Groundwater Monitoring at the Portsmouth Site." However, for regularly scheduled compliance monitoring, a more detailed discussion of the results follows.

RCRA Units

The following Portsmouth RCRA units are included in assessment monitoring, post-closure monitoring, or detection monitoring programs. Historical trends of groundwater contamination are important because changes in groundwater contaminant values help indicate the direction and rate of contaminant migration. Of particular importance are wells that show significant increases or decreases in concentrations or contamination that occurs in previously clean wells. A significant increase can be defined as an annual mean concentration that is at least two standard deviations higher than the previous year's mean.

X-701C Neutralization Pit

X-701C VOC Contamination

VOC contamination in the Gallia has been detected at X-701C. The highest contaminant concentrations (TCE) are about 2000 µg/L. Other VOCs detected at X-701C are DCEs and DCA. Analytical results show that TCE is the only VOC common to all three of the wells. TCE concentrations ranged from 1740 to 2690 µg/L. The highest concentration was detected in the upgradient well X701-69G. TCE concentrations are lower in the downgradient wells and range from 40 to 400 µg/L.

X-701C Radiological Contamination

Uranium concentrations ranged from <1 to 7 µg/L. The highest total uranium concentration was at the upgradient well. The technetium activity results for monitoring well X701-68G varied from slightly above detection limits in the second and third quarters to below detection limits in the first and fourth quarters. Technetium activity was not

detected at monitoring well X701-69G. Technetium activity was detected at monitoring well X701-70G all four quarters. The highest technetium activity was 71 pCi/L at monitoring well X701-70G.

X-735 Landfill

X-735 Organic and Inorganic Analytical Results

The groundwater data indicate that groundwater in the vicinity of the X-735 landfill has not been affected by operation of the landfill. There, detection monitoring will continue at this unit.

It was anticipated that there would be no contamination of downgradient wells at the X-735 landfill. However, a statistical t-test analysis of indicator parameters was necessary to confirm this. Total organic carbon (TOC), specific conductance, and pH were the indicators selected for statistical comparison between the upgradient (background) and downgradient (compliance) wells. In addition, the volatile organic analyses did not identify any constituents entering the groundwater.

Groundwater samples for total metals (filtered) and dissolved metals (unfiltered) were also collected at X-735. The dissolved metals samples were field-filtered through a 0.45-µm filter. All arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver results for downgradient wells were below either detection limits or maximum contaminant levels (MCLs), whichever were higher (i.e., in some instances, the method detection limit for a given sample batch exceeded the MCL). The only detectable concentrations above MCLs for the preceding metals occurred in upgradient wells.

The nitrate as nitrogen concentrations for all downgradient wells were below the MCL.

X-735 Radiological Analytical Results

Gross alpha and gross beta activity levels for all downgradient wells were at or below detection limits. The total uranium concentrations of all downgradient wells were below 5 µg/L.

X-701B Holding Pond

X-701B VOC Contamination

The primary VOC contaminant at X-701B is TCE, which is limited to the Gallia sand. All other contamination is contained within the extent of the TCE plume. TCE concentrations from the X-701B monitoring network are the highest among the RCRA units at the Portsmouth site. The maximum value of TCE was observed in well X701-08G at 449,000 µg/L. This well is adjacent to and hydraulically downgradient from the X-701B unit; thus, it consistently has the highest TCE concentrations. TCE concentrations ranged from 153,000 ppb to 460,000 µg/L. Well X701-14G also has consistently high TCE concentrations. TCE concentrations in X701-14G ranged from 163,000 (first sampling event) to 430,000 µg/L. Elevated concentrations of TCE are also observed in well X701-24G, ranging from 41,900 to 92,900 mg/L. Two of the X-701B wells had a significant change in TCE concentration (i.e., a 1994 mean concentration more than two standard deviations higher or lower than the 1993 mean concentration). The annual mean TCE concentration increased at well X701-08G, which is near the center of the plume. A slight decrease of TCE concentration was shown at X701-30G. This TCE was not detected in groundwater samples from Berea monitoring wells.

Occurrences of 1,2-DCE (*cis* and *trans*) are observed at the plume margin to the east, near the interceptor trench (X701-24G), and to the west, near the X-701B unit (X701-02G and X701-06G). Wells X701-02G and X701-06G both contain 1,2-DCE (*cis* and *trans*) concentrations below the MCL, which is 70 µg/L for the cis isomer and 100 µg/L for the trans isomer. An elevated concentration (27 µg/L) of 1,2-DCE was observed at X701-24G in the third sampling event. In 1994, 1,2-DCE was observed only one time at X701B-24G.

X-701B Radiological Contamination

Radiological results were elevated in a number of the Gallia wells located in the X-701B TCE plume. Consistently high levels of technetium occurred in wells X701-08G, X701-14G, X701-21G, and X701-24G. The maximum count of technetium beta was 238 pCi/L in X701-08G. For these same wells, the total uranium concentration is typically <1 µg/L with the maximum laboratory result of 6.8 µg/L at well X701-24G. An increase in annual mean technetium activity was observed in X701-14G. Radiological results from Berea wells at X-701B showed little change from 1993.

