3 AFFECTED ENVIRONMENT

Depleted UF_6 is currently managed at three locations: the Paducah site near Paducah, Kentucky; the Portsmouth site near Portsmouth, Ohio; and the K-25 site on the Oak Ridge Reservation near Oak Ridge, Tennessee. In the context of this PEIS, a distinction is made between "site" (the entire DOE facility), a gaseous diffusion plant (a USEC-operated facility within the larger site), and the storage yards (the location of the depleted UF_6 cylinders within the site). This section describes the affected environment at these sites, as well as the environmental settings assumed for the long-term storage, conversion, and disposal options.

3.1 PADUCAH SITE

The Paducah site is located in rural McCracken County, Kentucky, approximately 10 miles (16 km) west of the city of Paducah and 3.6 miles (6 km) south of the Ohio River (Figure 3.1). The Paducah site includes 3,423 acres (1,386 ha) surrounded by an additional 2,781 acres (1,125 ha) owned by DOE but managed by the State of Kentucky as part of the West Kentucky Wildlife Management Area (Martin Marietta Energy Systems [MMES] 1994b). According to a 1953 agreement granting the land to the Kentucky Department of Fish and Wildlife Resources, DOE can use any or all of this land whenever the need arises (MMES 1990). The city of Paducah is the largest urban area in the six counties surrounding the site. The six-county area is primarily rural, with industrial uses accounting for less than 5% of land use.

The Paducah Gaseous Diffusion Plant (PGDP) occupies a 750-acre (303-ha) complex within the Paducah site and is surrounded by a security fence (Figure 3.1). The PGDP, previously operated by DOE and now operated by the USEC, includes 115 buildings with a combined floor space of approximately 8.2 million ft^2 (0.76 million m^2) (MMES 1990). The PGDP has operated since 1955.

In 1994, the Paducah site was placed on the EPA National Priorities List (NPL), a list of sites across the nation that have been designated by EPA as high priority for site remediation. The NPL designation was mainly due to groundwater contamination with trichloroethylene and technetium-99, first detected in 1988. Being placed on the NPL meant that the cleanup requirements of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) would be met in conducting remediation efforts at the Paducah site. Hazardous waste and mixed waste management at the Paducah site must comply with *Resource Conservation and Recovery Act* (RCRA) regulations, which are administered by the Commonwealth of Kentucky, Division of Waste Management. The RCRA regulations also address implementation of corrective (or remedial) actions for solid waste management units. Thus, both CERCLA and RCRA have requirements for remedial actions for contaminated environmental media. A Federal Facilities Agreement (FFA) has been developed to integrate CERCLA/RCRA requirements into a single remediation procedure for the

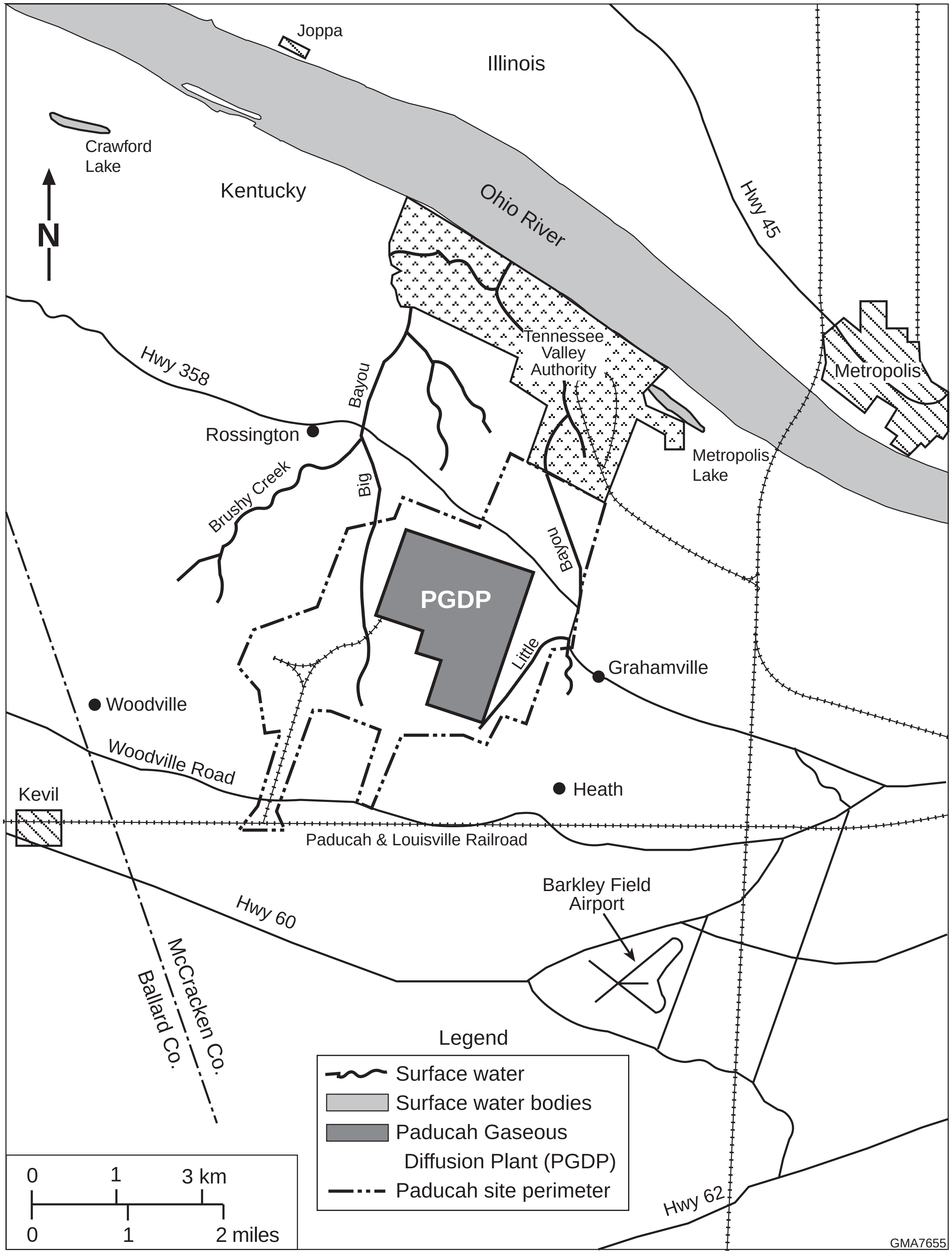

FIGURE 3.1 Regional Map of the Paducah Site Vicinity (Source: Adapted from LMES 1996a)

Paducah site. The discussion of affected environment in this PEIS focuses on conditions and contaminants pertinent to depleted UF_6 cylinder management. Some sitewide information from ongoing CERCLA/RCRA investigations is also included to put environmental conditions in the current depleted UF_6 cylinder storage areas into the context of sitewide conditions.

3.1.1 Cylinder Yards

The Paducah site has 13 yards used to store cylinders of DOE-generated depleted UF_6 (Table 3.1; Figure 3.2). The yards encompass approximately 13 acres (5.3 ha) and store 28,351 cylinders containing depleted UF_6. Nine of the Paducah storage yards have gravel bases. The C-745-F yard (F-yard) is located on a former building foundation. The C-745-S yard (S-yard), C-745-G yard (G-yard), and C-745-T yard (T-yard) are newly constructed with concrete bases.

TABLE 3.1 Locations of Cylinders of DOE-Generated Depleted UF_6 at the Paducah Site[a]

Yard	Area (ft^2)	Number of Cylinders
C-745-A[b]	199,899	1,802
C-745-B[b]	471,630	1,185
C-745-C	439,902	227
C-745-D	47,628	401
C-745-F	156,000	4,090
C-745-G	405,000	5,733
C-745-K	180,000	4,023
C-745-L	312,000	4,624
C-745-M	120,000	902
C-745-N	180,000	1,629
C-745-P	96,000	1,735
C-745-S	130,000	2,000
C-745-T	485,600	0
Total		28,351

[a] Locations of cylinders as of May 1996.

[b] USEC-leased yard with DOE cylinders in storage.

Source: Cash (1996).

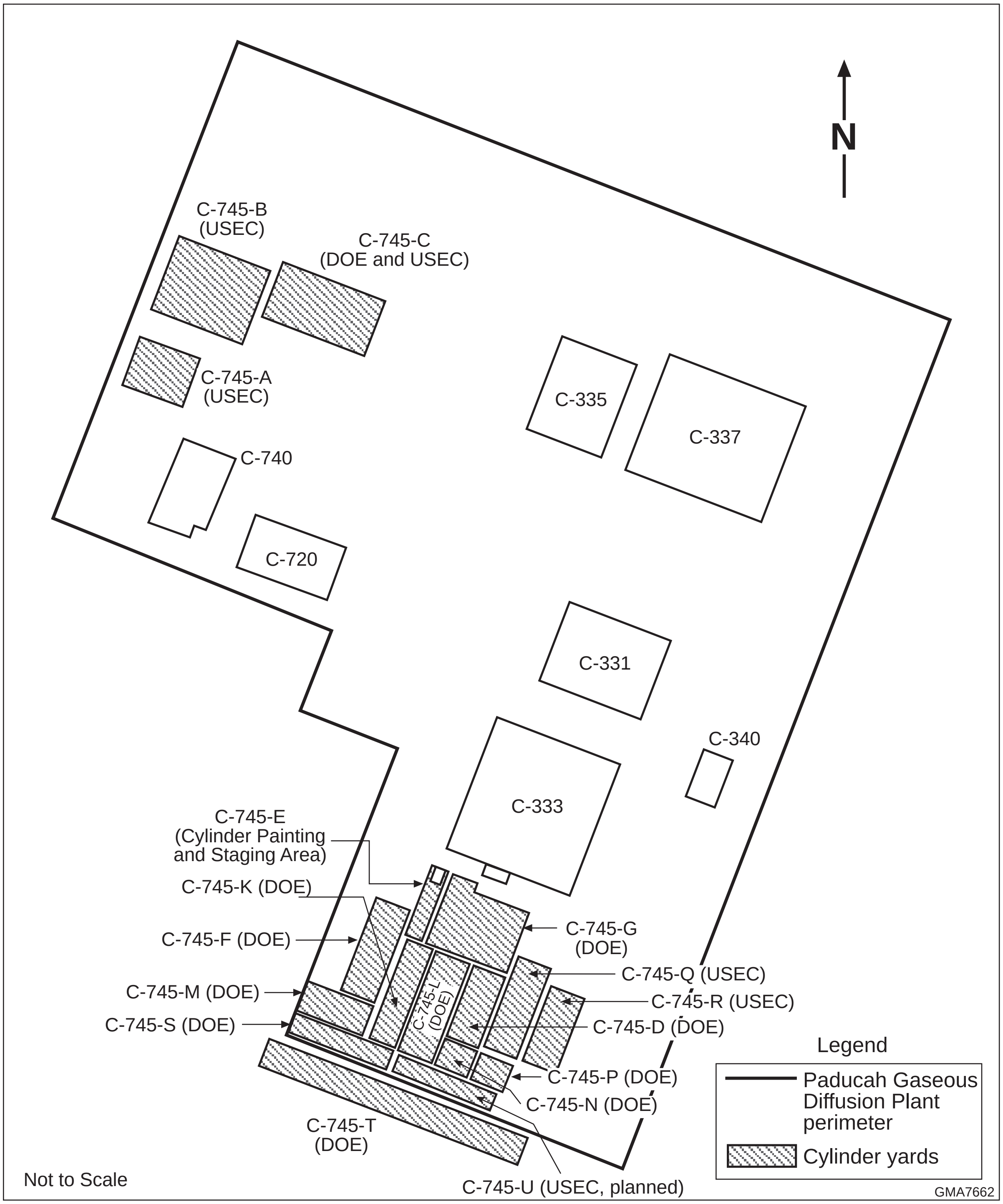

FIGURE 3.2 Locations of Cylinder Yards at the Paducah Site That Are Used to Store DOE Cylinders (Source: Adapted from DOE 1995c and Cash 1997)

The C-745-T (T-yard) was originally constructed outside the PGDP boundary but within the site perimeter. The PGDP boundary and fencing have been expanded to include the T-yard. The remaining cylinder yards will be rebuilt with concrete bases, starting with the C-745-K, C-745-L, C-745-M, C-745-N, and C-745-P yards (K-, L-, M-, N-, and P-yards). Cylinders are being restacked during relocation onto the newly constructed yards.

In addition to the DOE-generated cylinders, approximately 6,600 USEC-generated cylinders are stored in yards C-745-C, E, Q, and R (see Figure 3.2; DOE and USEC 1998a). Cylinder yard C-745-E is actually a cylinder staging area where cylinders are stored only temporarily; the USEC cylinders in this yard will be moved to C-745-Q or -R yards. The three yards C-745-C, Q, and R have gravel bases. Reconstruction of these yards with concrete bases is planned to follow the completion of reconstruction of the gravel yards currently storing DOE-generated cylinders (DOE and USEC 1998a). On the basis of a June 1998 Memorandum of Agreement, ownership and management of approximately 2,000 additional cylinders will be transferred from USEC to DOE between 1999 and 2004 (DOE and USEC 1998b). For purposes of analysis, this PEIS assumes that these cylinders will be located in yards C-745-C, Q, or R at the Paducah site.

One breached cylinder was identified in F-yard in November 1992. The small hole (about 1/16 in. × 2 in. [0.16 cm × 5 cm]) was attributed to handling damage, and a permanent patch was subsequently applied. In 1996, a steel engineered patch was welded onto another cylinder at the Paducah site. No material was thought to have been lost from either of these cylinders.

3.1.2 Site Infrastructure

The Paducah site is located in an area with an established transportation network. The area is served by two interstate highways, several U.S. and state highways, several rail lines, and a regional airport.

All water used by the site is obtained from the Ohio River through an intake at the steam plant near the Shawnee Power Plant north of the site. Before use, the water is treated on-site. Current water usage is approximately 15 million gal/d (57 million L/d). The maximum site capacity is 30 million gal/d (115 million L/d) (DOE 1996g).

Electric Energy, Inc., supplies electric power to the Paducah site. The current electrical need is 1,564 MW, with a maximum capacity of 3,040 MW. The coal system uses 82 tons (74 metric tons) per day, with a maximum capacity of 180 to 200 tons (160 to 180 metric tons) (DOE 1996g).

3.1.3 Ambient Air Quality and Airborne Emissions

The affected environment for air quality at the Paducah site is generally considered to be the Air Quality Control Region (AQCR) designated by the EPA: the Paducah (Kentucky) — Cairo (Illinois) Interstate AQCR in EPA Region 4. This AQCR includes McCracken County, Kentucky, in which the Paducah site is located. The EPA classifies McCracken County as an attainment area for all six National Ambient Air Quality Standards (NAAQS) criteria pollutants — carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM_{10}, particles with a mean diameter of 10 µm or less), ozone (O_3), nitrogen oxides (NO_x), and lead (Pb). An attainment area for a criteria pollutant is an area that has an ambient air concentration of the pollutant below the corresponding standard.

The Commonwealth of Kentucky has adopted ambient air quality standards that specify maximum permissible short-term and long-term concentrations of various contaminants (Table 3.2). These standards are generally the same as the national standards. In addition to standards for criteria pollutants, the Kentucky Department of Environmental Protection (KDEP) has adopted rules governing new or modified sources emitting toxic air pollutants ("General Standards of Performance," *Kentucky Administrative Regulations*, Title 401, Chapter 63, Regulation 022 [401 KAR 63:022]), as well as standards for the hazardous air pollutants regulated by the National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR Part 61).

DOE has responsibility for four air emission sources at the Paducah site, none of which involve the release of radiological effluents. The Paducah site is not required to conduct ambient air monitoring. DOE activities at the site in 1996 released quantities of criteria and hazardous air pollutants (HAPs) well below the amounts that would cause them to be classified by the *Clean Air Act* as a major source (LMES 1997c). An aggregate emission of 100 tons of any single criteria pollutant is required for the DOE operations to be classified as a major source. Emissions of criteria pollutants from cylinder refurbishment (grit blasting and painting) amounted to about 4.5 tons of particulate and 3.4 tons of volatile organic compounds (VOCs). Another 12 tons of VOCs may have been released from inactive closed landfills. In all, a total of as much as 16.6 tons of VOCs may have been emitted. The largest source of HAPs, a contaminated groundwater treatment facility, produced 1.4 tons of trichloroethylene, compared with the 10 tons of emissions of a single HAP necessary for major source designation.

3.1.4 Geology and Soil

3.1.4.1 Topography, Structure, and Seismic Risk

The topography of the Paducah site is relatively flat; within the boundaries of the PGDP security fence, the maximum difference in elevation is about 10 ft (3 m) (ERC/EDGe 1989). The site is underlain by bedrock of limestone and shale. Several zones of faulting occur in the vicinity of the site (Argonne National Laboratory [ANL] 1991a).

TABLE 3.2 Kentucky Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
Carbon monoxide (CO)		
1-hour average	35 ppm[a]	35 ppm
8-hour average	9 ppm[a]	9 ppm
Sulfur dioxide (SO_2)		
3-hour average	–	0.50 ppm[a]
24-hour average	0.14 ppm[a]	–
Annual average	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour average[b]	150 µg/m^3	150 µg/m^3
Annual arithmetic mean	50 µg/m^3	50 µg/m^3
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)		
Annual average	0.05 ppm	0.05 ppm
Lead (Pb)		
Quarterly average	1.5 µg/m^3	1.5 µg/m^3
Hydrogen sulfide		
Maximum 1-hour average	–	14 µg/m^3 (0.01 ppm)[a]
Gaseous fluorides (as HF)		
Annual arithmetic mean, not to exceed	0.5 ppm	–
Maximum 1-month average	–	1.00 ppb[a]
Maximum 1-week average	–	2.00 ppb[a]
Maximum 24-hour average	1.0 ppm[a]	3.50 ppb[a]
Maximum 12-hour average	–	4.50 ppb[a]
Total fluorides[c]		
Average concentration of monthly samples over growing season (not to exceed 6 consecutive months)	–	40 ppm (w/w)
2-month average	–	60 ppm (w/w)
1-month average	–	80 ppm (w/w)
Odors	At any time when one volume unit of ambient air is mixed with seven volume units of odorless air, the mixture must have no detectable odor.	

[a] Average not to be exceeded more than once per year.

[b] Standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 µg/m^3, as determined in accordance with Appendix K of 40 CFR Part 50, is equal to or less than one.

[c] Concentrations not to be exceeded on a dry weight basis (as fluoride ion) in and on forage for consumption by grazing ruminants; w/w = weight for weight.

Source: DOE (1996g).

The largest recorded earthquake in the region occurred in 1812 and was centered in the New Madrid fault zone. This earthquake had a magnitude of 7.3, and the epicenter was 60 miles (96 km) southwest of the site (LMES 1997f). This earthquake completely destroyed the town of New Madrid, Missouri.

