Chapter 2 Environmental Description

Chapter 2 describes the existing environmental conditions for the ESP site (see Section 1.1). The environmental description provides sufficient detail to identify those environmental resources that have the potential to be impacted by the construction, operation, or decommissioning of the new units. The environmental description, where referenced, includes the following definitions:

- NAPS site - the property within the NAPS site boundary, or fence line, including the Exclusion Area Boundary (EAB).
- ESP site - the property within the NAPS site intended for the construction and operation of new units
- Vicinity - the area within a 6-mile radius of the ESP site.
- Region - the area within a 50-mile radius of the ESP site.

The environmental description is segregated into the following discrete elements as outlined in NUREG-1555:

- Land
- Water
- Ecology
- Socioeconomics
- Geology
- Meteorology and air quality
- Related federal project activities

2.1 Site Location

The ESP site is contained within the NAPS site. The location for the new units would be confined to the plant envelope area see Figure 2.1-1. The eastern boundary of the ESP site is approximately 570 feet west of the center of the existing Unit 1 containment building. Universal Transverse Mercator (UTM) coordinates for the ESP plant envelope are not provided.

The ESP site is located in rural Louisa County in the northeastern portion of Virginia, approximately 7 miles east of the town of Mineral, Virginia, which had a population of 424 according to the 2000 census survey. The site is at the end of State Route 700 on a peninsula of the southern shore of Lake Anna. The earth dam that creates Lake Anna is about 5 miles southeast of the site. The North Anna River flows southeasterly, joining the South Anna River to form the Pamunkey River about 27 miles southeast of the site. Figure 2.1-2 shows the general location of the ESP site and localities surrounding the site within 10 miles.

Regionally, as shown in Figure 2.1-3, the site is about 40 miles north-northwest of Richmond, Virginia; 36 miles east of Charlottesville, Virginia; and 22 miles southwest of Fredericksburg, Virginia. Interstate 95 and U.S. Route 1 (parallel to I-95), the two principal highways joining Richmond with the rest of the eastern corridor, pass within 15 and 16 miles, respectively, east of the site.

Section 2.1 References

None

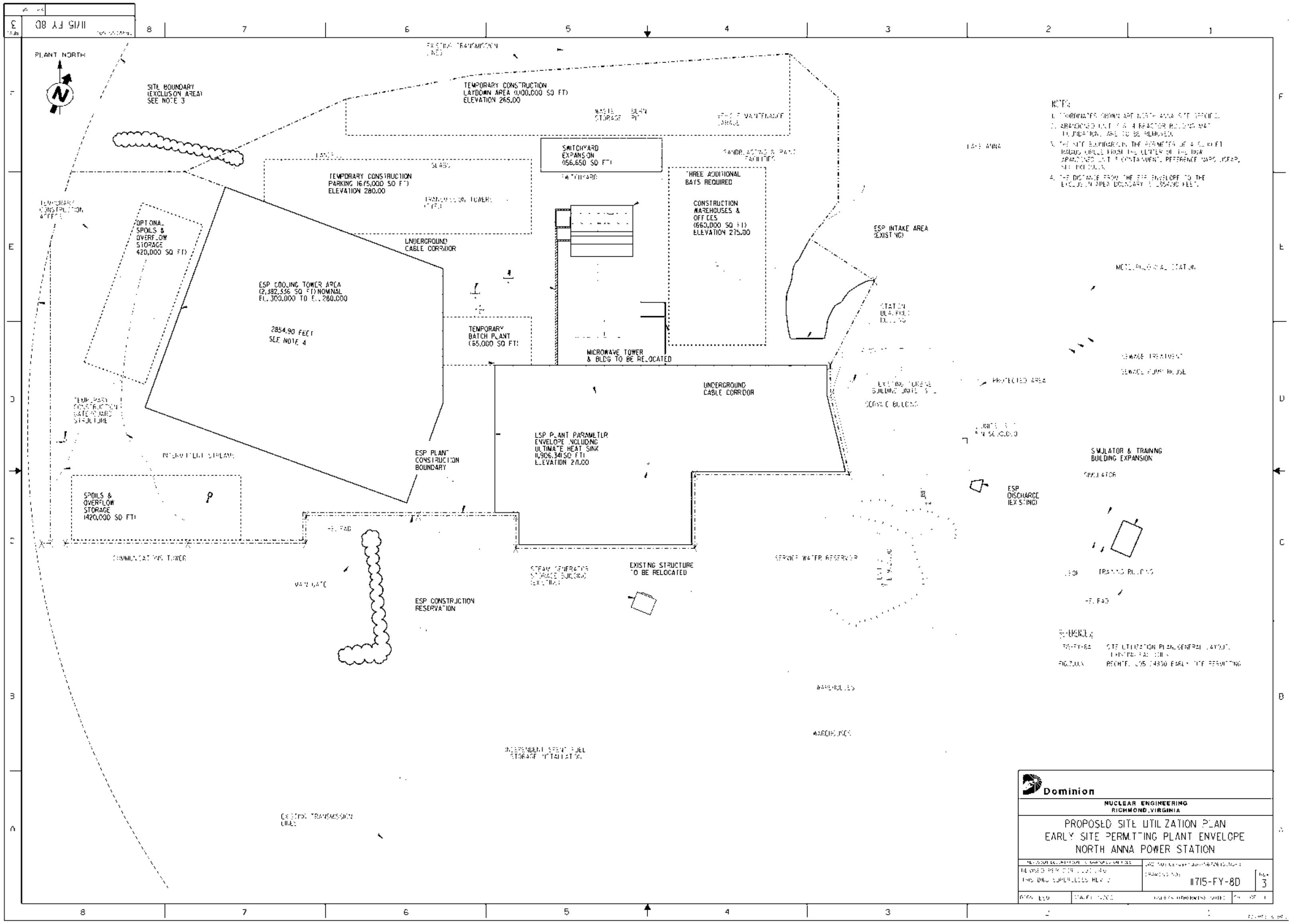

Figure 2.1-1   North Anna ESP Site Boundaries

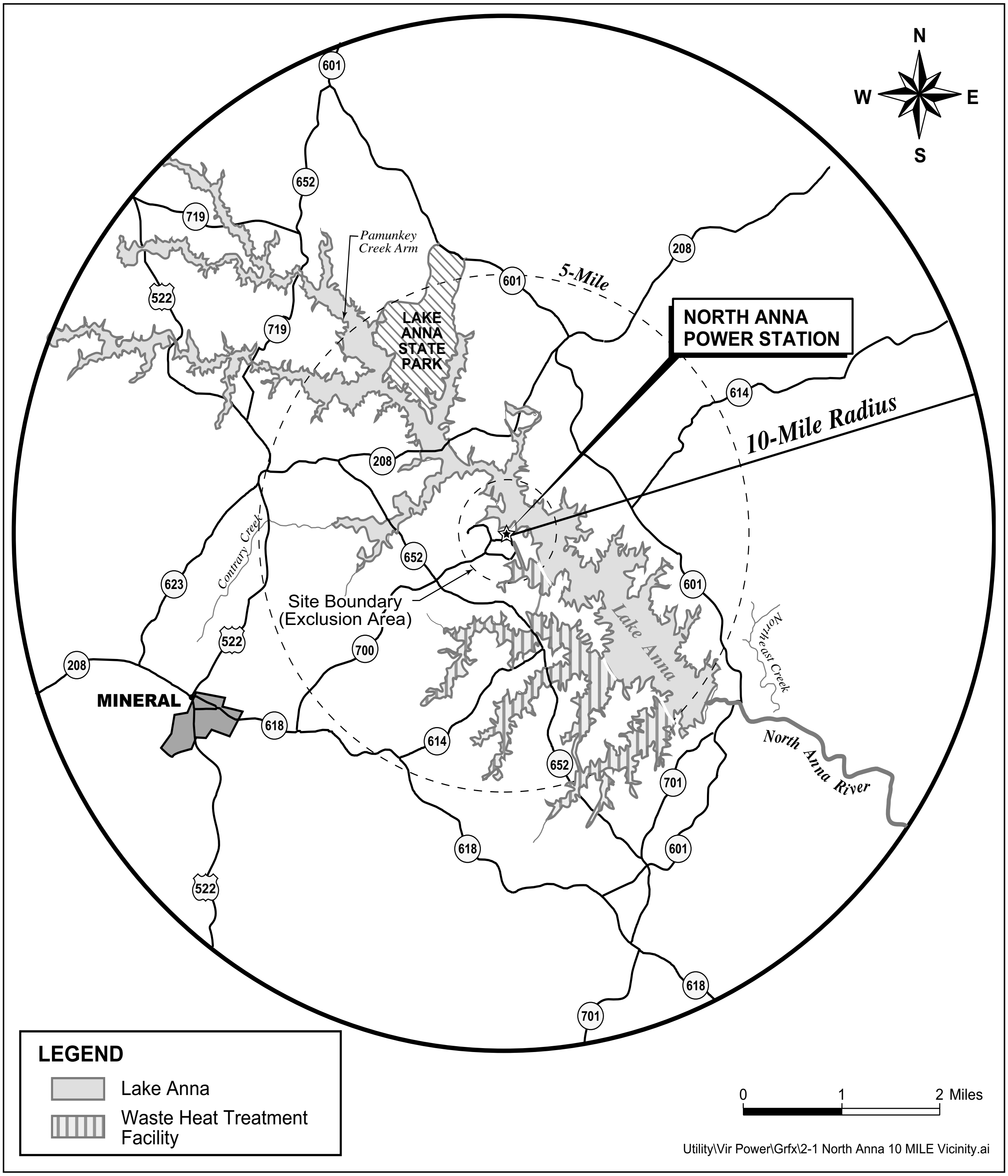

Figure 2.1-2 10 Mile North Anna Vicinity Map

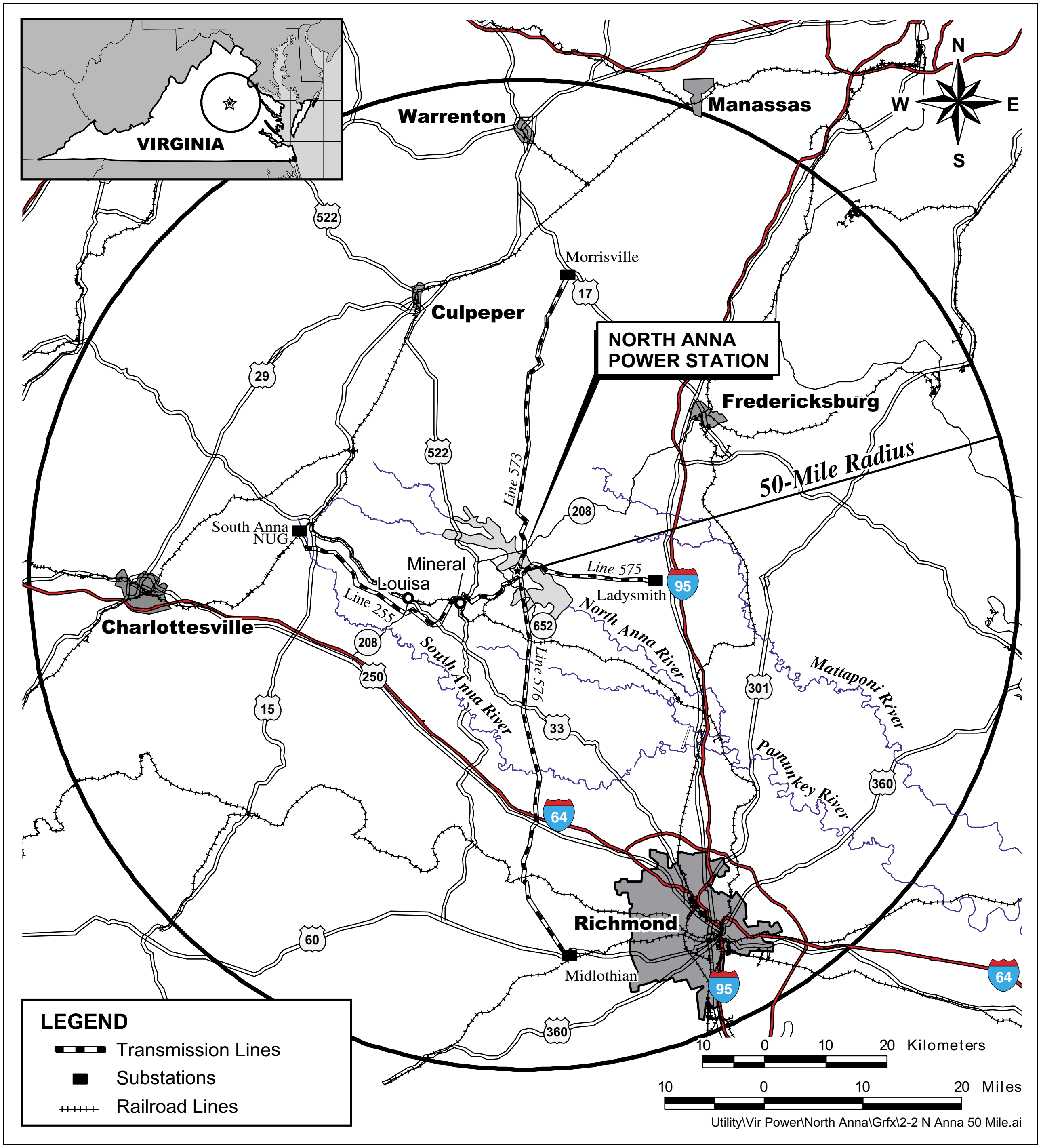

Figure 2.1-3 North Anna Power Station 50 Mile View

2.2 Land

This section describes the land characteristics of the areas within the ESP site (and where appropriate, the NAPS site) that are identified in this ESP application. This description was used as a baseline to assess the potential impacts on land uses that would result from the construction, operation, and decommissioning of the new units. This section is further segregated into three subsections: 1) site and vicinity, 2) transmission corridors and offsite areas, and 3) the region. These subsections include spatial considerations (e.g., region, vicinity, and site) as well as the nature and extent of current land uses and planned future land uses, where applicable, as referenced.

2.2.1 The Site and Vicinity

The ESP site is within the existing boundaries of the NAPS site, with the new units to be sited adjacent to the existing Units 1 and 2. The ESP site is situated on a peninsula of Lake Anna's southern shore at the end of State Route 700 (see Figure 2.1-2). Geographically, the ESP site is located within the central Piedmont Plateau of Virginia. The topography of the NAPS site is characterized as a gently undulating surface that varies from 60 m (200 ft) to 150 m (500 ft) above mean sea level (msl). Forests primarily of pine and hardwoods cover the majority of the peninsula on which NAPS is sited.

Regionally, the ESP site is approximately 40 miles north-northwest of Richmond, Virginia; 36 miles east of Charlottesville, Virginia; 22 miles southwest of Fredericksburg, Virginia, and 70 miles southwest of Washington, D.C. Interstates 95 and 64 pass within 16 miles to the east and 18 miles to the south of the ESP site, respectively (see Figure 2.1-3).

2.2.1.1 Site Description

The ESP site is located in Louisa County in northeastern Virginia. Virginia Power and ODEC own, and Virginia Power controls, all of the land within the NAPS site boundary, both above and beneath water surfaces, including those portions of the North Anna Reservoir and WHTF, that lie within the site boundary. Both companies also own all the land outside the NAPS site boundary that forms Lake Anna, up to their expected high-water marks (i.e., Elevation 255 feet above msl). Virginia Power purchased and owns a total of 18,643 acres of rural land (approximately 80 percent forested) for the original development of NAPS, including the land for Lake Anna; the earthen dams, dikes, railroad spur, roads and bridges; and miscellaneous other structures and facilities. Virginia Power also owns and operates the North Anna Hydroelectric Project, an 855 kW-capacity hydroelectric power plant at the base of the North Anna Dam.

Lake Anna, a man-made reservoir, was created in 1971 by erecting a dam on the main stem of the North Anna River. The lake is approximately 27 km (17 miles) long with 435 km (272 miles) of irregular shoreline and approximately 3900 ha (9600 acres) of water surface. Lake Anna was created primarily as a source of cooling water for the power station, although it has become a popular recreation area. The dam provides downstream flood control. Lake Anna is not used as a source of potable or industrial water.

Virginia Power has granted easements to landowners abutting Lake Anna (including the WHTF) who request permission to use Virginia Power property for the erection of docks, jetties, or other recreational structures for access to the lake waters. These structures require a re-approval by Virginia Power with each property ownership transaction, and all permissions are expressly revocable. Public boaters have access to the lake, and private boaters have access to the WHTF.

No public or commercial highways, railroads, transmission corridors (other than those owned and operated by Virginia Power), or major waterways traverse the ESP site. Ingress and egress from the ESP site is primarily through a Virginia Power-owned and maintained access road off State Route 700.

The Virginia Department of Mines, Minerals, and Energy maintains maps of Louisa County showing mines that are currently active or that are known to have commercial value. The maps indicate no mines with commercial value (i.e., either metallic or non-metallic) exist within or adjacent to the ESP site.

The primary land cover on the NAPS site is pine and pine-hardwood mixed forest (70 percent). Portions of the NAPS site are used for facility activities (20 percent) and as cleared areas (10 percent). Facility uses include electricity generation, maintenance and distribution facilities, warehouses, training and administration buildings, lagoons and settling basin, parking lots, roads, a railroad line, information center, and the Independent Spent Fuel Storage Installation (ISFSI). Cleared areas include the landscaped grounds, open areas, lay down areas, three historic cemeteries, security weapons range, and the John Goode Recreation Area, a recreation and picnic area for use by employees of DRI and its subsidiaries only (see Figure 2.2-1).

2.2.1.2 **The Vicinity**

There are no communities in the vicinity of the ESP site. The nearest largest community is the town of Mineral, Virginia, (2000 Census population of 424) located in Louisa County, 7 miles west of the site. The town of Louisa (2000 population of 1401) is approximately 12 miles west of the ESP site. Lake Anna State Park lies 5 miles northwest of the NAPS site and provides public facilities for picnicking, fishing, boat launching, swimming, and biking (see Figure 2.1-2 and Figure 2.1-3).

The Commonwealth of Virginia mandates that cities and counties have comprehensive land use plans, and all three counties surrounding the Lake (Louisa, Orange, and Spotsylvania) have such plans. Figure 2.2-2 and Figure 2.2-3 show land use classifications in Louisa and Spotsylvania counties for the NAPS site and vicinity. Table 2.2-2 shows a breakdown of land use, type, and area in those counties.

The predominant land use in Louisa County, and a major contributor to the Louisa economy, is forestry, which uses approximately 68 percent of the county's land area. Most of the forested land is privately owned. Agricultural lands occupy 23.5 percent and water resources occupy about 3 percent of land. Developed land occupies 6 percent and residential development predominates with 5.5 percent.

Louisa county experienced a 25 percent population growth (i.e., approximately 5100 additional people) between 1990 and 2000. However, there has been little industrial growth. Residential land use increased from 1.8 percent in 1979 to 5.5 percent by 2000. The county has prepared over 50 industrial sites for development. Many have access to various combinations of rail, gas, water, and sewer. Louisa County has recently updated its Comprehensive Plan (Reference 1), which defines nine goals for future development in the county. These goals include preserving the rural character of Louisa County through designation of “growth centers” to accommodate future growth in a manner consistent with maintaining the rural heritage of the county and a healthy, diverse economy, as well as providing job opportunities for Louisa County citizens.

Spotsylvania County, which consists of forests and agriculture, is fast-growing because of its proximity to Washington, D.C. and northern Virginia. Spotsylvania County has also recently updated its Comprehensive Plan (Reference 2) to define several development goals that allow for the maintenance of the historic, agricultural, and forested character of the county, while recognizing the need to sustain residential and business growth and community services for the benefit of county residents.

In Orange County to the northwest, 95 percent of the land consists of forests and agriculture and is beginning to be impacted by development.

Recreational and retirement development has grown substantially in the immediate vicinity of Lake Anna. Land between the many embayments remains privately held. Lake Anna has influenced land use development in Louisa, Orange, and Spotsylvania counties. Residential development of mid-to-upscale homes characterizes development around the lake. Prior to 1998, the three counties did not coordinate land use planning activities in the Lake Anna watershed. In 1998, however, a committee was formed to examine the watershed and to develop a plan that enables the counties to coordinate their efforts to address growth and protect the Lake Anna region.

The final Lake Anna Special Area Plan was issued in March 2000 (Reference 3). Several major findings resulted from the Special Area Plan Committee’s examination. These include:

- Development patterns of sprawl threaten the rural character, the environment, and the existing quality of life in the Lake Anna watershed
- Responsibility for on-going review of environmental conditions in the watershed is unclear.
- The environmental database necessary for responsible and informed decision-making is not available.

The Committee developed “priority recommendations” to address the major findings. These included:

- Create a Lake Anna Watershed Overlay District in all three counties with a charter to maintain the rural character of the area by implementing a cooperative, coordinated, consistent watershed program for Lake Anna.
- Charge the Lake Anna Advisory Committee to track progress toward meeting plan goals and to prepare and submit annual reports on progress made.
- Develop monitoring programs for both tributaries and the lake that address levels of heavy metals, nutrients and other pollutants and help to identify reductions strategies for fecal contamination.

2.2.2 **Transmission Corridors and Offsite Areas**

NAPS has three 500-kV transmission lines and one 230-kV transmission line leaving the site from the switchyard. Each transmission line occupies a separate right-of-way. The rights-of-way range in width from 37 to 84 meters (120 to 275 feet) and in length from 24 to 66 km (15 to 41 miles), covering a total of approximately 1174 hectares (2900 acres) (Reference 4). The rights-of-way extend from NAPS to the north, south, east, and west, terminating in Morrisville, Midlothian, Ladysmith, and at the South Anna non-utility generator, respectively Figure 2.2-4.

The NAPS transmission corridors were constructed between 1973 and 1984. The corridors pass through land use categories typical of north-central Virginia, such as row crops, pastures, forests, and abandoned (old) fields. In addition, the transmission corridors pass through more natural habitat types, such as hardwood and pine-hardwood forests, bottomland hardwood forests, and shrub boggs. No areas designated by the U. S. Fish and Wildlife Service (USFWS) or VDEQ as “critical habitat” for endangered species exist at the ESP site or along or adjacent to associated transmission line. In addition, the transmission corridors do not cross any state or federal parks, wildlife refuges, or wildlife management areas. Physical features (e.g., length, width, and route) of each of the transmission lines associated with NAPS are described in Table 2.2-1.

Corridors in timberlands and in the vicinity of road crossings are maintained by Virginia Power on a 3-year cycle by mowing or, if inaccessible to mowers, by use of nonrestricted-use herbicides. In other areas (e.g., wetlands, dense vegetation), hand-cutting treatments are used. (Reference 5)

Vegetation treatments have been developed in cooperation with the VDCR Natural Heritage Program. Areas of rare and sensitive plant species are identified and avoided, or modified treatment practices are used to avoid adverse impacts. In addition, wildlife food plots and Christmas tree plantations are located along the corridors and supported through cost sharing by Virginia Power. (Reference 4)

Virginia Power allows landowners, hunting clubs, and conservation organizations to establish wildlife food plots, Christmas tree plantations (not to exceed a height of 15 feet), gardens, athletic and park facilities, and drain fields under transmission lines. Land uses not permitted under the transmission lines include permanent structures (i.e., houses and barns), trash and brush stockpiling, wells, septic systems, and ATV trails. (Reference 5)

Based on an initial evaluation, any two 500 kV transmission lines, together with the 230 kV transmission line to have sufficient capacity to carry the total output of the existing units and the new units. If Dominion decides to proceed with development of new units at the ESP site, a system study (load flow) modeling these lines with the new units' power contribution would be performed, to confirm this conclusion. Additional information regarding the existing transmission system for NAPS is provided in Section 3.7.

2.2.3 **The Region**

The region, defined as 50 miles beyond the ESP site boundary, includes all or portions of the following counties in Virginia: Amelia, Albemarle, Buckingham, Caroline, Chesterfield, Culpeper, Cumberland, Essex, Fauquier, Fluvanna, Goochland, Greene, Hanover, Henrico, King and Queen, King George, King William, Louisa, Madison, New Kent, Orange, Page, Powhatan, Prince William, Rappahannock, Richmond, Rockingham, Spotsylvania, Stafford, and Westmoreland. The region also includes a portion of Charles County in Maryland.

Major waterways, highways, roads, railroads, and other transportation routes in the region are shown in Figure 2.1-2 and Figure 2.1-3. There are two major airports within the region, Richmond International Airport and Charlottesville-Albemarle County Airport, approximately 45 miles southeast and 40 miles west of the ESP site, respectively. There are three smaller airports within 15 miles of the ESP site; Lake Anna Airport (Bumpass, VA), Louisa County Airport and Cub Field, 7 miles south-southwest, 11 miles west-southwest, and 10 miles southwest of the ESP site, respectively.

Fourteen counties in the eastern part of the region (i.e., Caroline, Chesterfield, Essex, Hanover, Henrico, King and Queen, King George, King William, New Kent, Prince William, Richmond, Stafford, Spotsylvania, Westmoreland) are within the VDEQ designated Chesapeake Bay Coastal Zone Management Area.