X-749 South Contaminated Materials Storage Yard

X-749 VOC Contamination

The most extensive and most concentrated constituents at X-749 were VOCs, in particular TCE and 1,1,1-TCA. The maximum TCE and TCA concentrations were 10,600 and 5140 µg/L, respectively. Other VOCs detected above MCLs were 1,1-DCA, 1,1-DCE, 1,2-DCE, 1,2-DCA, vinyl chloride, 1,1,2-TCA, carbon tetrachloride, tetrachloroethene, and methylene chloride. All contaminants were generally lower in concentration than, and contained within the extent of, the TCE plume. VOC contamination in the Gallia wells at X-749 is composed primarily of TCE, TCA, DCE, DCA, Freon-113, chloroform, and vinyl chloride. TCE and TCA concentrations increased at wells X749-10G, X749-13G, and X749-PZ04G. TCE concentrations decreased at monitoring well X749-07G, and most VOCs decreased at X749-08G, X749-25G, and X749-26G.

The only VOCs detected in the Berea wells were DCAs (maximum concentration of 6 ppb) at well X749-50B. Limited cross-contamination from the Gallia area could have occurred during installation of the well because the well is screened beneath the Gallia VOC plume. However, the annular seal of the well was investigated and found to be intact, so additional cross-contamination should not occur. The VOC concentrations in this well are thought to be remnants of the original cross-contamination.

X-749 Radiological Contamination

Technetium-99 was detected in monitoring wells within the TCE plume; the maximum ^{99}Tc activity was 448 pCi/L at monitoring well X740-07G. Total uranium concentrations ranged from <1.0 to 13.6 µg/L. The total uranium concentrations at monitoring well X749-PZ05G were the exception; this well's maximum quarterly result was 80 µg/L. The lack of an obvious trend coupled with the well being outside of the TCE plume suggests that the total uranium results may be from background variation in natural water quality or simply artifacts caused by the turbidity of the sample. In 1994, the gross beta and technetium activities for X749-08G and X749-26G decreased. The radionuclide results for the remaining Gallia wells were relatively unchanged from 1993; likewise, results of the Berea radiochemical analyses were similar to the 1993 results.

X-231B Southwest Oil Biodegradation Plot

X-231B VOC Contamination

The primary VOC contaminant at X-231B is TCE; minor VOC constituents include TCA and DCE. The maximum TCE concentration was 2640 µg/L at monitoring well X231B-2G. The maximum concentration for TCA and 1,1-DCE were 520 and 279 µg/L, respectively. All contaminants are contained within the extent of the TCE plume. VOC concentrations did not increase significantly in any Gallia wells. However, TCE concentrations increased slightly in well X231B-02G and decreased slightly in wells X231B-04G and X231B-06G. The Berea wells at X-231B are not affected by VOC contamination.

X-231B Radiological Contamination

The highest uranium concentrations occurred at wells X231B-04G and X231B-06G, ranging from 2.7 to 18.6 ppb. The highest total concentration in each well occurred in different quarters. The remaining total uranium concentrations were below 5 µg/L.

The maximum technetium levels are from well X231B-06G. Two of the quarterly measurements exceeded 900 pCi/L. The remaining technetium activity measurements, for the other wells sampled, were near or below 22 pCi/L. No trends in technetium activity were observed. Results for radiological analyses were elevated in Gallia plume wells X231B-04G and X231B-06G. However, the 1994 values were generally lower than 1993 values. Radiological results from Berea wells showed little change from 1993.

X-616 Liquid Effluent Control Facility

X-616 VOC Contamination

VOC contamination was detected in both the Gallia sand and the Berea sandstone at three neighboring wells (X616-09G, X616-16G, and X616-20B). Results from the second and third sampling event showed a TCE concentration of 5 ppb at X616-16G. X616-20B contained TCE concentrations from 15 to 21 ppb. The small area of contamination appears to be centered near the southwest corner of the X-616 surface impoundment. The source of the VOCs may be the nonoperational X-615 sewage treatment unit or an associated adjacent sewage line. The source of the contamination is being investigated. Low levels of VOCs were also detected in an upgradient well (X616-28B) screened in the Berea sandstone.

X-616 Metals Contamination

Chromium was the primary contaminant of concern at X-616, versus VOCs for the other RCRA units in assessment monitoring. Both dissolved chromium (filtered) and total chromium (unfiltered) samples are collected at X-616. Monitoring well X616-05G is the only well with total chromium concentrations that consistently exceeded the MCL of 100 ppb through three sampling events. Third sampling event results from well X616-10G showed total chromium above 100 ppb. Monitoring wells X616-05G and X616-25G showed total nickel concentrations exceeding 100 ppb through three sampling events. Both dissolved and total chromium concentrations remain elevated at well X616-05G. However, groundwater chromium concentrations have decreased significantly for the remainder of the wells since X-616 closure activities were completed in 1991.