The seismic hazards at the Paducah site have been studied extensively. The safety analysis report (SAR) for this site, completed in March 1997, provided comprehensive analyses and discussions of seismic hazards at the site (see Sections 1.5 and 3.3 of the SAR; LMES 1997f). The analyses considered the possibility of large-magnitude earthquakes similar to the New Madrid earthquakes of 1811–1812. The analyses performed by DOE were independently reviewed by the U.S. Geological Survey (USGS). The independent review by the USGS indicated that the seismic sources, recurrence rates, maximum magnitudes, and the attenuation functions used in the SAR analyses were representative of a wide range of professional opinion and were suitable for obtaining probabilistically based seismic hazard estimates. Because of the proximity of the site to the New Madrid seismic zone, special deterministic analyses were also performed to estimate the ground motions at the site in the case of recurrence of an earthquake of the same magnitude as the 1811–1812 New Madrid earthquakes. The results of the deterministic analyses were similar to the probabilistic seismic hazard results for the probabilities associated with the recurrence of the New Madrid earthquake of 1811–1812. The results also indicated that continued storage of depleted UF_6 cylinders at the Paducah site is safe.

For the Paducah site, the evaluation basis earthquake (EBE) was designated by DOE to have a return period of 250 years. A detailed analysis indicated that the peak ground motion for the EBE was 0.15 times the acceleration of gravity (LMES 1997f). An earthquake of this size would have an equal probability of occurring any time during a 250-year period.

For this PEIS, the analyses of earthquake-initiated accidents at the Paducah site were based on the analyses and results provided in the SAR (LMES 1997f; see also Appendix C, Section C.4.2). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

3.1.4.2 Soil

Substances in soil possibly associated with cylinder management activities would be uranium and fluoride compounds, which could be released if breached cylinders or faulty valves were present. For the evaluation of ongoing activities at the Paducah site, the purpose of soil sampling has been to identify the accumulation of any airborne pollutants; thus, annual soil samples have been collected from 10 off-site locations: four at the site boundary, four at distances of 5 miles

(8 km) beyond the boundary, and two at more remote locations to characterize background levels (LMES 1996a; MMES 1994b). In 1994, uranium concentrations for the 10 sampling locations ranged from 2.0 to 5.8 µg/g; plant boundary concentrations ranged from 2.3 to 4.9 µg/g (LMES 1996a).

Because of a transfer of responsibility for air point sources from DOE to USEC, concentrations of nonradiological parameters in soil at these sampling locations are no longer reported (LMES 1996a); however, analytical results for polychlorinated biphenyls (PCBs) and metals are available for previous years. In 1993, no detectable concentrations of PCBs were found in any of the samples, but elevated concentrations of bismuth, lead, manganese, thallium, and thorium were detected in several samples (MMES 1994b). Fluoride was not analyzed in soil samples, but it is naturally occurring in soils and of low toxicity.

As part of ongoing CERCLA/RCRA investigations of Paducah site operable units, several areas of soil have been identified as contaminated with radionuclides and chemicals such as PCBs and metals. However, this contamination is not associated with the depleted UF_6 cylinder yards, and remediation is being implemented as a part of ongoing CERCLA/RCRA activities at the site.

3.1.5 Water Resources

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples have indicated the presence of some contamination resulting from previous gaseous diffusion plant operations.

3.1.5.1 Surface Water

Big Bayou Creek is located on the west side of the Paducah site and Little Bayou Creek on the east side (Figure 3.1). These two streams join north of the site and discharge to the Ohio River. Flows in Big Bayou Creek and Little Bayou Creek fluctuate greatly as a result of precipitation. During most of the year, flows in both streams are derived primarily from plant effluents. All water used by the site is obtained from the Ohio River through an intake north of the site (ANL 1991a).

Most of the liquid effluents from the Paducah site consist of cooling water, although a variety of liquid wastes are produced by activities such as metal finishing, uranium recovery, and facility cleaning (Rogers et al. 1988a). In addition to these discharges, a large variety of conventional liquid wastes enter the surface water system, including treated domestic sewage, steam plant wastewater, and coal pile runoff.

All effluent discharges are under the Kentucky Pollutant Discharge Elimination System (KPDES). At the present time, there are a total of 15 outfalls. Ten outfalls are authorized to USEC (KY0102083); five outfalls are authorized to DOE (KY000409). Of the DOE outfalls, three are to

Big Bayou Creek and one is to an unnamed tributary of Little Bayou Creek. The average discharge of wastewater to Big Bayou Creek is approximately 4 million gal/d (15 million L/d). The average discharge to the Ohio River through Big Bayou and Little Bayou Creeks is about 4.1 million gal/d (16 million L/d). The average flow in the Ohio River is 1.7×10^{11} gal/d (6.5×10^{11} L/d).

Monitoring of surface water in 1995 and 1996 indicated that the maximum average concentration of uranium was 0.012 mg/L in the downstream portion of Little Bayou Creek (LMES 1997a; 1997c). The maximum average concentration of fluoride was < 0.224 mg/L in the north/south diversion ditch within the PGDP (MMES 1994e). Comparable fluoride data were not reported for 1994, 1995, or 1996 (LMES 1996a, 1997a,c).

The KPDES-permitted outfalls are monitored for inorganic substances and about 45 organic substances, including PCBs. The monitoring frequency for most substances is two to four times per year; several substances are monitored monthly or quarterly to comply with KPDES permit requirements. The maximum average uranium concentration in effluents from the DOE outfalls from 1994 through 1996 was 0.037 mg/L (LMES 1996a, 1997a,c). In both 1994 and 1995, two USEC-leased outfalls received a “Notice of Violation” for PCB exceedances.

Sediment samples are also collected annually from six locations and analyzed for uranium, PCBs, and metals. In 1993, concentrations of uranium and PCBs were detected at significantly higher levels than background in Little Bayou Creek (sampling location SS2). The uranium concentration of 200 mg/kg at the measuring location was two times higher than in 1992. The PCB concentration also increased from 0.9 mg/kg in 1992 to 2.0 mg/kg in 1993. However, levels decreased in 1994 (22 mg/kg maximum uranium concentration; 1.4 mg/kg maximum PCB concentration) (LMES 1996a) and again in 1995 (13 mg/kg maximum uranium concentration; < 0.1 mg/kg maximum PCB concentration) (LMES 1997a). In 1996, the uranium concentration in sediment at location SS2 was 44 mg/kg; the PCB concentration was 1.3 mg/kg. A new sampling location (SS29) was added on Little Bayou Creek closer to the PGDP. The uranium concentration at this location was 360 mg/kg; no PCB value was reported (LMES 1997c).

3.1.5.2 Groundwater

Two near-surface aquifers are of importance at the Paducah site. The upper aquifer is a shallow, perched-water aquifer composed of sands and sand and clay mixtures that are discontinuous (Rogers et al. 1988a). Water yields from this aquifer are very low, and the hydraulic gradient (change in water elevation with distance) is difficult to detect. Water movement is generally in a northeasterly direction at less than 0.1 ft/yr (0.3 m/yr).

The lower aquifer is a good-yielding gravel aquifer that has an upper surface at a depth of about 39 ft (12 m) and a thickness that ranges from about 20 to 59 ft (6 to 18 m). This aquifer appears to be continuous beneath the Paducah site. Hydraulic conductivity is estimated to be 0.0001 to 1 cm/s for the regional gravel aquifer and 0.00001 to 0.01 cm/s for the upper continental deposits (sands). Water movement is 2 to 5 ft/yr (0.6 to 1.5 m/yr) and variable in direction (Rogers et al. 1988a).

On-site and off-site groundwater sampling for the Paducah site is performed in about 200 monitoring wells, residential wells, and Tennessee Valley Authority wells. Off-site sampling is performed to monitor three separate trichloroethylene and technetium plumes first detected in 1988 (LMES 1996a) (Figure 3.3). The Paducah site has provided a municipal water supply to all residents whose wells are within the area of groundwater contamination from the site; resident wells that are no longer sampled are locked and capped.

Although the magnitude of groundwater contamination originating from the Paducah site is greatest for trichloroethylene and technetium, the primary drinking water standards or derived concentration guidelines for several other inorganic, volatile organic, and radionuclide substances were also exceeded in one or more of the monitoring wells on or near the Paducah site in monitoring occurring from 1993 through 1996 (MMES 1994b; LMES 1996a, 1997a,c). (The derived concentration guideline is equivalent to the MCL; it is the concentration of a radionuclide that under conditions of continuous exposure for 1 year would result in an effective dose equivalent of 4 mrem [EPA 1996; DOE Order 5400.5]). The uranium guideline of 20 ug/L was exceeded in four wells, and the fluoride guideline of 4 mg/L was exceeded in two wells. The wells with uranium and fluoride exceedances were not located near the cylinder yards.

3.1.6 Biotic Resources

3.1.6.1 Vegetation

The Paducah site includes the highly developed PGDP, which has few natural vegetation communities. The DOE property between the PGDP and the West Kentucky Wildlife Management Area consists primarily of open, frequently mowed grassy areas. The DOE property also includes several small upland areas of mature forest, old field, and transitional habitats. The banks of Big Bayou Creek and Little Bayou Creek support mature riparian forest with river birch, black willow, and cottonwood (ANL 1991a). The West Kentucky Wildlife Management Area contains wooded areas from early and mid-successional stages to mature forest communities. Nonforested areas are managed by controlled burns, mowing, and planting.

3.1.6.2 Wildlife

The habitats at the Paducah site support a relatively high diversity of wildlife species. Ground-nesting species include the white-footed mouse, bobwhite, and eastern box turtle. Big Bayou Creek, upstream of the Paducah site, supports aquatic fauna indicative of oxygen-rich, clean water,

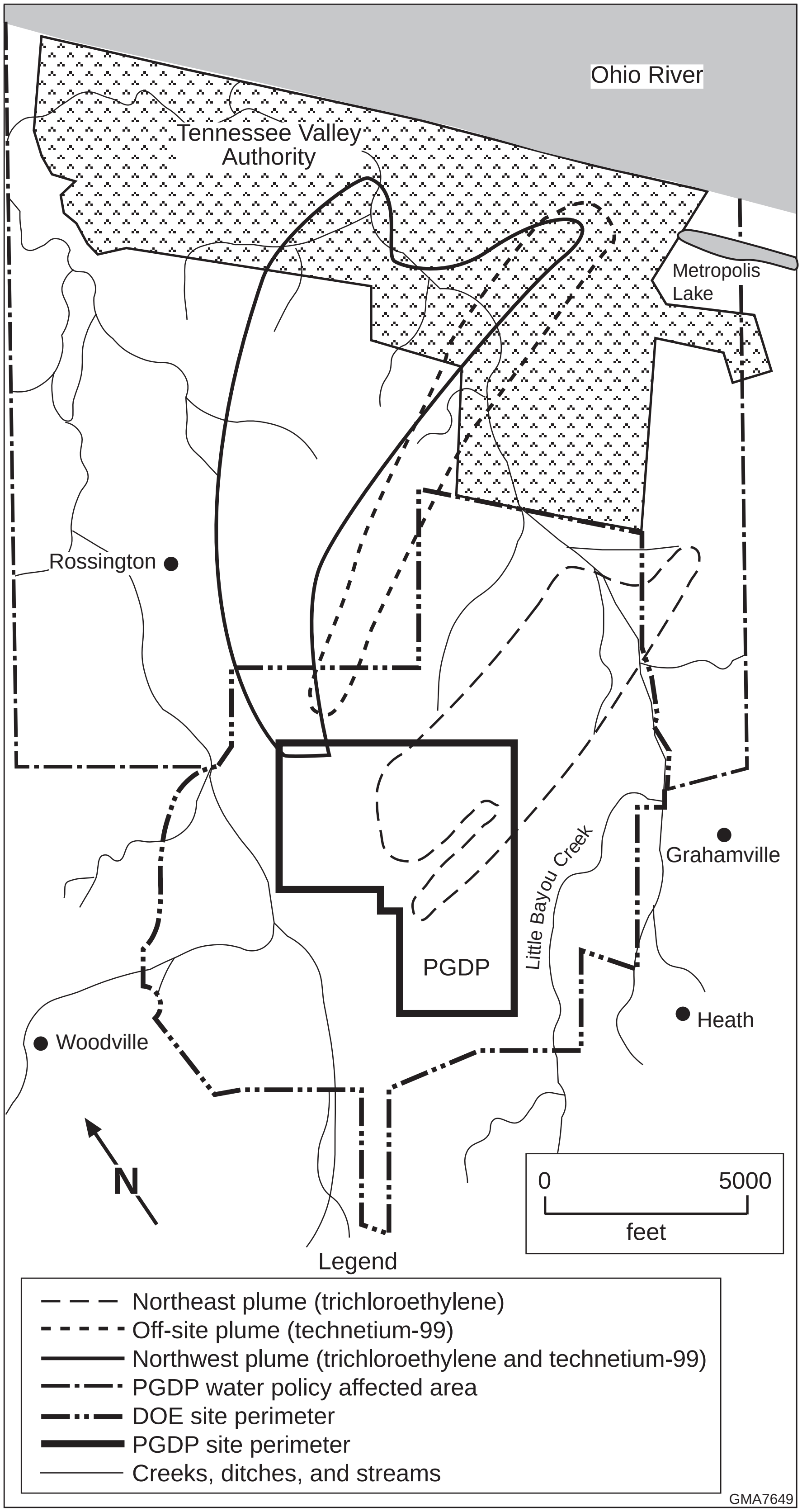

FIGURE 3.3 Locations of Contaminated Groundwater Plumes at the Paducah Site (Source: Adapted from MMES 1994b)

including 14 fish species. Aquatic species just downstream of the Paducah site discharge points include 11 fish species (LMES 1997c). The density and diversity of aquatic organisms are generally lower near the outfalls than upstream areas for both Little Bayou Creek and Big Bayou Creek (DOE 1994b).

3.1.6.3 Wetlands

Although no wetlands are identified on the PGDP by the National Wetlands Inventory, approximately 5 acres of jurisdictional wetlands have been identified in drainage ditches scattered throughout the PGDP (ANL 1991a; CDM Federal Programs Corporation 1994; Sadri 1995). Outside the PGDP, a large number of wetlands are scattered throughout the Paducah site. These include forested wetlands, ponds, wet meadows, vernal pools, and wetlands converted to agriculture (U.S. Department of the Army 1994c). Palustrine forested wetlands occur extensively along the banks of Big Bayou Creek and Little Bayou Creek. The National Wetlands Inventory identifies many wetlands on the Paducah site, primarily ponds and forested wetlands. A forested wetland dominated by tupelo trees in the West Kentucky Wildlife Management Area has been designated by the Kentucky Nature Preserves Commission and Kentucky Department of Fish and Wildlife as an area of ecological concern (DOE 1996g).

3.1.6.4 Threatened and Endangered Species

No federal-listed plant or animal species are known to occur on the Paducah site. However, the Indiana bat (federal- and state-listed as endangered) has been found near the confluence of Bayou Creek and the Ohio River 3 miles north of the PGDP. Potential habitat occurs on the Paducah site outside the PGDP (U.S. Department of the Army 1994b) and in adjacent wooded areas. State-listed species known to occur on the Paducah site include the compass plant, which is listed by the Kentucky State Nature Preserve Commission as threatened. The lake chubsucker, listed by the Nature Preserve Commission as threatened, is known from early, but not recent, surveys of Big Bayou Creek and Little Bayou Creek. State-listed species of special concern that occur on or near the Paducah site include Bell’s vireo, cream wild indigo, and Northern crawfish frog. The presence of state-listed species and requirements for consultation with the Kentucky State Nature Preserve Commission would be determined in site-specific environmental analyses.

3.1.7 Public and Occupational Health and Safety

3.1.7.1 Radiation Environment

Operations at the Paducah site result in radiation exposures of both on-site workers and off-site members of the general public (Table 3.3). Exposures of on-site workers generally are

TABLE 3.3 Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the Paducah Gaseous Diffusion Plant

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides	0.0023[b]
	Waterborne radionuclides	0.67[c]
	Direct gamma radiation	1[d]
	Ingestion of drinking water	0[e]
	Ingestion of wildlife	0.0023[f]
Cylinder yard worker	External radiation	16 – 56[g]
Member of public or worker	Natural background radiation and medical sources	360[h]
DOE worker limit		2,000[i]

[a] The maximally exposed individual (MEI) was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were calculated by using an air dispersion model and considered exposure from external radiation, inhalation, and ingestion of foodstuffs. The MEI is located approximately 1,170 m (3,836 ft) north-northeast of the plant site (LMES 1997c).

[c] Radiation doses could result from incidental ingestion of contaminated sediment and inhalation of contaminated particles from fishing, hunting, and other recreational activities in Little Bayou Creek (LMES 1997c).

[d] Radiation doses could result from hunting activities on the banks of Little Bayou Creek (LMES 1997c).

[e] According to the results of a 1990 survey, there was no reported use of surface water. Also, contaminated well water is not used because all residents in that area receive city water (LMES 1996a).

[f] Radiation doses could result from ingestion of the edible portion of two average-weight deer containing the maximum detected concentrations of radionuclides (LMES 1997c).

[g] Range of annual average doses from years 1990 through 1995 (Hodges 1996).

[h] Average dose to a member of the U.S. population as estimated in Report No. 93 of the National Council on Radiation Protection and Measurements (NCRP 1987b).

[i] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

associated with handling of radioactive materials used in the on-site facilities and with inhalation of radionuclides released from processes conducted on-site. Members of the off-site general public are exposed to radionuclides discharged from on-site facilities through airborne and/or waterborne emissions.

The total radiation dose to the maximally exposed individual (MEI) of the general public is estimated to be 1.7 mrem/yr, which is much lower than the maximum radiation dose limit set for the general public of 100 mrem/yr from operation of a DOE facility (DOE Order 5400.5). The average external radiation dose for cylinder yard workers has ranged from 16 to 56 mrem/yr (Hodges 1996) in the past few years and has been well below the maximum dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835). All of these exposures are a very small fraction of the 360 mrem/yr dose received by the general public and workers from natural background and medical sources (Table 3.3).

3.1.7.2 Chemical Environment

Estimated hazard quotients for members of the general public under existing environmental conditions near the Paducah site are presented in Table 3.4. The hazard quotient represents a comparison of estimated human intake levels with intake levels below which adverse effects are very unlikely to occur (see Chapter 4). The estimated hazard quotients indicate that exposures near the Paducah site are generally a small fraction of those that might be associated with adverse health effects. An exception is groundwater, where hazard quotients for several substances could exceed the threshold of 1. However, because this groundwater is not a drinking water source, there is no exposure. The residents near the PGDP whose wells have been contaminated have been provided with alternate water sources.

The Occupational Safety and Health Administration (OSHA) has proposed permissible exposure limits (PELs) for uranium compounds and HF in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998), as follows: 0.05 mg/m^3 for soluble uranium compounds; 2.5 mg/m^3 for HF. Paducah worker exposures are kept below these limits.