The following federally designated special land use classified areas exist within the region; George Washington Birthplace National Monument, Fredericksburg and Spotsylvania National Military Park, Thomas Stone National Historic Site, Richmond National Battlefield, Maggie L. Walker National Historic Site, Shenandoah National Park, Rappahannock National Wildlife Refuge, and Featherstone National Wildlife Refuge. There are no national forests, wilderness areas or wild and scenic rivers within the region. There are several Virginia state parks within the region. The closest, Lake Anna State Park, is approximately 5 miles northwest of the ESP site.

There are no Native American tribal land use plans for areas within the region. The closest reservations, the Mattaponi and Pamunkey, are outside of the ESP site region.

Land use within the region varies with distance from major population centers and high use transportation corridors. The metropolitan areas of Richmond, Fredericksburg, and Charlottesville, and the transportation corridors associated with Interstates 95 and 64 contain the highest density of residential, commercial, and industrial land use. As detailed in Section 2.2.1, land use in the immediate vicinity of ESP site and the areas outside the noted metropolitan areas and transportation corridors remains primarily in forestry and agriculture. A survey of land use development plans (i.e., comprehensive county plans) for the counties immediately adjacent to the ESP site indicate a primary goal of striking a balance between maintaining the historic rural character of the area with the recognized need for limited residential growth and business development. (Reference 1) (Reference 2)

The primary land use classifications for the region are representative of those noted for the Commonwealth of Virginia as a whole. The region, comprising about 20 percent of the total area of Virginia, encompasses four main land use classes: to the north are mainly urban areas surrounding Washington D.C. and cropland; to the east is primarily cropland; to the south is a mixture of cropland and pasture; and to the west is a mixture of forests and pasture. (Reference 6) (Reference 7)

Forests dominate Virginia, covering approximately 55.6 percent of the state's total land area (Table 2.2-3). The second most prevalent land use in Virginia is agriculture, covering 25.9 percent of the total land area. Cropland accounts for 2903 square miles, about 7.1 percent of the total area; pasture and hay production account for 6845.3 square miles, or about 16.8 percent of the state's land. Urban areas comprise 6029 square miles of land area, approximately 14.8 percent; and inland waters account for the remaining 3.7 percent.

In 2000, the four principal crops in Virginia in terms of acreage harvested, were hay (1,320,000 acres), soybeans (490,000 acres), corn (330,000 acres), and winter wheat (205,000 acres). The four principal livestock and products in Virginia for 2000, in terms of cash receipts, were broiler chickens ($441,320,000), cattle and calves ($307,862,000), wholesale milk ($278,832,000), and turkeys ($237,941,000) (Reference 11). In 2001, the four principal crops in Charles County Maryland in terms of total production were corn for grain (909,00 bushels), tobacco (450,000 bushels), soybeans (446,000 bushels), and wheat (169,000 bushels) (Reference 9).

Section 2.2 References

1. *Comprehensive Plan,* Louisa County Department of Planning/Zoning, County of Louisa, Virginia, September 4, 2001.

2. *2002 Comprehensive Plan*, Spotsylvania County Planning Department, Spotsylvania County, Virginia, February 12, 2002.

3. *Lake Anna Special Area Plan,* Special Area Plan Committee, March 2000.

4. Final Supplement 7 to the Generic Environmental Impact Statement (GEIS) Regarding License Renewal for the North Anna Power Station, Units 1 and 2, November 2002.

5. *Transmission Lines-Right-of-Way Encroachments,* Informational Bulletin, Department of Forestry, Dominion Energy, 2003.

6. Virginia County Data, Virginia Agricultural Statistics Service, 1997 Census Data, www.nass.usda.gov/va/page1.htm and www.nass.usda.gov/va/vpage2.htm (accessed July 10, 2003).

7. 1997 Census of Agriculture Volume 1: Part 46, Chapter 1, Virginia State-Level Data, Maps, United States Department of Agricultural, www.nass.usda.gov/census/census97/volume1/va-46/va1maps.pdf (accessed July 10, 2003).

8. *Land Use Classifications for Louisa County, Virginia (Site and Vicinity),* Louisa County Department of Planning/Zoning, Louisa County (Virginia), 2002.

9. Charles County 2001 Agricultural Profile, Charles County Agricultural Statistics www.nass.usda.gov/md/charles.pdf (accessed July 10, 2003).

10. *Land Use Classifications for Spotsylvania County, Virginia (Site and Vicinity),* Spotsylvania County Planning Department, Spotsylvania County (Virginia), 2002.

11. Virginia Agriculture – Facts and Figures, Virginia Department of Agriculture and Consumer Services (VCACS), 2000. www.vdacs.state.va.us/agfacts/index.html (accessed January 27, 2003).

12. Water Quality Assessment Report, Virginia Department of Environmental Quality (VDEQ), 2002, 2002 305(b), Table 2.1-2, Virginia Statewide Land Use Summary.

Table 2.2-1 North Anna Transmission Rights-of-Way[a]

					Area	
		Length		Width	Hectares (acres)	Construction Date
Substation	kV	km (mi.)	Direction	m (ft)	(acres)	Date
Morrisville	500	53 (33)	N	72 (235)	366 (905)	1973
Midlothian[b]	500	66 (41)	S	72 (235)	469 (1160)	1979
Ladysmith	500	24 (15)	E	84 (275)	192 (475)	1976
South Anna	230	50 (31)	W	30-37 (100-120)	146 (360)	1984
Total		193 (120)			1174 (2900)	

a. Source: Reference 4, Table 2-1

b. The transmission line to Midlothian Substation runs an additional 26 km (16 mi.) in a shared right-of-way with a non-North Anna line.

Table 2.2-2 Land Use in Louisa, Orange and Spotsylvania Counties[a]

County and Land Use	Hectares	Acres	Percent of Total
Louisa County			
Residential	7,322	17,655	5.0
Agriculture	31,979	79,019	23.5
Forest	92,474	228,500	68.0
Water	3,994	9,868	3.0
Other[b]	649	1,605	0.5
Total Louisa	136,418	336,646	100.0[c]
Orange County			
Developed Land[d]	4,597	11,360	5.0
Agriculture	34,021	84,064	37.0
Forest	53,330	131,776	58.0
Water	N/A[e]	N/A	N/A
Total Orange	91,948	227,200	100.0[c]
Spotsylvania County			
Residential	22,793	56,320	22.0
Developed Land[f]	3,108	7,680	3.0
Agriculture	18,649	46,080	18.0
Forest	53,874	133,120	52.0
Other	5,180	12,800	5.0
Total Spotsylvania	103,604	256,000	100.0

a. Source: Reference 4, Table 2-9.

b. Includes commercial and industrial lands.

c. Numbers have been adjusted to achieve a total of 100 percent.

d. Developed land is defined to include residential, commercial, industrial, and public use.

e. N/A – Not available

f. Developed land is defined to include industrial and commercial.

Table 2.2-3 Virginia Statewide Land Use Summary[a]

Land Use	Square Miles (hectares)	Percent of Total
Commercial Forest	20,059 (5,195,154)	49.2
National Forests	2,550 (660,447)	6.4
Total Forested Land	22,609 (5,855,601)	55.6
Cropland	2,903 (751,977)	7.1
Pasture/Hay	6,845 (1,772,925)	16.8
Other	828 (214,477)	2.0
Total Agricultural Land	10,577 (2,739,379)	25.9
Other (Including Urban)	6,029 (1,561,530)	14.8
Inland Waters	1,526 (395,336)	3.7
Total Area	40, 741 (10,551,845)	100.0

a. Source: Reference 12, Table 2.1-2

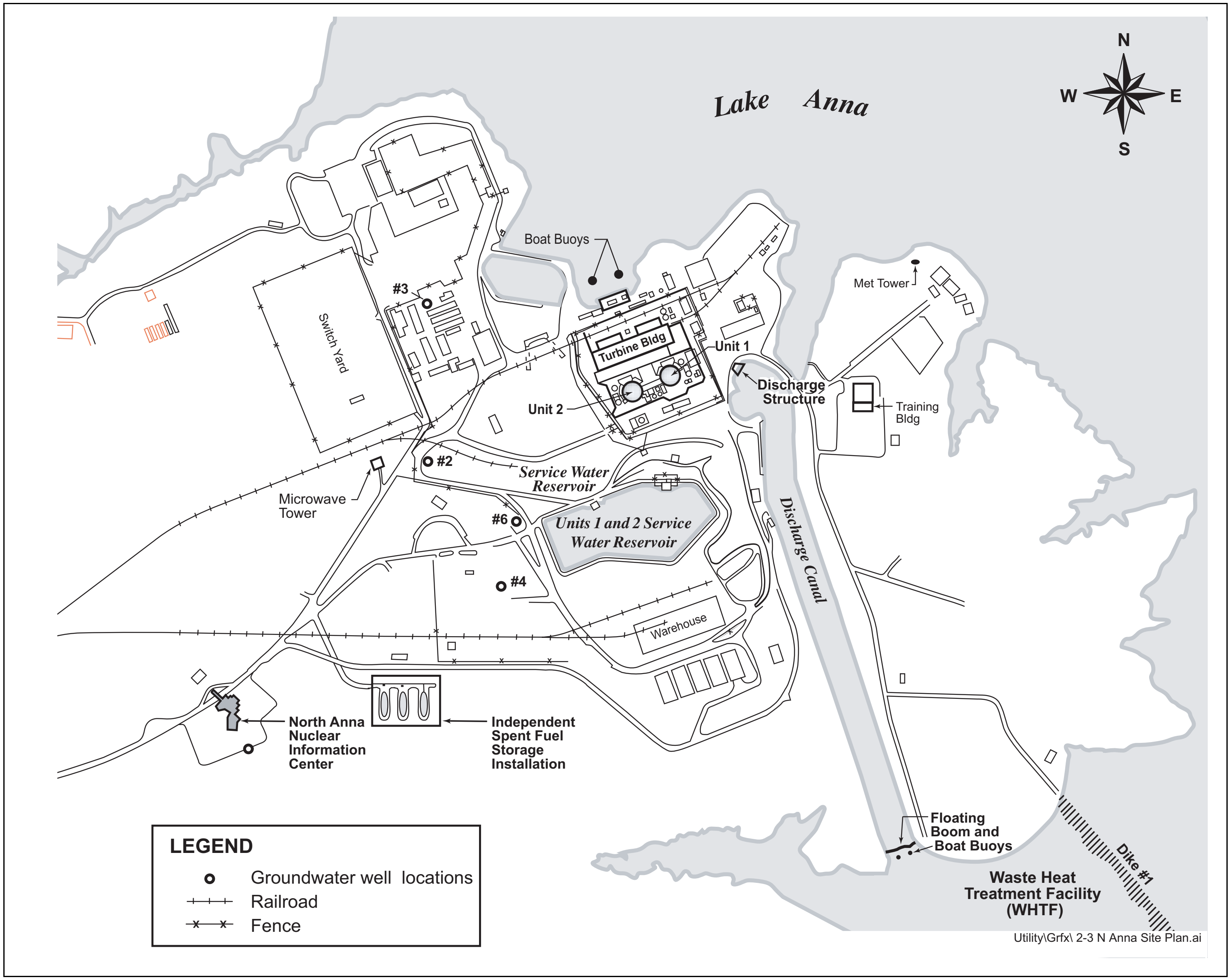

Figure 2.2-1 Existing NAPS Site Detail Map

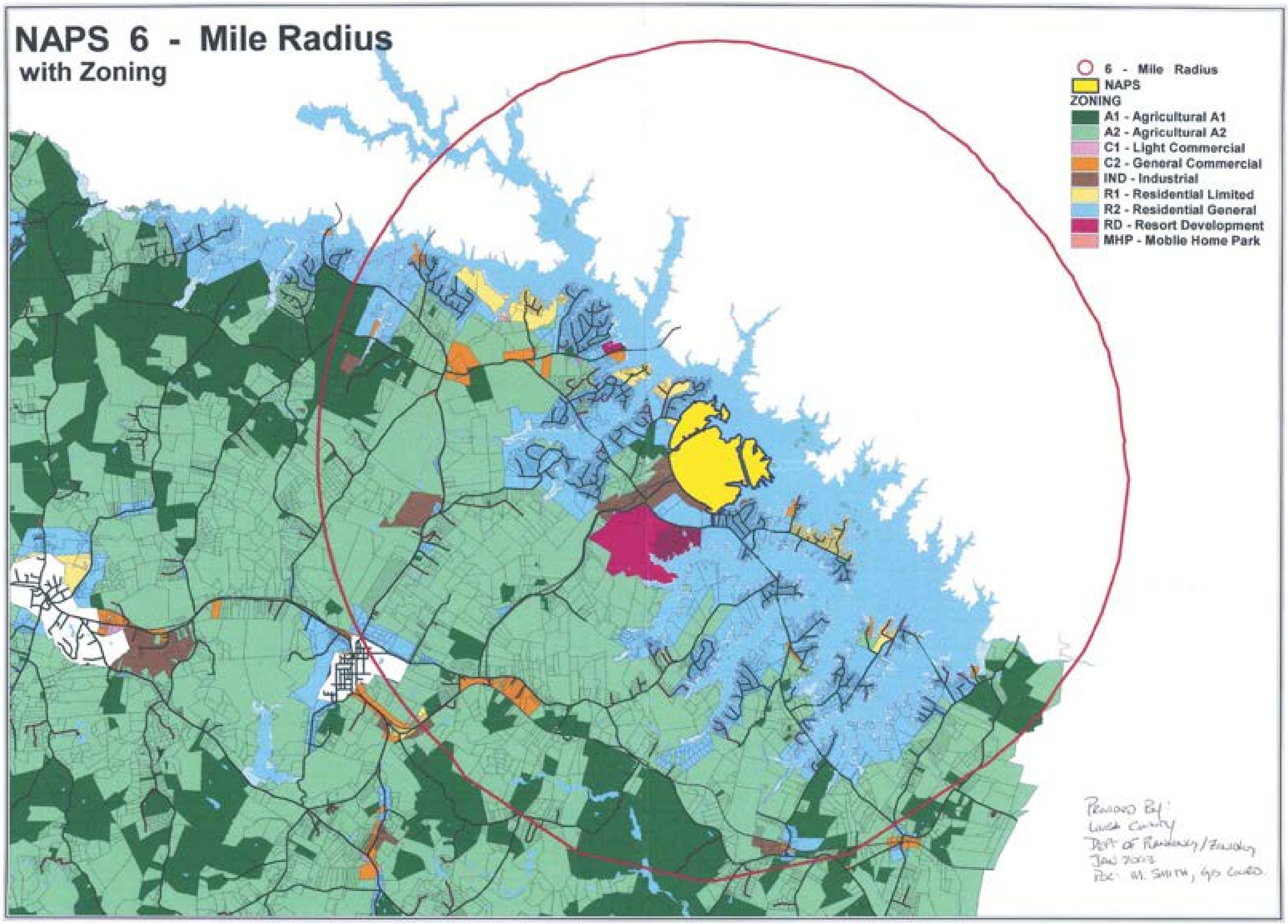

Figure 2.2-2 Land Use Classifications for Louisa County, Virginia (Site and Vicinity)
Source: Reference 8

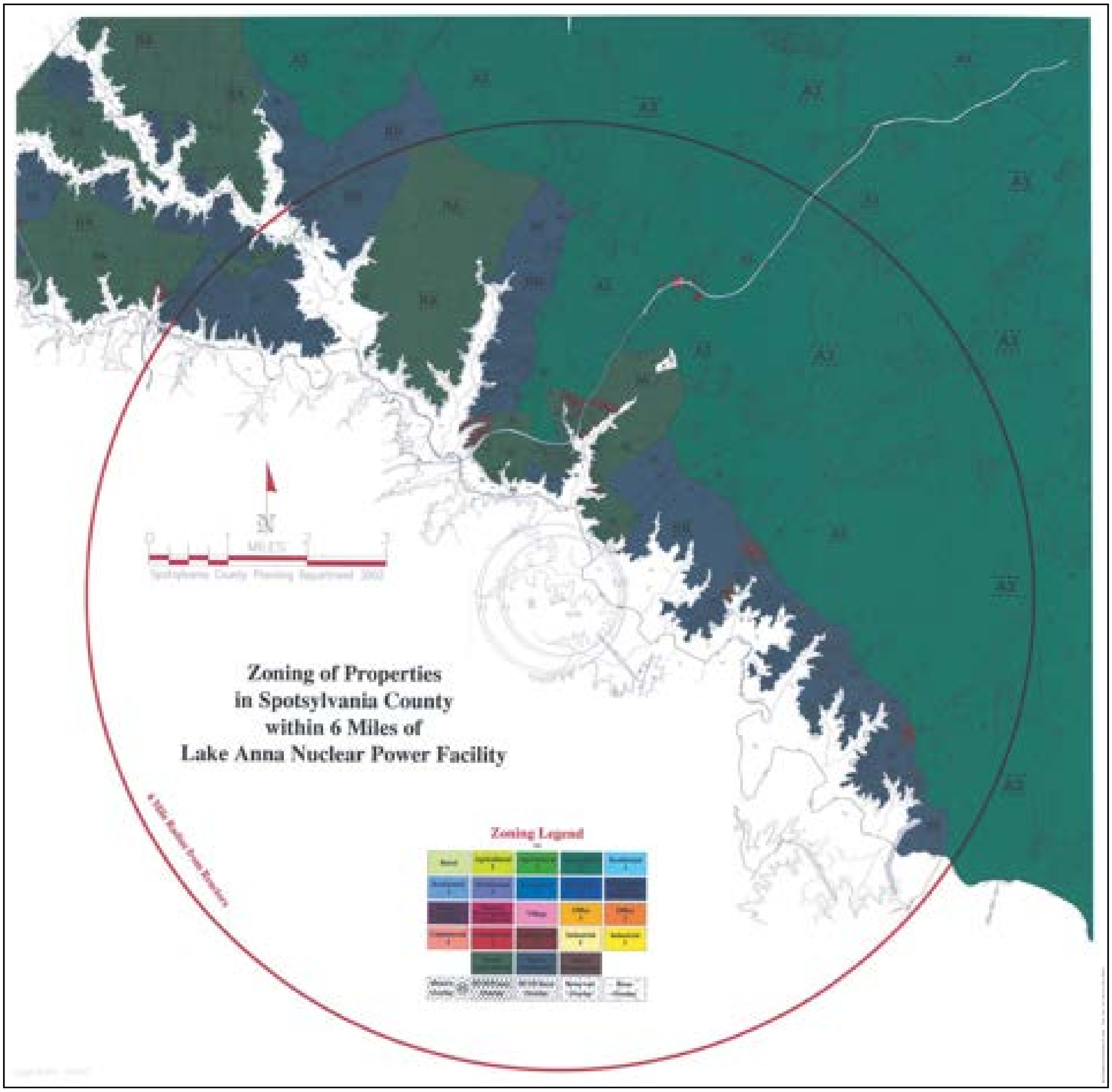

Figure 2.2-3 Land Use Classifications for Spotsylvania County, Virginia (Site and Vicinity)

Source: Reference 10

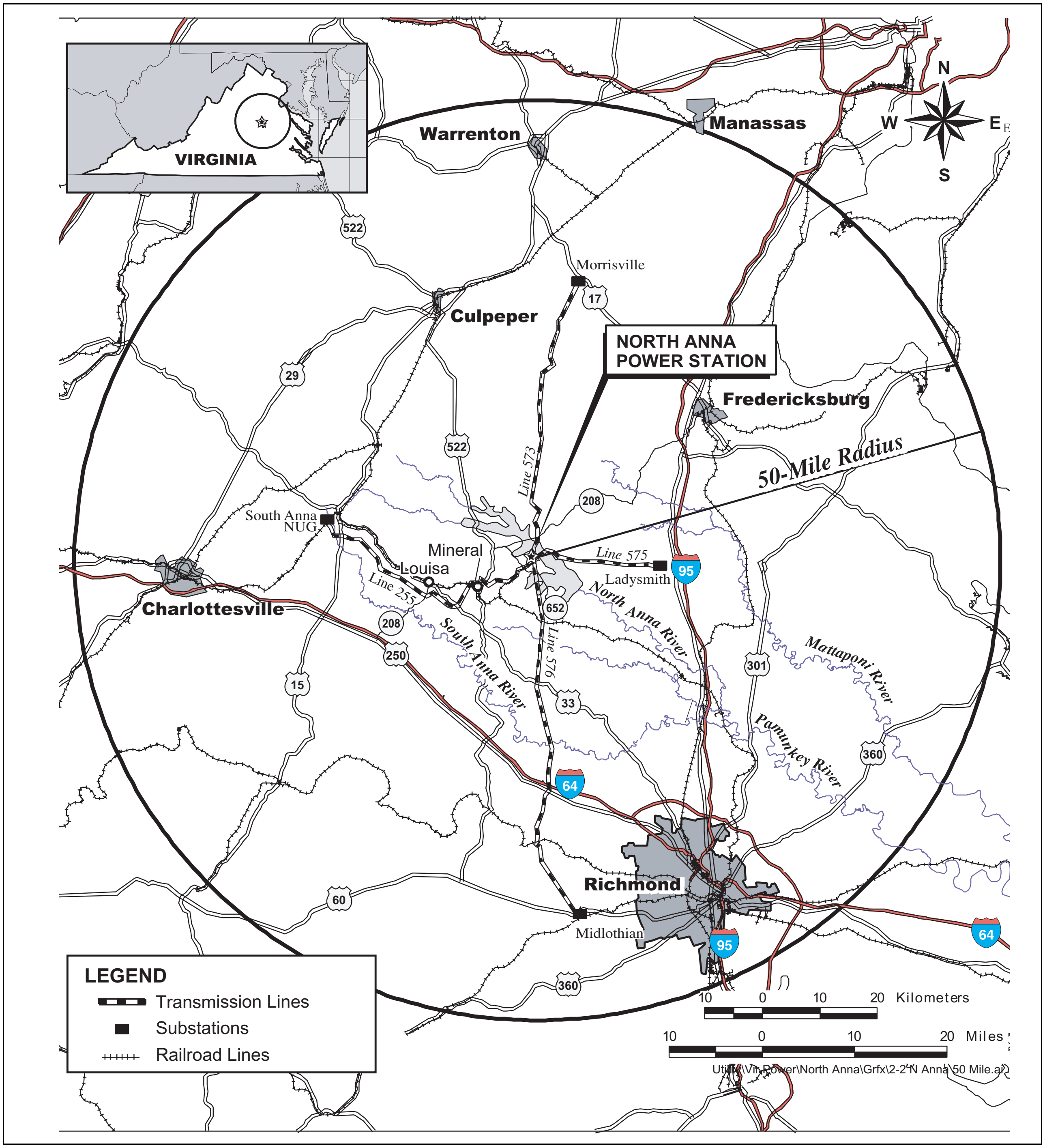

Figure 2.2-4 Existing Transmission Line Corridors

2.3 Water

This section includes site-specific and regional descriptions of the hydrology, water use, and water quality conditions that could affect, or be affected by, the construction, operation, or decommissioning of new units at the ESP site. The site-specific and regional surface water and groundwater information establishes the baseline hydrologic conditions against which to assess potential construction or operational impacts and the adequacy of related monitoring programs. The potential construction and operational impacts to water resources are presented in Chapter 4, and Chapter 5, respectively. Monitoring programs are presented in Chapter 6.

2.3.1 Hydrology

This section describes surface water bodies and groundwater aquifers that could affect the plant water supply, or that could be affected by the construction or operation of new units at the ESP site. The site-specific and regional data on the physical and hydrological characteristics of surface water and groundwater are summarized to provide the basic data for an evaluation of impacts on water bodies, aquifers, aquatic ecosystems, and social and economic structures of the area.

The following descriptions are based on a review of the NAPS Updated Final Safety Analysis Report (UFSAR) (Reference 1) and the Environmental Report Supplement (Reference 2), unless otherwise noted. The information has been verified and updated using current hydrologic databases.

2.3.1.1 Surface Water

The ESP site is located on the southern shore of Lake Anna adjacent to the existing units and approximately 8 km (5 miles) upstream of the North Anna Dam. Lake Anna was created by constructing a dam across the North Anna River as part of the overall development of the NAPS site. The North Anna Reservoir currently serves as the water source for the existing units, which use a once-through cooling system to dissipate heat from the turbine condensers.