X-616 Radiological Contamination

Total uranium concentrations ranged from <1.0 to 5.0 µg/L. Technetium-99 was below detectable levels except for one sampling result at monitoring well X616-21G. The technetium activity for the first sampling event was 94 pCi/L; however, the result from the subsequent sampling event was below detectable levels.

Surface Water

Surface water monitoring for Little Beaver Creek, the east drainage ditch, north holding pond, Big Run Creek, unnamed southwest drainage ditch, and the western drainage ditch is conducted as part of assessment monitoring at X-701B, X-749, X-231B, and X-616. The results discussed in this section pertain only to surface water monitoring conducted in support of the Portsmouth site groundwater protection program.

Surface Water VOC Contamination

The concentration of VOCs (primarily TCE) in the east drainage ditch and Little Beaver Creek near the X-701B contaminant plume has decreased since the intercept trench (X-237) for the plume was installed in October 1991. TCE was detected in Little Beaver Creek during the second quarter of 1994; however, this was likely the result of residual TCE being flushed from the soil by a seasonal increase in groundwater flow. TCE was not detected in either the east drainage ditch or Little Beaver Creek in the third and fourth quarters of 1994. At an unnamed southwest drainage ditch sampling site, UND-SW01, TCE was detected at low concentrations, less than the MCL of 5 µg/L, in the second, third, and fourth quarters of 1994. TCE was not detected in Big Run Creek, the north holding pond, or the west drainage ditch in 1994.

Surface Water Radiological Contamination

Radiological results for 1994 were generally low for all surface water locations. Technetium was detected in the east drainage ditch during the first quarter of 1994. However, there were no detectable technetium levels in any of the other surface water locations. None of the surface water monitoring sites showed statistically significant changes for radiological results in 1994.

8. Quality Assurance

Abstract

Quality assurance is an integral part of environmental surveillance at the Portsmouth site. Quality control (QC) is part of sampling and monitoring in the field as well as analytical work performed in the Portsmouth site laboratory. The Portsmouth site laboratory has its own internal QC program and participates in external QC programs administered by the U.S. Environmental Protection Agency, DOE, and commercial laboratories. Of the 2192 external QC measurements made by the Portsmouth site laboratory in 1994, 97.7% of the results were acceptable.

INTRODUCTION

Quality assurance (QA), 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 achieve the desired level of competence, the Portsmouth site uses the following major types of planned and systematic controls:

- implementation of standard operating procedures for sample collection and analysis,
- surveyor and analyst training and qualification,
- implementation of sample tracking and chain-of-custody procedures to ensure traceability and integrity of samples and data,
- participation in external quality control (QC) programs,
- frequent calibration and routine maintenance of measuring and test equipment,
- maintenance of internal QC programs,
- implementation of good measurement techniques and good laboratory practices, and
- frequent assessment of field sampling and measurement activities.

Environmental sampling at the Portsmouth site is conducted by members of the Utility Services Environmental Control Department. 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 Utility Services Portsmouth laboratory.

An administratively independent QA manager has general oversight responsibility for all phases of laboratory QA in the Portsmouth site analytical laboratory. The QA manager is also responsible for the activities of the Laboratory Controls and Standards Group, operation of the laboratory's central sample-receiving chain-of-custody facility, and administration of external and internal control programs. The Laboratory Controls and Standards Group generates internal QC samples using materials from the National Institute of Standards and Technology (NIST) or other reliable source materials. The samples are then submitted to the laboratories at an established frequency. Two laboratory statisticians provide support to the laboratory's QA efforts by performing statistical evaluations and administering the control chart program. Good measurement practices used by laboratory personnel include use of matrix spikes, matrix spike duplicates, replicate samples, check

samples, and various other internal controls. The extensive internal QC program helps ensure reliability of the analytical data on a day-to-day basis.

Environmental Control Department personnel track and interpret analytical results. Responsibility for interpreting and tracking environmental data is divided because of the large amount of surveillance information generated. Data are reviewed when made available to ascertain compliance with applicable regulations. In some instances, remedial action may be warranted. The data are reviewed periodically for overall interpretation and, where relevant, for their interprogram relationships. Documentation of these efforts serves as a resource for future activity.

FIELD SAMPLING AND MONITORING

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

Basic Concepts and Practices

Because data generated from field sampling can be greatly influenced by the methods used to collect and transport the samples, it is imperative that a QA 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 Portsmouth site QA program mandates compliance with written sampling procedures, using clean sampling devices and containers, employing approved sample-preservation techniques, and submitting field 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.

External Gamma Monitoring

Measurements of external gamma levels on and around the Portsmouth site are collected according to a written procedure based on American National Standards Institute guidelines (ANSI 1975). Thermoluminescent dosimeters are installed, collected, and evaluated by department personnel.