3.1.8 Socioeconomics

The socioeconomic environment of the Paducah site was assessed in terms of regional economic activity, population and housing, and local public finances. The region of influence (ROI) consists of Ballard, Carlisle, Graves, Marshall, and McCracken Counties in Kentucky, and Massac County in Illinois; 93.1% of employees at the site currently reside in those counties, with 59.1% residing in McCracken County (DOE 1997a). Allison and Folga (1997) provide a listing of the counties, cities, and school districts within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

TABLE 3.4 Estimated Hazard Quotients for Members of the General Public near the Paducah Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d,e]	Uranium	0.0078 µg/m^3	2.2×10^{-6}	0.0003	0.0074
	HF	0.096 µg/m^3	2.7×10^{-5}	0.02	0.0014
Soil[f]	Uranium	5.8 µg/g	7.7×10^{-5}	0.003	0.026
Surface water[e]	Uranium	16 µg/L	8.7×10^{-6}	0.003	0.003
	Fluoride	< 224 µg/L	1.2×10^{-4}	0.06	0.002
Sediments[e]	Uranium	360 µg/g	6.2×10^{-6}	0.003	0.033
	Aroclor 1254	1.4 µg/g	3.8×10^{-7}	0.00002	0.019
	Aroclor 1254[g]	1.4 µg/g	5.5×10^{-8}	2.0 (slope factor)	1.1×10^{-7} (cancer risk)
Groundwater[h]	Uranium	20 µg/L	5.7×10^{-4}	0.003	≥ 0.19
	Fluoride	4,000 µg/L	1.1×10^{-1}	0.06	≥ 1.9

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C. For carcinogens, the slope factor is also given; slope factors in units of $(mg/kg\text{-}d)^{-1}$ are multiplied by lifetime average intake to estimate excess cancer risk.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference level. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely. For carcinogens, the cancer risk (intake × slope factor) is also given. Increased cancer risks between 10^{-6} and 10^{-4} are considered tolerable at hazardous waste sites; risks less than 10^{-6} are considered negligible.

[d] Gross alpha was used as a surrogate measure of uranium concentration.

[e] Exposure concentrations are the maximum annual averages for all monitoring locations (MMES 1994b; LMES 1996a; 1997a, 1997c).

[f] Maximum uranium concentration from 10 plant boundary and off-site soil monitoring locations (LMES 1996a).

[g] Parameters analyzed for carcinogenic effects; all other parameters were analyzed for noncarcinogenic effects.

[h] Data are for monitoring and residential wells located on or near DOE property at the Paducah site (the residential wells are not currently used for drinking water). Several additional substances exceeded reference levels between 1993 and 1996 (Section 3.1.5.2); listed here are only substances of particular interest for this PEIS. Well-specific concentrations were not available; the exposure concentrations given are actually drinking water standards or guidelines. Hazard indices based on well-specific concentrations could exceed those presented.

3.1.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 72,300 to 78,900, an increase of 9.1%. Within the ROI, the largest percent employment increase occurred in McCracken County (13.8%), which had 51% of total ROI employment in 1995. The U.S. Bureau of Economic Analysis (BEA) projects a 1.9% increase in employment in the ROI over the period 1995 to 2020 (1,500 jobs), with the largest increase expected in McCracken County (3.5%, 1,400 jobs) (BEA 1996a). Unemployment in the ROI in 1996 was 5.4% (Allison 1996). Employment at the Paducah site in 1995 was 1,700 (DOE 1997a), amounting to approximately 2.2% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from $1.6 billion to $1.8 billion, an increase of 13%. The largest percent increase occurred in McCracken County (20%), which had 46% of total ROI personal income in 1995. The BEA projects a 31.9% increase in ROI personal income from 1995 to 2020 ($0.6 billion), with the largest increase in McCracken County (33%, $0.3 billion) (BEA 1996a).

3.1.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 150,271 to 153,000, an increase of 1.8%. The 1995 ROI population was concentrated in McCracken County (41.7%). The BEA projects the ROI population as a whole to increase by 9,600 (6.3%) from 1995 to 2020, with the largest increase in McCracken County (7.7%, 4,900 people) (BEA 1996a).

3.1.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased by 9.6%, from 61,000 to 66,900. McCracken County had 41% of the total housing units. Based on BEA (1996a) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the total number of vacant owner-occupied units in the ROI is expected to increase from 4,460 to 4,880 and the total number of vacant rental units from 1,520 to 1,620.

3.1.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 3.5. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

TABLE 3.5 Summary of Financial Characteristics for the Paducah Site County, City, and School District Regions of Influence

Category	Finances[a] ($ million) ROI Counties	ROI Cities	Category	Finances[a] ($ million) ROI School Districts
Revenues			**Revenues**	
Local sources	8.8	6.5	Local sources	23.8
Fines, fees, permits, etc.	1.3	14.5	State sources	67.2
Intergovernmental	1.3	6.1	Federal sources	4.1
Other	0.8	2.6	Other	16.5
Total	12.3	29.7	Total	111.6
Expenditures			**Expenditures**	
General government	6.3	4.7	Administration	2.2
Safety, health, community services	6.0	16.1	Instruction	67.1
			Services	8.5
Debt service	0.0	0.1	Physical plant	9.8
Other financing sources	1.4	-5.6	Other	24.4
Total	14.0	15.3	Total	112.1
Revenues less Expenditures	-1.7	14.4	**Revenues less Expenditures**	-0.4

[a] Data for fiscal year ending June 30, 1995.

Sources: see Allison and Folga (1997).

3.1.9 Waste Management

The affected environment with respect to waste management is considered to be wastewater and solid waste generated at the Paducah site. Disposal of this waste is currently managed by USEC, including any waste generated from ongoing management of the DOE-generated depleted UF_6 cylinders currently in storage. The cylinder storage yards at Paducah currently generate only a very small amount of waste compared with the volume of waste generated from ongoing plant operations. Cylinder yard waste consists of small amounts of metal, scrapings from cylinder maintenance operations, potentially contaminated soil, and miscellaneous items.

The Paducah site generates wastewater, solid LLW, solid and liquid LLMW, nonradioactive hazardous waste, and nonradioactive nonhazardous solid waste. The site has an active program to minimize the generation of solid LLW, hazardous waste, and LLMW. Waste minimization efforts for radioactive waste include prevention of packaging material from entering radiological areas and replacement of wood pallets used in radiological areas. Hazardous waste and LLMW minimization actions include use of less chlorinated solvents, recycling of paint wastes, and compaction of PCB wastes. Solid waste minimization actions include recycling of paper and cardboard and off-site recycling of fluorescent bulbs and used batteries.

3.1.9.1 Wastewater

Wastewater at the Paducah site consists of nonradioactive sanitary and process-related wastewater streams, cooling water blowdown, and radioactive process-related liquid effluents. Wastewater is processed at on-site treatment facilities and is discharged to Big Bayou Creek or Little Bayou Creek through eight outfalls identified under the site KPDES permit #KY0004049. In 1993, the wastewater treatment system processed approximately 0.4 million gal/d (1.5 million L/d) of wastewater. The total capacity of the site wastewater control facilities is approximately 1.75 million gal/d (6.6 million L/d). About 23% of the capacity of wastewater treatment facilities is currently used.

In 1992, the wastewater discharge at the Paducah site was in compliance with KPDES permit requirements 99.5% of the time. A few exceedances occurred for total residual chlorine, trichloroethylene, pH, and total suspended solids (MMES 1994b). In 1994, the PCB effluent limits were exceeded 18 times in site wastewater discharges. These exceedances were addressed through existing site agreements with the state (LMES 1996a).

3.1.9.2 Solid Nonhazardous, Nonradioactive Waste

Solid waste — including sanitary refuse, cafeteria waste, industrial waste, and construction and demolition waste — is collected and disposed of at the on-site landfill, which consists of three cells. The first cell is closed and capped, the second is near capacity, and the third cell awaits final authorization from the Kentucky Division of Waste Management. The total capacity of the landfill is 26,000 yd^3 (20,000 m^3). The site solid waste generation rate for 1993 was 2,740 yd^3/yr (2,100 m^3/yr) (DOE 1996g).

3.1.9.3 Nonradioactive Hazardous and Toxic Waste

Nonradioactive waste that is considered hazardous waste according to RCRA or contains PCBs as defined under the TSCA requires special handling, storage, and disposal. The Paducah site generates hazardous waste — including spent solvents and heavy-metal-contaminated waste — and PCB-contaminated toxic waste. The site has a Kentucky Division of Waste Management RCRA Part B permit (#KY8890008982), which expires in 2001. The permit authorizes the Paducah site to treat and store hazardous waste in 10 treatment units, 16 tanks, and 4 container storage areas at the site. There are several additional 90-day storage areas for temporary storage of hazardous waste.

Approximately 99 yd^3 (76 m^3), or 209 tons (190 metric tons), of solid hazardous waste was generated in 1992. Certain hazardous/toxic wastes are sent to permitted off-site contractors for final treatment and/or disposal. Much of the hazardous/toxic waste load consists of PCB-contaminated waste. More than 370 yd^3 (280 m^3) of PCBs is used in electrical equipment at the Paducah site (MMES 1994b). Some liquid hazardous and/or mixed waste streams are shipped to the K-25 site for incineration in a TSCA incinerator, which has a capacity of 1,800 yd^3/yr (1,400 m^3/yr).

3.1.9.4 Low-Level Waste

LLW generated at the Paducah site is stored on-site pending shipment to a commercial facility in Tennessee for volume reduction. Solid LLW generated at the Paducah site includes refuse, sludge, and debris contaminated with radionuclides, primarily uranium and technetium. The site generated 2,450 yd^3 (1,870 m^3) of solid LLW in 1991 and 650 yd^3 (500 m^3) in 1992. As of 1995, the site had 4,380 yd^3 (3,350 m^3) of LLW in storage (DOE 1996g). Site wastewater treatment facilities can process up to 1,480 yd^3 (1,140 m^3) per year of aqueous LLW.

3.1.9.5 Low-Level Mixed Waste

LLW that contains PCBs or RCRA hazardous components is considered to be low-level mixed waste (LLMW). As of 1995, 243 yd^3 (186 m^3) of LLMW was in storage at the Paducah site. Of this total, 63 yd^3 (48 m^3) represents waste subject to land disposal restrictions. Solid LLMW generation in 1992 was 1,080 yd^3 (824 m^3). In 1992, approximately 560,000 lb (256,000 kg) of organic liquid was sent to the TSCA incinerator on the K-25 site. On-site capacity for storing LLMW containers at the Paducah site is 3,600 yd^3 (2,800 m^3). The site can treat up to 204 ft^3/yr (156 m^3/yr) of aqueous LLMW (DOE 1996g).

3.1.10 Cultural Resources

Thirty-two cultural resource sites are currently recorded within and immediately surrounding the PGDP. Twenty-two were recorded during surveys conducted in the 1970s and early 1980s, and 10 more were recently recorded during a cultural resources study consisting of a 20% stratified random sample survey for prehistoric and historic archaeological sites. Results of a sensitivity analysis, also conducted as part of the study, indicate that much of the area surrounding the fenced complex has a low or very low index of sensitivity, meaning there is a low probability of finding prehistoric sites near the developed area. However, scattered areas of high sensitivity are located along Little Bayou Creek and Big Bayou Creek; at least three prehistoric sites and one historic site are potentially eligible for the *National Register of Historic Places* (U.S. Department of the Army 1994a-b).

An inventory of historic buildings is planned but has not been conducted at the Paducah site. It is likely that buildings related to uranium enrichment and the gaseous diffusion process that supported atomic weapon manufacture or to activities at the Kentucky Ordnance Works could be eligible for the *National Register*. No cemeteries are located on the Paducah site.

No religious or sacred sites, burial sites, or resources significant to Native Americans have been identified at the Paducah site to date.

3.1.11 Minority and Low-Income Populations

The affected environment for assessing the potential for depleted UF_6 management activities to result in environmental justice impacts was based on data from the U.S. Bureau of the Census (1992a-b). The population residing within a 50-mile (80-km) radius of the Paducah site consists of 9.2% minorities and 19.0% persons with low income (see Appendix C, Section C.8.1).

3.2 PORTSMOUTH SITE

The Portsmouth site is located in Pike County, Ohio, approximately 22 miles (35 km) north of the Ohio River and 3 miles (5 km) southeast of the town of Piketon (Figure 3.4). The two largest cities in the vicinity are Chillicothe, located 26 miles (42 km) north of the site, and Portsmouth, 22 miles (35 km) south.

The Portsmouth site includes the Portsmouth Uranium Enrichment Complex (PUEC), a gaseous diffusion plant previously operated by DOE and currently operated by the USEC. The Portsmouth site occupies 3,708 acres (1,500 ha) of land, with an 800-acre (320-ha) fenced core area that contains the PUEC production facilities. The 2,908 acres (1,180 ha) outside of the core area consist of restricted buffers, waste management areas, plant management and administrative facilities, gaseous diffusion plant support facilities, and vacant land (MMES 1992b). The PUEC has operated since 1995.

Wayne National Forest borders the plant site on the east and southeast, and Brush Creek State Forest is located to the southwest, slightly over 1 mile (1.6 km) from the site boundaries. Forests account for over 60% of the land in Pike County and over 70% in Scioto County. Neither county has residential land uses exceeding 2% or industrial/commercial land uses exceeding 1%.

No land-use maps or comprehensive or master plans have been developed for either Pike County or Scioto County, although the city of Portsmouth is in the process of developing one. The Portsmouth facility has a master plan, which indicates that future land-use patterns on the site are expected to remain essentially the same as current conditions (MMES 1992b).

The Portsmouth site is not on the NPL; environmental remediation activities at the site are overseen under the provisions of RCRA. The discussion of affected environment in this PEIS focuses on conditions and contaminants pertinent to depleted UF_6 cylinder management. Some

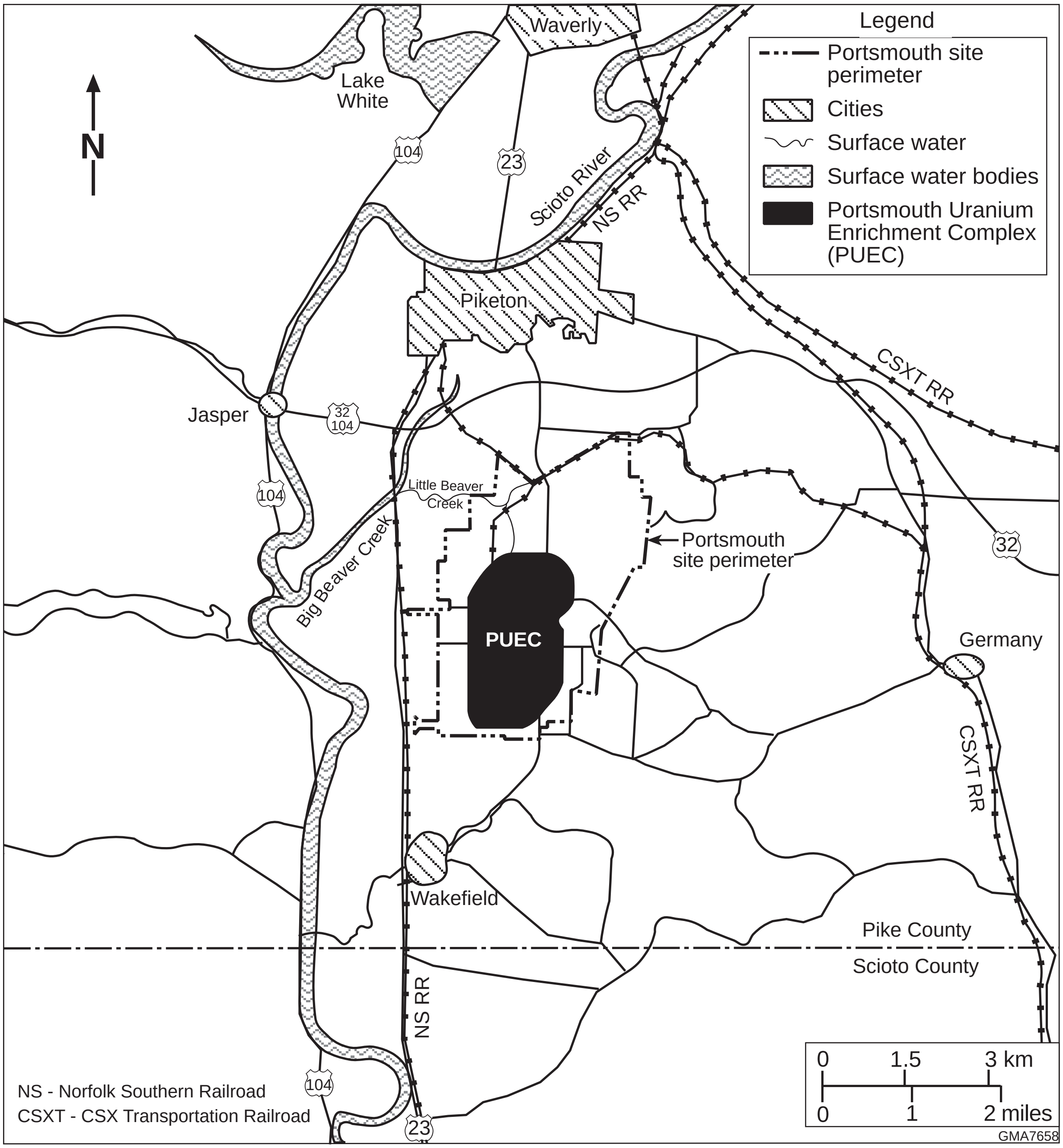

FIGURE 3.4 Regional Map of the Portsmouth Site Vicinity (Source: Adapted from LMES 1996b)

sitewide information from ongoing RCRA investigations is also included to put environmental conditions in the current cylinder storage areas into the context of sitewide conditions.

3.2.1 Cylinder Yards

TABLE 3.6 Locations of DOE Depleted UF_6 Cylinders at the Portsmouth Site[a]

Yard	Area (ft^2)	Number of Cylinders
X-745-C	550,000	8,988
X-745-E	215,000	4,400

[a] Locations of cylinders as of May 1996.

Source: Cash (1996).

The DOE-managed cylinders containing depleted UF_6 at the Portsmouth site are stored in two cylinder yards, X-745-C (C-yard) and X-745-E (E-yard) (Table 3.6; Figure 3.5). These storage yards have concrete bases. The cylinders are stacked two high to conserve yard storage space, with the cylinder-to-cylinder contact typically occurring in the areas of the stiffening rings. All 10- and 14-ton (9- and 12-metric ton) cylinders stored in these yards have been or are being inspected and repositioned. They are being placed on new concrete saddles with sufficient room between cylinders and cylinder rows to permit adequate visual inspection.

In addition to the DOE-generated cylinders, approximately 2,800 USEC-generated cylinders are stored in X-745-G yard (see Figure 3.5; DOE and USEC 1998a). These cylinders do not meet the 4-ft aisle spacing requirements; therefore, restacking of the cylinders is planned.

Two breached cylinders were identified in C-yard in June 1990; both breaches were attributed to handling damage and subsequent corrosion at the damaged point. One of the breached cylinders had a hole diameter of about 2 in. (5.1 cm); the estimated maximum material loss from this cylinder was 4 lb (1.8 kg). The cylinder contents were subsequently emptied into a new cylinder. The other cylinder had a much larger hole of approximately 9 in. × 18 in. (23 cm × 46 cm), with an estimated maximum material loss of about 109 lb (49 kg) (Barber et al. 1994). This cylinder was patched, and the contents were subsequently transferred to a new cylinder.

In March 1978, a cylinder containing liquid depleted UF_6 was accidentally dropped in the south-southwest portion of yard X-745-B (currently a USEC storage yard located north of Building X-330). Much of the material was carried into the storm sewer by melting snow. Cleanup efforts were conducted to collect as much of the lost material as possible; environmental sampling was also conducted to monitor uranium levels subsequent to the release (see Section 3.2.4).