Lake Anna is the primary surface water body that could affect plant water supply, or be affected by the construction and operation of new units at the ESP site based on the cooling systems proposed for the new units. New Unit 3 would use a closed-cycle, dry and wet cooling tower system for the circulating water system. A separate, service water cooling system would use a closed-cycle, wet cooling tower for dissipation of waste heat from auxiliary heat exchangers not cooled by the plant circulating water system. Make-up water for the wet cooling towers would be supplied from the North Anna Reservoir at a maximum instantaneous rate of 49.6 cubic feet per second (cfs). Blowdown discharge from the wet cooling towers would be returned to the reservoir at a maximum instantaneous rate of 12.4 cfs via the WHTF. New Unit 4 would use a closed-cycle cooling system with dry cooling towers in which the exhaust from the plant’s steam turbines would be directed to a surface condenser where the heat of vaporization would be rejected to a closed loop of cooling water. The heated cooling water would be circulated to the finned tubes of the dry cooling towers where heat content of the cooling water would be transferred to the ambient air. To increase heat rejection to the atmosphere, electric motor driven fans would be used to force airflow across the finned tubes. After passing through the cooling towers, the cooled water would be recirculated back to the surface condenser to complete the closed-cycle cooling water loop. Except for the initial filling of the cooling water loop, Unit 4 would have no make-up water need since dry tower systems typically have no evaporative water losses and would have no continuous blowdown discharge to the WHTF. In the event that the cooling water loop would use an open pump sump configuration with a free surface, a small amount of evaporation losses, estimated to be on the order of 1 gpm (0.002 cfs), would occur. Any make-up water necessary to replenish the small evaporative losses for Unit 4 would be obtained from the North Anna Reservoir. The plant service water cooling system for Unit 4 would use dry cooling towers, which would have minimal to no make-up water requirements.

The North Anna River rises in the eastern slopes of the Southwestern Mountains in the Appalachian Range near Gordonsville, Virginia, and flows along a southeasterly course to its confluence with the South Anna River 5 miles northeast of Ashland, Virginia, where the Pamunkey River is formed. The Pamunkey continues on a general southeasterly course to West Point, Virginia, where it is joined by the Mattaponi River to form the York River. The York River flows into the Chesapeake Bay about 15 miles north of Hampton, Virginia. The North Anna River drains a watershed of 343 square miles above the dam, which is located about 4 miles north of Bumpass, Virginia, and about 0.5 mile upstream of Virginia Route 601.

As shown in Figure 2.3-1, Lake Anna is about 17 miles long and inundates several small tributaries, thereby resulting in an irregular shape with a shoreline length of approximately 272 miles. To provide optimum thermal performance for the existing units, Lake Anna is separated into two sections by three dikes. The larger section of about 9600 acres, termed the North Anna Reservoir, is a storage impoundment for plant cooling water. The smaller section, the WHTF, has an area of about 3400 acres and functions as a heat exchanger to transfer most of the existing units' heat rejection to the atmosphere.

The elevation-volume curves for the North Anna Reservoir and the WHTF are provided in Figure 2.3-2. When both existing units are operating, eight circulating water pumps draw water from the North Anna Reservoir at a rate of 4246 cfs, circulate it through the condensers, and discharge it to the WHTF. Water moves through the three lagoons of the WHTF and back into the North Anna Reservoir at Dike 3 (Figure 2.3-1).

The North Anna Dam is an earth-filled structure about 5000 feet long and 90 feet high, with a central concrete spillway about 200 feet long. The dam crest is at Elevation 265 ft msl and has a width of 30 feet. The concrete spillway contains three radial crest gates, each 40 feet wide by 35 feet high, separated by concrete piers 10 feet wide. The discharge capacity of each of the three main gates is shown in Figure 2.3-4. The crest of the spillway ogee is at Elevation 219 ft msl. Two adjustable skimmer gates are provided for regulating small releases. The discharge capacity of each of the skimmer gates, which measure 8.5 feet by 8.5 feet, is shown in Figure 2.3-5. A concrete apron downstream from the spillway provides energy dissipation for releases from the North Anna Dam.

The North Anna Dam also incorporates at its base a small hydroelectric power plant of 855-kW capacity owned and operated by Virginia Power. The hydroelectric facility consists of two separate generating units (Units 5A and 5B), each unit possessing a single-state, open runner-type vertical turbine. Peak operational efficiency is at a flow of 40 cfs for Unit 5A and 133 cfs for Unit 5B. Water for the hydroelectric facility is withdrawn from near the surface of Lake Anna (depth of less than 7 feet). It comes through a skimmer gate and associated sluice pipe that is connected to a 5-foot diameter penstock. Water is then directed by a bifurcation piece through 24- and 48-inch conduits to Units 5A and 5B, respectively. After passing through the turbines, water is discharged into the North Anna River just downstream of the dam's spillway. (Reference 3)

The normal pool level for the North Anna Reservoir is maintained at Elevation 250 ft msl. The Commonwealth of Virginia requires a minimum discharge of 40 cfs from the North Anna Dam, except under drought conditions. These minimum flow requirements are established to maintain instream flows and water quality in the North Anna River below the dam, and in the Pamunkey and York Rivers further downstream. Should drought conditions occur and the Lake Anna water surface elevations fall below 248 ft msl, Virginia Power may reduce releases below 40 cfs in accordance with the Lake Level Contingency Plan as stipulated in Part I.F of the Virginia Pollutant Discharge Elimination System (VPDES) Permit (Reference 4). A flood surcharge of 15 feet above the normal pool level is provided for flood storage. The total Lake Anna volume of 550,000 acre-feet is allocated as described in Table 2.3-1.

Table 2.3-1 Lake Anna Storage Allocation

Purpose	Volume (acre-feet)
Minimum recreational pool and inactive storage below 246 ft msl	255,000
Conservation and active storage, 246 to 250 ft msl	50,000
Flood control storage, 250 to 265 ft msl	245,000
Total storage	550,000

Streamflows have been gauged at various locations in the North Anna River watershed. Table 2.3-2 summarizes the stream gauge site numbers, names, drainage areas, and periods of record, while Table 2.3-8 provides the associated monthly streamflow statistics. Figure 2.3-6 indicates the locations of the stream gauging stations. Inflows to Lake Anna have been gauged at Pamunkey Creek at Lahore, Virginia, and Contrary Creek, Near Mineral, Virginia. The Pamunkey Creek station gauges a drainage area of 40.5 square miles, while the Contrary Creek station gauges a drainage area of 5.53 square miles. Inflows from the remaining 297 square miles of the 343-square mile

Lake Anna catchment are not gauged. Outflows from Lake Anna have been measured on the North Anna River near Partlow, Virginia, which is located just downstream of the dam at the Virginia Route 601 bridge. The drainage area at this stream gauge is 344 square miles. Additional stream gauging stations are located further downstream on the North Anna River near Doswell, Virginia, and at Hart Corner Near Doswell, Virginia.

Table 2.3-2 USGS Stream Gauge Data

Site Number	Name	Location	Drainage Area (square miles)	Period of Record	Source
01670180	Pamunkey Creek at Lahore, VA	Latitude 38°11'33", Longitude 77°58'09"	40.5	1989-08-25 1993-07-19	(Reference 5)
01670300	Contrary Creek Near Mineral, VA	Latitude 38°03'53", Longitude 77°52'45"	5.53	1975-10-01 1987-01-09	(Reference 6)
01670400	North Anna River Near Partlow, Virginia	Latitude 38°00'46", Longitude 77°42'05"	344	1978-10-01 1995-10-09	(Reference 7)
01671000	North Anna River Near Doswell, VA	Latitude 37°53'15", Longitude 77°29'15"	441	1929-04-01 1988-09-30	(Reference 8)
01671020	North Anna River at Hart Corner Near Doswell, VA	Latitude 37°51'00", Longitude 77°25'41"	463	1979-10-01 2001-09-30	(Reference 9)
01673000	Pamunkey River Near Hanover, VA	Latitude 37°46'03", Longitude 77°19'57"	1081	1941-10-01 2001-09-30	(Reference 10)

Lake Anna water levels have been recorded since the existing units were placed into operation. The available record begins in August 1978 and continues to be recorded for each day. Table 2.3-3 summarizes the water level elevation statistics. Section 5.2.2 describes the historical variations in the Lake Anna water level and the dependability of the impoundment in more detail. That section also describes the net losses due to evaporation, including the forced evaporation associated with the existing units and the new units. Section 2.4.1.8 describes the wetlands located within the ESP site. Part 2: Section 2.4.3 provides the design basis flood elevation for Lake Anna.

Table 2.3-3 Monthly Water Level Statistics for Lake Anna, August 1978 through March 2003 (ft msl)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
N	22	23	24	22	21	23	24	25	22	23	24	24
Min	247.42	247.36	247.15	247.30	247.67	247.21	246.66	245.87	245.57	245.21	246.29	247.46
Mean	249.79	249.89	249.95	249.91	249.88	249.77	249.59	249.43	249.12	248.97	249.14	249.49
Max	250.25	250.39	250.30	250.21	250.15	250.12	250.12	250.06	250.11	250.10	250.13	250.31

Table 2.3-3 Monthly Water Level Statistics for Lake Anna, August 1978 through March 2003 (ft msl)

N = number of monthly observations (months with incomplete daily data excluded)
Min = minimum monthly value
Mean = average monthly value
Max = maximum monthly value

The hydrodynamic characteristics of Lake Anna are presented in Section 5.3.1.1. Section 5.3.2.1 provides information on the temperature distribution, stratification, and seasonal variation of density-induced currents.

2.3.1.2 Groundwater Aquifers

The ESP site lies within the Piedmont Physiographic Province. Three types of groundwater aquifers are present within the consolidated rocks of the Piedmont, along with a surficial aquifer system in the overlying unconsolidated sediments. The three consolidated-rock aquifers consist of: 1) crystalline and undifferentiated sedimentary rocks, 2) carbonate rocks, and 3) early Mesozoic age rift-basin sedimentary and igneous rocks. The unconsolidated sediments are likely to consist of residual soil, saprolite (bedrock that has been weathered to a soil but that retains the rock structure), or alluvial deposits along stream channels. Although crystalline rocks form the predominant aquifers in the Piedmont Province, carbonate rocks, which are primarily found in the portion of the Piedmont that extends from Maryland northward, form the most productive aquifers. (Reference 11)

Recharge to aquifers in the Piedmont aquifers occurs largely as infiltration of local precipitation in interstream areas. That portion of the precipitation that does not migrate laterally through the unconsolidated surficial materials for discharge to nearby streams or low areas percolates vertically downward to the bedrock, where it enters water-bearing openings in the rock. (Reference 11) The average recharge to aquifers from precipitation in the Virginia Piedmont is estimated to be about 8 to 10 inches per year (Reference 12) (Reference 13). Although an intricate network of rivers and streams that follow a dendritic drainage pattern generally dissects the Piedmont Province, some of the drainage (or portions thereof) follow nearly straight courses that are controlled by joint or fault systems in the underlying bedrock. Those streams passing through the area from other geologic provinces provide a secondary source of recharge to the groundwater. The Piedmont Province of Virginia is estimated to have as much as 1.5 billion gallons of water per square mile held in storage in the consolidated and unconsolidated aquifers. This volume of water is considered suitable for domestic and other small supply requirements. (Reference 13)

In the area around the ESP site, the bedrock consists of Precambrian to Paleozoic age crystalline metamorphic and igneous rocks, while the overlying unconsolidated material is largely a weathering product (residual soil or saprolite) of the underlying bedrock. Groundwater in the crystalline rocks is stored and transmitted through joints and fractures in the rocks, while the main body of the rock between the joints and fractures is essentially impermeable. The number and extent of the joints/fractures, and the width of the openings between their surfaces, generally decrease with depth, thus limiting the significance of the water-transmitting capability of the bedrock to its upper few hundred feet. (Reference 14)

Saprolite at the ESP site is generally exposed at the ground surface or underlies a thin layer of residual soil or fill. The saprolite extends to the top of the rock from which it was derived; however, the contact between the saprolite and sound rock may be gradational and not well defined (Reference 1). The saprolite is reported to range in thickness from about 2 to 125 feet and is of variable lithology, depending on the type of parent material from which it was derived (Reference 15). Borings drilled at the ESP site as part of the ESP subsurface investigation program penetrated saprolite to depths ranging from about 6 to 35 feet (Part 2: Appendix 2.5.4B). The saprolite penetrated by these borings is classified as a micaceous, silty-clayey, fine-to-coarse sand or sandy silt, with occasional rock fragments.

Bedrock beneath the saprolite belongs to the Ta River Metamorphic Suite. In the site area, these rocks are predominantly biotite gneiss and schist with smaller amounts of amphibolite gneiss. (Reference 16) The results of borings at the ESP site indicate the main rock type to be gneiss. The gneiss is generally described as quartz gneiss with some biotite quartz gneiss; and quartz gneiss, biotite quartz gneiss, and hornblende gneiss. The rock exhibits a variable weathering profile and joint/fracture presence. The degree of jointing and fracturing is the controlling factor for groundwater movement through the rock.

Groundwater at the ESP site occurs in unconfined conditions in both the saprolite and underlying bedrock. The results of previous investigations at the NAPS site indicate that a hydrologic connection exists between the saprolite and the bedrock. (Reference 17) This condition has been confirmed as part of the ESP subsurface investigation program (Part 2: Appendix 2.5.4B) by the presence of nearly equal water level elevations recorded in 2 observation wells (OW-845 and OW-846, Table 2.3-2) installed adjacent to each other and sealed in the bedrock and saprolite, respectively. At the ESP site, the water table is considered to be a subdued reflection of the ground surface and, therefore, the direction of groundwater movement is toward areas of lower elevations (Reference 17). Measurements made between December 2002 and June 2003 in observation wells at the ESP site exhibit water level elevations ranging from about Elevation 241 ft msl to Elevation 311 ft msl, with corresponding ground surface elevations of about Elevation 283 ft msl and Elevation 335 ft msl, respectively (Table 2.3-9). The measurements shown in Table 2.3-9 represent three quarterly rounds of groundwater level measurements taken at the ESP site to characterize seasonal variability in the water levels. Figure 2.3-7 presents hydrographs based on the water levels provided in this table for the nine observation wells (OW-841 through OW-849 on Figure 2.3-8) installed as part of the ESP subsurface investigation program. The other wells that were monitored (P- and WP-) were previously installed to monitor groundwater beneath the Service Water Reservoir (SWR) and the ISFSI, respectively.

A piezometric head contour map (Figure 2.3-8), prepared using the water levels measured in March 2003 (Table 2.3-9), indicates that groundwater flow is generally to the north and east, toward Lake Anna (). Freshwater Creek and Elk Creek, both of which flow to Lake Anna, form hydrologic boundaries to the west and south of the site, respectively (Reference 18). Because the water levels in the observation wells are generally above the top of the well screen, the water level elevation represents the piezometric head. An evaluation of the piezometric head contours shown on Figure 2.3-8 indicates a hydraulic gradient toward Lake Anna of about 3 feet per 100 feet. This gradient compares with an initial hydraulic gradient estimated for the NAPS site before the filling of Lake Anna of 8 feet per 100 feet (Reference 15). Prior to the filling of Lake Anna, it was estimated that a gradient of 6 feet per 100 feet would develop following the filling of the lake (Reference 1).

Prior to construction of the existing units, it was predicted that the filling of Lake Anna would raise the base level of groundwater discharge about 50 feet. It was estimated that this would result in a small rise in the water table where it intersects the surface of the impoundment area. Beyond this zone of intersection, however, it was estimated that the filling of the lake would have only a minor effect on the water table, and that the water table in the area of the existing units would essentially remain unchanged. (Reference 15) More recent evidence of the connection between Lake Anna and the surrounding groundwater regime is contained in the Lake Anna Special Area Plan (Reference 19). This Plan indicates that average well yields are higher in areas adjacent to the lake than in other areas of the Lake Anna watershed which are, in turn, slightly higher than in other areas of Louisa County. It was concluded that these higher yields are likely due to the presence of the lake, which enhances groundwater recharge.

The nine groundwater observation wells installed at the site as part of the ESP subsurface investigation program were tested using the slug test method to determine hydraulic conductivity values for the saprolite and underlying shallow bedrock (Part 2: Appendix 2.5.4B). Hydraulic conductivities calculated for the saprolite, based on tests in eight of the wells, range from about 0.2 to 3.4 feet per day, with a geometric mean value of 1.3 feet per day. The hydraulic conductivity of the shallow bedrock, as determined from the tests in one of the wells, is estimated to be about 2 to 3 feet per day, although the results of the test are of limited value due to the short duration of stable water level recovery measurements. Table 2.3-10 summarizes the available hydraulic conductivity data.

Laboratory tests performed on samples of saprolite from the site indicate a bulk density for this material of 125 to 130 pounds per cubic foot (pcf). Bulk densities for the bedrock range from 145 pcf for highly to moderately weathered rock to 163 pcf for moderately weathered to fresh rock. Laboratory tests to determine moisture contents of saprolite samples indicate an average moisture content of about 26 percent, while the moisture content in the vadose zone ranges from about 11 to 40 percent with an average of about 22 percent. Using the average moisture content of 26 percent and a value of 2.68 for the specific gravity of the saprolite (Reference 1), the void ratio of the saprolite is estimated to be about 0.7. A total porosity of about 41 percent is estimated from this void ratio and an effective porosity of about 33 percent is estimated based on 80 percent of the total porosity. The specific yield of the saprolite was not determined; however, an estimate of this value taken from published literature for materials of similar composition indicates that it may be in the range of 0.30 to 0.33 (Reference 20).

Based on the estimated hydraulic gradient, hydraulic conductivity, and effective porosity indicated above, groundwater beneath the ESP site is expected to flow toward Lake Anna at a rate of about 0.12 feet per day. Using a distance of approximately 1800 feet from the center of the proposed overall plant footprint for the new units to the closest point along the shoreline of Lake Anna, the groundwater travel time from the ESP site to Lake Anna is estimated to be about 40 years.

No aquifers in the Piedmont Province of Virginia have been designated as sole source by the U.S. Environmental Protection Agency (EPA) (Reference 21). The aquifer (designated as sole source) nearest the ESP site is about 120 miles to the southeast, at the southern end of the Delmarva Peninsula in Accomack and North Hampton Counties, Virginia, within the Coastal Plain Physiographic Province. An area southeast of the site has been designated as the Eastern Virginia Ground Water Management Area by the VDEQ. Groundwater withdrawal in this area is permitted based on need and an evaluation by the VDEQ of the impacts of proposed withdrawals. The area, comprised of several counties or portions thereof in southeastern Virginia, lies entirely within the Coastal Plain Province. (Reference 22)

2.3.2 **Water Use**

This section describes surface water and groundwater uses that could affect or be affected by the construction, operation, or decommissioning of new units at the ESP site. Included are descriptions of the types of consumptive and non-consumptive water uses, identification of their locations, and quantification of water withdrawals and returns. Plant water use is described in Section 3.3.

2.3.2.1 **Surface Water**

The surface water bodies that are within the hydrologic system in which the ESP site is located and that may affect or be affected by the construction, operation, or decommissioning of new units include Lake Anna and associated downstream surface water bodies. These downstream surface water bodies include the North Anna River from below the North Anna Dam to its confluence with the South Anna River where the Pamunkey River is formed, the Pamunkey River to its confluence with the Mattaponi River where the York River is formed, the York River estuary to the Chesapeake Bay, and the Chesapeake Bay. Figure 2.3-9 illustrates these surface water bodies.

Consumptive surface water users within this hydrologic system have been identified from the water use database maintained by VDEQ (Reference 24), which includes users whose average daily withdrawal during any single month exceeds 10,000 gallons per day (gpd). Users include the existing units, Bear Island Paper Company, the Doswell Water Treatment Plant, and St. Laurent Paper Products Corporation. Figure 2.3-10 identifies the locations of these surface water withdrawals. Table 2.3-4 identifies the water use and the water body from which withdrawals are made, while Table 2.3-5 summarizes the monthly withdrawal rates. These data indicate that withdrawal of water by the existing units from the North Anna Reservoir for cooling purposes represents the single largest consumptive use in the affected hydrologic system. Virtually all of the water withdrawn from the North Anna Reservoir portion of Lake Anna is returned to the reservoir via the WHTF (Reference 1). A portion of the returned water is lost to the atmosphere by evaporation as presented in Section 5.2.2.

Table 2.3-4 Consumptive Surface Water Users in the Affected Hydrologic System[a]

Facility	Water Use	Water Body
NAPS Unit 1	Cooling	Lake Anna
NAPS Unit 2	Cooling	Lake Anna
Bear Island Paper, Ashland Plant	Manufacturing	North Anna River
Doswell Water Treatment Plant	Municipal water system	North Anna River
St. Laurent Paper, West Point Plant	Manufacturing	Pamunkey River

a. (Reference 24)

No known future surface water withdrawals from the affected hydrologic system are planned for Louisa County, even though the county population and water supply demand is projected to increase (Reference 25). The surface water sources, such as Northeast Creek Reservoir and Lake Gordonsville, that are anticipated to supply the future demand are located outside the Lake Anna watershed and the affected hydrologic system.

Surface water bodies within a 10-km (6.2-mile) radius of the ESP site include Lake Anna and some of its tributaries, as illustrated on Figure 2.3-10. Non-consumptive water use of these surface water bodies is primarily recreational. Public use of the North Anna Reservoir includes fishing, boating, swimming, and water skiing. Public access is provided via Lake Anna State Park, which is on the Spotsylvania County side of the Lake. In the mid-1990s total park attendance peaked, reaching 180,000 visitors in 1997. In 1998, attendance decreased to about 142,500 visitors, with the beach area being the destination for about 20% of the park visitors. Access to the WHTF is limited to adjacent property owners. Recreational use of Lake Anna is seasonal with higher usage rates in the summer months. Future non-consumptive water use of the lake is expected to continue to be primarily recreational at usage rates comparable to current levels. (Reference 26)

The Commonwealth of Virginia's Surface Water Management Act of 1989 and associated regulations (9 VAC 25-220-10 et seq.) impose legal restrictions on surface water withdrawals where surface water resources have a history of low flow conditions that threaten important in-stream and off-stream uses. The purposes of these regulations are to maintain surface water flow at minimum

Table 2.3-5 Consumptive Surface Water Use Statistics for the Affected Hydrologic System[a]

Month	NAPS Unit 1	NAPS Unit 2	Bear Island Paper, Ashland Plant	St. Laurent Paper, West Point Plant[b, c]	Doswell [c] Water Treatment Plant
			(Millions of Gallons)		
January	24,930	24,833	8.02	-	-
February	20,555	22,645	24.32	-	-
March	21,869	20,445	8.15	-	-
April	26,665	21,845	14.15	-	-
May	33,653	36,947	8.36	-	-
June	37,693	39,465	19.70	-	-
July	41,975	41,975	40.78	-	-
August	41,713	41,749	35.33	-	-
September	32,319	31,303	29.63	-	-
October	32,974	34,136	22.92	-	-
November	30,818	29,278	31.53	-	-
December	27,573	26,954	12.33	-	-
Annual	372,737	371,576	252.22	-	-
Daily[d]	1,021	1,018	0.70	-	4.0[e]

a. Reference 24 numeric data represent mean values for the 1996-2001 period.

b. Listed in the VDEQ water use database, but no withdrawals reported in the 1996-2001 period.

c. Data not available.

d. Million gallons per day.

e. Rated capacity.

levels during periods of drought, ensure assimilation of treated wastewater, and support of aquatic and other water-dependent wildlife. In an area designated by the State Water Control Board as a surface water management area, water withdrawals of 300,000 gallons per month or more are required to have a surface water withdrawal permit. Permits and certificates must include a conservation plan that is activated during low-flow surface water conditions. As of October 2001, the Virginia State Water Control Board had not designated any surface water management areas in the state (Reference 27).

2.3.2.2 Groundwater Use

Groundwater for use at and in the vicinity of the ESP site is obtained from springs and wells in either the saprolite or underlying crystalline bedrock. Most wells completed in the saprolite have been excavated either by hand digging or augering. These wells are susceptible to becoming dry due to seasonal fluctuations in the water table. Drilled wells generally extend through the saprolite to depths of up to several hundred feet in the underlying bedrock. These wells are cased from the ground surface to the top of bedrock. (Reference 25) The production of groundwater in the vicinity of the ESP site is generally not sufficient to satisfy large water demands because of the relatively low yield of the aquifers, as presented in Section 2.3.1.2. The majority of groundwater development in the area is for domestic and agricultural use, with some public, light industrial and commercial use (Reference 28).

The following sections discuss groundwater use in the vicinity of the ESP site and by the existing units. Aquifers designated by the EPA as sole source are presented with respect to the ESP site in Section 2.3.1.2.

2.3.2.2.1 Local Use

There are no known users of large quantities of groundwater within 25 miles of the ESP site (Reference 1). The vast majority of wells in the area yield less than 50 gallons per minute (gpm) (Reference 25). Based on the presence of Lake Anna and the hydrologic boundary it presents to groundwater movement north and east of the ESP site, further discussion of groundwater use in the vicinity of the ESP site is limited to Louisa County.

Every 5 years, the U. S. Geological Survey (USGS) compiles national water-use estimates and publishes a report containing the results of this effort. Data from the latest available report, for the year 1995, are provided on the USGS web site for Virginia, by county or independent city (Reference 29). The following groundwater withdrawal estimates for Louisa County, in millions of gallons per day (mgpd), are provided by withdrawal category:

- Public water supply = 0.18 mgpd
- Domestic water supply = 1.45 mgpd
- Commercial/Industrial water supply = 0.10 mgpd
- Thermoelectric power water supply = 0.02 mgpd
- Agricultural water supply = 0.05 mgpd

VDEQ requires that any groundwater user in Virginia whose average daily withdrawal during any single month exceeds 10,000 gpd provide a report by January 31 of each year stating the water withdrawal and use data for the previous year. The only exceptions to this regulation are agricultural users who have slightly modified requirements based on their location, withdrawal, or withdrawal facility. (Reference 24) For the year 2001, no withdrawals were reported for Louisa County that meet or exceed this threshold.