Air Monitoring

As part of the Portsmouth site air monitoring network, a Teflon particulate filter is used to collect radionuclides and a pretreated filter-paper fluoride collector is placed behind it to collect fluorides. Materials that will not react with fluorides are used in the sampling train. This ensures that all gaseous fluorides drawn into the sample train reach the collector. The flow calibration of the devices that measure total air drawn through the sample trains during the sampling period is checked semiannually to ensure that results accurately reflect airborne concentrations. Written procedures are in place to guide personnel when collecting

and analyzing the samples. These procedures provide instruction for monitoring the calibration of the air-metering device.

Surface Water Monitoring

Liquid effluent streams from the Portsmouth site are sampled and analyzed in compliance with the NPDES discharge permit. Written procedures are used as guides for both sampling and analysis of effluent streams. Flow and pH are measured and recorded at several discharge points.

Groundwater Monitoring

The Portsmouth site groundwater monitoring program requires the use of individually dedicated pumps and delivery lines to purge and pump wells. Dedicated equipment reduces the risk of cross-contamination of wells and samples. Written procedures are followed when collecting and analyzing samples. Field blanks and duplicate samples are also submitted to the laboratory to ensure that sampling techniques are not influencing the data being collected.

ANALYTICAL QUALITY ASSURANCE

The Portsmouth site analytical laboratory continues a long tradition of QA and has a well-established QA program. Integral to this program are a highly trained, well-qualified staff; use of approved written procedures and current analytical methodology; availability of excellent equipment and facilities; well-established in-house surveillance, noncompliance reporting, and corrective action programs; and routine use of accepted laboratory practices and measurement techniques. As part of the QA effort, the analytical laboratory maintains comprehensive internal QC programs, participates in a number of external QC programs, and extensively uses statistical interpretation to evaluate its performance.

The laboratory QA program is based on the QA/QC requirements mandated by the OEPA, the USEPA, and DOE. Analyses are performed using USEPA-approved methods. Other reliable methods are used when USEPA methods are not available.

During 1994, the Portsmouth site laboratory was reaccredited as an American Industrial Hygiene Association Industrial Hygiene Laboratory. In addition, the lab has maintained accreditation from NIST for bulk asbestos fiber analysis under the National Voluntary Laboratory Accreditation Program.

Internal Quality Control

Internal QC programs at the Portsmouth site are the basis for ensuring reliable analytical results on a day-to-day and batch-to-batch basis. In accordance with USEPA expectations, the total QC effort in these programs averages from 10 to 20% of the total laboratory effort. The QC programs also frequently serve as the basis for on-the-job training and qualification of laboratory analysts performing environmental analyses. Internal QC programs, which include both known and blind controls, are routinely administered by the Laboratory Controls and Standards Group independently of the analytical laboratories. Statistical evaluation of the QC programs is performed by the laboratory statistician.

All analytical activities are supported by the routine use of either standard or reference materials from NIST, the USEPA, other DOE laboratories, or reliable commercial sources. QC is accomplished through the use of such standards or reference materials for instrument calibrations; preparation of known, blind, and double-blind controls; yield/efficiency determinations; and spike recoveries. Numerous process control charts maintained by the laboratory assist in assessing the adequacy of analytical programs and procedures. If serious deviations are noted, noncompliance reports are initiated, investigations are conducted, and corrective actions are implemented. QC data can be retrieved when necessary to support the analytical results.

External Quality Control

In addition to the internal QC programs, the Portsmouth site regularly participates in external QC programs. These programs, which are administered by the USEPA, the National Institute of Occupational Safety and Health (NIOSH), DOE, NIST, and commercial laboratories, generate data that serve as a periodic indicator of performance. Results are usually characterized as being acceptable, marginal, or unacceptable. For purposes of the summary that follows, marginal results are included in the acceptable category. Unacceptable results in external control programs are investigated through either the surveillance program or the nonconformance reporting program, and corrective actions are implemented as warranted. A summary of the Portsmouth site analytical laboratory's performance in external QC programs from 1990 through 1994 is shown in Table 8.1.

Radiological Quality Control

In 1994, the Portsmouth site analytical laboratory participated in two external radiological QC programs: the USEPA Intercomparison Radionuclide Control Program, administered by the USEPA Environmental Monitoring Systems Laboratory at Las Vegas (EMSL-LV) and the DOE Environmental Measurements Laboratory (EML) Radionuclide Quality Assessment Program. In conjunction with the EMSL-LV, 16 analyses were performed on 4 parameters (alpha and beta activity, total uranium, and plutonium-239) in an aqueous matrix. Results in the acceptable range amounted to 85%. Various matrix samples such as water, air filters, soil, tissue, and vegetation are analyzed semiannually for a variety of radioactive isotopes as part of the EML program. In 1994, the Portsmouth site performed a total of 69 analyses in the two rounds of this program (EML 561 and EML 565). The percentage of results in the acceptable range was 96%.

Nonradiological Quality Control

The Portsmouth site laboratory participated in several nonradiological QC programs in 1994, including the Proficiency Environmental Testing Program, the USEPA Discharge Monitoring Report Quality Assurance Study (DMR-QA), the USEPA Water Pollution Performance Evaluation Study (WP), the NIOSH Proficiency Analytical Testing Program, and the NIOSH Environmental Lead Proficiency Analytical Testing Program.