3.2.2 Site Infrastructure

The Portsmouth site has direct access to major highway and rail systems, a nearby regional airport, and barge terminals on the Ohio River. Use of the Ohio River barge terminals requires transportation by public road from the Portsmouth site.

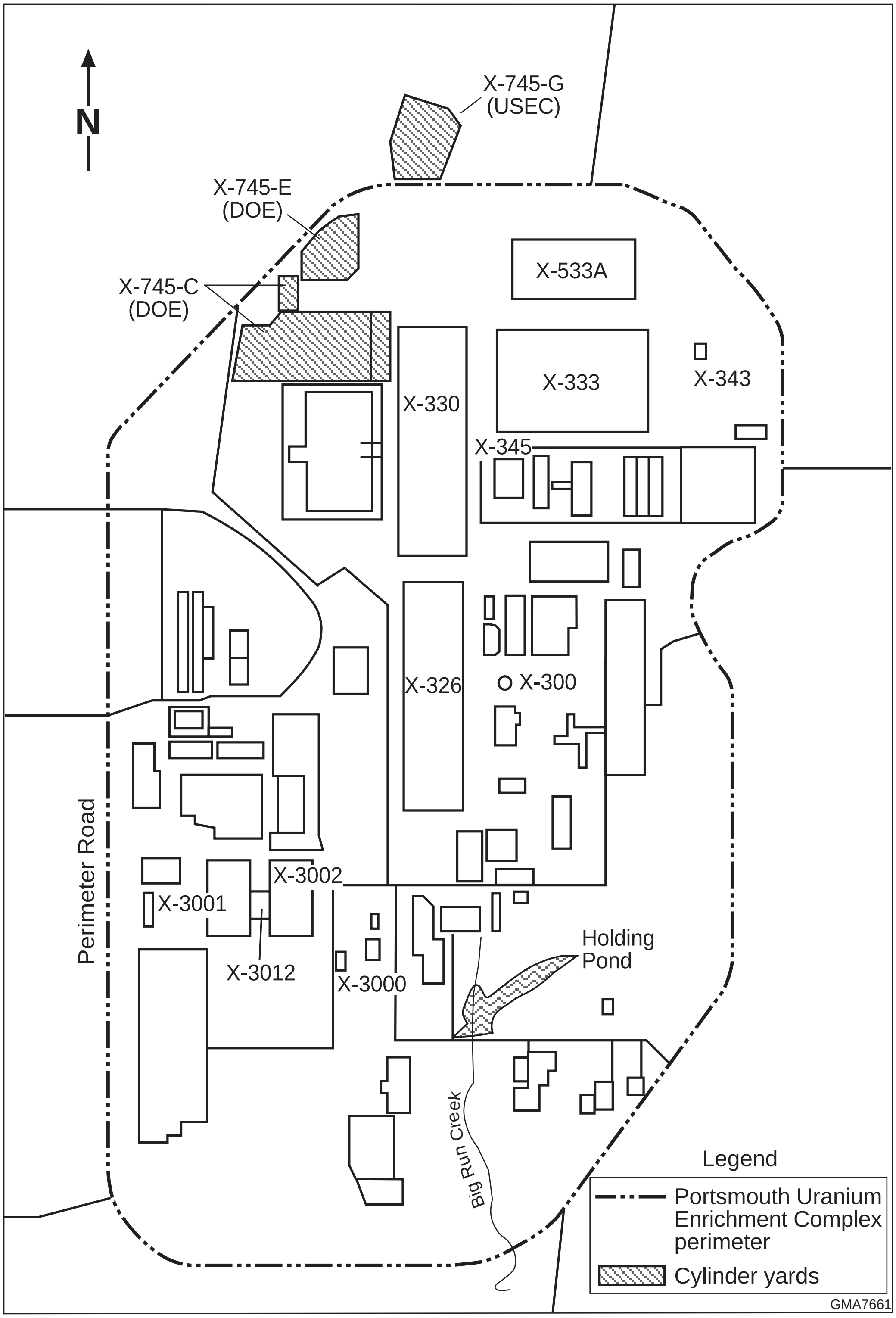

FIGURE 3.5 Locations of Cylinder Yards at the Portsmouth Site That Are Used to Store DOE-Managed Cylinders (Source: Adapted from DOE 1996g and MMES 1992a) |

The Portsmouth site draws its water supply from an on-site facility consisting of four wells and from 31 off-site supply wells. Current water usage is about 14 million gal/d (53 million L/d). The maximum site capacity is 38 million gal/d (140 million L/d).

The Ohio Valley Electric Corporation supplies the site with electrical power. The current electrical consumption is 1,537 MW, with additional power supplied by a coal system using 4,500 tons per month. The maximum electrical design capacity is 2,260 MW, but a power supply of only 1,940 MW is guaranteed by the local power utility (MMES 1992b).

3.2.3 Ambient Air Quality and Airborne Emissions

The affected environment for air quality at the Portsmouth site is generally considered to be the EPA-defined AQCR. The EPA has designated the Portsmouth site as being in the Wilmington-Chillicothe-Logan AQCR in EPA Region 5. The EPA classifies Pike County, in which the Portsmouth site is located, as an attainment area for all six NAAQS criteria pollutants.

The State of Ohio has adopted ambient air quality standards for six criteria pollutants that specify maximum permissible short-term and long-term concentrations of these contaminants. These standards are listed in Table 3.7 and are generally the same as the national standards. In addition to standards for criteria pollutants, the Ohio Environmental Protection Agency has adopted emissions limits, guidelines, and acceptable ambient concentration levels for the 189 hazardous air pollutants specified in Section 112(b) of the *Clean Air Act Amendments* (CAAA). Regulations for these hazardous air pollutants are established in the NESHAPS (40 CFR Part 61).

Gaseous radiological emissions were monitored at one active source during 1996. The total discharge of uranium to the air from DOE sources at Portsmouth in 1996 was less than 0.01 Ci, a reduction of more than 90% compared with the 1994 total. The active source has been transferred to USEC responsibility, leaving DOE responsible for a single radiological source that is currently inactive (LMES 1997e).

Nonradiological emissions consisted mainly of fugitive dust. Other small sources of pollutants emitted chlorine, HF, methanol, assorted solvents, and coolants. The emission of the HAP trichloroethylene (TCE), several hundred gallons of which were collected in groundwater treatment facilities, was prevented by activated carbon filtration of the treatment facility air stripper off-gases (LMES 1997e).

TABLE 3.7 Ohio Ambient Air Quality Standards

Pollutant	Ohio Standard[a] Primary	Ohio Standard[a] Secondary
Carbon monoxide (CO)		
1-hour average	35 ppm	35 ppm
8-hour average	9 ppm	9 ppm
Sulfur dioxide (SO_2)		
3-hour average	–[b]	0.50 ppm
24-hour average	0.14 ppm	–
Annual average	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour average	150 $\mu g/m^3$	150 $\mu g/m^3$
Annual arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)		
Annual average	0.053 ppm	0.053 ppm
Lead (Pb)		
Quarterly average	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
Gaseous fluorides (as HF)	NS[c]	NS[c]

[a] Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year, unless noted.

[b] A hyphen (–) indicates no standard available for this averaging period.

[c] Ohio has no standard for gaseous fluorides.

Source: DOE (1996g).

3.2.4 Geology and Soil

3.2.4.1 Topography, Structure, and Seismic Risk

The topography of the Portsmouth site area consists of steep hills and narrow valleys, except where major rivers have formed broad floodplains. The site is underlain by bedrock of shale and sandstone.

The Portsmouth site is within 60 miles (96 km) of the Bryant Station-Hickman Creek Fault (ANL 1991b). No correlation has been made between this fault and historical seismicity. Seismic Source Zone 60 is a north-northeast-trending zone in central and eastern Ohio and includes the Portsmouth facility. For this site, the EBE was designated by DOE to have a return period of 250 years. A detailed analysis indicated that the peak ground motion for the EBE was approximately 0.06 times the acceleration of gravity (LMES 1997g). An earthquake of this size would have an equal probability of occurring any time during a 250-year period.

The seismic hazards at the Portsmouth site have been analyzed and documented in a SAR completed in March 1997 (see Sections 1.5 and 3.3 in LMES 1997g). The results presented in the SAR indicate that continued storage of depleted UF_6 cylinders at the Portsmouth site is safe. The results of the SAR analyses were used for the accident analyses in this PEIS (see Appendix C, Section C.4.2). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

3.2.4.2 Soil

The substances in soil that might be associated with cylinder management activities at the Portsmouth site are uranium and fluoride compounds, which could be released if breached cylinders or faulty valves were present. In 1993, soil was sampled for radioactive parameters and chromium at 23 on-site, 32 off-site, and 4 background locations; soil sample analyses indicated no major environmental contamination (MMES 1994c). Analytical results for all off-site and most on-site sampling locations were similar to background values (MMES 1994d). One on-site sampling point (RIS-19, adjacent to the X-705 decontamination building) was contaminated with technetium-99 (143 pCi/g) and low levels of uranium (45 µg/g). This area is known to be contaminated from historical small spills; the source of uranium was not considered to be cylinder storage yards. Chromium concentrations were elevated at two locations immediately adjacent to and downwind of the X-633 cooling towers. Fluoride has not been analyzed in soil samples, but it is naturally occurring in soils and of low toxicity. Soils data have not been reported in more recent annual environmental reports (LMES 1996b, 1997e).

After the March 1978 cylinder handling accident (see Section 3.2.1), soil samples were collected to determine whether the X-745-C and X-745-B yards were contaminated (Geraghty & Miller 1994a-b). Total uranium concentrations in the X-745-C yard did not appear to be elevated, ranging from 2.2 to 4.4 mg/kg. Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and PCBs were detected in shallow soil samples at maximum levels up to about 3 mg/kg (for polycyclic aromatic hydrocarbons [PAHs]). Although a few VOCs were detected at low concentrations in groundwater from one well, the source is unlikely to be the X-745-C yard (Geraghty & Miller 1994a).

Total uranium concentrations in the X-745-B yard were elevated in some soil samples, ranging from 2.7 to 352 mg/kg. The source of the uranium contamination might have been the 1978 spill. Some VOCs, SVOCs, and PCBs were also detected in shallow soil samples at maximum levels up to 31 mg/kg (for the PAH phenanthrene). However, no uranium, VOCs, SVOCs, or PCBs were detected in groundwater associated with the X-745-B yard. The contamination was confined to shallow soils and limited to the immediate proximity of the unit (Geraghty & Miller 1994b).

3.2.5 Water Resources

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples has indicated the presence of some contamination resulting from previous gaseous diffusion plant operations. Although several contaminants are present in the water, only small amounts of uranium and fluoride compounds are related to releases from the cylinders.

3.2.5.1 Surface Water

The Portsmouth site is drained by several small tributaries of the Scioto River (see Figure 3.4). The largest stream on the plant property is Little Beaver Creek, which drains the northern and northeastern portions of the site before discharging into Big Beaver Creek. Upstream of the plant, Little Beaver Creek flows intermittently during the year. On-site, it receives treated process wastewater from a holding pond (via the east drainage ditch) and storm-water runoff from the northwestern and northern sections of the plant via several storm sewers, watercourses, and the north holding pond. The average release to Little Beaver Creek for 1993 was 940 gpm (3,600 L/min).

All plant liquid effluents are regulated by an NPDES permit and are either discharged to Little Beaver Creek or piped directly to the Scioto River (Rogers et al. 1988b). The Portsmouth site has 21 NPDES-permitted outfalls, of which 9 required routine monitoring in 1993. The maximum annual average uranium concentration (0.024 mg/L) for 1993 was measured at NPDES outfall 003 on the west side of the site (MMES 1994c). Responsibility for all but two of these outfalls has been transferred to the USEC. The maximum uranium concentration in these two outfalls in 1996 sampling was 0.002 mg/L (LMES 1997d).

In addition to NPDES outfall monitoring, surface water bodies were monitored for radioactive and nonradioactive contamination at one on-site and nine off-site locations, which include upstream and downstream locations on the Scioto River. The surface water monitoring results for 1993 indicated that the measured radioactive contamination was consistently less than the applicable drinking water standards (MMES 1994d). In 1996, TCE was detected in one sampling round for Little Beaver Creek. The TCE levels returned to below detection limits by the fourth quarter of 1996, after an interceptor trench and pump were repaired (LMES 1997e).

In addition to surface water sampling, sediment sampling was performed twice in 1993 to monitor for potential radioactive contamination. The fall-quarter sediment sampling results indicated minor radioactive contamination in Little Beaver Creek sediments downstream of the east drainage ditch (MMES 1994d). Uranium was elevated only slightly at about 7 to 11 µg/g (MMES 1994c). Technetium-99 was present at an activity level of about 130 to 160 pCi/L in Little Beaver Creek below the site. No uranium contamination was detected in Big Beaver Creek downstream of the confluence with Little Beaver Creek; however, technetium-99 was measured at 23 pCi/g in the spring and 55 pCi/g in the fall. No radioactive contamination was detected in sediments from Big Run Creek or the Scioto River. Sediment data were not reported in more recent annual environmental reports (LMES 1996b, 1997e).

Results for 1993 for nonradioactive constituents indicated the presence of iron and zinc contamination in the streams (MMES 1994d). Fluoride and phosphate concentrations have also been monitored at upstream and downstream locations on the Scioto River. Results of this monitoring indicate no major difference between upstream and downstream concentrations of either chemical.

In addition, unusually high concentrations of thallium (up to about 400 mg/kg) were detected in Scioto River sediments in 1993 and 1994 (MMES 1994c; Manual 1998). These high measurements may have been due to an analytical laboratory problem (MMES 1994c). Levels at the same locations in 1995, 1996, and 1997 have been much lower, ranging from less than 3 to 19 mg/kg (Manual 1998).

3.2.5.2 Groundwater

Five hydrologic units at the Portsmouth site are important for groundwater flow and contaminant migration. These units are, in descending order, the Minford Clay, Gallia Sand, Sunbury Shale, Berea Sandstone, and Bedford Shale. The upper two units form an aquifer in unconsolidated deposits; the lower three units form a bedrock aquifer. At the site, the hydraulic conductivity (rate at which water moves) of all units is very low (Geraghty & Miller 1989a). The most conductive unit is the Gallia Sand, which has a mean hydraulic conductivity of 3.4 ft/d (0.0012 cm/s) and a range of 0.11 to 150 ft/d (0.000039 to 0.05 cm/s). This unit acts as the principal conduit for contaminant transport.

The direction of groundwater flow beneath the Portsmouth site is controlled by a complex interaction between the Gallia and Berea units (Geraghty & Miller 1989a). The flow patterns are also affected by the presence of storm sewers and the reduction in recharge caused by the presence of buildings and paved areas. Three main discharge areas exist for the groundwater system beneath the site: Little Beaver Creek to the north and east; Big Run Creek to the south; and two unnamed drainages to the west (Geraghty & Miller 1989a).

Although the Portsmouth site could use Scioto River water, all on-site water is currently supplied by wells. Four wells have the capacity to supply between 23.5 and 26 million gal/d (89 and 98 million L/d). Currently, about 14 million gal/d (53 million L/d) of groundwater is used for sanitary and production needs (ANL 1991b). Recharge of the aquifers is from river and stream flow, as well as from precipitation.

On-site groundwater at the Portsmouth site is monitored for radioactive and nonradioactive constituents at more than 245 wells. Additional off-site wells are used to monitor groundwater quality away from the site. On-site, three areas of groundwater contamination have been identified (Figure 3.6) that contain contaminants, including TCE, Freon-113, uranium, and technetium. In 1996, the maximum detected concentration of uranium was 26 µg/L for an on-site well in the X-701B holding pond area adjacent to Building X-333 (see Figure 3.6) (LMES 1997d).

3.2.6 Biotic Resources

3.2.6.1 Vegetation

The Portsmouth site within the perimeter road consists primarily of open grassy areas, including frequently mowed lawns, pasture, and old-field. Small areas of pine plantation, upland mixed hardwood forest, oak-hickory forest, bottomland mixed hardwood forest, and shrub thicket also occur on the site (DOE 1995c).

3.2.6.2 Wildlife

Habitats on the Portsmouth site support a relatively high diversity of terrestrial and aquatic wildlife species. Ground-nesting species include bobwhite and eastern box turtle. Various species of reptiles and amphibians are associated with streams and other surface water on the site. Migrating waterfowl use site retention ponds (ANL 1991b). Additional information on wildlife resources is available from MMES (1993) and ANL (1991b).

Little Beaver Creek, upstream of the site outfall, supports a high diversity of aquatic species. However, diversity is considerably lower downstream in Little Beaver Creek and in an unnamed stream (ANL 1991b).

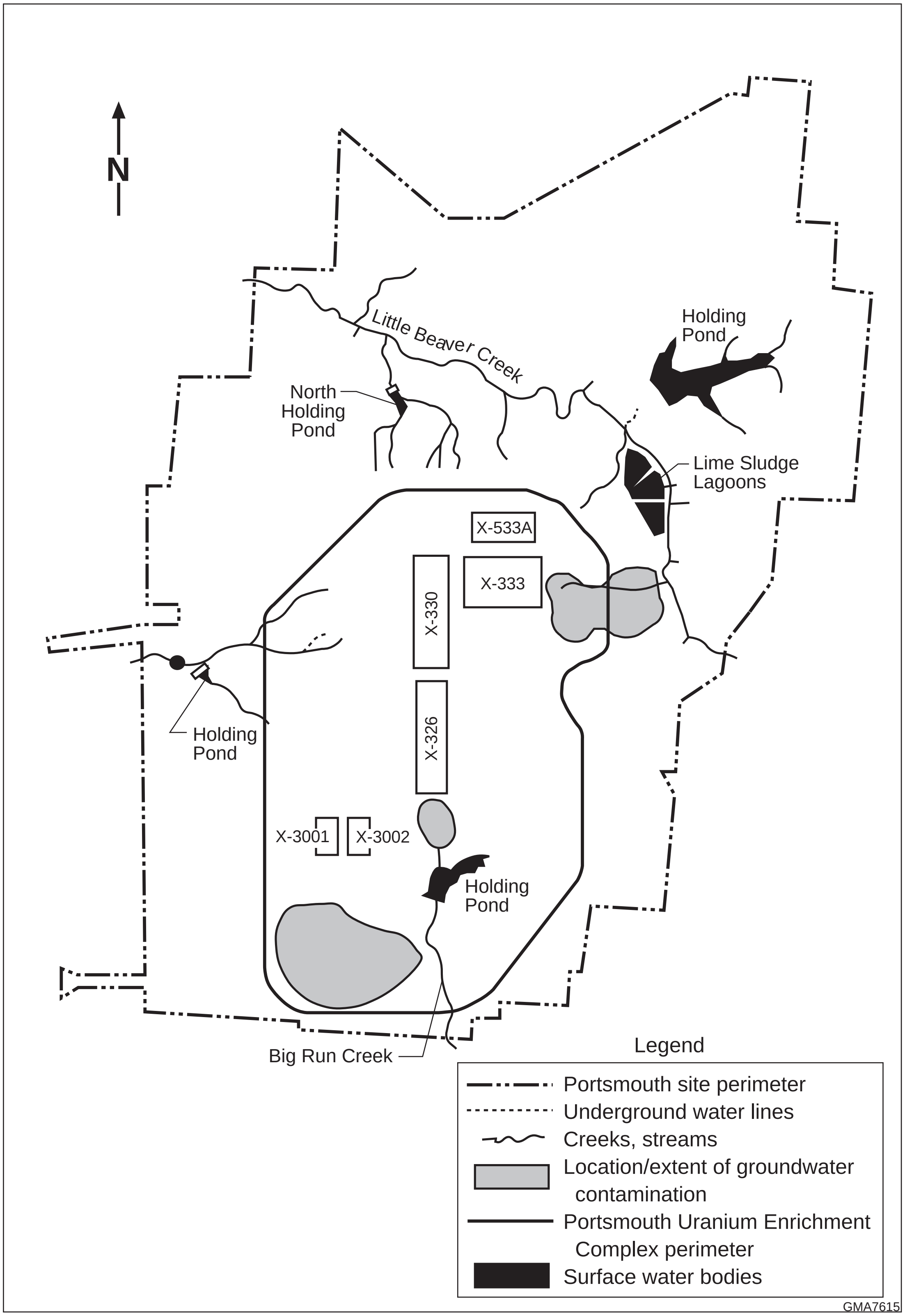

FIGURE 3.6 Locations of Contaminated Groundwater at the Portsmouth Site (Source: LMES 1996b)

3.2.6.3 Wetlands

A wetland survey of the Portsmouth site was conducted in 1995. Approximately 34 acres (13.8 ha) of wetlands occur on the site, excluding retention ponds. Forty-one wetlands meet the criteria for jurisdictional wetlands, while four wetlands are nonjurisdictional (Bechtel Jacobs Company LLC 1998). Wetlands on the site primarily support emergent vegetation that includes cattail, great bulrush, and rush. Palustrine forested wetlands occur on the site along Little Beaver Creek (ANL 1991b). The Ohio State Division of Natural Areas and Preserves has listed two wetland areas near the site as significant wetland communities: (1) a palustrine forested wetland, about 5 miles (8 km) east of the site, and (2) Givens Marsh, a palustrine wetland with persistent emergent vegetation, about 2.5 miles (4 km) northeast of the site.