A study previously performed for Louisa County included the compilation and evaluation of records of wells permitted by the Louisa County Health Department. (Reference 25) These records addressed 2155 drilled wells and 1743 dug or augered (bored) wells. The majority of the drilled wells serve single-family residences. The locations of the wells are currently referenced only to county tax maps.

The average yield of all wells in Louisa County is estimated to be about 14.5 gpm. However, the average yield of public wells is estimated to be about 42 gpm. The public water supply wells have an average depth of nearly 300 feet, and almost all are less than about 400 feet deep. The residential wells are generally only 100 to 200 feet deep. The Louisa County and previous studies in the Piedmont Province suggest that yields from individual wells in this area can vary greatly over distances as small as 100 feet. (Reference 25)

There are 45 public water supplies in Louisa County capable of obtaining their water from springs or wells. Data describing these public water supplies are presented in Table 2.3-11. The public supplies closest to the existing units are Lake Anna Plaza, about 2.6 miles to the northwest, and Jerdone Island, about 4.3 miles to the south-southeast. Based on their distance from the ESP site and the presence of one or more arms of Lake Anna between the site and these public water supplies, any impact the new units may have on the aquifers beneath the site is not expected to affect these supplies. Likewise, withdrawal by these public supplies is not expected to affect the ability of the new units to withdraw groundwater for potable water needs.

Private water wells provide about 80 percent of the domestic water supply to residents of Louisa County (Reference 30). The residential water supply well nearest the existing units is located about one mile to the south-southeast in Lot 32 of the Aspen Hill subdivision. Based on its distance from the ESP site and the presence of Sedges Creek between the site and this well, any impact the new units may have on the aquifers beneath the ESP site would not affect the domestic water supply provided by this well. Likewise, withdrawal by the well would not affect the ability of the new units to withdraw groundwater for potable water needs.

Population growth projections for Louisa County by the year 2015 range from about 32,000 to 46,000. Such growth would result in an estimated public water supply demand of between 2.8 and 4.1 mgpd for an average day and between 4.5 and 6.6 mgpd on a peak day. This water supply demand is expected to be satisfied largely by the use of surface water sources such as Northeast Creek Reservoir and Lake Gordonsville. However, these sources are expected to be supplemented by groundwater supply where available. To meet projected water demands beyond the year 2015, a large groundwater supply may need to be considered in conjunction with the development of alternative surface water sources. (Reference 25)

2.3.2.2.2 **On-Site Use**

Groundwater withdrawal for use by the existing units is accomplished from 4 water supply wells permitted for public use by the Virginia Department of Health (VDH). These 4 wells (Nos. 2, 3A, 4

[new], and 6) comprise a single water supply system at the site. A 5th well (No. 4 [old]) is no longer used as part of this system, but is available for emergency purposes only. A separately permitted well (NANIC) provides the water supply for the North Anna Nuclear Information Center. A new well was constructed at the site in 2003 to support an increase in water demand at the security training building. The proposed location of this well was evaluated by the VDH prior to its construction. The locations of these wells are shown on Figure 2.3-11 and the wells are described in Table 2.3-6. Four small wells not requiring permits at the NAPS site provide minor additional water for plant use (Reference 3). The locations of these 4 wells are not well documented. One of the wells is likely to be the well used to supply the Metrology laboratory and its location is shown on Figure 2.3-11. A second well is located at the security training building in the vicinity of the newly constructed well described above.

Table 2.3-6 North Anna Power Station Water Supply Wells

Well	Depth (ft)	Measured Yield (gpd)	Water Treatment
No. 2 [a, b]	385	12,960	Chlorination (normally not in use)
No. 3A [a, b]	185	74,880	
No. 4 (new) [a, b]	305	63,360	
No. 6 [a, b]	375	79,200	
No. 4 (old) [a, b] (not used)	200	77,760	NA
NANIC [a, c]	260	106,560	Calcite filtration
Security Training Building	[d]	[d]	[d]

a. Reference 25

b. Reference 31

c. Reference 32

d. Information not available.

The 4 active wells comprising the primary groundwater supply system for the new units have individual capacities ranging from 9 to 55 gpm and a total capacity of 160 gpm. However, these 4 wells are permitted for a total design capacity of only 53,040 gpd or about 37 gpm. This capacity is currently dictated by the available storage tank capacity at the site. The NANIC well has a measured capacity of 74 gpm (106,560 gpd) but a design capacity of 19,600 gpd. (Reference 31) (Reference 32)

As a condition of the well permits, Virginia Power is required to submit to the VDEQ by January 31 of every year an annual report of water withdrawals for the previous year. Table 2.3-12 shows the monthly withdrawal quantities that were reported for the year ending December 31, 2002. It can be determined from this table that the 4 primary wells withdrew a combined average of almost 14 gpm for the year, and that the NANIC well withdrew an average of a little over 1 gpm. The highest total monthly withdrawal in 2002 for the 5 wells averaged almost 38 gpm in January. The highest reported monthly withdrawal average was 41 gpm in March 1994 (Reference 3). The four wells not requiring permits are also not required to report their withdrawals, but based on their small size and limited use they are not expected to add more than 1 or 2 gpm to the average withdrawal by the permitted wells (Reference 3).

Any groundwater supply required by the new units would likely come from an increase in the storage capacity for the existing wells or from drilling additional wells. In either event, additional groundwater withdrawal by the new units is not expected to impact any offsite wells due to: 1) their distance from the site, 2) the direction of the hydraulic gradient toward Lake Anna and the lake's recharge effect, and 3) the existence of hydrologic divides between the ESP site and the offsite wells.

2.3.3 Water Quality

This section describes the water quality characteristics of surface water bodies and groundwater aquifers that could affect plant water use and effluent disposal, or be affected by the construction, operation, or decommissioning of new units at the ESP site. Site-specific and regional data on the physical, chemical, and biological water quality characteristics of surface water and groundwater are summarized to provide the basic data for evaluating water quality impacts on water bodies, aquifers, aquatic ecosystems, and water use.

2.3.3.1 Surface Water

As described in Section 2.3.1, it is anticipated that new Unit 3 would use a closed-cycle, dry and wet cooling tower system for the main condenser, with make-up water for the wet cooling towers being supplied from the North Anna Reservoir and blowdown discharge being returned to the reservoir via the WHTF. It is anticipated that new Unit 4 would use a closed-cycle cooling system with dry system cooling towers with small make-up water requirements (1 gpm or less) supplied from the North Anna Reservoir and no blowdown discharge to the WHTF. Therefore, Lake Anna is the primary surface water body that could affect plant water use and effluent disposal, or be affected by the construction and operation of new units at the ESP site.

An extensive set of water temperature data for Lake Anna has been collected in accordance with the VPDES monitoring requirements for the existing units. The VPDES permit (Reference 4) requires continuous monitoring of temperature at 11 stations. Temperature measurements are taken hourly at the surface at Stations 1 through 9 inclusive and 11 and at a depth of 3 meters at Station 10. Figure 2.3-12 identifies the locations of the fixed continuous temperature recorders. The VPDES permit (Reference 4) also requires that a quarterly thermal plume survey be conducted at 14 stations located along the length of the North Anna Reservoir. At each station, temperature measurements are taken from the water surface to the lake bottom at one-meter intervals. Figure 2.3-12 identifies the locations of these stations, which are designated as Stations A through N.

Water temperature statistics from 4 of the fixed continuous monitors are summarized in Table 2.3-7. The locations of these stations are as follows:

- North Anna Reservoir near the cooling water intakes for the existing units (Station 2/NALINT)
- The end of the discharge canal leading into Lagoon 1 of the WHTF (Station 7/NADISC1)
- Upstream of Dike 3 in Lagoon 3 of the WHTF (Station 9/NAWHTF3)
- North Anna Reservoir across from Burrus Point (Station 3/NALBRPT)

The same data are plotted in Figure 2.3-13 from 1978 through 2001 to illustrate temporal trends.

Table 2.3-7 Daily Water Temperature Statistics for Lake Anna

Statistic	Station 2 (NALINT)	Station 7 (NADISC1)	Station 9 (NAWHTF3)	Station 3 (NALBRPT)
Number measurements	8087	8175	8301	7823
Average, °F	63.8	77.1	69.7	65.6
Minimum, °F	34.2	39.4	36.1	34.7
Maximum, °F	90.1	102.2	95.0	89.4
80% quantile, °F	80.6	92.1	85.5	81.1
90% quantile, °F	83.7	96.1	88.7	84.2
95% quantile, °F	85.1	97.7	90.1	85.8
99% quantile, °F	87.3	100.2	92.5	87.6

Additional physical and chemical water quality parameters were measured as part of a Clean Water Act (CWA) 316(a) demonstration for the existing units (Reference 33). Fifteen physical and chemical parameters, in addition to water temperature, were monitored at 14 water quality stations in the North Anna Reservoir and the WHTF. The locations of these stations are shown on Figure 2.3-12. Eight of these water quality monitoring stations coincide with current fixed continuous temperature recorders, while the remaining six were located independently. Virginia Power has also measured selected water quality parameters at the same 14 water quality stations to support their operation of the existing units. Table 2.3-13 summarizes the water quality data obtained from the sources cited above for each of the water quality stations.

Pre-existing environmental stresses on the water quality of Lake Anna are described in the CWA 316(a) demonstration report (Reference 33). One known impact is associated with acid mine drainage into Contrary Creek due to historical mining of the Contrary Creek watershed for pyrite ore. This drainage produced higher concentrations of metals and an acidic pH in the Contrary

Creek arm of Lake Anna relative to the rest of the lake, which is evident in the data presented in Table 2.3-13.

Other known lake water impacts include elevated concentrations of nutrients associated with the application of fertilizers for crop production in the watershed. With declining agricultural activity in recent years, however, nutrient concentrations have decreased and stabilized since inundation. Compared to other regional lakes, there does not appear to be an excess of nutrients (Reference 33).

Several tributaries to the North Anna Reservoir, and portions of North Anna Reservoir, appear on the VDEQ's 303(d) list of impaired waters (Reference 34). Many of these waterways have been listed based on the presence of fecal coliform bacteria. The source of fecal coliform bacteria is stated to be unknown in the 303(d) report. Sources might include livestock, wildlife, failing septic systems, pets, and waste from boats (Reference 19). Contrary Creek, Goldmine Creek, and Lake Anna are listed due to the presence of polychlorinated biphenyls in fish tissues at concentrations in excess of the human health-based screening value. The source of this impairment is unknown. Contrary Creek has also been listed because of low pH.

The known permitted discharges to Lake Anna are limited to those from the existing units. These sources and permitted discharge limits are described in the VPDES permit (Reference 4).

2.3.3.2 Groundwater Aquifers

Groundwater at the ESP site occurs under water table conditions at depths ranging from about 6 to 58 feet in the saprolite and underlying metamorphic bedrock. The most dependable supplies of groundwater are obtained by wells drilled into the lower part of the weathered zone and the upper part of the underlying fractured bedrock (Reference 35). As presented in Section 2.3.2, the existing units obtain potable water from wells in these zones. Regionally, this aquifer can be considered a Piedmont crystalline aquifer (Reference 13). This aquifer is the primary groundwater aquifer that could affect plant water use and effluent disposal, or be affected by the construction, operation, or decommissioning of new units at the ESP site.

No site-specific data are available to establish the physical, chemical, and biological water quality characteristics of the groundwater at the ESP site. However, a number of studies have been conducted to characterize the water quality of the Piedmont crystalline aquifers in the region. Data published in these studies are expected to be representative of site conditions. Table 2.3-14 summarizes these regional data.

In comparison with groundwater in widely scattered regions of the world, the water in the Piedmont region ranks among the best in chemical quality (Reference 36). The groundwater from most light-colored crystalline metamorphic and igneous rocks of the region is generally soft (hardness ≤60 mg/l), slightly acidic (pH <7.0), and low in dissolved solids; while that from the dark-colored crystalline metamorphic and igneous rocks is generally harder, slightly more alkaline, and moderately higher in dissolved solids (Reference 36). As Figure 2.3-13 illustrates, water from the crystalline rocks contains a balanced mixture of calcium, magnesium, and sodium ions. This figure also indicates that the water is rich in bicarbonate ions. The crystalline igneous and metamorphic rocks of the Piedmont province also have relatively high levels of naturally occurring radioactivity in the groundwater (Reference 37).

Based on the Louisa County Water Testing Program undertaken in 1992, there is evidence of groundwater quality degradation near the ESP site due to coliform contamination (Reference 19). Of the 119 wells tested by Louisa County in 1992, 29 wells were in the Lake Anna watershed. Of those 29, 18 were residential, 10 were on farms, and one was at a quarry. Sixteen of the 29 wells were in the lakeside area. All wells in the Louisa County Water Testing Program were tested for pH, total and fecal coliforms, metals, anions, and total organic carbon. Of the 29 wells in the Lake Anna watershed, total and fecal coliforms were present in 41 percent and 31 percent of the wells, respectively. Sources of this coliform contamination likely include the septic systems typically used by the residential developments and farms surrounding Lake Anna. Of the remaining parameters for which tests were conducted, only manganese and nitrate were found at elevated levels in the Louisa County portion of the Lake Anna watershed. Four of the 29 wells had manganese present at concentrations in excess of the secondary maximum contaminant level of 0.05 mg/l. One well, located on a farm, had nitrate present at a concentration in excess the maximum contaminant level of 10 mg/l. (Reference 19)

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Table 2.3-8 Monthly Streamflow Statistics (cfs)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pamunkey Creek at Lahore, VA												
N	4	4	3	4	3	3	3	3	4	3	3	4
Min	25.7	25	37.9	35.3	19.9	14.4	14.9	1.46	2.03	2.3	6.25	24.6
Mean	61.2	37.5	49.0	62.0	43.0	23.9	19.3	9.72	14.5	31.8	31.8	47.6
Max	91.5	53.5	65.3	114	81	32.8	26.6	16.6	22.2	57.1	49.1	87.7
Contrary Creek near Mineral, VA												
N	11	11	11	11	11	11	11	11	11	12	12	12
Min	1.69	3.49	2.05	2.18	1.66	0.63	0.31	0.1	0.13	0.67	0.68	1.64
Mean	7.97	9.37	8.92	8.36	4.33	2.46	1.34	3.40	1.20	3.16	5.05	5.46
Max	20.1	25.5	21.9	21.1	12.8	6.76	2.27	14.3	4.13	10.5	19	8.68
North Anna River near Partlow, VA												
N	17	17	17	17	17	17	17	17	17	17	17	17
Min	45.2	55.6	51.8	55.7	53.5	46.1	45.7	49.1	44.3	42.4	44	45.4
Mean	401	507	601	485	330	215	133	134	109	138	244	265
Max	926	1361	1762	1378	947	784	563	478	530	1085	1230	682
North Anna River near Doswell, VA												
N	58	58	58	59	59	59	59	59	59	59	59	59
Min	68.1	87.2	77.7	91.6	111	71.2	32.2	14.7	6.16	5.45	24.8	53.2
Mean	554	602	645	592	368	244	210	269	177	230	285	407
Max	1974	1767	1515	1922	1043	1325	1321	2688	1490	1345	1464	1723
North Anna River at Hart Corner near Doswell, VA												
N	22	22	22	22	22	22	22	22	22	22	22	22
Min	71.9	100	90.5	108	61.9	50.6	47.7	49.3	41.7	43.7	46.7	75.2
Mean	536	677	820	648	424	244	159	155	144	207	315	377
Max	1389	2660	2345	1887	1217	795	591	614	1185	1428	1561	1320
Pamunkey River near Hanover, VA												
N	60	60	60	60	60	60	60	60	60	60	60	60
Min	197	396	248	434	197	82	91.9	63.1	30.3	60.6	113	166
Mean	1434	1624	1883	1535	1027	680	501	619	427	581	727	1114
Max	4334	7118	5430	5009	2821	4293	2747	6381	2939	3461	3505	3782

N = number of monthly observations
Min = minimum monthly value
Mean = average monthly value
Max = maximum monthly value

Table 2.3-9 Quarterly Groundwater Level Elevations

Observation Well No.	Well Depth* (ft)	Reference Point Elev. (ft)	Reference Point Stickup** (ft)	Top of Well Screen Elev. (ft)	Well Screen Length (ft)	Groundwater Level Elevations 12/17/02	03/17/03	06/17/03
OW-841	34.3	251.6	1.5	228.1	9.7	248.9	249.6	249.6
OW-842	49.6	336.7	1.5	297.8	9.6	307.5	308.9	310.8
OW-843	49.2	320.6	1.5	282.1	9.7	285.1	288.1	290.8
OW-844	24.6	273.5	1.5	257.6	9.6	265.5	266.7	267.3
OW-845	55.0	297.3	1.5	253.0	9.7	272.7	274.9	277.4
OW-846	32.7	297.3	1.5	273.5	9.8	272.5	274.8	277.1
OW-847	49.8	319.7	1.5	280.6	9.6	285.4	287.0	289.5
OW-848	47.3	284.5	1.5	240.8	5.0	241.7	242.9	243.6
OW-849	49.8	298.5	1.5	259.4	9.7	265.5	269.5	271.7
P-10	22.5	286.4	2.4	267.0	5	274.4	274.8	275.2
P-14	N/A	327.1	N/A	N/A	N/A	271.6	272.2	272.8
P-18	N/A	329.0	N/A	N/A	N/A	285.7	286.5	287.5
P-19	58.5	322.3	N/A	N/A	5	284.3	285.2	286.3
P-20	61.0	320.6	N/A	N/A	5	274.9	275.4	275.8
P-21	58.5	319.2	N/A	N/A	5	Dry	261.2	262.0
P-22	60.0	320.5	N/A	N/A	5	276.8	277.8	278.6
P-23	41.2	296.4	1.9	258.7	5	261.1	262.6	263.3
P-24	25.0	293.4	2.3	271.3	5	276.4	277.1	278.4
WP-3	N/A	317.9(?)	N/A	266.5	5	299.7	301.0	302.8
Lake Anna Water Level Elevation						248.1	250.1	250.4
Service Water Reservoir Water Level Elevation						314.6	313.3	314.6

OW - wells installed in December 2002 as part of ESP Subsurface Investigation Program.
P - wells installed previously to monitor NAPS Units 1 and 2 Service Water Reservoir.
WP - well installed previously as part of Independent Spent Fuel Storage Installation monitoring program.
* Below ground surface at time of installation.
** Above ground surface at time of installation.
N/A - not available

Table 2.3-10 Hydraulic Conductivity Values

Observation Well No.	Depth Interval Tested (ft)	Elevation	Material	Hydraulic Conductivity cm/sec	Hydraulic Conductivity ft/day
PT-1[a]	Near-surface	Unknown	Saprolite	2.8×10^{-5}	0.08
PT-2[a]	Near-surface	Unknown	Saprolite	1.4×10^{-5}	0.04
P-10[b]	14.5 - 22.5	269.5 - 261.5	Saprolite	6.1×10^{-4} to 6.1×10^{-5}	1.7 to 0.17
P-24[b]	16.8 - 25.0	274.3 - 266.1	Saprolite	2.9×10^{-4} to 6.6×10^{-6}	0.8 to 0.02
P-23[b]	33.7 - 41.2	260.7 - 253.2	Saprolite	6.6×10^{-5}	0.19
OW-844[c]	12.7 - 24.6	259.3 - 247.4	Saprolite	9.9 to 8.9×10^{-5}	0.28 to 0.25
OW-841[c]	20.1 - 34.3	230.0 - 215.8	Saprolite	8.2 to 7.8×10^{-4}	2.3 to 2.2
OW-846[c]	20.3 - 32.7	275.5 - 263.1	Saprolite	1.2×10^{-3} to 6.8×10^{-4}	3.4 to 1.9
OW-847[c]	35.0 - 49.8	283.2 - 268.4	Saprolite	2.3 to 2.1×10^{-4}	0.66 to 0.58
OW-842[c]	35.3 - 49.6	299.9 - 285.6	Saprolite	3.3×10^{-4}	0.93
OW-849[c]	35.6 - 49.8	261.4 - 247.2	Saprolite	1.1×10^{-3} to 7.0×10^{-4}	3.2 to 2.0
OW-843[c]	36.4 - 49.2	282.7 - 269.9	Saprolite	4.9 to 4.5×10^{-4}	1.4 to 1.3
OW-848[c]	39.1 - 47.3	243.9 - 235.7	Saprolite	1.2×10^{-3} to 9.9×10^{-4} [d]	3.4 to 2.8 [d]
OW-845[c]	39.7 - 55.0	256.1 - 240.8	Quartz Gneiss	1.1×10^{-3} to 6.3×10^{-4} [e]	3.1 to 1.8 [e]
Test Results					
B-48[a]	3.5	290.5	Sandy silt	1×10^{-6}	0.003
B-8[a]	5.5	293.5	Fine sand, tr. silt	1×10^{-6}	0.003
B-2[a]	15.5	269.5	Fine to med. sand, w/clayey silt	4×10^{-5}	0.11
B-15[a]	36	281	Silty fine sand	1.3×10^{-5}	0.04

a. Reference 15
b. Reference 23
c. Part 2: Appendix 2.5.4B
d. Results may not be accurate due to static water level approximately 0.5 ft below top of well screen.
e. Results not be accurate due to short duration of stable water level recovery measurements.