The Proficiency Environmental Testing Program is a commercial control program for environmental analysis sponsored by Analytical Products Group, Inc. (APG), of Belpre, Ohio. Samples at two concentration levels representing a wide variety of environmental parameters are distributed monthly to laboratories nationwide. Results are statistically evaluated by APG and are issued to participating laboratories. The report includes two evaluations as a measure of performance for each analysis: percent recovery of the

Table 8.1. Performance summary of the Portsmouth site analytical laboratory external quality control programs, 1990–1994

Program	Year	Number of measurements		
		Total	Acceptable/marginal (%)	Unacceptable (%)
PET[a]	1990	1139	1127 (99)	12 (1)
	1991	1271	1243 (98)	28 (2)
	1992	1583	1564 (99)	19 (1)
	1993	1772	1752 (99)	20 (1)
	1994	1659	1631 (98)	28 (2)
EMSL-LV[b]	1990	6	6 (100)	0 (0)
	1991	19	17 (90)	2 (10)
	1992	19	18 (95)	1 (5)
	1993	16	12 (75)	4 (25)
	1994	16	14 (88)	2 (12)
EML[c]	1990	9	9 (100)	0 (0)
	1991	42	41 (98)	1 (2)
	1992	41	41 (100)	0 (0)
	1993	60	60 (100)	0 (0)
	1994	69	66 (96)	3 (4)
DMR-QA[d]	1990	18	16 (89)	2 (11)
	1991	20	19 (95)	1 (5)
	1992	19	17 (89)	2 (11)
	1993	16	15 (94)	1 (6)
	1994	17	17 (100)	0 (0)
PAT[e]	1990	128	125 (98)	3 (2)
	1991	128	120 (94)	8 (6)
	1992	128	126 (98)	2 (2)
	1993	128	128 (100)	0 (0)
	1994	128	128 (100)	0 (0)
WP[f]	1992	97	82 (85)	15 (15)[g]
	1993	227[h]	215 (95)	12 (5)
	1994	243	228 (88)	15 (12)
ELPAT[i]	1993	48	48 (100)	0 (0)
	1994	48	48 (100)	0 (0)
Total	1990	1300	1283 (99)	17 (1)
	1991	1480	1440 (97)	40 (3)
	1992	1887	1848 (98)	39 (2)
	1993	2267	2230 (98)	37 (2)
	1994	2180	2130 (98)	50 (2)

[a]Proficiency Environmental Testing Program (Analytical Products Group, Inc.).
[b]Environmental Monitoring Systems Laboratory at Las Vegas (USEPA).
[c]Environmental Measurements Laboratory (DOE).
[d]Discharge Monitoring Report Quality Assurance Study (USEPA).
[e]Proficiency Analytical Testing Program (NIOSH).
[f]Water Pollution Performance Evaluation Study (USEPA).
[g]Eleven of the fifteen outliers occurred because of the cross-mixing of control solution vials for WP minerals prior to analysis.
[h]Excludes three "unusual results" not included in either acceptable or unacceptable categories.
[i]Environmental Lead Proficiency Analytical Testing Program (USEPA, NIOSH, American Industrial Hygiene Association).

reference value (which is based on APG's reference value for the analyte) and deviation from the mean result of all reporting laboratories in the program (which provides a performance comparison with all participants). During 1994, 1659 analyses representing 76 analytes were performed; of the total results, 98% were deemed acceptable.

The USEPA conducts DMR-QA, a national QA program, in support of the NPDES program. All holders of major NPDES permits are required to participate. The USEPA furnishes QC samples and evaluates the results. During 1994, 100% of laboratory results for 17 analytes were deemed acceptable. In addition, results for two parameters (pH and residual chlorine) analyzed by the sample group were also acceptable.

The USEPA WP Study includes a wide variety of organic, inorganic, and miscellaneous test parameters applicable to water pollution analyses. The test materials are prepared and distributed from the EMSL in Cincinnati. Results are evaluated by the participating laboratory's USEPA regional office. In rounds WP032 and WP033, the Portsmouth site submitted 243 usable results, 94% of which were acceptable.

Laboratories nationwide participate in the NIOSH Proficiency Analytical Testing Program. Although its primary purpose is to support safety and health programs, this program includes a number of analyses that represent environmental concerns. In each round, four analyses were performed for each of eight parameters (i.e., three metals, silica, asbestos, and three organic solvents). The Portsmouth site laboratory achieved 98% acceptable results for the 128 results submitted during 1994.

The Environmental Lead Proficiency Analytical Testing Program, established in 1992, is a cooperative effort among NIOSH, the USEPA, and the American Industrial Hygiene Association to improve and evaluate the performance of laboratories involved in the analysis of lead in paint, dust, and soil matrices. During 1994, the Portsmouth site laboratory participated in all four rounds (006–009) of this program. Acceptability for the 48 results submitted was 100%.

Performance Summary

During 1994, the Portsmouth site laboratory performed 2180 external control measurements, 97.7% of which were acceptable.