3.2.6.4 Threatened and Endangered Species

No federal-listed plant or animal species are known to occur on the Portsmouth site. The Indiana bat, federal- and state-listed as endangered, has been reported in the site area and may occur on the site during spring or summer in breeding colonies. Roosting and nursery sites may include forested areas with loose barked trees (such as shagbark hickory) and standing dead trees (DOE 1995c).

The sharp-shinned hawk, listed by the State of Ohio as endangered, has been sighted occasionally at the Portsmouth site and has been observed foraging on the site (ANL 1991b). A population of long-beaked arrowhead, a wetland plant listed by the state as threatened, occurs just north of the site.

3.2.7 Public and Occupational Health and Safety

3.2.7.1 Radiation Environment

Operations at the Portsmouth site result in radiation exposures of on-site workers and members of the general public (Table 3.8). The total radiation dose to an off-site member of the public as a result of gaseous diffusion plant operations is estimated to be 0.07 mrem/yr, which is less than 0.02% of the average dose of 360 mrem/yr that an individual in the United States receives each year from natural background and medical sources of radiation.

Radiation exposures of the cylinder yard workers include exposures from activities performed outside the cylinder yards. The average dose ranged from 55 to 196 mrem/yr between 1990 and 1995 (Hodges 1996), considerably below the maximum dose limit of 5,000 mrem/yr set for workers (10 CFR Part 835).

TABLE 3.8 Estimated Radiation Doses to Members of the General Public and to Uranium Material Handlers at the Portsmouth Gaseous Diffusion Plant

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides	0.016[b]
	Waterborne radionuclides	0.006[c]
	Direct gamma radiation	~0[d]
	Ingestion of foodstuffs	~0.044[e]
Uranium material handler[f]	External radiation	55 – 196[g]
Member of public or worker	Natural background radiation and medical sources	360[h]
DOE worker limit		2,000[i]

[a] The MEI was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were estimated using air concentrations calculated by an air dispersion model (LMES 1996b).

[c] The MEI was assumed to use the Scioto River as a source of drinking water and for fishing and recreation (LMES 1996b).

[d] Radiation levels around the site could result in doses about the same as those from off-site radiation levels (LMES 1996b).

[e] Radiation doses could result from consumption of locally produced foodstuffs (including fish caught in the Scioto River). Estimated doses were obtained by subtracting doses from airborne and waterborne radionuclides from the total dose (0.07 mrem/yr) received by the MEI (LMES 1996b).

[f] Uranium material handlers at the Portsmouth plant perform feed and withdrawal operations, cylinder movements, inspections, and radiation surveys (Hodges 1996).

[g] Range of annual average doses from years 1990 through 1995 (Hodges 1996).

[h] Average dose to a member of the U.S. population as estimated in Report No. 93 of the NCRP (1987b).

[i] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

3.2.7.2 Chemical Environment

The estimated hazard quotients for MEIs under existing environmental conditions near the Portsmouth site are listed in Table 3.9. These hazard quotients indicate that exposures to uranium, fluoride, and chromium for members of the general public near the Portsmouth site are much lower than those that might be associated with deleterious health effects. Portsmouth worker exposures are kept below the proposed OSHA permissible exposure limits (PELs) for uranium compounds and HF in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998) (see Section 3.1.7.2).

3.2.8 Socioeconomics

The socioeconomic environment of the Portsmouth site was assessed in terms of regional economic activity, population and housing, and local public finances. The ROI consists of Jackson, Pike, Ross, and Scioto Counties in Ohio; 92.4% of employees at the site currently reside in these counties, with 46% residing in Scioto County (DOE 1996b). Allison and Folga (1997) provide a listing of the cities and school districts in each county within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

3.2.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 75,600 to 81,000, an increase of 7.1%. Within the ROI, the largest percent employment increase occurred in Pike County (19.1%). Employment in the ROI is concentrated in Ross and Scioto Counties, which together had 71.1% of the ROI total in 1995. The BEA projects no overall increase in employment in the ROI over the period 1995 to 2020. However, Pike County (2.0%, 200 jobs) and Scioto County (0.4%, 100 jobs) are expected to gain in ROI employment, with losses expected elsewhere (BEA 1996b). Unemployment in the ROI in 1996 was 9.3% (Allison 1996). Employment at the Portsmouth site in 1995 was 2,400 (DOE 1997a), amounting to approximately 3.0% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from \$1.8 billion to \$2.0 billion, an increase of 11%. The largest percent increase occurred in Pike County (41.7%). Personal income is concentrated in Ross and Scioto Counties, which together had 75.1% of total ROI personal income in 1995. The BEA projects a 26.8% increase in ROI personal income from 1995 to 2020 (\$0.5 billion), with the largest increase in Pike County (38.2%, \$0.09 billion) (BEA 1996b).

TABLE 3.9 Estimated Hazard Quotients for Members of the General Public near the Portsmouth Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d]	Uranium	< 0.01 µg/m^3	$< 4.3 \times 10^{-6}$	0.0003	0.0095
	HF	< 0.11 µg/m^3	$< 3.1 \times 10^{-5}$	0.02	0.0016
Soil[e]	Uranium	5.3 mg/kg	7.0×10^{-5}	0.003	0.024
	Chromium	23 mg/kg	3.0×10^{-4}	0.005	0.060
Surface water[f]	Uranium	24 µg/L	1.3×10^{-5}	0.003	0.0044
	Fluoride	600 µg/L	3.3×10^{-4}	0.06	0.0055
Sediments[f]	Uranium	11 mg/kg	3.0×10^{-6}	0.003	0.0010
Groundwater[g]	Uranium	26 µg/L	6.9×10^{-5}	0.003	0.25

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference level. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely.

[d] Property-line sampling locations were used for assessment of general public exposures. Gross alpha was reported, which was used as a surrogate for uranium. Air exposure concentrations are the maximum annual average reported for all property-line and off-site monitoring locations (LMES 1996b).

[e] Soil exposure concentrations are the maximum values from 32 property-line and off-site sampling locations (MMES 1994c).

[f] Surface water and sediment exposure concentrations are the maximum annual averages reported for all NPDES outfall locations and other monitoring locations (MMES 1994c-d).

[g] Groundwater exposure concentration is the maximum concentration reported for on-site monitoring wells (LMES 1997d). These wells are not used for drinking water. Several additional substances exceeded drinking water standards or guidelines in 1996 (see Section 3.2.5.2); listed here are only substances of particular interest for this PEIS. Groundwater fluoride concentrations were not available.

3.2.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 202,900 to 205,200, an increase of 1.1%. The 1995 ROI population was concentrated in Ross and Scioto Counties (73.3%). The BEA projects the ROI population to increase by 9,800 (4.8%) from 1995 to 2020, with the largest increase in Pike County (7.7%, 1,900 people) (BEA 1996b).

3.2.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased 6.5%, from 75,800 to 80,800. Scioto and Ross Counties had 73.1% of the total housing units. Based on BEA (1996b) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the number of vacant owner-occupied units in the ROI is expected to increase from 4,630 to 4,850 and the number of vacant rental units from 1,940 to 2,030.

3.2.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 3.10. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

3.2.9 Waste Management

The Portsmouth site generates several categories of waste, including wastewater, solid LLW, solid and liquid LLMW, nonradioactive hazardous waste, and nonradioactive nonhazardous solid waste. The site has an active program to minimize the generation of solid LLW, hazardous waste, and LLMW. Radioactive waste minimization efforts include segregating radioactive waste from nonradioactive waste; reduction of radiologically controlled areas, thereby reducing the use of disposable personal protective equipment; and improved segregation and handling of laboratory waste. Hazardous and mixed waste minimization actions include the sorting of burnable waste from radioactively contaminated materials, reduction of absorbent cloth use in PCB spill cleanup, reduction in floor sweeping waste, and substitution of materials containing nonhazardous components. Solid waste minimization actions include the recycling of corrugated cardboard and aluminum.

3.2.9.1 Wastewater

Wastewater at Portsmouth consists of nonradioactive sanitary and process-related wastewater streams, cooling water blowdown, radioactive process-related liquid effluent, discharges

TABLE 3.10 Summary of Financial Characteristics for the Portsmouth Site County, City, and School District Regions of Influence

Category	Finances[a] ($ million) ROI Counties	Finances[a] ($ million) ROI Cities	Category	Finances[a] ($ million) ROI School Districts
Revenues			**Revenues**	
Local sources	18.1	13.1	Local sources	22.8
Fines, fees, permits, etc.	3.3	3.2	State sources	33.6
Intergovernmental	3.7	4.1	Federal sources	4.6
Other	3.0	3.4	Other	0.2
Total	28.1	23.8	Total	61.2
Expenditures			**Expenditures**	
General government	12.1	6.7	Administration	0.0
Safety, health, community services	8.6	14.3	Instruction	36.9
			Services	23.4
Debt service	0.0	0.0	Physical plant	0.4
Other financing sources	7.6	2.5	Other	2.0
Total	28.3	23.6	Total	62.8
Revenues less Expenditures	-0.2	0.2	**Revenues less Expenditures**	-1.6

[a] Data for fiscal year ending December 31, 1994.

Sources: see Allison and Folga (1997).

from groundwater treatment systems, and storm-water runoff from plant areas, including runoff from the coal pile. Wastewater is processed at several on-site treatment facilities and is discharged to either the Scioto River or its immediate tributaries, including Little Beaver Creek, through 21 outfalls identified under the site NPDES permit. Treatment facilities include an activated sludge sewage treatment plant; several facilities that employ waste-specific pretreatment technologies (e.g., pH adjustment, activated carbon adsorption, metals removal, denitrification, and ion absorption); and numerous settling basins designed to facilitate solids settling, oil collection, and chlorine dissipation. In 1993, about 4.3 million gal/d (16 million L/d) of wastewater was discharged through the permitted outfalls. The site wastewater facilities are used at about 80% of a total capacity of approximately 5.3 million gal/d (20 million L/d) (DOE 1996g).

3.2.9.2 Solid Nonhazardous, Nonradioactive Waste

Solid waste — including sanitary refuse, cafeteria waste, industrial waste, disinfected medical waste (excluding drugs), and construction and demolition wastes — is collected and disposed of on-site at the X-735 sanitary landfill. Disposal is in shallow trenches covered with earthen fill. The site operates the landfill under an annual permit issued by Pike County, Ohio. No RCRA hazardous waste, PCB waste, or radioactive materials are allowed in the landfill. Asbestos waste is disposed of in specially designated areas of the sanitary landfill. In 1993, the landfill load was 236,000 yd^3 (180,000 m^3), which represented 86% of the landfill capacity of 273,000 yd^3 (209,000 m^3) (DOE 1996g).

Materials, such as certain construction and demolition debris, that are not regulated as solid waste by the state of Ohio are disposed of at the Portsmouth X-736 construction spoils area, located immediately west of the sanitary landfill.

3.2.9.3 Nonradioactive Hazardous and Toxic Waste

Nonradioactive waste that is considered hazardous waste according to RCRA or contains PCBs as defined under TSCA requires special handling, storage, and disposal. The Portsmouth site generates hazardous waste, including spent solvents and heavy-metal-contaminated waste, and PCB-contaminated toxic waste. As of 1994, Portsmouth had a RCRA Part B permit application pending before the Ohio Environmental Protection Agency. Portsmouth provides long-term on-site storage for hazardous waste at the X-7725 and X-326L RCRA container storage units. Several additional 90-day satellite storage areas are available for temporary storage of hazardous waste. In 1993, the site had 7,200 yd^3 (5,500 m^3) of hazardous waste in storage; site storage capacity is 9,700 yd^3 (7,400 m^3) (DOE 1996g).

Hazardous waste is sent to permitted off-site contractors for final treatment and/or disposal. Annual generation of solid hazardous waste ranged from 130 to 160 yd^3/yr (100 to 120 m^3/yr) in 1991 and 1992, respectively. Much of the hazardous waste load consists of PCB-contaminated waste. The site has over 2×10^6 lb (900,000 kg) of PCBs in various site electrical equipment in both active and inventory equipment (1993 data). In 1992, about 325 yd^3 (250 m^3) of hazardous organic liquid waste streams was sent to the K-25 site TSCA-approved incinerator. The capacity of the incinerator is 1,800 yd^3/yr (1,400 m^3/yr) (DOE 1996g).

3.2.9.4 Low-Level Waste

LLW generated at the Portsmouth site is stored on-site pending shipment to off-site treatment/disposal facilities. Portsmouth has initiated shipment of some LLW to the Hanford site (Washington) for disposal. Solid LLW generated at the site includes refuse, sludge, and debris contaminated with radionuclides, primarily uranium and technetium. As of 1995, 38,600 yd^3

(29,500 m^3) of LLW was in storage at the Portsmouth site (DOE 1996g). The annual generation of LLW ranged from 2,920 yd^3 (2,230 m^3) in 1991 to 2,160 yd^3 (1,650 m^3) in 1992.

3.2.9.5 Low-Level Mixed Waste

LLW that contains PCBs or RCRA hazardous components is considered to be LLMW. All of the LLMW inventory at Portsmouth is subject to RCRA land disposal restrictions; LLMW is currently stored at the site. Treatment technologies exist for all of the LLMW streams in the Portsmouth inventory. As of 1995, 7,290 yd^3 (5,570 m^3) of mixed waste was in storage at the site. Of this, approximately 18% was derived from operations, and the rest was packaged solvent and/or metals-contaminated soil from environmental restoration activities. Mixed waste generation in 1992 was 510 yd^3 (390 m^3) liquid and 460 yd^3 (350 m^3) solid. In 1992, approximately 558,000 lb (254,000 kg) of organic liquid LLMW was sent to the TSCA incinerator or the K-25 site (DOE 1996g). In 1995 and 1996, approximately 1,300 yd^3 (1,000 m^3) of contaminated soil (LLMW) was shipped to a commercial facility in Utah for disposal.

3.2.10 Cultural Resources

An archaeological survey has been initiated at the Portsmouth site but has not been completed at this time. A survey conducted in 1952 recorded no sites. However, because of the archaeological site density in the surrounding area (over 200 sites have been recorded for Pike County alone), there is potential for discovering sites at Portsmouth using modern archaeological methods.

An inventory of historic buildings has been planned but has not been conducted at the Portsmouth site. It is likely that buildings related to uranium enrichment and atomic weapons manufacture would be eligible for the *National Register of Historic Places*. Two cemeteries, Holt Cemetery and Mount Gilead Cemetery, are located within the boundary of the facility.

No religious or sacred sites, burial sites, or resources significant to Native Americans have been identified at the Portsmouth site to date.

3.2.11 Minority and Low-Income Populations

The affected environment for assessing the potential for depleted UF_6 management activities to result in environmental justice impacts was based on data from the U.S. Bureau of the Census (1992a-b). The population residing within a 50-mile (80-km) radius of the Portsmouth site consists of 3.2% minorities and 20.7% persons with low income (see Appendix C, Section C.8.1).

3.3 K-25 SITE AT OAK RIDGE

The K-25 site is part of the Oak Ridge Reservation, which is located in Anderson and Roane Counties, Tennessee, approximately 25 miles (40 km) west of the city of Knoxville (Figure 3.7). The reservation consists of three major facilities — the K-25 site, Oak Ridge National Laboratory, and Y-12 plant (Figure 3.8) — and surrounding property. The 1,700-acre (688-ha) K-25 site contains the Oak Ridge Gaseous Diffusion Plant, which has been inactive since 1985. Currently, the primary mission of the K-25 site is environmental restoration and waste management activities (MMES 1994f).

Anderson County and the City of Oak Ridge have developed planning documents to control land use. Anderson County's comprehensive plan was created in 1982, and the City of Oak Ridge updated its comprehensive plan in 1988. Roane County has not formally developed or adopted a comprehensive or master plan.