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive (a)
Town of Louisa (b) (primary source is surface water)	Community	spring	NA	38,880		1950	
		3 wells	200–405	43,200–53,280			
Town of Mineral (b)	Community	2 springs	NA	57,600		670	A
		4 wells	200–600	14,400–165,600			
Acorn West Trailer Park (b)	Community	well	120	8640		70	I
Apple Grove School (a)	Transient Non-Community					200	I
Blue Ridge Shores (b)	Community	4 wells	163–405	288,000	160,000	1450	A
Bumpass Park/Lake Anna Rescue (a)	Transient Non-Community					250	A
Burger King Zion Crossroads (a)	Transient Non-Community					250	A
Cable Form (a)	Transient Non-Community					11	I
Christopher Run Campground (a)	Transient Non-Community					608	A
Country Side II (a)	Transient Non-Community					50	I
Crescent Inn Restaurant (a)	Transient Non-Community					150	A
Crossing Point (VA Oil Co) (b)	Non-Transient Non-Community	2 wells	305	21,600–28,800	10,400	45	A
Deb's Place (a)	Transient Non-Community					50	I

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive [(a)]
East End Elementary School [(b)]		well	345	61,920	31,200		
Expressions Learning Center [(b)]	Non-Transient Non-Community	well	205	17,280		45	A
Green Springs School [(a)]	Transient Non-Community					300	I
Jerdone Island [(b,c)]	Community	well	200	83,520	19,600	49	A
Jouette Elementary School [(b)]	Non-Transient Non-Community	well	345	61,920	19,600	741	A
Junction Restaurant [(a)]	Transient Non-Community					25	I
Junction Restaurant [(a)]	Transient Non-Community					50	I
Klockner Barrier Films [(b)]		well	305	53,280	22,000		
Klockner-Pentaplast [(b)]	Non-Transient Non-Community	2 wells	205–280	21,600–57,600	44,000	526	A
Lake Anna Estates Trailer Park [(a)]	Community					50	I
L A Pizza [(a)]	Transient Non-Community					25	I
Lake Anna Plaza [(d)]	Community	2 wells	335–230	11,520–86,400	41,200	100	A
Louisa County Senior Center [(a)]	Transient Non-Community					45	I
Louisa County Water Authority [(a,b)]	Non-Transient Non-Community	well	550	34,560		192	I
Louisa County Zion Crossroads [(a)]	Non-Transient Non-Community					600	A

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive [(a)]
Louisa Day Care Center [(a)]	Transient Non-Community					30	I
Louisa Intermediate School [(a)]	Transient Non-Community					900	I
Mount Garland School [(a)]	Transient Non-Community					140	I
Ole Country Inn [(a)]	Transient Non-Community					50	I
Prospect Hill [(a)]	Transient Non-Community					50	A
Raynell's [(a)]	Transient Non-Community					25	I
Sandra Carter [(a)]	Community					36	I
Shenandoah Crossing [(b)]	Non-Transient Non-Community	2 wells	280–300	123,840–97,920	98,400	850	A
Siebert's Amoco & Dairy Queen [(a)]	Transient Non-Community					950	A
Six-o-Five Village [(b)]	Community	2 wells	310–365	64,800–10,800	10,700	201	A
Small Country Campground [(a)]	Transient Non-Community					112	A
Tavern on the Rail [(a)]	Transient Non-Community					150	A
Trevillians Elementary School [(b)]	Non-Transient Non-Community	well	204	57,600	19,600	676	A
Trevilians Square Apartments [(a)]	Community					61	A

Table 2.3-11 Public Groundwater Supplies In Louisa County

Installation	Type[a]	Water Source	Depth (ft)	Measured Yield (gpd)	Design Yield (gpd)	Population Served [a]	Active/ Inactive [(a)]
Twin Oaks Community [(b)]	Community	well	250 [(e)]	7200		75	A
West End Elementary School [(b)]		well	204	57,600	20,000		
Wooden Nickle [(a)]	Transient Non-Community					25	I

Note: Blank entries indicate data not provided in cited reference.

a. Reference 38

b. Reference 25

c. Reference 39

d. Reference 40

e. Reference 1

Table 2.3-12 North Anna Power Station Groundwater Use[a] January 1, 2002 to December 31, 2002

Month	Well #2	Well #3A	Well #4	Well #6	NANIC
			(Millions of Gallons)		
January	0.0032	0.4268	0.4519	0.7444	0.0485
February	0.0032	0.1395	0.4010	0.5095	0.0467
March	0.0025	0.0263	0.1050	0.1642	0.0555
April	0.0046	0.0368	0.1253	0.1459	0.0474
May	0.0076	0.0376	0.2565	0.1041	0.0690
June	0.0021	0.0531	0.2524	0.1458	0.0502
July	0.0018	0.0511	0.3585	0.0189	0.0525
August	0.0077	0.0611	0.3434	0.0526	0.0656
September	0.0071	0.1020	0.4018	0.1655	0.0474
October	0.0062	0.0874	0.2118	0.1574	0.0651
November	0.0148	0.0694	0.2126	0.1846	0.0586
December	0.0037	0.2005	0.0648	0.2070	0.0482
Total	0.0645	1.2916	3.1850	2.5999	0.6547
Monthly Average	0.0054	0.1076	0.2654	0.2167	0.0546

a. Reference 41

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Pamunkey Creek Arm of Lake Anna at Route 719 Bridge (Station 5/NAL719N)															
Observations	84	192	192	97	49	79	106	99	192	116	22	99	5	33	206
Average	18.92	8.07	8.41	0.05	0.02	0.04	0.07	0.48	14.62	7.70	0.02	0.30	0.12	0.02	7.07
Maximum	39.3	37	13.6	0.33	0.26	0.21	0.24	3.16	21.2	17.5	0.05	3.4	0.3	0.15	8.9
Minimum	7.8	0.4	0.1	0.01	0	0	0.01	0.01	6.8	1.6	0.003	0.01	0.002	0.01	6.3
North Anna River Arm of Lake Anna at Route 719 Bridge (Station 6/NAL719S)															
Observations	84	192	192	94	45	88	95	95	192	115	24	98	9	34	206
Average	18.37	6.80	8.63	0.05	0.02	0.04	0.05	0.41	14.64	7.46	0.02	0.34	0.13	0.02	7.08
Maximum	39.3	41	14.2	0.16	0.05	0.16	0.2	2.05	25.8	18	0.04	6.81	0.38	0.11	8.5
Minimum	8.9	0.4	0	0.01	0	0	0.01	0.01	6.1	1.3	0.001	0.05	0.002	0.01	6.2
Lake Anna at Route 208 Bridge (Station 4/NAL208)															
Observations	51	192	192	53	8	50	73	80	192	80	28	102	7	66	213
Average	14.14	3.46	8.50	0.04	0.06	0.04	0.07	0.15	10.83	8.16	0.06	0.48	0.10	0.03	6.90
Maximum	22.2	20	13.8	0.3	0.3	0.25	0.91	0.58	19.3	11.6	1.1	22.15	0.38	0.11	7.4
Minimum	5.1	0.3	0.1	0.01	0.01	0.01	0.01	0.01	7.1	4	0.003	0.03	0	0.01	5.6
Contrary Creek Arm of Lake Anna															
Observations	36	176	176	8	5	5	36	32	167	36	50	85	6	78	191
Average	17.81	3.84	8.88	0.07	0.03	0.09	0.06	0.09	5.51	17.15	0.07	0.78	0.11	0.28	6.09
Maximum	32.5	40.4	13.5	0.32	0.06	0.26	0.35	0.22	15.2	39.8	0.22	6.4	0.18	1.14	7.4
Minimum	12	0.2	0.2	0.01	0.01	0.01	0.01	0.01	0	10.6	0.01	0.07	0.01	0.01	3.8

Note: Blank entries indicate no data available.

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Lake Anna at North Anna Power Station Intakes (Station 2/NALINT)															
Observations	72	178	178	76	29	59	89	102	178	105	27	94	11	60	199
Average	14.14	2.66	8.46	0.04	0.03	0.04	0.07	0.39	10.13	9.06	0.02	0.23	0.07	0.02	6.89
Maximum	27.4	13	13.2	0.45	0.16	0.29	0.19	1.57	18	18	0.04	3.97	0.19	0.043	7.5
Minimum	5.2	0.6	0.1	0	0	0	0.01	0.04	6.9	3.5	0.001	0.03	0.002	0.008	5.1
Lake Anna at Mid Lake															
Observations	36	72	72	42	11	38	56	68	72	67	2	52	2	26	93
Average	13.65	2.42	8.30	0.05	0.07	0.04	0.07	0.17	9.17	8.44	0.02	0.38	0.01	0.02	6.88
Maximum	18.8	9.5	12.8	0.35	0.25	0.14	0.19	0.48	15	14	0.03	8.96	0.02	0.04	7.3
Minimum	10.3	0.6	0.2	0.01	0.01	0.01	0.02	0.05	6.9	3.6	0.003	0.03	0.001	0.01	6.1
Lake Anna Near Burrus Point															
Observations	33	72	72	14	6	13	36	36	72	36		35		18	72
Average	13.37	2.29	8.26	0.12	0.07	0.10	0.07	0.15	9.19	8.52		0.10		0.01	6.92
Maximum	18.8	6	12.8	0.45	0.18	0.41	0.12	0.34	16.4	11.8		0.16		0.02	7.3
Minimum	1.2	0.2	0.6	0.01	0.02	0.01	0.03	0.06	7.3	7.3		0.04		0.01	6.7
Lake Anna Near Dike 3 (Station 10/NALST10)															
Observations	36	72	72	13	5	10	36	36	72	36		36		21	72
Average	13.70	2.23	8.29	0.10	0.22	0.02	0.08	0.15	9.00	8.34		0.11		0.01	6.90
Maximum	17.1	7.4	12.5	0.9	0.9	0.04	0.13	0.3	12.1	9.8		0.17		0.03	7.2
Minimum	10.3	0.7	4.7	0.01	0.02	0.01	0.03	0.06	5	7.2		0.03		0.01	6.3

Note: Blank entries indicate no data available.

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Lake Anna at the Dam															
Observations	84	192	192	79	31	61	99	115	192	116		101		69	213
Average	15.27	3.03	7.89	0.03	0.01	0.03	0.10	0.39	10.64	9.01		0.29		0.03	6.86
Maximum	42.8	17	12.8	0.09	0.05	0.08	0.84	2.13	34.4	18.8		5.19		0.15	7.3
Minimum	5.1	0.2	0	0.01	0	0.01	0.01	0.01	6.6	3.5		0.01		0.01	6.2
Lagoon 1 of the WHTF (Station 7/NADISC1)															
Observations	72	180	180	75	35	59	92	100	180	101		85		44	194
Average	14.98	2.65	8.66	0.03	0.02	0.02	0.06	0.39	10.02	9.03		0.15		0.03	6.92
Maximum	29.1	8.5	13	0.17	0.16	0.08	0.18	1.57	18	16.8		0.71		0.17	7.3
Minimum	6.1	0.2	5	0	0	0	0.01	0.05	6.3	0.3		0.01		0.01	6.4
Elk Creek Arm of the Waste Heat Treatment Facility															
Observations		174	174						174						174
Average		2.48	8.69						9.91						6.98
Maximum		6.9	13.2						14.4						7.6
Minimum		0.2	1.2						6.2						6.5
Millpond Creek Arm of the Waste Heat Treatment Facility															
Observations		180	180						180						180
Average		2.66	8.56						9.76						6.97
Maximum		17	13						16.5						7.4
Minimum		0.2	0.3						6.5						6.5

Note: Blank entries indicate no data available.

Table 2.3-13 Water Quality Statistics for Lake Anna

Statistic	Hardness (mg/l as $CaCO_3$)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Total Phosphate (mg/l as P)	Ortho-phosphate (mg/l as P)	Meta-phosphate (mg/l as P)	Ammonia (mg/l as N)	Nitrate (mg/l as N)	Alkalinity (mg/l as $CaCO_3$)	Sulfate (mg/l as SO_4)	Copper (mg/l as Cu)	Iron (mg/l as Fe)	Lead (mg/l as Pb)	Zinc (mg/l as Zn)	pH (SU)
Lagoon 2 of the WHTF (Station 8/NAWHTF2)															
Observations	24	183	183	30	1	30	48	56	183	56	2	39	1	14	204
Average	13.06	2.36	8.08	0.04	0.13	0.04	0.05	0.17	9.75	8.30	0.03	0.20	0.02	0.02	6.90
Maximum	17.1	6.2	12.7	0.41	0.13	0.41	0.1	0.66	16	13.4	0.03	0.88	0.02	0.1	7.4
Minimum	10.3	0.2	0.2	0.01	0.13	0.01	0	0.01	6.6	6	0.02	0.04	0.02	0.01	6.2
Lagoon 3 of the WHTF (Station 9/NAWHTF3)															
Observations	69	180	179	71	30	56	84	101	180	101	24	89	6	45	200
Average	14.81	2.54	8.36	0.03	0.04	0.03	0.07	0.39	9.53	9.06	0.03	0.19	0.11	0.02	6.90
Maximum	32.5	7.2	12.7	0.4	0.42	0.15	0.14	2.89	17	16.8	0.05	3.01	0.18	0.06	7.3
Minimum	4.4	0.2	1.5	0.01	0	0	0.01	0	6.2	3.5	0.01	0.03	0.01	0.01	6.2

Note: Blank entries indicate no data available.

Table 2.3-14 Water Quality Data for the Piedmont Crystalline Aquifers

Parameter	Average	Maximum	Minimum	Source
Total Dissolved Solids (mg/l)	100	200	40	Reference 37
	70-150	250		Reference 42
	60-120			Reference 43
Hardness (mg/l as $CaCO_3$)	40	100	10	Reference 37
	10-50	100	10	Reference 42
	20-70			Reference 43
Nitrate (mg/l as N)	0.05	1	< 0.01	Reference 37
	< 10	20		Reference 42
Chloride (mg/l)	1-20	40	1	Reference 42
Sulfate (mg/l)	1-40	100	1	Reference 42
Calcium (mg/l)	5-20	60	5	Reference 42
Magnesium (mg/l)	5-20	60	5	Reference 42
Silica (mg/l)	20-35	45	15	Reference 42
Iron (mg/l)	20	600	< 10	Reference 37
	< 0.3			Reference 42
Bicarbonate (mg/l as HCO_3)	30-100	150	15	Reference 42
pH	5.5-6.8	7.5	5.5	Reference 42

Note: Blank entries indicate data not provided in cited reference.

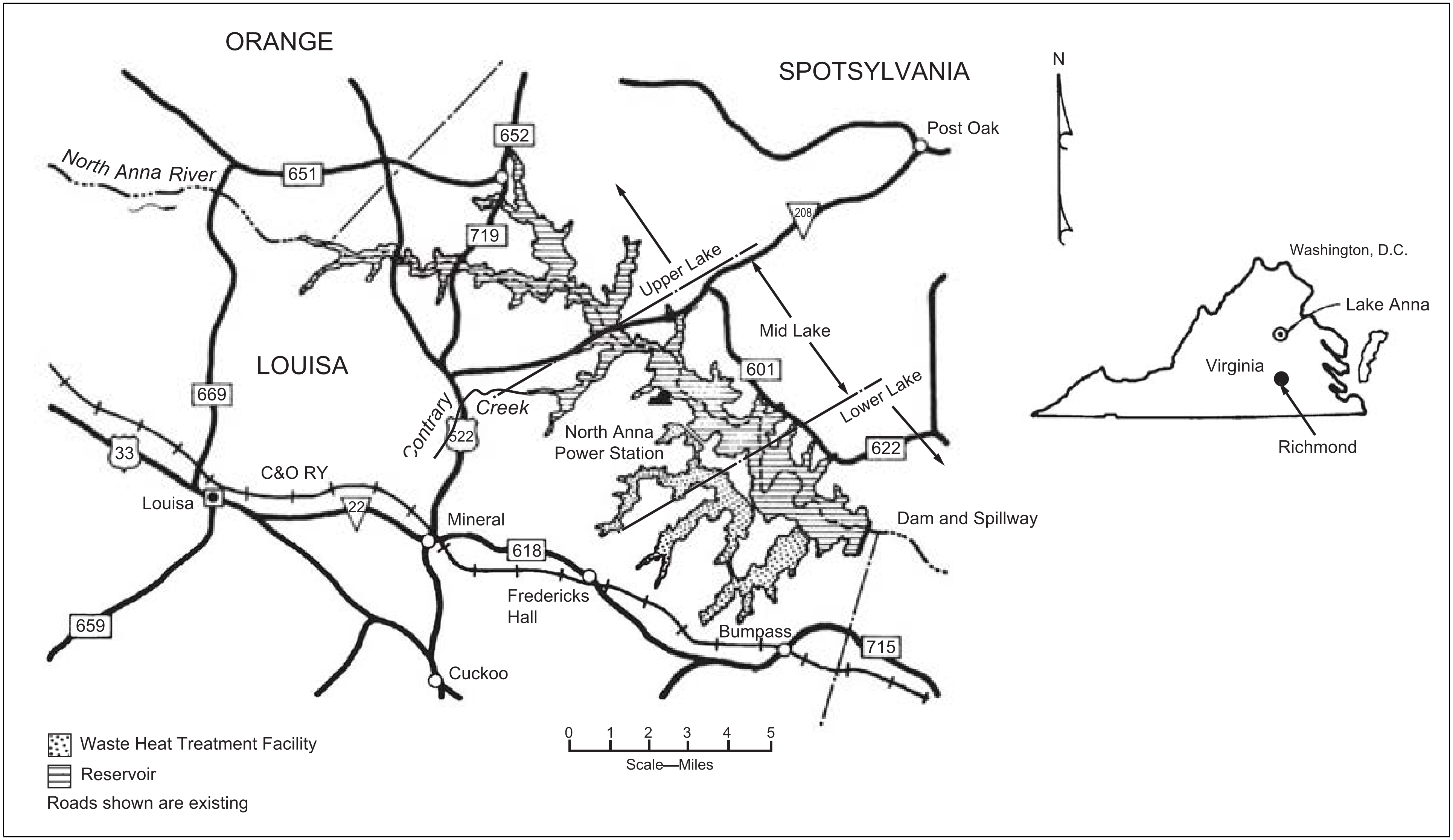

Figure 2.3-1 Lake Anna

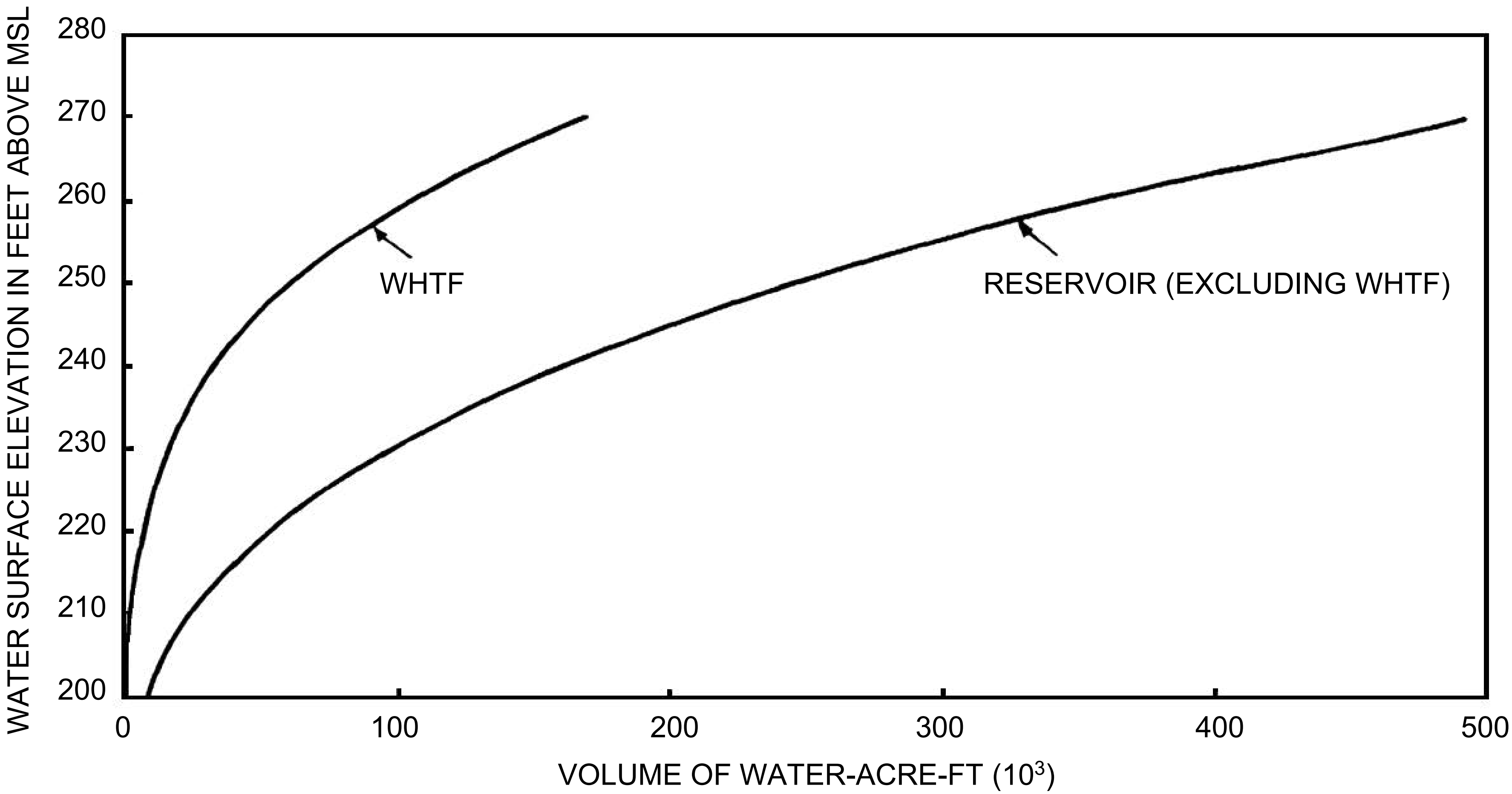

Figure 2.3-2 Elevation-Storage Curves for North Anna Reservoir and Waste Heat Treatment Facility

Figure 2.3-3 Deleted

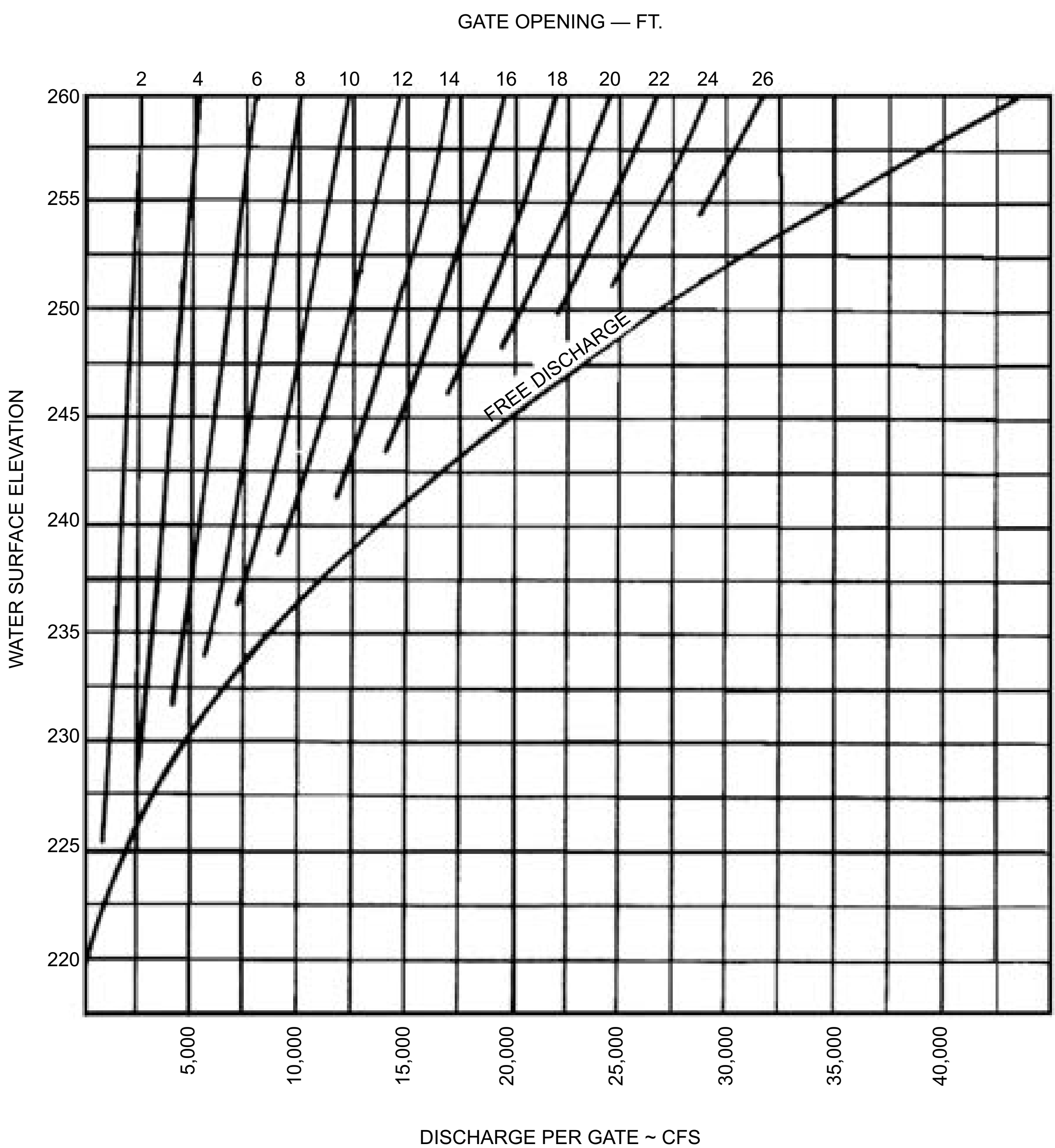

Figure 2.3-4 Spillway Discharge Capacity (One Gate of Three) North Anna Dam

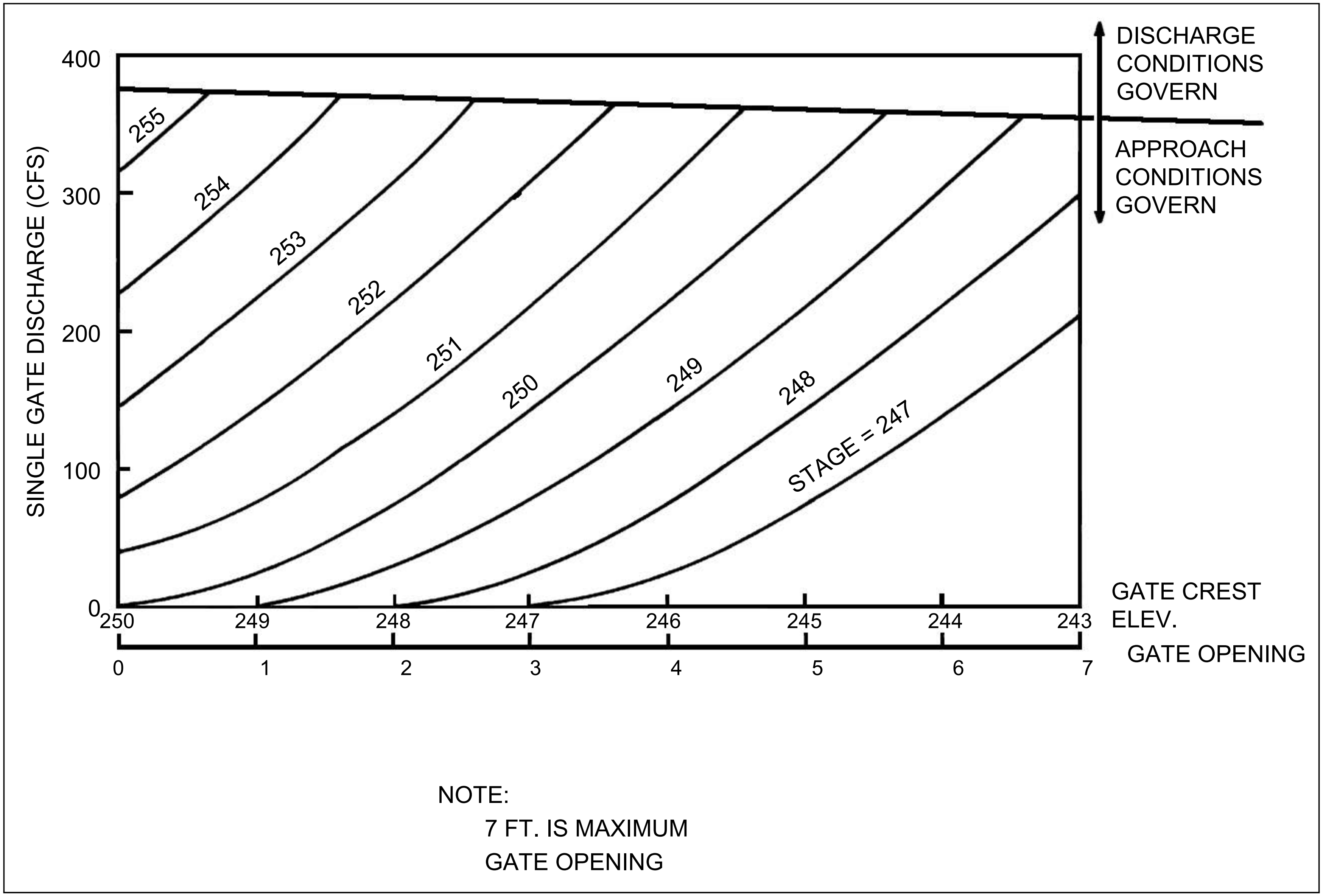

Figure 2.3-5 Skimmer Gate Discharge Capacity for North Anna Dam

Figure 2.3-6 Locations of USGS Stream Gauging Stations in the North Anna River Watershed