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 the Portsmouth site, not as a comprehensive discussion of radiation and its effects on the environment and biological systems. The McGraw-Hill dictionary defines radiation and radioactivity as follows.

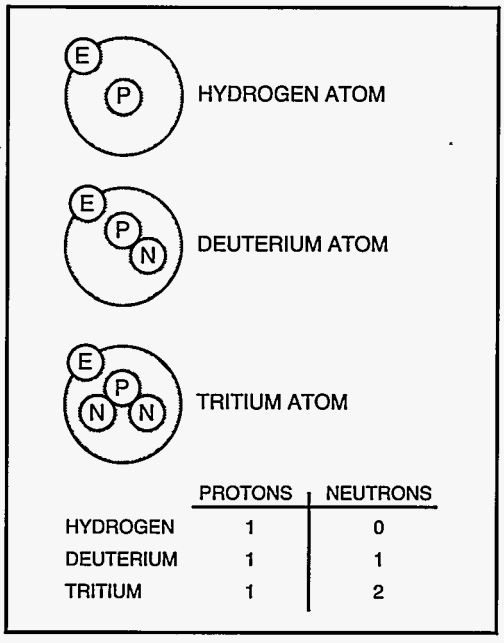
radiation—1. The emission and propagation of waves transmitting energy through space or through some medium; for example, the emission and propagation of electromagnetic, sound, or elastic waves. 2. The energy transmitted through space or some medium; when unqualified, usually refers to electromagnetic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



	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1
TRITIUM	1	2

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

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.

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.

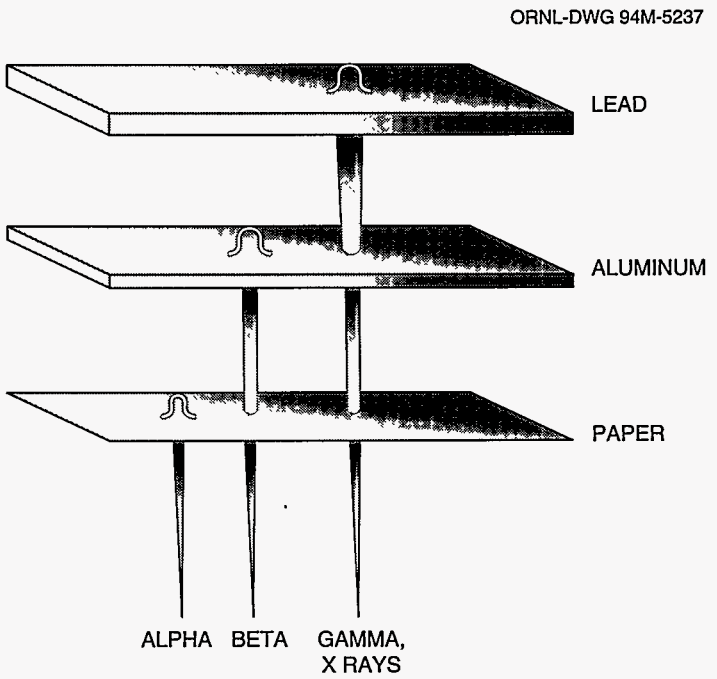


Fig. A.2. Penetrating power of radiation. Some types of radiation can be easily shielded against. For example, a sheet of paper is sufficient to stop an alpha particle. Gamma rays can pass through paper but can be stopped by the appropriate amount of lead. Radiation's ability to penetrate is an important consideration in protecting human health. Adequate shielding decreases the power of radiation by absorbing part or all of it.

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. In other words, 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.) 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 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 show up 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).

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.

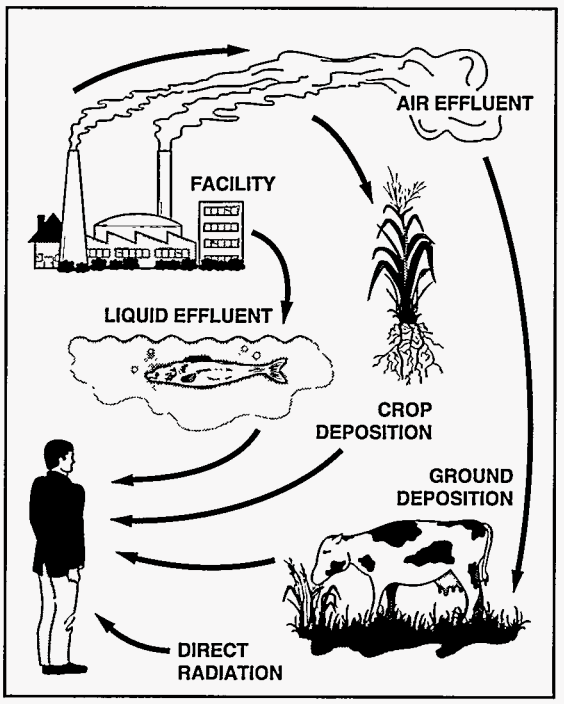


Fig. A.3. Possible radiation pathways.

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).