The K-25 site includes more than 300 buildings with a combined floor space of 13 million ft^2 (1.2 million m^2) (MMES 1994f). Site management, in conjunction with DOE's land management policy, is currently pursuing an option to lease a 957-acre (387-ha) parcel of site land to the Community Reuse Organization of East Tennessee. The K-25 parcel, which is located

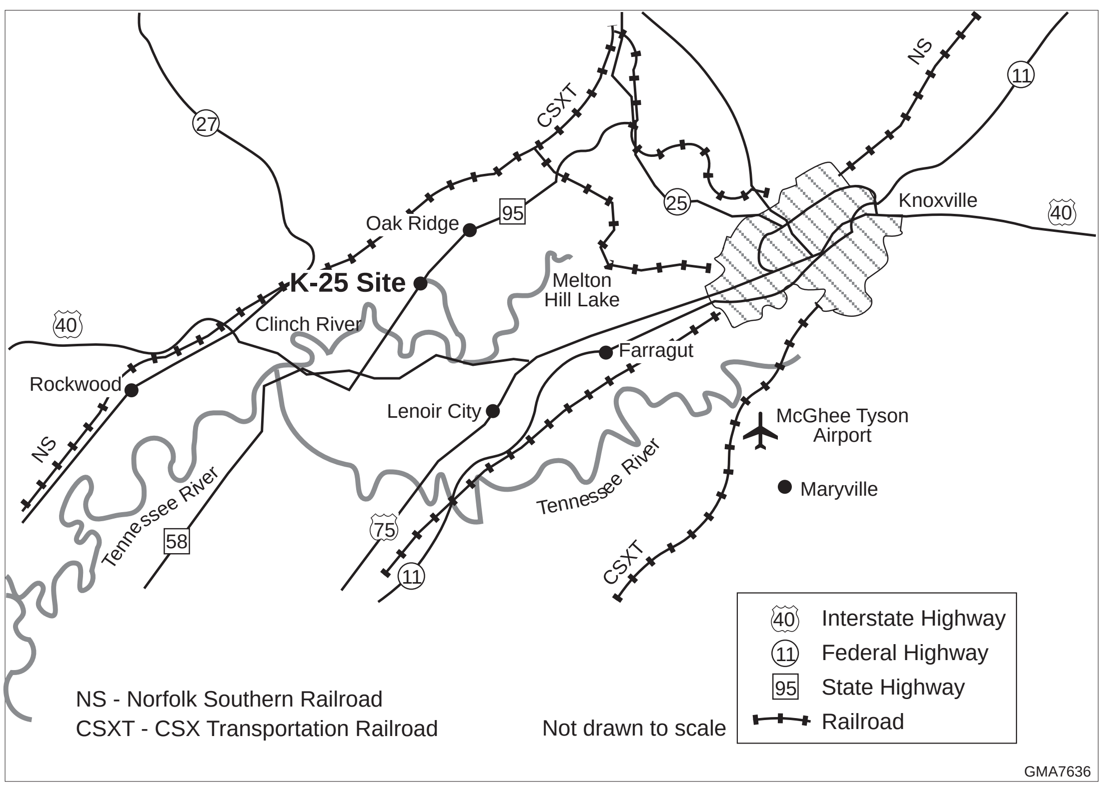

FIGURE 3.7 Regional Map of the K-25 Site Vicinity (Source: Adapted from ANL 1991c)

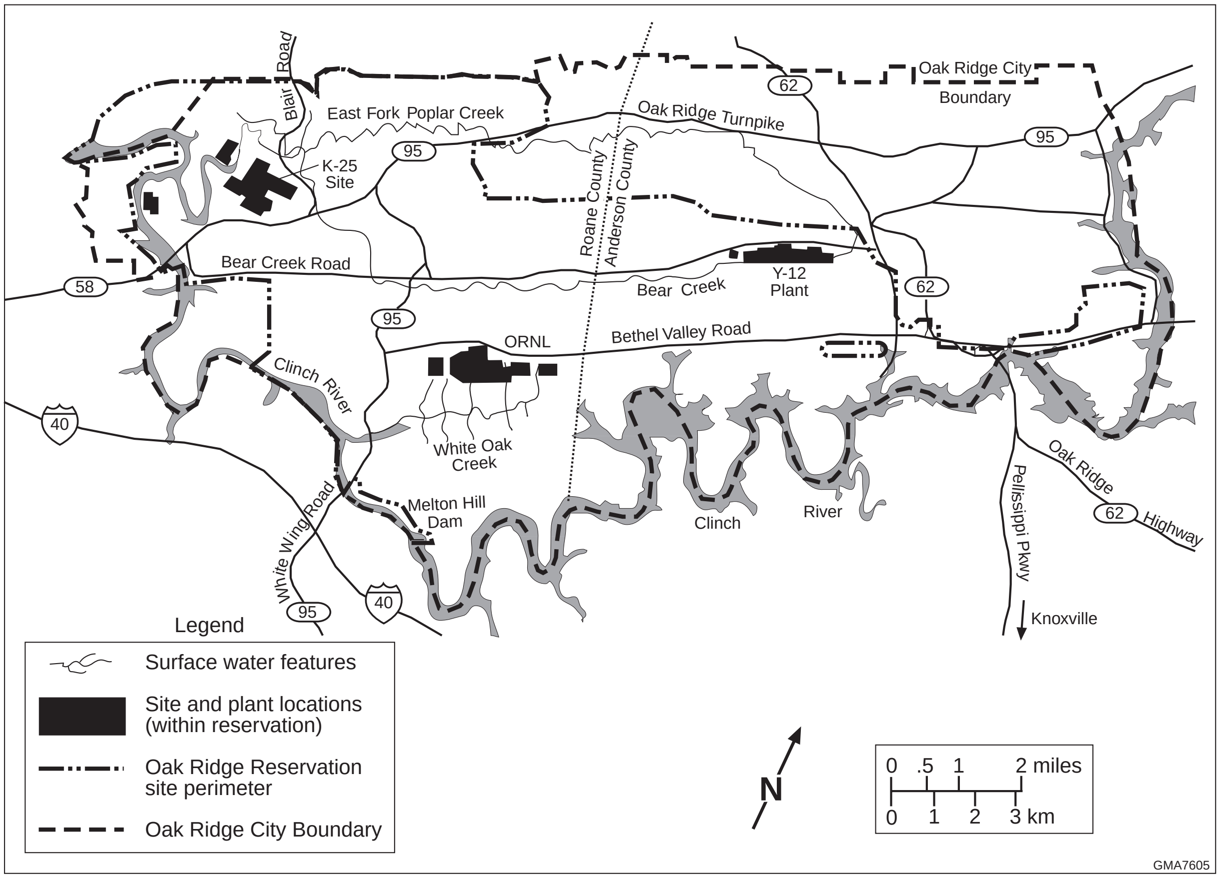

FIGURE 3.8 Map of the Oak Ridge Reservation (Source: MMES 1994f)

northeast of the core area, would be used as an industrial park, a use that is compatible with current site development plans. The Oak Ridge Reservation has a master plan that is updated every 5 years.

In 1989, the Oak Ridge Reservation was placed on the NPL, meaning that CERCLA cleanup requirements would be met in conducting remediation efforts. Several operable units (groups of similar potentially contaminated units) have been identified at the Y-12 plant, 20 waste area groupings (similar to operable units) have been identified at Oak Ridge National Laboratory, and 15 operable units have been identified at the K-25 site. Hazardous waste and mixed waste management at the Oak Ridge Reservation must also comply with RCRA regulations. The Oak Ridge Reservation FFA was developed to integrate CERCLA/RCRA requirements into a single remediation procedure. The discussion of affected environment in this PEIS focuses on conditions and contaminants pertinent to depleted UF_6 cylinder management. Some K-25 sitewide information from ongoing CERCLA/RCRA investigations is also included to put environmental conditions in the current depleted UF_6 cylinder storage areas into the context of sitewide conditions.

3.3.1 Cylinder Yards

There are 4,683 depleted UF_6 storage cylinders located in three K-25 site cylinder yards (Table 3.11; Figure 3.9). Cylinders are stacked two high to conserve storage yard space. The K-1066-K yard (K-yard) currently contains the most cylinders (2,945); it is constructed of concrete and crushed stone. Due to historical poor drainage conditions in K-yard, all cylinders in the K-yard are currently inspected annually. Most of the remaining K-25 site cylinders (1,716) are stored in the K-1066-E yard (E-yard), which is constructed of concrete; the K-1066-L yard (L-yard) contains only 22 cylinders. The E-yard and L-yard cylinders are inspected once every 4 years.

Four breached cylinders were discovered at the K-25 site in early 1992; two were located in K-yard and two in E-yard. The cause of the K-yard breaches seemed to be external corrosion from poor storage conditions, whereas the cause of the E-yard breaches could be attributed to handling damage and subsequent corrosion at the damaged points. The hole diameters for three of the breached cylinders ranged from 2 to 10 in. (5 to 25 cm); the dimensions of the fourth breach, the largest (an E-yard breached cylinder), were approximately 17 in. × 12 in. (43 cm × 30 cm). The four breached cylinders have been patched to restore their integrity, segregated from the other cylinders in K- and E-yards, and placed under temporary awnings. Because equipment to weigh the cylinders was not available at the K-25 site, the extent of material loss from these cylinders could not be determined.

One additional cylinder breach occurred in 1998 during the course of cylinder maintenance operations (i.e., surface preparation and painting). The breach was patched to prevent material loss from the cylinder.

3.3.2 Site Infrastructure

The K-25 site is located in an area with a well-established transportation network. The site is near two interstate highways, several U.S. and state highways, two major rail lines, and a regional airport (Figure 3.7).

Water is supplied to the K-25 site through a pumping station on the Clinch River. The water is treated and stored in two storage tanks. This system, with a capacity of 4 million gal/d (15 million L/d), also provides water to the Transportation Safeguards Facility and the K-25 site. Average water consumption for these three facilities in 1994 was 2 million gal/d (8 million L/d) (DOE 1995a).

Electric power is supplied by the Tennessee Valley Authority. The distribution of power is managed through the K-25 Power Operations Department. The average demand for electricity by all of the Oak Ridge DOE facilities, including the K-25 site, is approximately 100 MVa. The maximum capacity of the system is 920 MVa (DOE 1995a). Natural gas is supplied by the East Tennessee Natural Gas Company; the current daily capacity of 7,600 decatherms is capable of being increased, if necessary. The average daily usage in 1994 was 3,600 decatherms (DOE 1995a).

TABLE 3.11 Locations of DOE Depleted UF_6 Cylinders at the K-25 Site[a]

Yard	Area (ft^2)	Number of Cylinders
K-1066-K	134,825	2,945
K-1066-E	157,376	1,716
K-1066-L	43,824	22

[a] Locations of cylinders as of May 1996.

Source: Cash (1996).

3.3.3 Ambient Air Quality and Airborne Emissions

The affected environment for air quality at the K-25 site was generally considered to be the EPA-defined AQCR. The EPA has designated the K-25 site as being in the Eastern Tennessee-Southwestern Virginia Interstate AQCR in EPA Region 4. The EPA classifies this AQCR as an attainment area for all six NAAQS criteria pollutants.

The State of Tennessee has adopted NAAQS, which are presented in Table 3.12. In addition to the standards for criteria pollutants, the Tennessee Department of Environment and Conservation (TDEC) has adopted regulations to provide guidance for evaluating HAPs and air toxics that specify permissible short-term and long-term concentrations of various contaminants ("Hazardous Air Contaminants," *Air Pollution Control Regulations*, Chapter 11). The TDEC list is the same as the

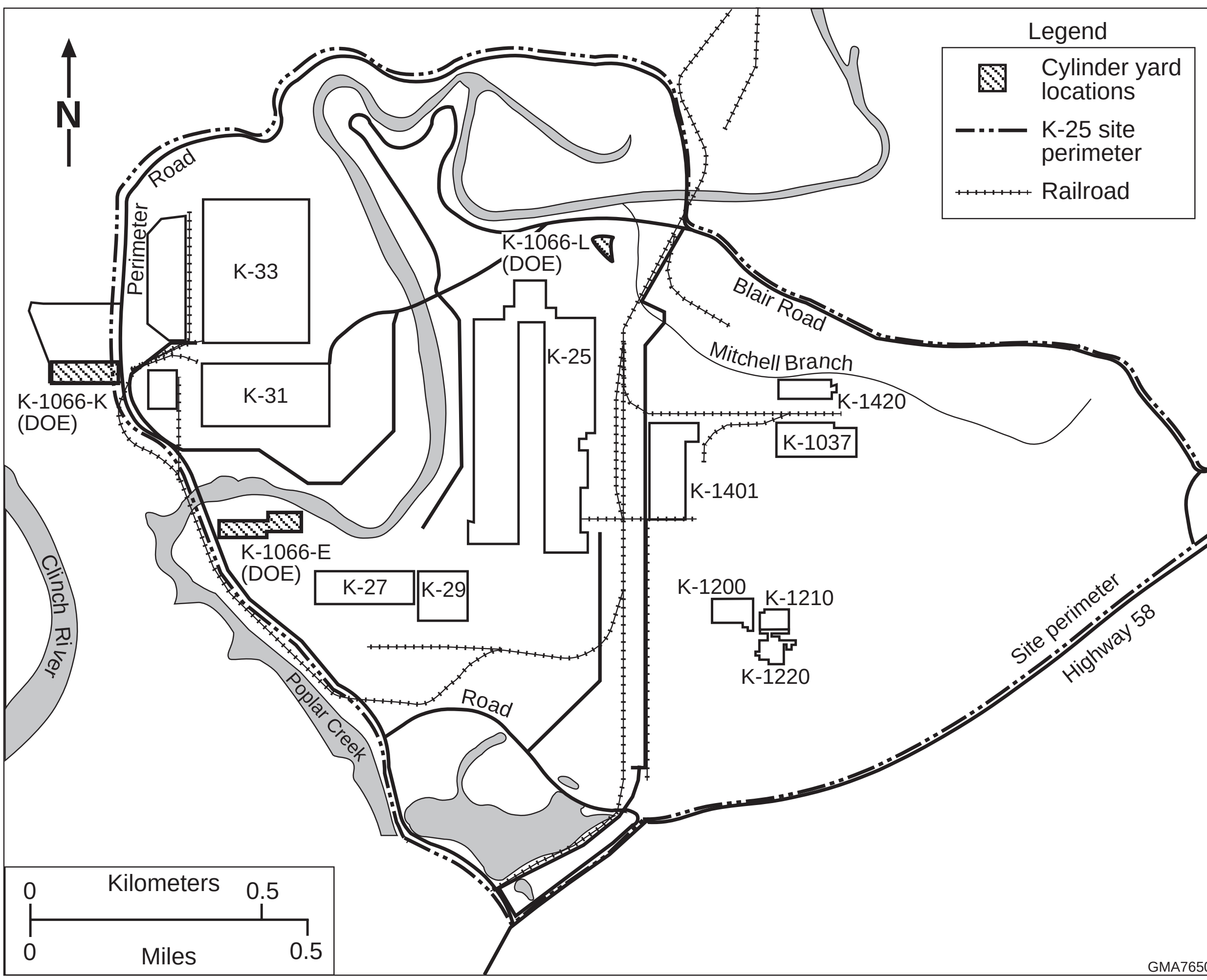

FIGURE 3.9 Locations of Cylinder Yards at the K-25 Site That Are Used to Store DOE Cylinders (Source: Adapted from MMES 1994a and LMES 1996c)

189 HAPs listed in Section 112(b) of the *Clean Air Act Amendments* (42 USC Parts 7401–7626). Emission standards for these HAPs are established in NESHAPS (40 CFR Part 61).

Ambient air quality is monitored in Anderson and Roane Counties by the Tennessee Division of Air Pollution Control. During 1992, no violations were recorded at the ozone monitor on the Oak Ridge Reservation or in nearby Nancy's Grove.

Although uranium enrichment activities at K-25 were discontinued in 1987, ambient air monitoring for uranium, PM_{10}, and several metals has continued at six on-site and off-site locations, with samples collected weekly; fluoride monitoring has been discontinued. As of 1996, monitoring was discontinued at four of the locations after review and concurrence by DOE and the Tennessee Department of Environmental Conservation (LMES 1997b).

For the period 1994 through 1996, the maximum annual average concentration of uranium for the six monitoring locations was 0.00039 $\mu g/m^3$ at Station K2 (LMES 1995a, 1996d, 1997b). The maximum annual average PM_{10} concentration for the same time period was 24.3 $\mu g/m^3$ (40% of the Tennessee and national primary and secondary standards); the maximum quarterly lead concentration was 0.0076 $\mu g/m^3$ (0.5% of the Tennessee and national primary and secondary standards) (LMES 1995a, 1996d, 1997b).

Steam plant emissions have accounted for most of the criteria pollutant emissions at the K-25 site (LMES 1995a). In 1994, all estimated emissions were less than the allowable ones. The K-25 site also contains a TSCA incinerator. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Estimated emissions from the incinerator are significantly less than the permitted allowable emissions.

TABLE 3.12 Tennessee Ambient Air Quality Standards

Pollutant	Tennessee Standard[a] Primary	Tennessee Standard[a] Secondary
Carbon monoxide (CO)		
1-hour average	35.0 ppm	35.0 ppm
8-hour average	9.0 ppm	9.0 ppm
Sulfur dioxide (SO_2)		
3-hour average	–[b]	0.50 ppm
24-hour average	0.14 ppm	–
Annual arithmetic mean	0.03 ppm	–
Particulate matter (PM_{10})		
24-hour	150 $\mu g/m^3$	150 $\mu g/m^3$
Annual geometric mean	50 $\mu g/m^3$	50 $\mu g/m^3$
Ozone (O_3)		
1-hour average	0.12 ppm	0.12 ppm
Nitrogen dioxide (NO_2)		
Annual arithmetic mean	0.05 ppm	0.05 ppm
Lead (Pb)		
Quarterly average	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$
Gaseous fluorides (as HF)		
12-hour average	4.5 ppb	4.5 ppb
24-hour average	3.5 ppb	3.5 ppb
7-day average	2.0 ppb	2.0 ppb
30-day average	1.5 ppb	1.5 ppb

[a] Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year, unless noted.

[b] A hyphen (–) indicates no standard available for this averaging period.

Source: DOE (1996g).

3.3.4 Geology and Soil

3.3.4.1 Topography, Structure, and Seismic Risk

The topography of the K-25 site is varied; the maximum change in elevation across the site is about 420 ft (130 m). The site is underlain by sedimentary rocks composed of limestone and dolomite. Sinkholes, large springs, and other karst features can occur in the limestone formations adjacent to the site (DOE 1995a).

The most important structural feature near the site is a system of three faults: the Whiteoak Mountain Fault, which runs through the southeastern corner of K-25; the Kingston Fault, a parallel fault that occurs north of Poplar Creek; and the Copper Creek Fault, located in Melton Valley. A branch of the Whiteoak Mountain Fault originates just south of the site and runs due north through its center. None of these faults appear to have any topographic expression, and it is assumed that displacement took place prior to the development of the current surface of erosion (DOE 1979). Because no surface movement has occurred along these faults for more than 35,000 years and there has been no movement of a recurring nature within the past 500,000 years, the faults are not considered to be capable. Therefore, the evaluation-basis earthquake for this site was designated by DOE to have a return period of 1,000 years. For K-25, an earthquake that has a 1,000-year return period would have a horizontal top-of-soil acceleration of 0.2 times the acceleration of gravity. Such an earthquake could occur with equal probability any time during the 1,000-year period. For these conditions, slope stability and soil liquefaction (loss of shear strength) would not be problems, and rocking and rolling-out of cylinders would not occur for single or multiple-stacked cylinders (LMES 1997h).

The seismic hazards at the K-25 site have been analyzed and documented in a SAR completed in March 1997 (see Sections 1.5 and 3.4 in LMES 1997h). The results presented in the SAR indicate that continued storage of depleted UF_6 cylinders at the K-25 site is safe. The results of the SAR analyses were used for the accident analyses in this PEIS (see Appendix C, Section C.4.2). A spectrum of accidents was considered, ranging from those having a high probability of occurrence but low consequences to those having high consequences but a low probability of occurrence. Natural phenomena accidents including earthquakes, floods, and tornadoes were among the accidents considered.

3.3.4.2 Soil

Soil and groundwater data have been collected to determine whether contamination is associated with the K-25 cylinder yards (DOE 1994a). Substances in soil possibly associated with cylinder management activities are uranium and fluoride compounds, which could be released to soil if breached cylinders or faulty valves were present. In 1991, 122 systematic soil samples were collected at the K-yard; these samples had maximum concentrations of 0.14 mg/kg uranium-235 and

13 mg/kg uranium-238. Soil samples collected in March 1992 at the K-yard had a maximum uranium concentration of 36 ± 2 mg/kg.