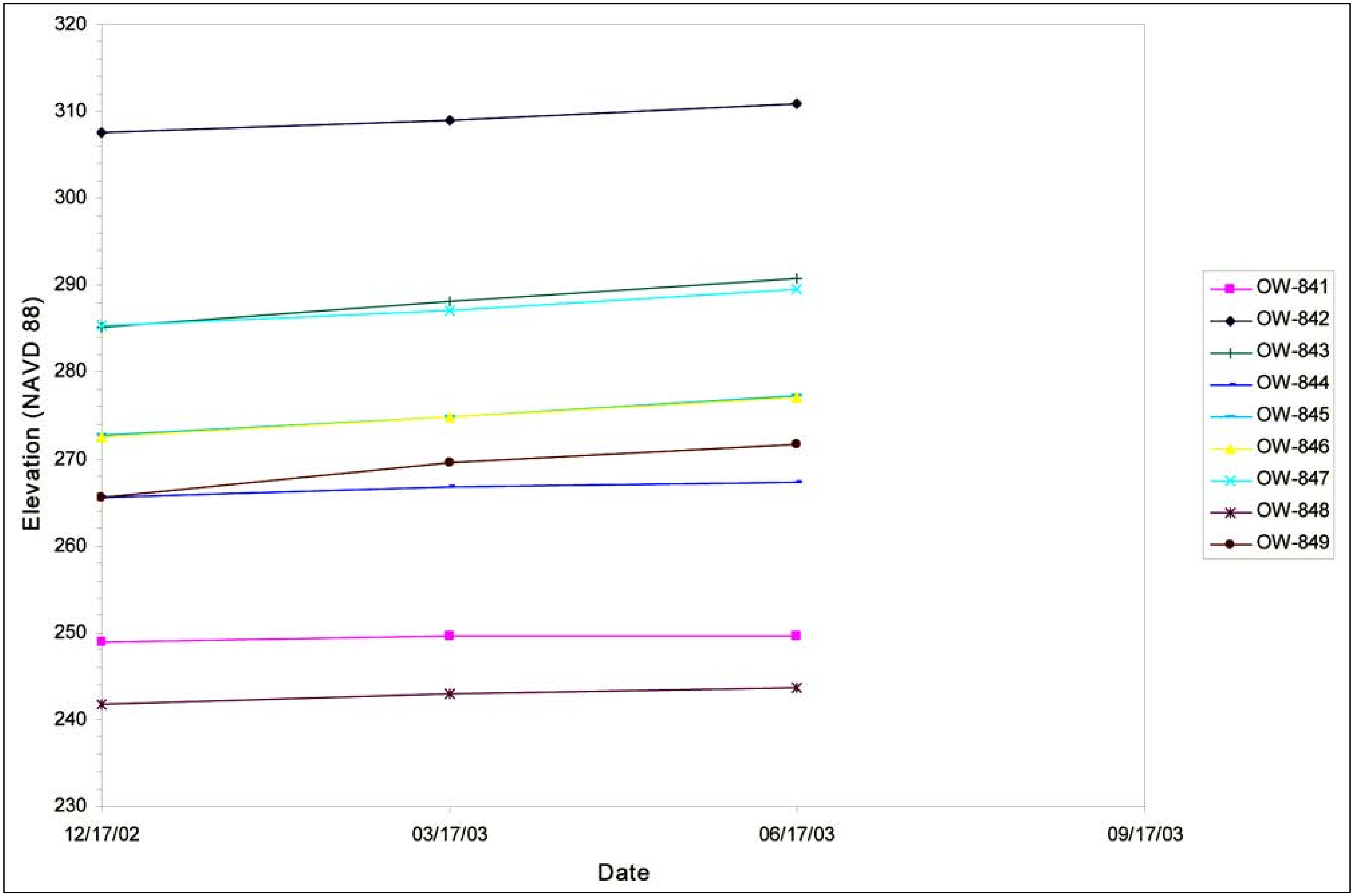

Figure 2.3-7 Ground Water Level Hydrographs

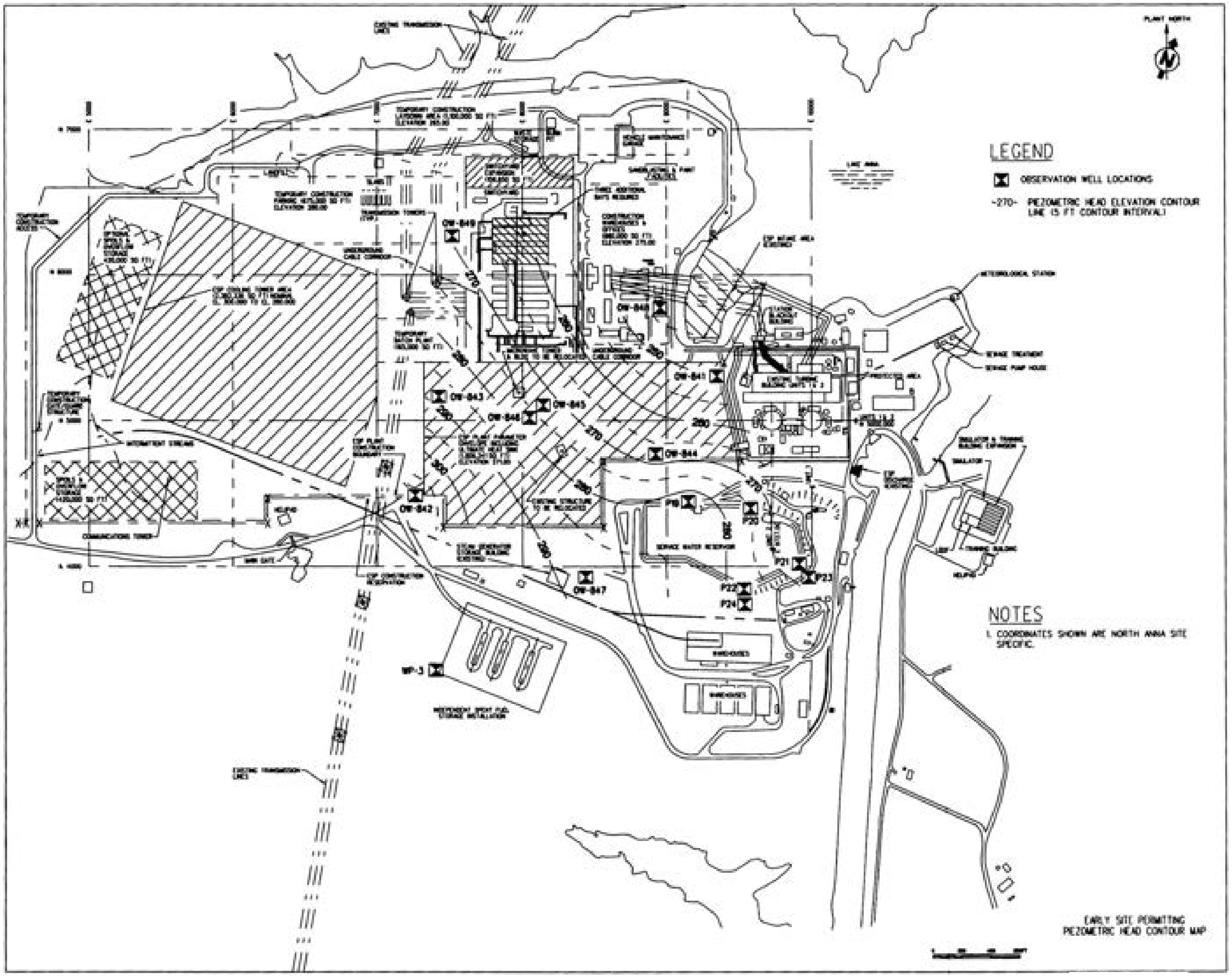

Figure 2.3-8 Piezometric Head Contour Map

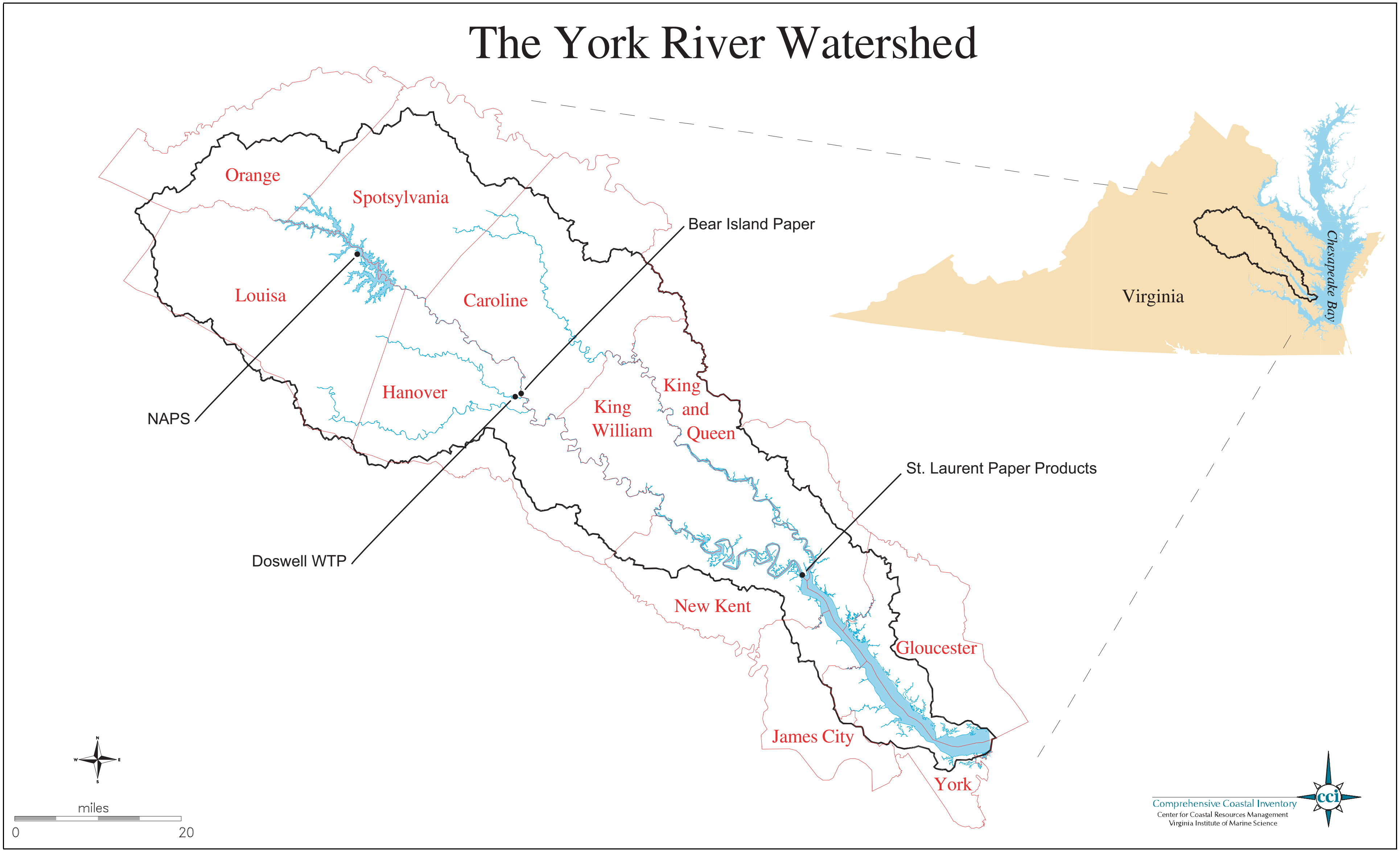

Figure 2.3-9 Surface Water Bodies That Could Affect or Be Affected by Plant Water Use

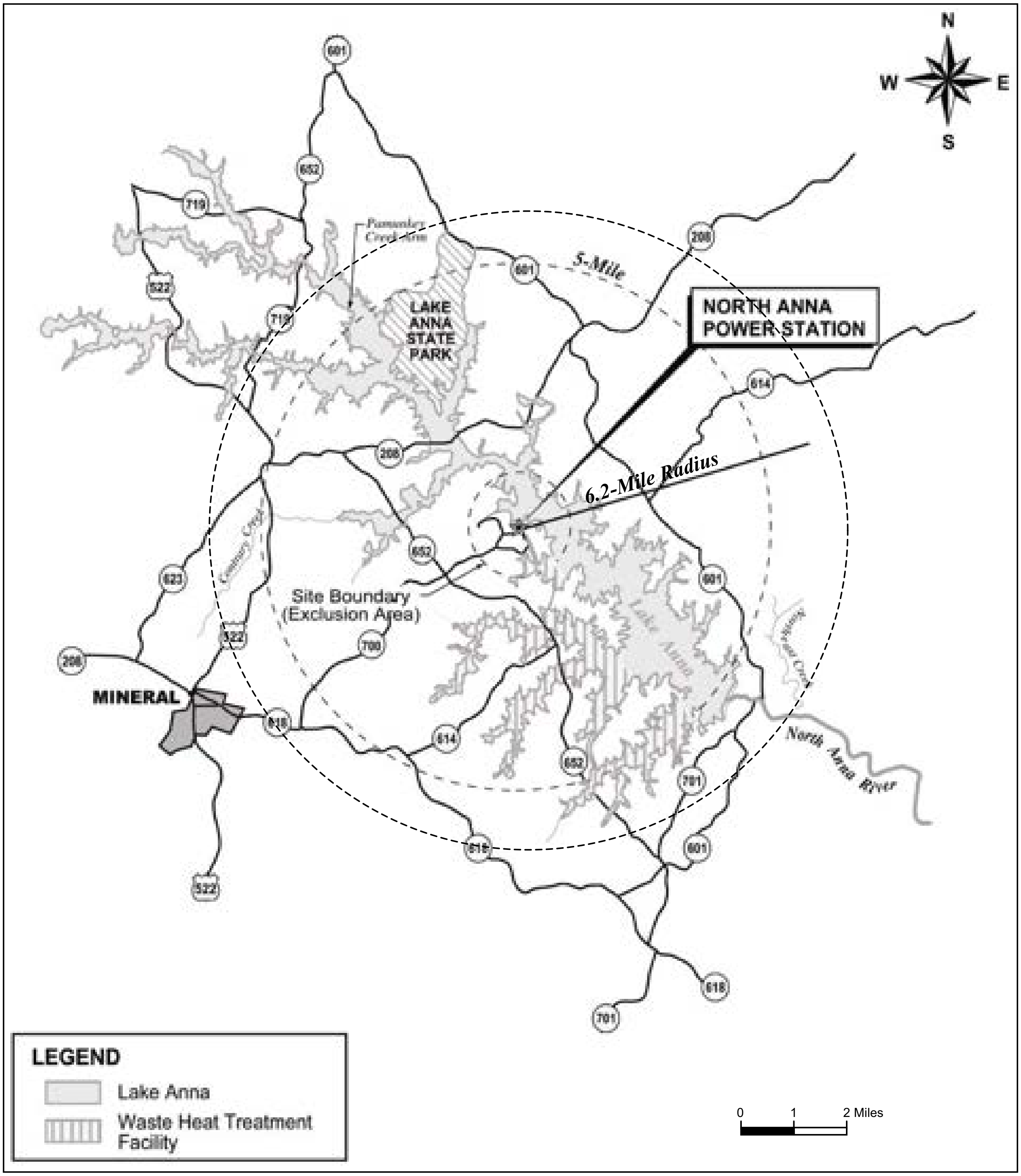

Figure 2.3-10 Surface Water Bodies Within 10 Kilometers (6.2 Miles)

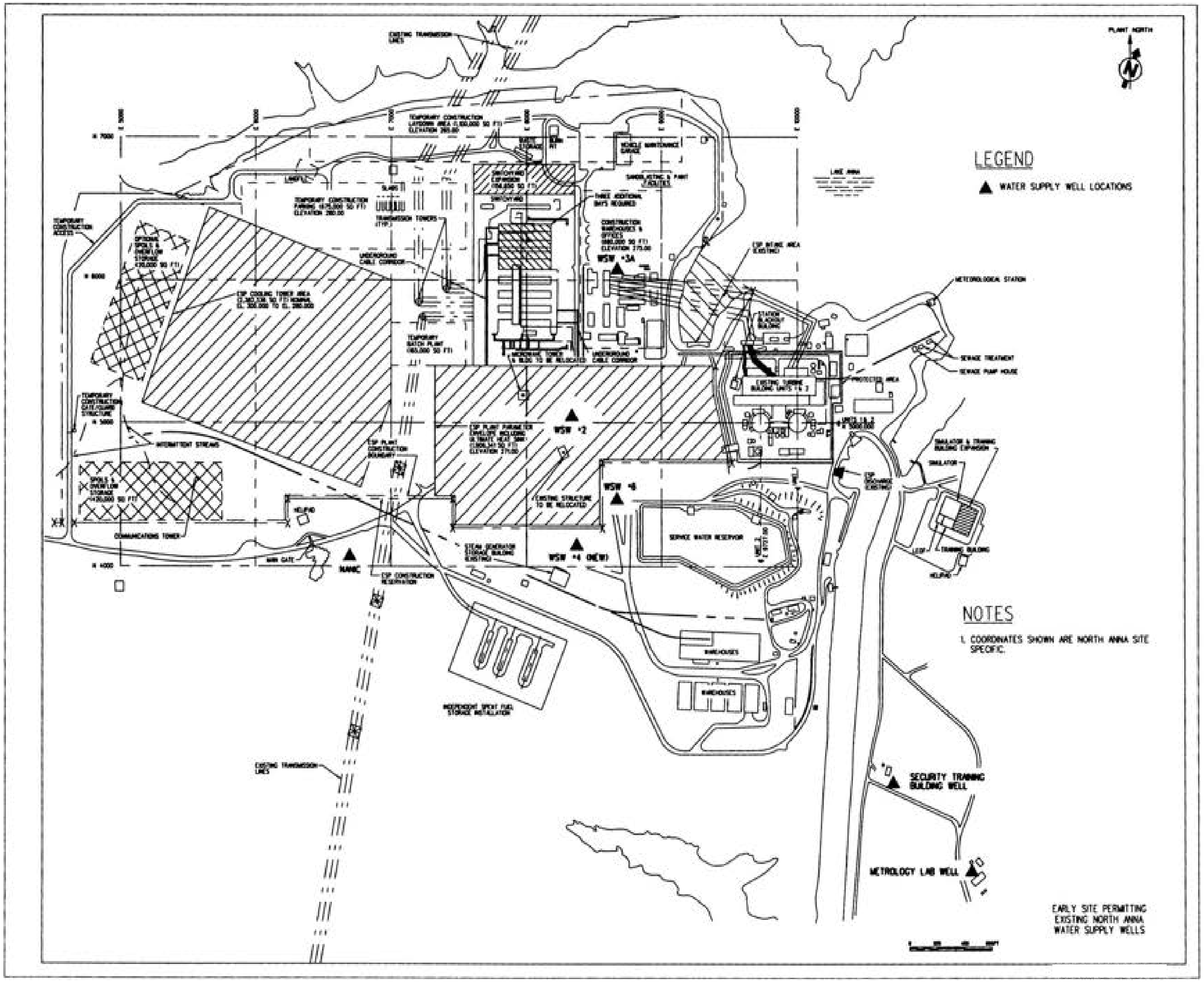

Figure 2.3-11   Existing Water Supply Wells

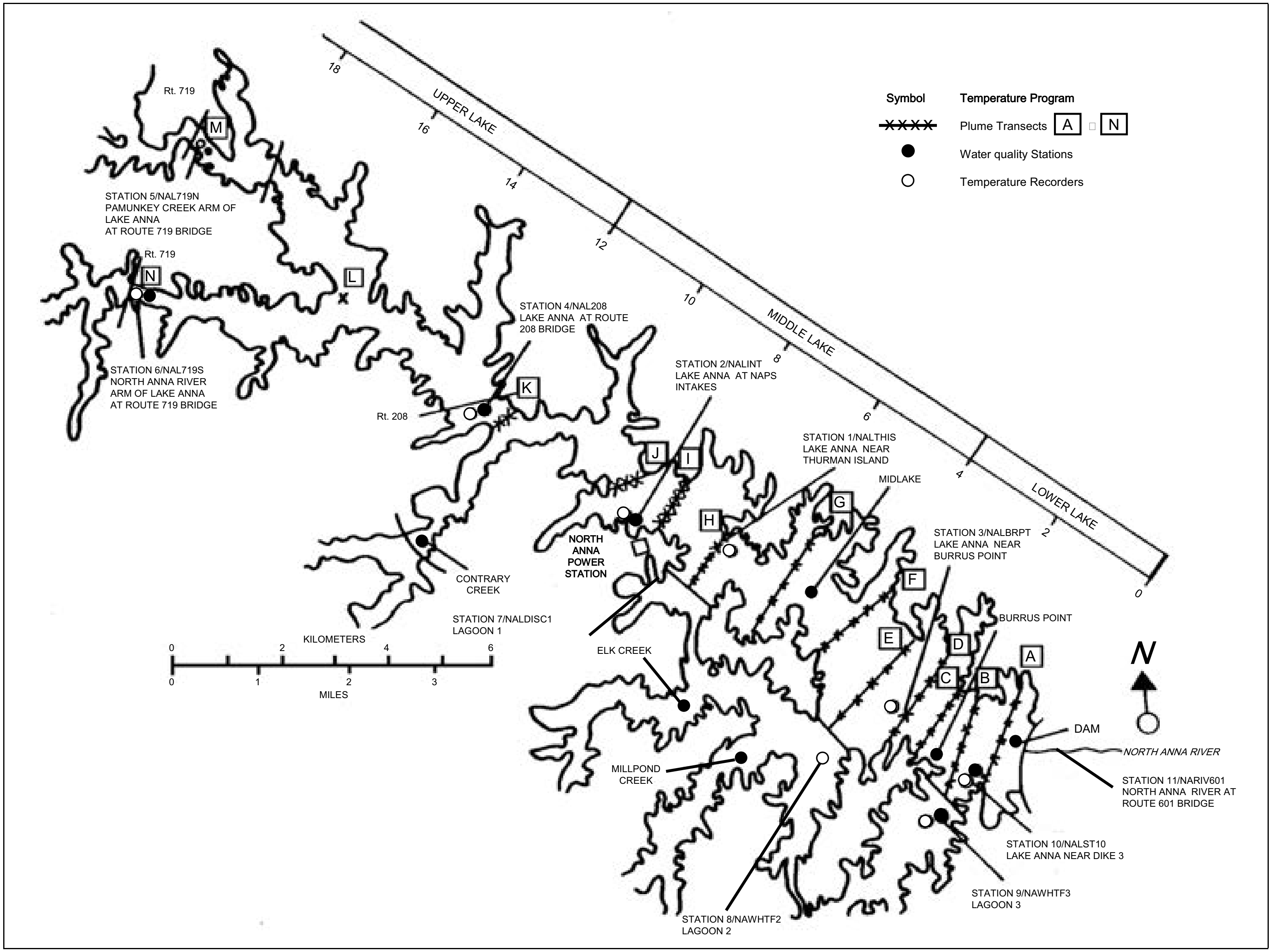

Figure 2.3-12 Temperature and Water Quality Sampling Stations

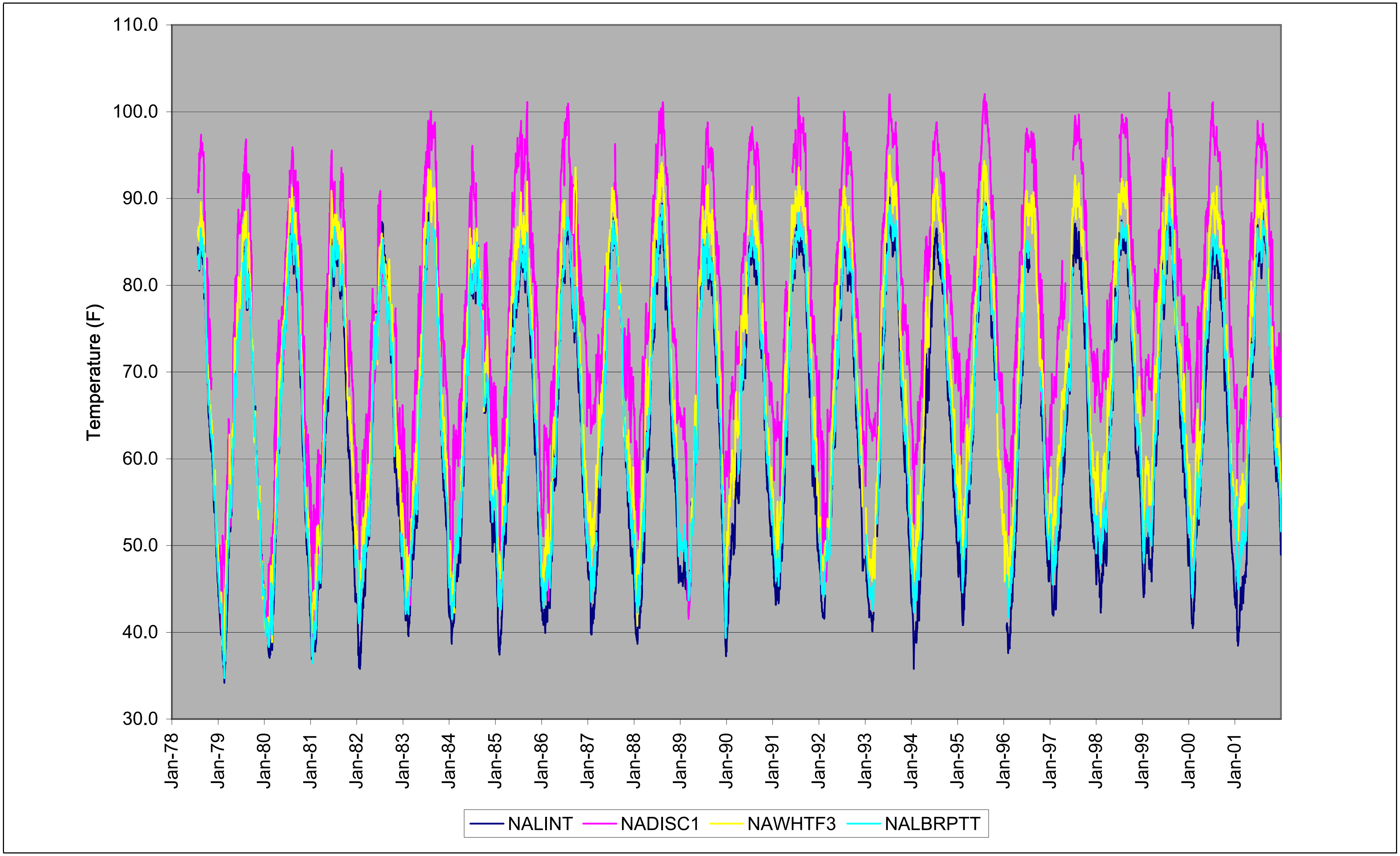

Figure 2.3-13 Temporal Variation in Lake Anna Water Temperature at Selected Locations