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 (EDE) and the EDE 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.

Dose Terminology	
absorbed dose	quantity of radiation energy absorbed by an organ divided by an organ's mass
dose equivalent	absorbed dose to an organ multiplied by a quality factor
effective dose equivalent	single weighted sum of combined dose equivalents received by all organs
committed dose equivalent	effective dose equivalent to an organ over a 50-year period following intake
committed effective dose equivalent	total effective dose equivalent to all organs in the human body over a 50-year period following intake
collective effective dose equivalent	sum of effective dose equivalents of all members of a given population
quality factor	modifying factor used to adjust for the effect of the type of radiation, for example, alpha particles or gamma rays, on tissue
weighting factor	tissue-specific modifying factor representing the fraction of the total health risk from uniform, whole-body exposure

Comparison of Dose Levels

A scale of dose levels is presented in Table A.1. 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) (NCRP 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 (NCRP 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) (NCRP 1987).

Table A.1. 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 U.S. Department of Energy 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 U.S. Nuclear Regulatory Commission and the U.S. Department of Energy
10 rem (0.10 Sv)	The BEIR 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% (BEIR 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.

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 (NCRP 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) (NCRP 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 EDE, which relates exposure of organs or body parts to one effective whole-body dose. The average annual EDE 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 (NCRP 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 (NCRP 1989).

How are Workers and the Public Being Protected?

Each process operations building at the Portsmouth site is equipped with alarms that automatically warn employees of significant increases in radiation levels. Dosimeters, or radiation-sensitive personnel badges, are worn by all employees and visitors entering any plant-site limited area. Protective clothing and respiratory equipment are worn during work assignments involving an increased risk of contacting radioactive materials, and workers are monitored for contamination when leaving restricted areas. Employees undergo extensive training so that they understand operating procedures and all emergency and safety requirements.

A public warning system has also been in place at the site since 1988. In the unlikely event of a significant environmental release with the potential to go off site, the public warning sirens would be activated to notify all residents within a 2-mile radius of the plant. Local emergency preparedness agencies and area media would also be notified simultaneously.

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 (NCRP 1987).

A comprehensive U.S. Environmental Protection Agency (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. Portsmouth site environmental permits as of March 30, 1995

Permitted unit	Issue date	Expiration date
	Air permits[a]	
X-700 solvent-contaminated water treatment system[b]	July 3, 1992	July 2, 1995
X-735 refuse/asbestos handling	February 9, 1993	February 8, 1996
X-735 roads/parking area landfill	February 9, 1993	February 8, 1996
	Wastewater permits	
National Pollutant Discharge Elimination System	September 23, 1991	July 29, 1994[c]
	Hazardous waste permits	
Applications for Resource Conservation and Recovery Act Part A and Part B permits were submitted May 13, 1992, and June 5, 1992.		

[a]Applications for 16 air emission source permits are pending with the Ohio Environmental Protection Agency (OEPA).

[b]This source is not in use, and a project has been initiated to remove it. The permit will not be renewed.

[c]This permit has expired but until the renewal application is approved, the Portsmouth facility is operating under the expired permit with OEPA approval.

Appendix C: Chemical Release Data

Table C.1. Portsmouth site DOE toxic chemical release inventory for 1994

Chemical	Type of release	Release quantity[a] (lb)	Release sources	Basis of estimate
Zinc	Water: West drainage ditch	47	Water treatment	Monitoring data
	Southwest drainage ditch	170	Water treatment	Monitoring data
	Little Beaver Creek	3	Water treatment	Mass balance
	GCEP pond surface impoundment	21	Water treatment	Mass balance
Hydrogen fluoride	Air: stack	1600	Decontamination activities	Mass balance

[a]Data quantities rounded to two significant figures.

Appendix D: Radionuclide and Chemical Nomenclature

Nomenclature and half-life for radionuclides

Radionuclide	Symbol	Half-life	Radionuclide	Symbol	Half-life
Bismuth-210	^{210}Bi	5.01 days	Radium-226	^{226}Ra	1,602 years
Bismuth-214	^{214}Bi	19.7 minutes	Radon-222	^{222}Rn	3.821 days
Lead-206	^{206}Pb	Stable	Technetium-99	^{99}Tc	212,000 years
Lead-210	^{210}Pb	21 years	Thorium-230	^{230}Th	80,000 years
Lead-214	^{214}Pb	26.8 minutes	Thorium-231	^{231}Th	25.5 hours
Polonium-210	^{210}Po	138.9 days	Thorium-234	^{234}Th	24.1 days
Polonium-214	^{214}Po	164 microseconds	Uranium-234	^{234}U	247,000 years
Polonium-218	^{218}Po	3.05 minutes	Uranium-235	^{235}U	710,000,000 years
Potassium-40	^{40}K	1,260,000,000 years	Uranium-236	^{236}U	23,900,000 years
Protactinium-234*m*	^{234m}Pa	1.17 minutes	Uranium-238	^{238}U	4,510,000,000 years