In 1994, 200 systematic and 28 biased soil samples were collected in areas surrounding the cylinder yards; the maximum concentrations detected in these samples were 0.83 mg/kg uranium-235 at K-1066-F yard (F-yard) and 75 mg/kg uranium-238 at E-yard. Groundwater concentrations of total uranium (measured as gross alpha and gross beta) for upgradient and downgradient wells have indicated that although some elevated levels of uranium have been detected in cylinder yard soil, no migration to groundwater has occurred (DOE 1994a). The cause of the isolated elevated uranium-238 level in soil was not identified.

Soil samples collected as part of general site monitoring at K-25 and the immediate surrounding area in 1994 had the following maximum concentrations: uranium, 6.7 mg/kg; Aroclor 1254 (a PCB), 0.16 mg/kg; cadmium, 0.34 mg/kg; mercury, 0.15 mg/kg; and nickel, 33 mg/kg (LMES 1996c). Fluoride was not analyzed in the soil samples, but it is naturally occurring and of low toxicity. Concentrations of uranium in 1995 and 1996 soil monitoring were lower (LMES 1996d, 1997b).

As part of ongoing CERCLA/RCRA investigations for the K-25 site, several areas of soil have been identified as contaminated with radionuclides and/or chemicals. However, this contamination is not associated with the depleted UF_6 cylinder yards, and remediation is being implemented as a part of ongoing CERCLA/RCRA activities at the site.

3.3.5 Water Resources

The affected environment for water resources consists of surface water within and in the vicinity of the site boundary and groundwater beneath the site. Analyses of surface water, stream sediment, and groundwater samples has indicated the presence of some contamination resulting from previous gaseous diffusion plant operations. Although several contaminants are present in the water, only small amounts of uranium and fluoride compounds are related to releases from the cylinders.

3.3.5.1 Surface Water

The K-25 site is located near the confluence of the Clinch River (a tributary of the Tennessee River) and Poplar Creek (Figure 3.10). There are effluent discharge points on both Poplar Creek and the Clinch River and two water withdrawal points on the Clinch River (DOE 1979).

Because of the presence of the Melton Hill and Watts Bar Dams, the hydrology of the Clinch River-Poplar Creek system near K-25 is very complex. In the vicinity of K-25, most of the facilities are free of flood hazards for both the 100-year and 500-year maximum probable floods in Poplar Creek (Rothschild et al. 1984).

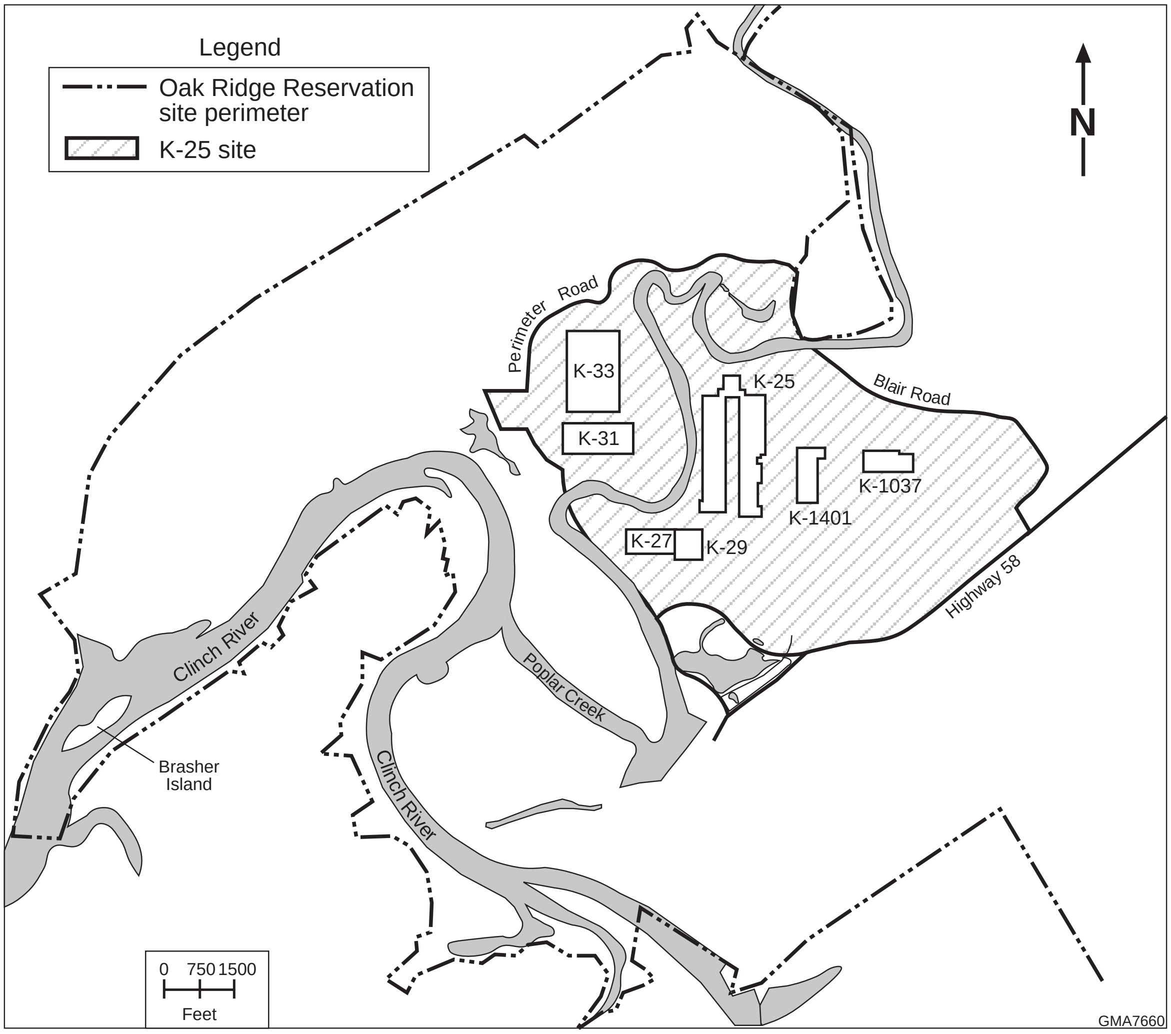

FIGURE 3.10 Locations of Surface Water Bodies near the K-25 Site

As of 1996, surface water monitoring at K-25 has been conducted at five locations (LMES 1997b). The K-1710 sampling location provides information on surface water conditions upstream of K-25. Station K-716 is downstream of most of the K-25 operations and provides information on the cumulative effects of K-25 operations. The remaining sampling locations are at points where drainage in the major surface water basins converge before discharging to Poplar Creek.

Samples from the K-25 site are analyzed monthly for radionuclides; quarterly samples are collected and analyzed for general water quality parameters, selected metals, and organic compounds (LMES 1997b). Uranium levels have been considerably below permitted levels based on radiological standards. In most instances, results for nonradiological parameters are considerably below their applicable Tennessee water quality standards. In 1994, zinc, which occurs naturally in the soils of the area, was detected just above the limit in one sample from the K-1700 sampling location (LMES

1995a). Lead, nickel, and mercury were occasionally detected but always at low concentrations. In general, analytical results for samples collected upstream of K-25 are chemically similar to those collected downstream of the site.

Sediment sampling has also been performed at points that coincide with the K-25 water sampling locations. These samples were analyzed for uranium and other parameters. For 1994, the following maximum concentrations were measured: uranium, 43 µg/g; mercury, 6 µg/g; nickel, 89 µg/g; and Aroclor 1254, 10 µg/g (LMES 1996c).

3.3.5.2 Groundwater

Groundwater in the vicinity of the K-25 site occurs in a surficial aquifer and in bedrock aquifers. The surficial aquifer is made up of man-made fill, alluvium, and the residuum of weathered bedrock (Geraghty & Miller 1989b). The depth to unweathered bedrock varies from less than 10 ft (3 m) to more than 50 ft (15 m), depending on the characteristics of the underlying rocks. Bedrock aquifers in the area are composed of sandstones, siltstones, shales, dolostones, and limestones. The uppermost bedrock aquifer occurs in the Chickamauga Group. Shale beds restrict groundwater flow in the aquifer, resulting in concentrated flow along the limestone-shale contact, with resultant solution cavities. The next lower aquifer occurs in the Knox Group, which is composed of dolostone with interbeds of limestone. Solution features such as sinkholes and caverns are common and are an important route for groundwater flow. This unit is the principal aquifer on the K-25 site (Rothschild et al. 1984).

In 1994 and 1995, groundwater samples were collected from a network of between 200 and 225 monitoring wells at the K-25 site (LMES 1995a, 1996d). The number of wells monitored was greatly decreased in 1996, based on reorganization of the site into six watersheds and reduced monitoring requirements (LMES 1997b). In the 1994 and 1995 sampling conducted for the larger network of monitoring wells, the following substances were detected at levels exceeding their associated primary drinking water standards: antimony, arsenic, barium, cadmium, chromium (up to 0.741 mg/L), fluoride (only at 2 wells), lead, nickel (up to 0.626 mg/L), thallium (up to 0.021 mg/L), benzene (up to 6 µg/L), carbon tetrachloride, 1,1-dichloroethene (greater than 1,000 µg/L), chloroform, 1,2 dichloroethene (greater than 1,000 µg/L), methylene chloride, toluene (greater than 1,000 µg/L), 1,1,2-trichloro-1,2,2-trifluoroethane (greater than 1,000 µg/L), trichloroethylene (up to 11,000 µg/L), 1,1,1-trichloroethane (up to 140,000 µg/L), 1,1,2-trichlororethane, tetrachloroethene (up to 17 µg/L), vinyl chloride, gross alpha activity (up to 43 pCi/L), and gross beta activity (up to 6,770 pCi/L) (LMES 1995a, 1996d). Aluminum, iron, and manganese also consistently exceeded secondary, non-health-based standards because of the natural geochemical nature of the groundwater underlying the site (LMES 1996d).

Exit-pathway groundwater surveillance monitoring was also conducted in 1994 and 1995 at convergence points where shallow groundwater flows from relatively large areas of the K-25 site and converges before discharging to surface water locations (LMES 1995a, 1996d). The exit pathway monitoring data are representative of maximum groundwater contamination levels associated with the K-25 site to which the general public might possibly have access in the future. For 1994, monitoring indicated that thallium, bis(2-ethylhexyl)phthalate, and trichloroethylene were present in at least one exit pathway well sample at concentrations exceeding primary drinking water standards (LMES 1996c). The following average concentrations of these constituents were measured: thallium, 0.007 mg/L; bis(2-ethylhexyl)phthalate, 0.169 mg/L; and trichloroethylene, 0.008 mg/L. Alpha activity and fluoride levels were also measured but did not exceed reference levels (average concentration was 4.4 pCi/L for alpha activity and 0.4 mg/L for fluoride). For 1995, monitoring indicated that no inorganic or organic substances exceeded primary drinking water standards, but alpha activity exceeded the reference level in one well during the spring sampling event only (level of 17 pCi/L) (LMES 1996d).

3.3.6 Biotic Resources

3.3.6.1 Vegetation

About 65% of the land within a 5-mile (8-km) radius of the K-25 site is forested, although most of the K-25 site consists of mowed grasses. Oak-hickory forest is the predominant community on ridges and dry slopes. Mixed pine forests or pine plantations, many of which are managed, have replaced former agricultural fields. Selective logging occurred over much of the site prior to 1986. Cedar barrens are small communities, primarily on shallow limestone soils, which support drought-tolerant species such as little bluestem, dropseed, eastern red cedar, and stunted oak. A cedar barrens across the Clinch River from the K-25 site may be the best example of this habitat in the state and has been designated a State Natural Area.

3.3.6.2 Wildlife

The high diversity of habitats in the area supports a large number of wildlife species. Ground-nesting species commonly occurring on the K-25 site include the red fox, ruffed grouse, and eastern box turtle. Canada geese are also common in the K-25 area, and most are probably residents (ANL 1991c). Waterfowl, wading birds, and shorebirds are numerous along the Clinch River in its backwaters and in ponds. Two great blue heron rookeries are located north of the K-25 site on Poplar Creek (ANL 1991c). Species commonly associated with streams and ponds include the muskrat, beaver, and several species of turtles and frogs.

The aquatic communities within the Clinch River and Poplar Creek support a high diversity of fish species and other aquatic fauna. Mitchell Branch supports fewer fish species, although the diversity of fish species increased considerably downstream of most K-25 discharges between 1989 and 1995 (LMES 1995a).

3.3.6.3 Wetlands

Numerous wetlands occur in the vicinity of K-25, including three small wetlands along Mitchell Branch (ANL 1991c). Extensive forested wetlands occur along Poplar Creek, East Fork Poplar Creek, Bear Creek, and their tributaries. Shallow water embayments of Melton Hill Reservoir and Watts Bar Reservoir support large areas of palustrine emergent wetlands with persistent vegetation. Forested wetlands occur along these marshy areas and extend into tributaries (DOE 1995a).

3.3.6.4 Threatened and Endangered Species

No federal listed threatened or endangered species are known to occur on the K-25 site. Bachman's sparrow, state-listed as endangered, nests on the Oak Ridge Reservation. Suitable habitat on the reservation includes open pine woods with shrubs and dense ground cover (ANL 1991c). Sharp-shinned hawk and Cooper's hawk, both listed by the state as endangered, forage on the Oak Ridge Reservation. The purple fringeless orchid, state-listed as threatened, occurs in a wetland near the south boundary of the K-25 site and in several areas along Bear Creek and its tributaries southeast of K-25.

3.3.7 Public and Occupational Health and Safety

3.3.7.1 Radiation Environment

Radiation doses to the K-25 cylinder yard workers and to off-site members of the general public are summarized in Table 3.13. Airborne emissions from operations of the K-25 site constitute a small fraction of the emissions from the entire Oak Ridge Reservation and result in approximately 10 times less exposure of the off-site general public than do emissions from the entire reservation. The total radiation dose to the off-site MEI of the general public is estimated to be about 4.5 mrem/yr (LMES 1997b). This dose is much less than the maximum dose limit of 100 mrem/yr set for the general public (DOE Order 5400.5) and a small fraction of the dose from natural background and medical sources of radiation.

Between 1991 and 1995, the average annual dose to cylinder yard workers ranged from 32 to 92 mrem/yr, which is less than 2% of the maximum radiation dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835).

TABLE 3.13 Estimated Radiation Doses to Members of the General Public and to Cylinder Yard Workers at the K-25 Site

Receptor	Radiation Source	Dose to Individual (mrem/yr)
Member of the general public (MEI)[a]	Routine site operations	
	Airborne radionuclides[b]	
	K-25 site only	0.056
	Entire Oak Ridge Reservation	0.45
	Waterborne radionuclides[c]	1.52
	Direct gamma radiation	1[d]
	Ingestion of wildlife	1.58[e]
Cylinder yard worker	External radiation	32 – 92[f]
Member of public or worker	Natural background radiation and medical sources	360[g]
DOE worker limit		2,000[h]

[a] The MEI was assumed to reside at an off-site location that would yield the largest dose. An average person would receive a radiation dose much less than the values shown in this table.

[b] Radiation doses from airborne releases were estimated using an air dispersion model and considered exposures from external radiation, inhalation, and ingestion of foodstuffs. Doses were estimated on the basis of the emission rate from the K-25 site only and from the entire Oak Ridge Reservation (LMES 1997b).

[c] Radiation doses would result from drinking 730 L of water per year provided by the Kingston Municipal Water Plant (0.32 mrem/yr) and ingesting 21 kg of the maximally contaminated fish caught from lower Poplar Creek per year (1.2 mrem/yr) (LMES 1997b).

[d] Radiation doses would result from 250 hours of shoreline activity per year along the banks of Poplar Creek or Clinch River (LMES 1997b).

[e] Radiation doses would result from ingestion of two deer containing the field-derived concentration of cesium-137 (1.5 mrem/yr) and ingestion of eight Canada geese per year with an average cesium-137 concentration of 0.12 pCi/g (0.08 mrem/yr) (LMES 1997b).

[f] Range of annual average doses from years 1991 through 1995 (Hodges 1996).

[g] Average dose to a member of the U.S. population as estimated in Report No. 93 of the NCRP (1987b).

[h] DOE administrative procedures limit DOE workers to 2,000 mrem/yr (DOE 1992), whereas the regulatory dose limit for radiation workers is 5,000 mrem/yr (10 CFR Part 835).

3.3.7.2 Chemical Environment

The estimated hazard quotients for members of the general public under existing environmental conditions near the K-25 site are listed in Table 3.14. The estimated hazard quotients indicate that exposures to uranium compounds, fluoride compounds, and other contaminants near the K-25 site are generally lower than those that might be associated with deleterious health effects (hazard quotient less than 1). An exception is groundwater, where hazard quotients for several substances could exceed the threshold of 1. However, it is highly unlikely that this groundwater will be used as a drinking water source.

Oak Ridge worker exposures are kept below the proposed OSHA PELs for uranium compounds and HF in the workplace (29 CFR Part 1910, Subpart Z, as of March 1998) (see Section 3.1.7.2).

3.3.8 Socioeconomics

The socioeconomic environment of the Oak Ridge K-25 site was assessed in terms of regional economic activity, population and housing, and local public finances. The ROI consists of Anderson, Knox, Loudon, and Roane Counties in Tennessee; 91.3% of employees at the site currently reside in these counties, with 36% residing in Knox County and 33.3% in Anderson County (DOE 1997a). Allison and Folga (1997) provide a list of the cities and school districts in each county within the ROI, together with supporting data for the socioeconomic characteristics described in this section.

3.3.8.1 Regional Economic Activity

Employment in the ROI rose relatively steadily between 1980 and 1995, growing from 242,600 to 311,700, an increase of 28.5%. Within the ROI, the largest percent employment increase occurred in Knox County (31.9%), which had 74.6% of total ROI employment in 1995. The BEA projects a 9.4% increase in employment in the ROI over the period 1995 to 2020 (29,400 jobs), with the largest increase expected to occur in Knox County (10.2%, 23,700 jobs) (BEA 1996c). Unemployment in the ROI in 1996 was 3.7% (Allison 1996). Employment at the site in 1995 was 21,500 (DOE 1996e), amounting to approximately 4.3% of total employment in the ROI.

Personal income in the ROI rose relatively steadily between 1980 and 1995, growing from \$4.7 billion to \$6.7 billion, an increase of 43%. The largest percent increase occurred in Knox County (48.7%), which had 72.3% of total ROI personal income in 1995. The BEA projects a 40.7% increase in ROI personal income from 1995 to 2020 (\$2.7 billion), with the largest increase in Knox County (41.8%, \$2.0 billion) (BEA 1996c).