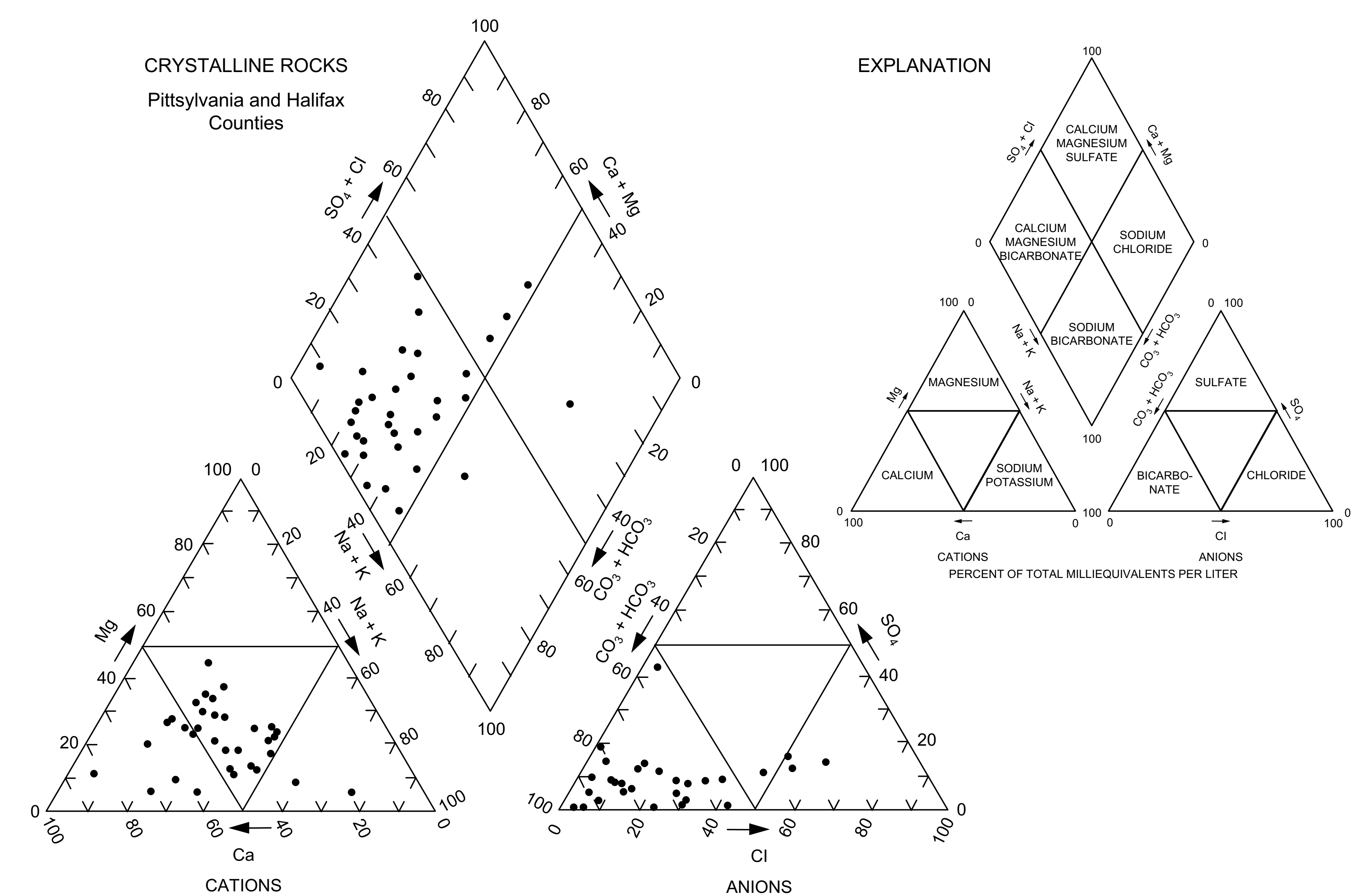

Figure 2.3-14 Water Quality in Crystalline Terrane (Pittsylvania and Halifax Counties, Virginia)

2.4 Ecology

This section describes the terrestrial and aquatic ecological resources that exist within the ESP site, vicinity, and correlating transmission corridors, and potential impacts on those resources from the new units. Ecological resources are those species and habitats that are considered “important” as presented in NUREG-1555, Tables 2.4.1-1 and 2.4.2-1. The description of ecological resources focuses on the terrestrial and aquatic environments that could affect or be affected by the construction or operation of the new units.

2.4.1 Terrestrial Ecology

This section describes the terrestrial ecology of the ESP site. Chapter 4 describes the impact of the construction of new units on the terrestrial ecology of the ESP site, and Chapter 5 describes the impact of the new units’ operation on the terrestrial ecology.

The ESP site is located in the Piedmont Physiographic Province. This portion of north-central Virginia, settled in the Colonial era, no longer contains virgin forests. Land use surrounding the ESP site is an irregular patchwork of row crops, pastures, pine plantations, abandoned (old) fields, and second growth forests of hardwoods and mixed pine-hardwoods.

Construction activities would occur within the NAPS site boundary, so no discussion of the terrestrial environment except at the NAPS site is presented here. Current land use at the ESP site is presented in Section 2.2. Approximately 30 percent of the NAPS site consists of generation and maintenance facilities, parking lots, roads, cleared areas, and mowed grass. No other pre-existing NAPS-generated site stresses or stressors to wildlife are known. Hardwood forests exist on the approximately 70 percent of the site that has not been cleared for the construction or operation of the existing units. These wooded areas are remnants of forests that were used for timber production prior to acquisition by Virginia Power and are dominated by a variety of oaks, yellow poplar, sweet gum, and red maple trees. Scattered loblolly pines, Virginia pines, and short-leaf pines exist in some wooded areas. Electric transmission corridors that originate at the existing units pass through forested and agricultural lands typical of north central Virginia.

2.4.1.1 Terrain

The Piedmont region of Virginia is characterized by gently rolling hills with scattered moderately steep ridges; although moderately steep ridges are absent from the ESP site. The rolling terrain at the site extends down slope to the waters of Lake Anna, resulting in essentially no marsh habitat along the shoreline. Hydrophytic vegetation, such as cattail and rushes, are typically absent or extend only 1 to 3 feet beyond the shoreline.

2.4.1.2 Wildlife Species

Wildlife species found in the forested portions of the NAPS site are those typically found in upland Piedmont forests of north-central Virginia. Frequently observed mammals, such as the white-tailed deer, raccoon, opossum, gray squirrel, and gray fox, exist at the site, as do smaller mammals such as moles, shrews, and a variety of mice and voles. Woodchucks live in the grassy areas near forest edges at the NAPS site, and beavers occur in Lake Anna and its tributaries. Various birds, reptiles, and amphibians (e.g., snakes, lizards, and toads) live in uplands and along the edge of Lake Anna.

2.4.1.3 **Common Bird Species**

Virginia Power has cooperated with the National Audubon Society in conducting periodic “Christmas Bird Counts” during December or January. Common bird species recorded in upland areas on and near the NAPS site during these surveys include the American crow, blue jay, Carolina chickadee, mourning dove, black vulture, turkey vulture, European starling, song sparrow, white-throated sparrow, dark-eyed junco, Northern cardinal, house finch, tufted titmouse, red-bellied woodpecker, downy woodpecker, and Northern flicker (Reference 1).

Birds known to nest within forested areas at the NAPS site, along forested edges, and in open areas (e.g., Northern cardinal, Carolina chickadee, blue jay) commonly nest in upland Virginia habitats. Virginia Power has placed bluebird nest boxes in suitable habitats at the NAPS site and has constructed roofed structures for swallows in some locations. Eastern bluebirds annually utilize the nest boxes, and barn swallows nest beneath the roofed structures.

2.4.1.4 **Wading Birds and Waterfowl**

Several species of residential and migratory wading birds and waterfowl utilize Lake Anna. Virginia Power biologists have documented breeding at Lake Anna by mallards, wood ducks, and Canada geese (Reference 2, Section 4.5). Virginia Power, in association with the Louisa County Chapter of Ducks Unlimited, has placed wood duck nest boxes on Lake Anna and wood ducks have utilized several of these nest boxes (Reference 2, Section 4.5). Belted kingfishers, great blue herons, and green-backed herons are present at Lake Anna throughout the year, and kingfishers and green-backed herons presumably nest on or near Lake Anna’s shoreline. Great blue herons typically nest in rookeries, and because there are no known rookeries at Lake Anna (Reference 3), it is unlikely that great blue herons nest on the lake.

Waterfowl are typically most abundant at Lake Anna during the winter. Lake Anna provides important habitat for migratory waterfowl on the Atlantic Flyway, especially during extremely cold winters when the elevated water temperature from station operation maintains a large ice-free body of water. The most common ducks observed during winter are mallard, American black duck, bufflehead, and greater scaup. The Canada goose, American coot, ringed-billed gull, and herring gull are also abundant on Lake Anna during the winter. (Reference 1) (Reference 2, Section 4.5).

2.4.1.5 Critical Habitat

No areas designated by the USFWS as critical habitat for endangered species exist at or near the ESP site, or along or adjacent to associated transmission lines. In addition, the transmission corridors do not cross any state or federal parks, wildlife refuges, or wildlife management areas.

2.4.1.6 Endangered Species

The USFWS maintains current lists of threatened or endangered species at its website (Reference 4). The VDGIF also maintains lists of state protected species at its website (Reference 3). These lists have been consulted to determine the species that might live at the ESP site. This review identified no protected species other than those previously identified by Virginia Power.

Bald eagles, state and federally classified as threatened, are occasionally observed along Lake Anna. However, there are no known eagle nests at the ESP site (Reference 5). The nearest known bald eagle nest is near the north end of Lake Anna, approximately 10 miles upstream of the existing units. Dominion is not aware of any eagle nests along NAPS-associated transmission lines.

Loggerhead shrikes, classified by the state as threatened, have been observed in the vicinity of NAPS during Christmas bird counts, but breeding loggerhead shrikes have not been recorded at the NAPS site or along the transmission corridors (Reference 3). Loggerhead shrikes inhabit mowed or grazed grassy areas and margins of wooded areas.

With the exception of the bald eagle and loggerhead shrike, terrestrial species that are federally- and/or state-listed as endangered or threatened species are not known to exist at the NAPS site or along the transmission corridors.

2.4.1.7 Rare Plant Species

The transmission corridors are managed to prevent woody growth from reaching the transmission lines. The removal of woody species can provide outstanding grassland and bog-like habitat for many rare plant species dependent on open conditions. Virginia Power has cooperated with the VDCR’s Natural Heritage Program in rare plant surveys within transmission corridors. The Natural Heritage Program prepared reports on the results of the rare plant species surveys. Although several rare plant species have been located along other Virginia Power transmission corridors, no endangered or threatened plants were noted along the corridors associated with the NAPS site.

2.4.1.8 Wetlands

Two intermittent streams flowing north into an unnamed arm of Lake Anna, just northwest of the power-block area bisect the area where cooling towers would be located. A narrow band of wetlands is associated with each of these streams. Wetlands within and around the ESP site have been delineated and property surveys have been conducted to present to the U.S. Army Corps of Engineers for confirmation, and in preparation of appropriate wetlands permitting. See Figure 2.4-5 and Figure 2.4-6. These permitting actions will include decision-making for implementing approved mitigation options, when necessary. (Reference 44).

2.4.1.9 **Important Species**

No "important species" as defined by NUREG-1555 live on the NAPS site, and with the exception of the wetlands described above, no "important habitats" exist on the NAPS site. Important species are those that are: listed by the state or federal government as threatened or endangered, proposed for listing as threatened or endangered, commercially or recreationally valuable, essential to the maintenance or survival of species that are rare or commercially or recreationally valuable, critical to the structure and function of the local terrestrial ecosystem, or biological indicators. Important habitats are wildlife sanctuaries, refuges, or preserves; habitats identified by state or federal agencies as unique, rare, or of priority for protection; wetlands, floodplains, or other resources specifically protected by federal or state regulations; or land areas identified as "critical habitat" for threatened or endangered species.

2.4.1.10 **Proposed Site**

Section 4.1.1 provides information on the acreage that would comprise the construction site. Much of the proposed laydown area consists of dirt roads, cleared areas, parking lots, buildings, and weedy habitats. The western portion of the current and proposed laydown area can be classified as "old-field" habitat. None of the current or proposed laydown area is forested. The area proposed for temporary offices is an existing office complex; thus, natural habitats are absent from this area. Generally, wildlife species found in the forested portions of the ESP site and support areas are those typically found in the forested portions of the NAPS site and in upland Piedmont forests of north-central Virginia. Wildlife species in the old-field habitat of the laydown area and in the transmission rights-of-way within the ESP site would include most of those found in the adjacent wooded areas.

2.4.2 **Aquatic Ecology**

2.4.2.1 **North Anna Drainage System**

The North Anna River rises in Louisa and Orange Counties, Virginia, and flows east for about 60 miles before joining the South Anna River to form the Pamunkey River Figure 2.4-1. The Pamunkey River flows to the southeast, joining with the Mattaponi River to form the York River, which flows into the Chesapeake Bay north of the Hampton Roads area of Virginia. The entire North Anna River watershed is approximately 600 square miles (Reference 6).

Lake Anna, built to supply cooling water for the power station, was created in 1971 by erecting a dam on the main stem of the North Anna River, just upstream of the confluence of the North Anna River and Northeast Creek (Figure 2.4-2). Lake Anna drains an area of 343 square miles (Reference 2). The dam is approximately 90 feet high and 5,000 feet long and contains

900,000 cubic yards of earth and rock (Reference 6). Lake Anna began filling in January 1972 and reached full pool in December of that year (Reference 6). For discussion purposes, Lake Anna may be divided into two distinct bodies of water, the WHTF and the North Anna Reservoir. The WHTF is the smaller body of water into which existing units' waste heat is discharged via the discharge canal. The North Anna Reservoir is the larger body of water and is physically separated from the WHTF by a series of dikes.

Lake Anna is approximately 17 miles long, with 272 miles of shoreline. It is relatively shallow (maximum depth 90 feet; average depth approximately 25 feet at full pool), with a surface area of 13,000 acres (Reference 6). The normal elevation of the reservoir is 250 ft msl, at which stage it holds 305,000 acre-feet of water (Reference 6). The Commonwealth of Virginia requires a 40-cfs minimum discharge of water from the North Anna Dam, except under extreme drought conditions. These minimum flow requirements have been established to maintain instream flows and water quality in the North Anna River below the dam and in the Pamunkey and York Rivers further downstream (Figure 2.4-1). Should these types of drought conditions occur, and Lake Anna surface water levels fall to 248 ft msl, Virginia Power would begin reducing releases incrementally below the 40 cfs level in accordance with the Lake Level Contingency Plan, as stipulated in Part I.F of the VPDES Permit.

Prior to impoundment, water quality in the North Anna River was degraded by sedimentation and acid mine drainage from Contrary Creek, an 8.5-mile-long tributary that flowed into the river from the west, near the town of Mineral, Virginia (Figure 2.4-2). Land adjacent to Contrary Creek had been the site of extensive iron pyrite mining operations during the late 19th and early 20th centuries (Reference 2). When the mine was abandoned (circa 1920), mine shafts and tailings piles were left exposed to the weather. Runoff from the mine area was acidic, with high concentrations of metals. Virtually no aquatic life was found in Contrary Creek downstream of the mine site (Reference 6). Prior to impoundment, the density and diversity of fish and benthic macroinvertebrates were markedly reduced in the North Anna River immediately downstream of its confluence with Contrary Creek. Subtle changes were evident as far as 15 miles downstream, although water quality was generally satisfactory (Reference 2).

In 1976, the Virginia State Water Control Board, in association with the EPA, attempted to reclaim previously-mined and disturbed areas along Contrary Creek to reduce the impacts of sedimentation and acid mine drainage (Reference 2). The reclamation project reduced, to some extent, erosion and sedimentation in the area.

The creation of Lake Anna has mitigated most water quality impacts from Contrary Creek area runoff. Low-pH creek water is neutralized as it mixes with higher-pH reservoir water. Heavy metals are removed from the water column by adsorption to clay particles and the subsequent settling of these particles. Chemical precipitation (and co-precipitation with iron) may also remove zinc and copper ions from Contrary Creek water when it mixes with Lake Anna water.

A comprehensive study of Lake Anna's water quality and aquatic communities was conducted in support of a CWA Section 316(a) Demonstration for NAPS (Reference 2). This evaluation was based on five years (1973-1977) of pre-operational studies and eight years (1978-1985) of operational studies. Water quality, water temperature, and biological monitoring were conducted in upper, middle, and lower portions of the North Anna Reservoir, and in the North Anna River below the reservoir.

Water quality in Lake Anna has historically been good to excellent. Turbidity levels are generally low, except during periods of heavy inflows from tributary streams.

Nutrient levels (nitrates and phosphates) from flooded farmland were elevated in the years following impoundment of the river and its valley, but stabilized in the 1980s at low levels sufficient to support a thriving community of benthic macroinvertebrates, plankton, and fish. As noted previously, there have been no indications of nutrient enrichment or eutrophication in Lake Anna, beyond those associated with normal reservoir aging. Lake Anna and the North Anna River are not among the water bodies designated by the Virginia State Water Control Board as "nutrient-enriched waters." (Reference 7)

Recently, the Virginia DEQ has listed several of the upper-lake tributaries in its 303(d) list of impaired waters because of seasonal exceedances of fecal coliform. Also portions of the North Anna Reservoir itself have been added because of high values of PCBs in certain fish tissue analyses.

Since its creation, the North Anna Reservoir has developed into three ecological areas that were identified in the CWA 316(a) Demonstration as upper lake, mid- lake, and lower lake (Reference 2). The physical characteristics are different among the areas. The upper lake is primarily riverine and shallow (average depth of 13 feet), and shows some evidence of stratification in summer. The mid-lake is deeper and stratifies in summer. It receives waters from Contrary Creek that, because of years of mining in its floodplain, are sometimes low in pH and high in metals. The lower lake is the deepest part of the reservoir, with an average depth of 36 feet. It is clearer (with more light penetration), and shows pronounced annual patterns of winter mixing and summer stratification. The epilimnion (warm layer above the thermocline) was generally 8 feet deep during pre-operational years and 26 to 33 feet deep during operational years. The increase in depth of the epilimnion appears to be related to the heated discharge entering the reservoir from Dike 3 (see Figure 2.4-3) and the withdrawal of cooler, deeper water at the existing units intake (Reference 2). The heated discharge, attendant mixing, and withdrawal of water at the intake have also increased the depth of oxygenation, with the layer of water holding at least 5 milligrams per liter of dissolved oxygen increasing from 16 feet (pre-operational) to 29 feet (operational).

The existing units use a once-through cooling system that withdraws water from mid-Lake and discharges it into a discharge canal. The canal is approximately 3600 feet long and discharges into the WHTF, which was formed by diking off a portion of Lake Anna. The cooling water residence time in the WHTF is approximately 14 days, depending on condenser flow rate. More than half the existing units' waste heat is dissipated in the WHTF. The only discharge from the WHTF into the North Anna Reservoir is through Dike 3, which abuts the lower lake near the dam. The discharge is a submerged, high-velocity jet that promotes rapid mixing with reservoir waters.

Temperature monitoring at Lake Anna indicates that the shallower upper lake warms earlier in spring and reaches maximum temperature in summer sooner than the lower lake. The lower lake, with its greater depth and volume, warms more slowly in spring and retains its heat later in the year. It is estimated that the heat contributed by the existing units corresponds to about 10 percent of the solar heat entering the reservoir on summer days. (Reference 2)

From 1975 through 1985, Virginia Power monitored water temperatures at 10 (7 in North Anna Reservoir and 3 in WHTF) Lake Anna locations, as part of a CWA Section 316(a) Demonstration for NAPS (Reference 2, Section 3.5, Table 3.5-2). Temperatures were recorded hourly at most of these locations. Highest (hourly average) temperatures recorded in June, July, and August over this period were 91.8°F at an upper lake location in 1984, 92.7°F at an upper lake location in 1977, and 91.6°F at a lower lake location in 1980, respectively. The highest (hourly average) water temperature before the existing units began operating (92.7°F) was measured on July 19, 1977, at the northern-most location (Pamunkey Creek arm). The highest (hourly average) water temperature measured in an operational year was 92.3°F, recorded in July 1983. (Reference 2)

In recent years, Virginia Power has continued to monitor Lake Anna water temperatures, using fixed temperature recorders at 7 locations in North Anna Reservoir and 3 locations in the WHTF (Figure 2.4-4). This temperature monitoring is part of a larger post-316(a) Demonstration environmental monitoring effort that includes fish population studies. To allow for direct comparisons with historical data, temperatures in Lake Anna are reported as monthly means of daily high, mean, and low temperatures. The range of temperatures and between-location temperature trends recorded over a recent six-year period (1995–2000) have shown strong similarities to historical data (Reference 8) (Reference 9) (Reference 10) (Reference 11) (Reference 12) (Reference 13). These temperature data do not indicate an overall long-term warming trend in North Anna Reservoir. Further, differences in temperature throughout the reservoir continue to be small, regardless of time of year or power station operating levels. Virginia Power submits annual reports to VDEQ and VDGIF on water temperatures and fisheries monitoring in Lake Anna and the lower North Anna River.

2.4.2.2 **Biological Communities of Lake Anna**

The Environmental Impact Statement for NAPS License Renewal (Reference 5) summarizes studies of phytoplankton, zooplankton, and benthic organisms conducted by Virginia Power over the 1973-1985 period. These studies are not reviewed here. The plankton and benthos communities that developed over the first several years of the existing units' operation were typical of those seen in other Piedmont reservoirs.

The long narrow arm of Lake Anna just northwest of the power-block area is associated with two small intermittent streams that could be affected by the new units. Following heavy rainfall, these streams flow in a northerly direction into Lake Anna. Due to their intermittent nature, neither stream supports significant numbers or diversity of fish.