Nomenclature for elements and chemical constituents

Constituent	Symbol	Constituent	Symbol
Aluminum	Al	Manganese	Mn
Ammonia	NH_3	Mercury	Hg
Antimony	Sb	Nickel	Ni
Arsenic	As	Nitrogen	N
Barium	Ba	Nitrate	NO_3
Beryllium	Be	Nitrite	NO_2
Cadmium	Cd	Oxygen	O
Calcium	Ca	Ozone	O_3
Calcium carbonate	$CaCO_3$	Phosphorus	P
Carbon	C	Phosphate	PO_4
Chlorine	Cl	Potassium	K
Chromium	Cr	Radium	Ra
Chromium, hexavalent	Cr^{6+}	Radon	Rn
Cobalt	Co	Selenium	Se
Copper	Cu	Silver	Ag
Fluorine	F	Sodium	Na
Hydrogen fluoride	HF	Sulfate	SO_4
Iron	Fe	Sulfur dioxide	SO_2
Lead	Pb	Thorium	Th
Lithium	Li	Uranium	U
Magnesium	Mg	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 is 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).

alpha particle—A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

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.

aquitard—A geologic unit that inhibits the flow of water.

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.

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

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

CERCLA-reportable release—A release to the environment that exceeds reportable quantities as defined by CERCLA (Comprehensive Environmental Response, Compensation, and Liability 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.

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.

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.

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

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

daughter—A nuclide formed by the radioactive decay of a parent nuclide.

DCG—See derived concentration guide.

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—See Environmental Restoration.

dense nonaqueous phase liquid (DNAPL)—The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethylene and trichloroethylene.

derived concentration guide (DCG)—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.

DNAPL—See dense nonaqueous phase liquid.

dose—The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

absorbed dose—The quantity of radiation energy absorbed by an organ divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).
dose equivalent—The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 Sv).
committed dose equivalent—The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).
committed effective dose equivalent—The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).
effective dose equivalent—The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.
collective dose equivalent/collective effective dose equivalent—The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

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

DWS—See drinking water standards.

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—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—The coliform group comprises all of the aerobic, non-spore-forming, rod-shaped bacteria. The test determines the presence or absence of coliform organisms.

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.

gamma ray—High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited 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 (GM) 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.

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).

groundwater, unconfined—Groundwater exposed to the unsaturated zone.

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.

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

hydrogeology—Hydraulic aspects of site geology.

in situ—In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

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.

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).

LLD—See lower limit of detection.

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

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.

milliroentgen (mR)—A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

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 (such as radon) sources in the environment.

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

outcrop—A place where groundwater is discharged to the surface. Springs, swamps, and beds of streams and rivers are the outcrops of the water table.

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

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 6, neutral solutions have a pH equal to 7, and basic solutions have a pH > 7.

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

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.

QA—See quality assurance.

QC—See quality control.

quality assurance (QA)—Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC)—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.

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.

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 × the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation—The correction of a problem. See Environmental Restoration.

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

RFI Program—RCRA Facility Investigation Program; U.S. Environmental Protection Agency–regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

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

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

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

Solid waste disposal facility (SWDF)—A place for burying unwanted radioactive material to prevent escape of radioactivity. The surrounding water acts as a shield. Such material is placed in watertight, noncorrodible containers so that it cannot leach out and invade underground water.

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

specific conductance—The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

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.

substrate—The substance, base, surface, or medium in which an organism lives and grows.

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

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

Sv—See sievert.

SWDF—See solid waste disposal facility.

terrestrial radiation—Ionizing radiation emitted from radioactive materials, primarily ^{40}K, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

thermoluminescent dosimeter (TLD)—A device used to measure external gamma radiation.

TLD—See thermoluminescent dosimeter.

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 irrespective of the nature, source, or size of the particulates.

t-test—Statistical method used to determine if the means of groups of observations are equal.

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—1,1,1-TCA, perclene, and triclene are common names for trichloroethane, tetrachloroethylene, and trichloroethylene, respectively. Used in many processes, the levels of these carcinogenic compounds must be kept to a minimum. They are measured by volatile organic analyses content.

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.

wind rose—A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

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Conversions

Multiply	by	to obtain
in.	2.54	cm
ft	0.305	m
mi	1.61	km
lb	0.4536	kg
liq qt (U.S.)	0.946	L
ft^2	0.093	m^2
mi^2	2.59	km^2
ft^3	0.028	m^3
dpm	0.450	pCi
pCi	10^{-6}	Ci
pCi/L (water)	10^{-9}	Ci/mL (water)
pCi/m^3 (air)	10^{-12}	Ci/mL (air)
cm	0.394	in.
m	3.28	ft
km	0.621	mi
kg	2.205	lb
L	1.057	liq qt (U.S.)
m^2	10.764	ft^2
km^2	0.386	mi^2
m^3	35.31	ft^3
pCi	2.22	dpm
µCi	10^6	pCi
µCi/mL (water)	10^9	pCi/L (water)
µCi/mL (air)	10^{12}	pCi/m^3 (air)
ha	2.47	acre