TABLE 3.14 Estimated Hazard Quotients for Members of the General Public near the K-25 Site under Existing Environmental Conditions[a]

Environmental Medium	Parameter	Assumed Exposure Concentration	Estimated Chronic Intake (mg/kg-d)	Reference Level[b] (mg/kg-d)	Hazard Quotient[c]
Air[d,e]	Uranium	0.0004 µg/m^3	1.1×10^{-7}	0.0003	0.0004
Soil[d]	Uranium	6.7 µg/g	8.9×10^{-5}	0.003	0.03
	Cadmium	0.34 µg/g	4.5×10^{-6}	0.001	0.0045
	Mercury	0.15 µg/g	2.0×10^{-6}	0.0003	0.0067
	Nickel	33 µg/g	4.4×10^{-4}	0.02	0.022
	Aroclor 1254	0.16 µg/g	2.1×10^{-6}	0.00002	0.11
	Aroclor 1254[f]	0.16 µg/g	9.1×10^{-7}	2.0 (slope factor)	1.8×10^{-6} (cancer risk)
Surface water[d]	Uranium	13 µg/L	7.1×10^{-6}	0.003	0.0024
	Fluoride	180 µg/L	9.9×10^{-5}	0.06	0.0016
Sediments[d]	Uranium	43 µg/g	1.2×10^{-5}	0.003	0.0039
	Cadmium	0.38 µg/g	1.0×10^{-7}	0.001	0.0001
	Mercury	6 µg/g	1.6×10^{-6}	0.0003	0.0055
	Nickel	89 µg/g	2.4×10^{-5}	0.02	0.0012
	Aroclor 1254	10 µg/g	2.7×10^{-6}	0.00002	0.14
	Aroclor 1254[f]	10 µg/g	3.9×10^{-7}	2.0 (slope factor)	7.8×10^{-7} (cancer risk)
Groundwater[g]	Uranium	25 µg/L	1.8×10^{-4}	0.003	0.24
	Fluoride	4,000 µg/L	1.1×10^{-2}	0.06	1.9

[a] The receptor was assumed to be a long-term resident near the site boundary or other off-site monitoring location that would have the highest concentration of the contaminant being addressed; reasonable maximum exposure conditions were assumed. Only the exposure pathway contributing the most to intake levels was considered (i.e., inhalation for air and ingestion for soil, sediment, surface water, and groundwater). Residential exposure scenarios were assumed for air, soil, and groundwater analyses; recreational exposure scenarios were assumed for surface water and sediment analyses.

[b] The reference level is an estimate of the daily human exposure level that is likely to be without an appreciable risk of deleterious effects. The reference levels used in this assessment are defined in Appendix C. For carcinogens, the slope factor is also given; slope factors in units of (mg/kg-d)$^{-1}$ are multiplied by lifetime average intake to estimate excess cancer risk.

[c] The hazard quotient is the ratio of the intake of the human receptor to the reference does. A hazard quotient of less than 1 indicates that adverse health effects resulting from exposure to that chemical alone are highly unlikely. For carcinogens, the cancer risk (intake × slope factor) is also given. Increased cancer risks between 10^{-6} and 10^{-4} are considered tolerable at hazardous waste sites; risks less than 10^{-6} are considered negligible.

[d] Exposure concentrations are the maximum annual averages for all monitoring locations (LMES 1995a, 1996c).

[e] HF was not measured.

[f] Parameters analyzed for carcinogenic effects; all other parameters were analyzed for noncarcinogenic effects.

[g] Concentration for uranium is the maximum annual average for all exit pathway monitoring locations because these are the locations where the general public could most likely be exposed in the future. Alpha activity was used as a surrogate measure of uranium concentration. The well-specific concentration for fluoride was not available; the exposure concentration given is actually the drinking water standard. The hazard index for fluoride could therefore exceed that presented. Several additional substances exceeded drinking water standards or guidelines in 1994 and 1995 monitoring; listed here are only substances of particular interest for this PEIS. Data are from LMES (1996c,d).

3.3.8.2 Population

The ROI experienced small increases in population over the period 1980 to 1995, with total population growing from 464,000 to 506,600, an increase of 9.2%. The 1995 ROI population was concentrated in Knox County (69.8%). The BEA projects the ROI population as a whole to increase by 77,200 (15.2%) from 1995 to 2020, with the largest increase in Knox County (15.9%, 56,300 people) (BEA 1996c).

3.3.8.3 Housing

Between 1980 and 1995, the number of housing units in the ROI increased 13.8%, from 181,300 to 206,200. Knox County had 69.6% of the total housing units. Based on BEA (1996c) population forecasts for 1995 to 2020 and U.S. Bureau of the Census (1994) statistics, the number of vacant owner-occupied units in the ROI is expected to increase from 10,190 to 11,750 and the number of vacant rental units from 5,030 to 5,800.

3.3.8.4 Public Finance

The financial characteristics of local public jurisdictions included in the ROI are summarized in Table 3.15. Data are shown for the major revenue and expenditure categories and for the annual fiscal balance of the general fund account for cities, counties, and school districts.

3.3.9 Waste Management

The K-25 site generates industrial and sanitary waste, including wastewater, solid non-hazardous waste, solid and liquid hazardous waste, and radioactive waste. Much of the waste generated at K-25 is by-products of the ongoing environmental remediation efforts at the site. The K-25 site has the capability to treat wastewater and certain radioactive and hazardous waste; other waste treatment facilities that can process and/or dispose of K-25 waste are located at the Y-12 Plant and Oak Ridge National Laboratory. The K-25 waste facilities also store and process waste generated at K-25, as well as waste from Y-12 and Oak Ridge National Laboratory and from other DOE installations at Paducah, Portsmouth, and Fernald. Most radioactive waste at K-25 is contaminated with uranium and uranium decay products, with small amounts of fission products.

The K-25 site is active in the program for waste minimization and recycling at the Oak Ridge Reservation. In 1994, the Oak Ridge Reservation recycled about 700 tons (640 metric tons) of paper, 350 tons (320 metric tons) of cardboard, and 30 to 50 tons (27 to 45 metric tons) of aluminum (LMES 1995a).

TABLE 3.15 Summary of Financial Characteristics for the K-25 Site County, City, and School District Regions of Influence

Category	Finances[a] ($ million) ROI Counties	Finances[a] ($ million) ROI Cities	Category	Finances[a] ($ million) ROI School Districts
Revenues			**Revenues**	
Local sources	66.7	118.6	Local sources	143.6
Fines, fees, permits, etc.	9.1	2.7	State sources	145.7
Intergovernmental	8.9	26.5	Federal sources	3.2
Other	5.4	9.5	Other	1.1
Total	90.1	157.2	Total	323.2
Expenditures			**Expenditures**	
General government	31.5	14.1	Administration	30.2
Safety, health, community services	50.7	91.6	Instruction	189.7
			Services	16.3
Debt service	0.0	2.3	Physical plant	17.2
Other financing sources	1.3	48.6	Other	16.3
Total	83.4	156.6	Total	298.7
Revenues less Expenditures	6.7	0.6	**Revenues less Expenditures**	24.5

[a] Data for fiscal year ending June 30, 1995.

Sources: see Allison and Folga (1997).

3.3.9.1 Wastewater

Treated wastewater at the K-25 site is discharged under NPDES permit TN0002950. In 1994, the discharge was in compliance more than 99% of the time. Sanitary wastewater is processed at the K-1203 sewage treatment plant, which has a capacity of 0.92 million gal/d (3.5 million L/d). In 1994, the average loading to the facility was 0.64 million gal/d (70% of capacity). Currently, there is a project to reline sewer lines to reduce rainfall infiltration (DOE 1996g).

3.3.9.2 Solid Nonhazardous, Nonradioactive Waste

The Oak Ridge Reservation, including the K-25 site, generates about 35,000 yd^3/yr (27,000 m^3/yr) of solid nonhazardous waste. The waste is disposed of at the Y-12 landfill, which has a capacity of 405,000 yd^3 (310,000 m^3) (DOE 1996g). An additional 1.8 million yd^3 (1.4 million m^3)

of capacity will be developed at the landfill. Given current and/or future projected waste loading, the landfill will have approximately 50% of capacity, or 920,000 yd^3 (700,000 m^3), available in the year 2020.

3.3.9.3 Nonradioactive Hazardous and Toxic Waste

The K-25 site generates both RCRA-hazardous and TSCA-hazardous waste. The site operates several RCRA Part B hazardous waste treatment/storage facilities. The majority of the hazardous waste consists of PCB-containing solids and liquids regulated according to TSCA guidelines. In 1992, the site generated 1,124 tons (1,020 metric tons) of PCB waste. The site operates a permitted TSCA incinerator to treat hazardous and LLMW liquids contaminated with PCBs. The incinerator also processes PCB waste from other facilities at the Oak Ridge Reservation and from off-site DOE installations. Total capacity of the TSCA incinerator is 1,800 yd^3/yr (1,400 m^3/yr). The K-25 waste input of 1,300 yd^3/yr (1,000 m^3/yr) (DOE 1996g) represents 70% of incinerator capacity. In 1991, the hazardous waste generation for the Oak Ridge Reservation was 154 yd^3 (118 m^3). On-site storage capacity for hazardous waste is 16,100 yd^3 (12,300 m^3).

3.3.9.4 Low-Level Waste

The K-25 site generated approximately 1,400 yd^3 (1,100 m^3) of solid LLW in 1992. The Oak Ridge Reservation has a compaction/shredding facility with the capacity to treat approximately 1,800 yd^3/yr (1,400 m^3/yr) of LLW. The Oak Ridge Reservation disposed of approximately 1,100 yd^3 (840 m^3) of LLW in 1994. Low-level waste that is not treated or disposed of on-site at the Oak Ridge Reservation is placed in storage, pending either treatment or disposal, or both, at off-site facilities. In 1993, approximately 57,900 yd^3 (44,300 m^3) of LLW was in storage at the K-25 site (DOE 1996g).

3.3.9.5 Low-Level Mixed Waste

The majority of radioactive waste generated at the K-25 site is LLMW. The site LLMW consists of two major categories: (1) aqueous RCRA-hazardous radioactive waste contaminated with corrosives or metals and (2) organic liquids contaminated with PCBs. About 4,000 yd^3 (3,000 m^3) of contaminated soil (LLMW) is stored at the Oak Ridge Reservation.

In 1992, the K-25 site generated 100,000 yd^3 (76,000 m^3) of liquid LLMW. Aqueous LLMW is treated at the K-1407H central neutralization facility, which processes aqueous waste by pH adjustment of corrosives and chemical precipitation of metals. Treated wastewaters are discharged to the NPDES-permitted discharges, which have a capacity of 450,000 yd^3/yr (340,000 m^3/yr). The K-25 TSCA incinerator, with a capacity of 1,800 yd^3/yr (1,400 m^3/yr), is used to treat organic LLMW liquids contaminated with PCBs. Total K-25 input to the TSCA incinerator (both PCB-contaminated radioactive and nonradioactive waste) is approximately 1,300 yd^3/yr (1,000 m^3/yr).

The K-25 site has the capability to treat approximately 6,500 yd^3/yr (5,000 m^3/yr) of liquid LLMW via grout stabilization. The site currently stores 38,000 yd^3 (29,000 m^3) of grouted LLMW (DOE 1996g), with a capacity for 88,600 yd^3 (67,800 m^3) of LLMW container storage. The current inventory of LLMW stored at the Oak Ridge Reservation (and the K-25 site) is proposed to be treated in Oak Ridge Reservation facilities. The planned waste treatment will require more than 20 years to complete (LMES 1995b).

3.3.10 Cultural Resources

An archaeological survey was completed at the K-25 site during 1994. This survey confirmed findings of previous surveys of the Oak Ridge Reservation, which had identified 45 prehistoric sites, 10 of which are potentially eligible for the *National Register of Historic Places*. Twelve of the sites are located near the K-25 site (Fielder 1974). More than 240 historic resources have also been recorded at the Oak Ridge Reservation; six are listed on the *National Register*, and 20 or more may be eligible.

The K-25 site was associated with the Manhattan Project and played a significant role in the production of highly enriched uranium for weapons manufacture between 1944 and 1964. Buildings at the K-25 site were evaluated in 1994. One historic district, the Main Plant Historic District, is eligible for the *National Register*. The district consists of 157 buildings, of which 120 buildings contribute to the district and 37 do not. Eleven additional buildings not adjacent to the district are also considered eligible based on their supporting roles in the uranium-235 enrichment process. The George Jones Memorial Baptist Church and Cemetery (established 1901) is also located on the K-25 site and is included in the *National Register*.

On May 6, 1994, a programmatic agreement concerning management of historic properties on the Oak Ridge Reservation was signed by the DOE Oak Ridge Operations Office, the Advisory Council on Historic Preservation, and the Tennessee State Historic Preservation Officer. This agreement concerned management of significant cultural resources that meet eligibility criteria for listing in the *National Register*. DOE committed to developing a draft cultural resources management plan within 2 years of the signing of the agreement. The draft plan was completed in May 1996 and is currently being reviewed. Once final, this plan will supersede the programmatic agreement.

The Overhill Cherokee occupied part of eastern Tennessee from the 1700s until their relocation to Oklahoma in 1838. However, no religious or sacred sites, burial sites, or resources significant to the Overhill Cherokee have been identified at the K-25 site to date.

3.3.11 Minority and Low-Income Populations

The affected environment for assessing the potential for depleted UF_6 management activities to result in environmental justice impacts was based on data from the U.S. Bureau of the Census (1992a-b). The population residing within a 50-mile (80-km) radius of the K-25 site consists of 6.1% minorities and 16.2% persons with low income (see Appendix C, Section C.8.1).

3.4 ENVIRONMENTAL SETTINGS FOR CONVERSION, LONG-TERM STORAGE, MANUFACTURE AND USE, AND DISPOSAL

The locations of potential conversion, long-term storage, disposal, or manufacturing/use facilities will not be evaluated or selected on the basis of the analysis conducted for this PEIS; site selection will be evaluated at a later time during the second tier of NEPA program activities. Because the evaluation of environmental impacts generally depends to a large degree on site characteristics — such as the population distribution around a site, local air quality and weather, local ecology, and proximity of surface water and subsurface water (groundwater) — representative or generic environmental settings were defined for each of the PEIS categories of options. These environmental settings were defined to provide a reasonable, generalized range of environmental conditions for the purposes of impact assessment in this PEIS. Assumptions for the environmental settings are described further in Chapter 4.

3.4.1 Conversion

For the evaluation of conversion options, the potential environmental setting was assumed to be similar to the settings of the three current cylinder storage sites. Environmental data from the three current sites were used to provide a reasonable range of environmental conditions. The impacts of conversion are presented as ranges based on the differences in conditions represented by data used to define the environmental settings.

3.4.2 Long-Term Storage

Similar to the conversion options, the potential environmental settings for storage in yards, buildings, and vaults were selected on the basis of environmental conditions at the three current cylinder storage sites. The impacts of long-term storage are presented as ranges based on the differences in conditions represented by differences in data used to define the environmental settings. For assessment of mine storage, a generic environmental setting for a dry location was assumed (storage in a wet mine environment was not considered reasonable due to potential corrosion of containers). The environmental conditions of a generic dry setting are discussed in Section 3.4.4.1.

3.4.3 Manufacture and Use

The environmental settings for the manufacture and use options were developed for a manufacturing facility located in a generic dry setting and a generic wet setting. The dry setting would be typical of conditions in the arid western United States, and the wet setting would be typical of conditions in the eastern United States. The conditions assumed for the generic wet and dry settings were the same as those used for the assessment of disposal impacts, described in detail in Sections 3.4.4.1 and 3.4.4.2. For both dry and wet settings, manufacturing impacts were calculated for a rural area with a population density corresponding to 15 persons/mi^2 (6 persons/km^2), 120,000 people within a 50-mile (80-km) radius; and an urban area with a population density of 700 persons/mi^2 (275 persons/km^2), 5,500,000 people within a 50-mile (80-km) radius, respectively.

3.4.4 Disposal

The potential environmental settings for the disposal options were based on data representing a dry setting and a wet setting — as described in Sections 3.4.4.1 and 3.4.4.2. Both the dry and wet settings were assumed to be in a rural environment with an average population density of 15 persons/mi^2 (6 persons/km^2).

3.4.4.1 Generic Setting for a Dry Location

For the representative dry setting, a disposal facility was assumed to be located in an arid to semiarid climate. Under these conditions, annual precipitation typically would be about 10 in./yr (25 cm/yr). Approximately 1% of the annual rainfall (Rice et al. 1989), or about 0.1 in./yr (0.25 cm/yr), would be expected to infiltrate the ground, recharging the groundwater. The remainder of the precipitation would be lost to runoff or evapotranspiration (evaporation plus plant transpiration). No ponded waters would be expected to occur nearby, although it was assumed for assessment purposes that a nearby river could be used to supply raw water and to receive liquid waste discharges. The area would be well drained and free of flooding or frequent ponding.

The dry setting was assumed to be in a relatively flat area, overlying approximately 500 ft (150 m) of unconsolidated soil. This soil material was assumed to consist of sandy gravel and gravelly sand interbedded with lenses of clay, silt, and sand that have a variable thickness from about 1 ft (0.3 m) to more than 30 ft (9.1 m). Caliche (layers cemented together by calcium carbonate and other salts), commonly formed on exposed surfaces, would further limit infiltration. The presence of clay layers would impede vertical contaminant transport to the underlying water table. Because of the arid climate, water content of the soil would generally be less than 10% by volume. The unconsolidated material was assumed to have a limited number of small, discontinuous fractures and no significant voids or flow channels.

The groundwater aquifer was assumed to be located at a depth of about 500 ft (150 m) below the surface. This aquifer was assumed to consist of 100 ft (30 m) of semiconsolidated sands, gravels, silts, and clays.

The assessment of air dispersion following potential releases to the atmosphere was based on historical meteorological conditions for five actual "dry" locations in the southwestern United States to provide a range for impact calculations.

3.4.4.2 Generic Setting for a Wet Location

For the generic wet setting, a disposal facility was assumed to be in a modified continental climate. Under these conditions, annual precipitation would be about 40 in./yr (100 cm/yr). About 50% of the rainfall would be expected to be lost to runoff and evapotranspiration, with the remainder, 20 in./yr (51 cm/yr), infiltrating the ground and recharging the underlying groundwater aquifer (Rice et al. 1989). Because of moderate climatic conditions, nearby surface water features would likely be present; however, the setting would be above the elevation of any 100-year floodplain. It was assumed that a nearby river would be available to supply raw water and to receive liquid waste discharges. The area was assumed to be well drained and free of areas of flooding or frequent ponding.

The wet setting was assumed to be in a relatively flat area, overlying approximately 30 ft (9 m) of unconsolidated soil. This material would consist of layers of sand, gravel, and clay. The presence of clay layers would impede vertical contaminant transport to the underlying water table. Because of frequent rainfall events, the water content of the soil would be high. The unconsolidated material was assumed to have a limited number of small, discontinuous fractures and no significant voids or flow channels. Frost penetration of the uppermost layer of soil would be less than 3 ft (0.9 m).

The groundwater aquifer was assumed to be located at a depth of about 30 ft (9 m) below the surface. This aquifer was assumed to consist of 20 ft (6.1 m) of semiconsolidated sands, gravels, silts, and clays.

The assessment of air dispersion following potential releases to the atmosphere was based on historical meteorological conditions for five actual "wet" locations in the central and southeastern United States to provide a range for impact calculations.

3.4.5 Transportation

Transport of depleted UF_6 cylinders, uranium products, and waste materials would be generally over established highways, interstates, and rail lines in accordance with the applicable routing regulations and guidelines of the DOT and the Federal Railway Administration. For PEIS assessment purposes, representative truck and rail route characteristics were defined on the basis of national averages.