Because of the importance of recreational fishing in Lake Anna, its fish community has been the subject of wide-ranging studies. Abundance and distribution of fish were evaluated over a period from 1975-1985, using a variety of sampling methods to ensure that gear selectivity did not bias results. Larval fish studies, creel surveys, and a number of special studies focused on the reproduction and growth of important species, such as largemouth bass (*Micropterus salmoides*). Seasonal movement and habitat preferences of striped bass (*Morone saxatilis*) were investigated, using ultrasonic tags.

From 1975 through 1985, 39 species of fish (representing 12 families) were found in Lake Anna Reference 2. Species included those historically found in the North Anna River, those that had been in local farm ponds inundated by the new reservoir, and nine species (four non-native) introduced by the VDGIF.

The community structure remained relatively stable over the 1975–1985 period, with some year-to-year variation in species composition. These variations were caused by 1) normal population fluctuations, 2) reservoir aging, 3) the introduction of forage species and competing predators, 4) the installation of fish attractors and artificial habitat, and 5) the increase in *Corbicula fluminia* (Asiatic clam) densities. Post-1975 changes included 1) a decline in relative abundance of yellow perch (*Perca flavescens*) and black crappie (*Pomoxis nigromaculatus*), 2) an increase in the relative abundance of white perch (*Morone americana*) and threadfin shad (*Dorosoma petenense*), and 3) an increase in redear sunfish (*Lepomis microlophus*) abundance, with a corresponding decrease in pumpkinseed (*Lepomis gibbosus*). None of these changes appeared to be related to existing units operation.

From 1975 to 1984, the mean standing crop ranged between 232 and 296 pounds of fish per acre, but it increased substantially in 1985 (to 417 pounds per acre) because of a large increase in introduced threadfin shad and an increase in the abundance of gizzard shad (*Dorosoma cepedianum*). Both species provide forage for Lake Anna's game fish, which include largemouth bass, walleye (*Stizostedion vitreum*), and striped bass. Lake Anna appears to support a standing crop of fish higher than most U.S. reservoirs, with thriving populations of several forage species and highertrophiclevel (gamefish) species.

Standing stocks of largemouth bass, Lake Anna's most popular sport fish, remained stable over the 1975–1985 period. In 1985, Lake Anna produced more largemouth bass of "citation" size (eight pounds or more) than any other lake or reservoir in Virginia. Life history studies of Lake Anna largemouth bass, summarized in the 316(a) Demonstration (Reference 2), suggest that the reproductive success, feeding ecology, and growth of this species were similar in pre-operational and operational years.

Four non-native fish species (striped bass, walleye, threadfin shad, and blueback herring (*Alosa aestivalis*) have been stocked in the North Anna Reservoir by the VDGIF since 1972. Striped bass, introduced in 1973, have been stocked annually since 1975. They provide a “put-grow-and-take” fishery. Streams, including the North Anna River, that flow into the North Anna Reservoir lack the flow, depth, and length to support striped bass spawning runs. Studies show that striped bass grow and provide a substantial recreational fishery, but adults are subject to late-summer habitat restrictions (may be restricted to cooler-water refuge areas). As a consequence, they may lose weight and show a decline in condition. Walleyes are also stocked annually by the VDGIF and are highly sought-after game fish.

Threadfin shad, introduced in 1983 to provide additional forage for striped bass and other top-of-the-food-chain predators, are vulnerable to cold shock and winter kills, and would not be able to survive in Lake Anna if it were not for power station operation. Threadfin shad appear to be thriving and are an important source of food for game fish. Blueback herring, stocked by the VDGIF in 1980 as a forage species, have not been as successful.

In 1994, a fifth non-native species, the herbivorous grass carp (*Ctenopharyngodon idella*), was stocked by Virginia Power (with the approval of the VDGIF) in the WHTF to control the growth of the nuisance submersed aquatic plant hydrilla (*Hydrilla verticillata*).

In addition to the previously described stocking programs, which are designed to expand fishing opportunities in the North Anna Reservoir, Virginia Power, in cooperation with VDGIF, placed 20 underwater fish structures in the reservoir over the 1983–1990 period to provide additional fish habitat in areas with “clean” bottoms (Reference 14). The structures, consisting of conically-shaped piles of cinder blocks, small trees, and brush (secured to the blocks) were designed to provide escape cover for young fish and spawning and feeding areas for larger fish. Although designed to provide habitat for largemouth bass, black crappie, and bluegill (*Lepomis macrochirus*) in particular, these fish structures benefit a variety of other species.

As noted previously in this section, Virginia Power has continued to monitor fish populations in Lake Anna since 1986, as part of a larger post-316(a) Demonstration environmental monitoring program. Fisheries monitoring over a recent six-year period (1995–2000) reveals a balanced reservoir fish community comprised of healthy populations of top-of-the-food-chain predators (e.g., largemouth bass and striped bass) and the forage species on which they feed (e.g., threadfin shad and gizzard shad), panfish (e.g., bluegill, redear sunfish, redbreast), and catfish (channel catfish and white catfish), in particular.

Lake Anna is well known as a producer of trophy largemouth bass and large numbers of striped bass. In 2000, Lake Anna ranked third in the Commonwealth of Virginia in producing trophy certificate (“citation”) largemouth bass (Reference 13), with 72 fish meeting the standard (at least 22 inches in length or 8 pounds in weight).

2.4.2.2.1 Commercially-Important Fisheries

There is no commercial fishing on Lake Anna or the North Anna River. There are professional fishing guides who regularly take clients fishing for largemouth, striped bass and walleye on the North Anna Reservoir, but there are no commercial fishing operations in the sense that fish are netted or trapped and sold at market. Professional fishing guides must adhere to state fishing regulations, and are prohibited by law from selling their catch.

2.4.2.2.2 Recreationally Important Fisheries

Lake Anna is a popular destination for anglers from central and northern Virginia. Its healthy fish populations and its proximity to the cities of Washington, D.C., Richmond, and Charlottesville mean that the reservoir is heavily fished, particularly in spring and fall. In summer, an influx of recreational boaters, water-skiers, and jet skiers discourages some fishermen. The heated effluent that flows into the North Anna Reservoir at Dike 3 creates conditions conducive to good fishing in winter, making the reservoir a popular fishing spot when cold weather slows or shuts down fishing at other ponds and lakes in the region.

The VDGIF estimated that 42,731 anglers fished Lake Anna for 232,439 hours over a 12-month period in 2000 and 2001. The species most often sought were largemouth bass, striped bass, and crappie, with 69 percent, 15 percent, and 12 percent of anglers, respectively, pursuing these species (Reference 15). Black crappie, not largemouth bass, was the species most often harvested. Depending on the time of year, species such as bluegill, white perch, channel catfish, and walleye are also sought by Lake Anna fishermen.

2.4.2.2.3 Important North Anna Reservoir Species

The VDGIF manages the fisheries of the North Anna Reservoir “…with particular emphasis on providing quality largemouth and striped bass fisheries within the capacity of available habitat” (Reference 16). As a consequence, the VDGIF district biologists who conduct monitoring studies and research on the fishes of the North Anna Reservoir focus on these two species, both highly esteemed by local anglers. Other species, such as black crappie and channel catfish, are monitored by VDGIF but are not as actively managed.

a. **Largemouth bass**

   Electro-fishing catch rates for largemouth bass greater than 8 inches long in the North Anna Reservoir have been high in recent years (Reference 16) (Reference 17) (Reference 18). Young-of-the-year catch rates, although lower, have been indicative of consistent recruitment. Structural indices of the largemouth bass population indicate a population dominated by larger, older individuals. Growth of younger (1-to-4 year old) largemouth bass is excellent; however, growth of older bass (5 years and older) is below the district average (Reference 16).

On average (all age classes considered), largemouth bass in the North Anna Reservoir grow more rapidly than largemouth bass in other large Virginia impoundments (Reference 18).

In summary, largemouth bass tend to grow rapidly in their first four years of life, "plateau" at age 5, and grow relatively slowly thereafter. The population contains a high proportion of harvestable individuals, and provides excellent opportunities for anglers seeking larger, trophy-sized fish.

b. **Striped bass**

Annual stockings of fry and fingerlings sustain the North Anna Reservoir's striped bass population. Normally, between 100,000 and 200,000 fingerlings are stocked annually, which equates to between 10 and 20 fish per acre (Reference 16). VDGIF is experimenting with lower (5 fish/acre) stocking rates to determine if recruitment is significantly affected.

Striped bass growth patterns in the North Anna Reservoir vary from year to year, with some of the variability apparently related to the size of fish stocked (dependent on size of fish supplied by hatcheries). Generally speaking, young striped bass grow rapidly, and reach harvestable size (20 inches) in about 30 months (Reference 16). Estimates of annual mortality range from 35 to 50 percent, depending on the cohort evaluated, with the lower percentage likely more accurate (Reference 16) (Reference 17) (Reference 18). Excellent year classes in 1997, 1998, and 1999 should provide outstanding fishing in 2003 and beyond. All three year classes should be of harvestable size by 2003.

Since the early 1990s, VDGIF has been evaluating late-summer striped bass habitat in the North Anna Reservoir, taking temperature and dissolved oxygen profiles at representative locations in the reservoir. In July-August 2000, temperature and dissolved oxygen profiles revealed that portions of the North Anna Reservoir, in the area between NAPS and the Lake Anna Dam, did not provide acceptable striped bass habitat (water temperature less than 26°C and dissolved oxygen concentration greater than 2.0 milligrams per liter) (Reference 17). However, the striped bass habitat uplake of the existing units was acceptable, and striped bass were presumed to have moved to these uplake areas seeking cooler, oxygenated water. This late-summer dispersal of striped bass has been observed in other southeastern reservoirs (Reference 19). No late-summer die-offs of striped bass have been observed in the North Anna Reservoir although they have occurred in reservoirs in North Carolina, South Carolina, Tennessee, and Alabama (Reference 20) (Reference 21).

c. **Black Crappie**

Based on experimental gill net catches, black crappie abundance in North Anna Reservoir was very high in 1997 and 1998, but has declined in recent years (Reference 16) (Reference 17) (Reference 18). Growth of black crappie is good, and agrees with other impoundments in the region. There is considerable year-to-year variability in population size structure (i.e., average size of fish captured), but it is unclear if this is an indication of changes in age composition or changes in growth rates. The catch-per-unit-effort of “quality” black crappie declined by 50 percent between 1997 and 1998, an indication that (fishing) mortality is high. Most crappie (92 percent) caught in gill nets were caught in the “upper lake” (Reference 16).

d. **Catfish**

Channel catfish ranked fifth in abundance in gill nets in 1997 and fourth in abundance in 1998 (Reference 16). Much higher numbers of channel catfish and white catfish were captured in gill nets in 1998 than in 1997, but this phenomenon was attributed to low reservoir levels (related to drought) rather than an actual increase in numbers of catfish. VDGIF reports provide no information on age and growth, condition, or age/size structure of catfish populations.

e. **Shad**

Because threadfin shad abundance is cyclic, gizzard shad serve in most years as North Anna Reservoir’s forage base (Reference 16). Gizzard shad are regarded by fisheries managers as a less-than-ideal forage species, because their rapid growth makes them unavailable to predators in a year or two. Threadfin shad, while the ideal size, are subject to mass die-offs from low temperatures or sudden temperature changes. In 1997 and 1998, gizzard shad numbered second and first, respectively, in North Anna Reservoir gill net catches. Threadfin shad were seventh in 1997 and eighth in 1998. Most shad (71 percent in 1997 and 76 percent in 1998) were caught in the upper reservoir (Reference 16).

2.4.2.2.4 **Nuisance Species**

Virginia Power first collected the non-native Asiatic clam in benthos samples in 1979. Densities increased sharply thereafter, as this species with its high reproductive potential quickly occupied suitable habitat in the reservoir (Reference 2). In response to NRC Generic Letter 89-13, Virginia Power initiated a semi-annual sampling program in the fall of 1990 to monitor Asiatic clam in the North Anna Reservoir, the WHTF, and the emergency SWR. Virginia Power biologists collect replicate samples at two North Anna Reservoir locations (i.e., at the intake and a location in mid lake), two WHTF locations, and a single location in the existing units’ SWR. They report the total number and density of clams at the various locations and discuss population trends in semi-annual reports.

These monitoring studies indicate that total numbers and densities of Asiatic clam at the various locations in the North Anna Reservoir and the WHTF show sizable fluctuations between years, mostly as a result of spawning activity (Reference 22) (Reference 23) (Reference 24) (Reference 25) (Reference 26) (Reference 27) (Reference 28) (Reference 29) (Reference 30). Small “sand-sized” clams less than 2 millimeters long are sometimes locally abundant immediately after spawning takes place, and inflate numbers and densities at a particular sampling location.

Asiatic clam numbers in the WHTF near the existing units discharge show the most dramatic fluctuations. For example, densities of clams at this location declined from 1,619 clams per square meter in Spring 1992 to 11 clams per square meter in fall 1992 (Reference 31) (Reference 32). Clams in this area are subject to “boom and bust” cycles, because under extreme conditions (high plant operating levels, high ambient temperatures, drought), water temperatures can get high enough to cause localized die-offs.

Larger (i.e., greater than 15 millimeters in length), older (i.e., 1 to 3 years old) Asiatic clams are uncommon in North Anna Reservoir samples, generally comprising less than 10 percent of the total collected (Reference 17) (Reference 23) (Reference 24) (Reference 25) (Reference 26) (Reference 27) (Reference 28) (Reference 29) (Reference 30). Larger Asiatic clams are generally uncommon in WHTF samples as well, but sometimes make up a significant percentage (i.e., greater than 50 percent) of the total at WHTF-3 when sample sizes are small (Reference 24) (Reference 25) (Reference 26) (Reference 29).

Although Asiatic clam shells have been observed in the SWR, Virginia Power biologists have collected no live clams at this location. The SWR is treated with algicides and molluscicides, preventing Asiatic clam from becoming established in this small reservoir.

When Virginia Power compared 1990-2002 Asiatic clam survey results to similar surveys conducted in the 1980s, data indicated a decline in the North Anna Reservoir population. The highest totals recorded in the spring in the 1980s were in 1988 and 1985, when 294 and 194 clams, respectively, were collected in replicate samples from a mid lake location. The highest totals recorded in the fall were in 1987 and 1986, when 1,227 and 237 clams were collected in replicate samples from a mid lake location. The highest number of clams collected over the 1990-2002 period from the mid lake location was 148, in Spring 1994 sampling. Operational experience at the existing units provides further evidence of a stable or declining North Anna Reservoir Asiatic clam population: no condenser tube blockages have been reported since Asiatic clam appeared in the North Anna Reservoir in the late 1970s.

In the course of monitoring Asiatic clam populations, Virginia Power also looks for evidence that the zebra mussel (*Dreissena polymorpha*) has invaded Lake Anna. Biologists conducting clam surveys examine all bottom samples for the presence of this nuisance species, which became established in the Great Lakes region in the late 1980s after being inadvertently introduced from Northern Europe. Zebra mussels have clogged pipes in power plants and municipal water systems and disrupted the ecological balance of streams, lakes, and reservoirs into which they have been introduced.

As of the end of 2002, Virginia Power biologists had observed no zebra mussels in the North Anna Reservoir or the WHTF. Dissolved calcium levels in North Anna Reservoir and the WHTF are well below those known to promote shell growth in zebra mussels, which should limit its establishment in those waterbodies (Reference 30). Zebra mussels are known from only one location in the state of Virginia: Millbrook Quarry, in Prince William County, Virginia, approximately 60 miles north of the site. This population, believed to have been unintentionally introduced by SCUBA divers, was discovered in August 2002 by a recreational diver who subsequently notified the VDGIF (Reference 33) (Reference 34).

2.4.2.2.5 Threatened and Endangered Aquatic Species

Virginia Power has monitored fish populations in Lake Anna and the North Anna River for more than 25 years. No federally- or state-listed fish species has been collected in any of these monitoring studies, nor has any listed species been observed in creel surveys or occasional special studies conducted by Virginia Power biologists. No state- or federally-listed fish species' range includes Lake Anna or the North Anna River, and none is believed to occur in counties adjacent to Lake Anna or the North Anna River (i.e., Caroline, Hanover, Louisa, Orange, and Spotsylvania Counties).

Based on VDGIF and VDCR (Division of Natural Heritage) databases, one federally-listed mussel species, one state-listed mussel species, and one mussel species that is a candidate for federal listing occur in counties that border Lake Anna or the North Anna River. None of the three has been found in Lake Anna or the North Anna River.

The dwarf wedgemussel (*Alasmidonta heterodon*) was historically found in Hanover, Louisa, and Spotsylvania Counties (Reference 35). It is listed as endangered by both the Commonwealth of Virginia and the USFWS. The USFWS Recovery Plan for the species, completed in 1993, indicated that one population survived in these counties, in the South Anna River, in Louisa County (Reference 36). The VDGIF Fish and Wildlife Information Service database currently lists a "remnant" population in the South Anna River in Louisa County, presumably the same population (Reference 37).

The VDCR database lists another mussel species, the slippershell mussel (*Alasmidonta viridis*), as occurring in Orange County. The slippershell mussel is listed by the Commonwealth of Virginia as endangered, but it has no federal status. Given the known distribution of this species, Virginia Power believes the reported occurrence of the slippershell mussel in Orange County may be in error. The slippershell mussel is widely distributed in the Upper Mississippi River basin and the Ohio River and Tennessee River sub-basins, including three streams in southwestern Virginia, but is not found in Atlantic Slope drainages (Reference 38) (Reference 39) (Reference 40).

A third mussel species reported as occurring in the vicinity of the NAPS site, the fluted kidneyshell mussel (*Ptychobranchus subtentum*), is a candidate for federal listing. The VDGIF's Fish and Wildlife Information Service database lists this species as occurring in a stream or streams in Louisa County. However, based on the fact that all other confirmed accounts of this species are confined to mountain streams in southwestern Virginia that are tributaries of the Tennessee River, it is unlikely that a disjunct population would occur several hundred miles away in a river system that flows eastward to the Atlantic Ocean. Virginia Power believes the reported occurrence of the fluted kidneyshell mussel in Louisa County may be in error.

None of these mussel species were collected in pre-impoundment surveys of the North Anna River, and none have been collected in more recent years during routine monitoring surveys.

2.4.2.3 Biological Communities of North Anna River

The North Anna River joins the South Anna River 23 miles downstream of the North Anna Dam, forming the Pamunkey River. Before 1972, when the river was impounded, flows varied considerably (1 to 24,000 cfs) from year to year and water quality was degraded by acid mine drainage from Contrary Creek. After 1972, fluctuations in flow were moderated (40 to 16,000 cfs from 1972 through 1985) and water quality has improved as a result of reclamation activities at the Contrary Creek mine site and the acid-neutralizing effect of Lake Anna's waters.

Water quality downstream of the North Anna Dam is strongly influenced by conditions in the reservoir and releases at the dam. Water moving from the North Anna Reservoir to the North Anna River is less turbid and more chemically stable than the pre-impoundment flow. Dissolved oxygen levels are high (averaging 9.6 milligrams per liter over the 1981–1985 period) immediately downstream of the North Anna Dam, and increase further downstream, presumably as a result of turbulent mixing (Reference 2).

Summer water temperatures from 1970 to 1985 were higher near the North Anna Dam than further downstream, reflecting temperatures in the reservoir. The highest water temperature recorded in pre-operational years in the river was 89.4°F in July 1977, at a location 0.6 miles below the dam. The highest temperature recorded in the river in operational years was slightly higher, 90.9°F, recorded in August 1983 at the same location.

Historically, the North Anna River periphyton community below the North Anna Dam was dominated by diatoms and was similar to that of other Southeastern streams. The benthic macroinvertebrate community in the stretch of the river below the dam was dominated by filter-feeding caddisflies that feed on seston (living and dead plankton, plus particulate matter) from the North Anna Reservoir. Farther downstream, macroinvertebrate communities showed more diversity and were similar to those of the South Anna River, which served as a control.

In pre-impoundment surveys, the fish community of the North Anna River downstream of the Contrary Creek inflow was dominated by pollution-tolerant species. In the years following impoundment (and reclamation of the Contrary Creek mine site), there was a steady increase in measures of abundance and diversity (species richness) of fish. In 1984–85, 38 species from 10 families were found in the North Anna River, compared to 25 species from 8 families in the control stream, the South Anna River. When species from the North Anna Reservoir were subtracted from the North Anna River totals, the 2 fish communities showed striking similarities, indicating that the operation of the existing units had little or no effect on fish populations downstream from the dam.

In 2000, the number of fish collected at 4 stations downstream of the North Anna Dam was low but similar to 1989, 1993, and 1996 collections. High spring flows and cancelled surveys in the fall may have contributed to the low fish numbers. Experience has shown that high flows are associated with low electrofishing catch rates, and vice versa. Although the number of fish collected in 2000 was low, the species composition of the catch was similar to previous years, with 6 species comprising 80 percent of the electrofishing catch by number and 6 species comprising 83 percent of the electrofishing catch by weight. All indications are that the low catch in 2000 was an anomaly, and the North Anna River continues to support a healthy, well-balanced community of aquatic organisms.

2.4.2.3.1 Commercially-Important Fisheries

As noted in Section 2.4.2.2, there is no commercial fishing in Lake Anna or the North Anna River. There are no runs of anadromous fish in the North Anna River. The North Anna River is a tributary of the Pamunkey River, which has an annual run of American shad; but these shad do not move into the North Anna River (Reference 41) (Reference 42). The Pamunkey Tribal Council operates an American shad hatchery on the Pamunkey River approximately 75 miles downstream of the North Anna Dam. Shad reared at this facility are normally stocked in the Pamunkey River and the James River as fry.

Young American eels (*Anguilla rostrata*) are found in the North Anna River, but are not sought by commercial fishermen. The American eel is a catadromous species, meaning that these fish begin their lives in the open ocean, then migrate into coastal rivers where they spend more of their lives in fresh water. (Reference 43) Upon reaching sexual maturity, at age 5 to 7 years, the eels migrate back to the ocean where they spawn and die. Eels in the North Anna River are juveniles, also known as “yellow eels.”

2.4.2.3.2 Recreationally-Important Fisheries

The lower North Anna River below the North Anna Dam is small, approximately 75 to 150 feet wide, but supports a diverse assemblage of stream fishes. It is a popular fishing spot. Unless stream flow is unusually high, powerboats are impractical: most anglers fish from shore or from canoes and kayaks. Recreational fishermen generally seek one or more of the following fish species: largemouth bass, smallmouth bass, or redbreast sunfish. Bluegill and redear sunfish are present as well, but receive less attention from anglers.

2.4.2.3.3 Important Species in North Anna River

Although the VDGIF periodically surveys the fish of the lower North Anna River and monitors the condition of the recreational fishery, it does not actively manage these populations. VDGIF is most concerned about the largemouth bass and smallmouth bass populations in the lower river, as these are the species most often sought by anglers and the species most likely to attain harvestable size. Recent VDGIF surveys have indicated that largemouth bass and smallmouth bass populations are healthy, despite the river’s limited supply of forage.

a. **Largemouth Bass and Smallmouth Bass**

Since 1987, Virginia Power biologists have gathered data on the abundance and distribution of these bass species in the lower North Anna River via direct (snorkel) observation (Reference 13). Biologists swim established transects at four locations in the lower river, counting and categorizing (by size) all bass that are observed and noting the type of cover being used. Historically, largemouth bass have dominated the fish counts at upstream locations, while smallmouth bass have been more prevalent at downstream locations (Reference 13). In recent years, both species have occupied the entire study area. As a general rule, however, largemouth bass are more abundant at the upstream locations and smallmouth bass are more abundant at the downstream locations. Density estimates for both largemouth and smallmouth bass at all locations were lower in 2000 than average densities for the entire study period, but dense growth of hydrilla adjacent to stream banks limited the ability of observers to accurately count fish (Reference 13).

b. **Redbreast**

Redbreast ranked first in abundance in North Anna River electrofishing samples in 1998, 1999, and 2000, and have ranked in the top four every year since 1981 (Reference 13). The redbreast is found across the coastal plain and Piedmont of Virginia in warm-water creeks and rivers of low-to-moderate gradient (Reference 41). It is an adaptable species, and may also be found in ponds, lakes, reservoirs, and even slightly brackish waters near the coast. The redbreast of the lower North Anna River appear to be a typical stream-dwelling population, with unremarkable growth rates, food habits, and spawning habits.

2.4.2.3.4 Nuisance Species

Asiatic clams first appeared in benthos samples from the North Anna River during the operational phase of the NAPS 316(a) study, conducted over the period 1981–1985. By the end of this period, Asiatic clams were firmly established in the lower North Anna River and were a “major” component of the benthos at several sampling locations (Reference 2).

2.4.2.3.5 Threatened and Endangered Aquatic Species

As presented in Section 2.4.2.2, Virginia Power has monitored fish populations in Lake Anna and the North Anna River for more than 25 years. No federally-listed or state-listed fish species has been collected in any of these monitoring studies, nor has any listed species been observed in creel surveys or occasional special studies conducted by Virginia Power biologists. No state- or federally-listed fish species’ range includes Lake Anna or the North Anna River, and none is believed to occur in counties adjacent to Lake Anna or the North Anna River (i.e., Caroline, Hanover, Louisa, Orange, and Spotsylvania Counties).

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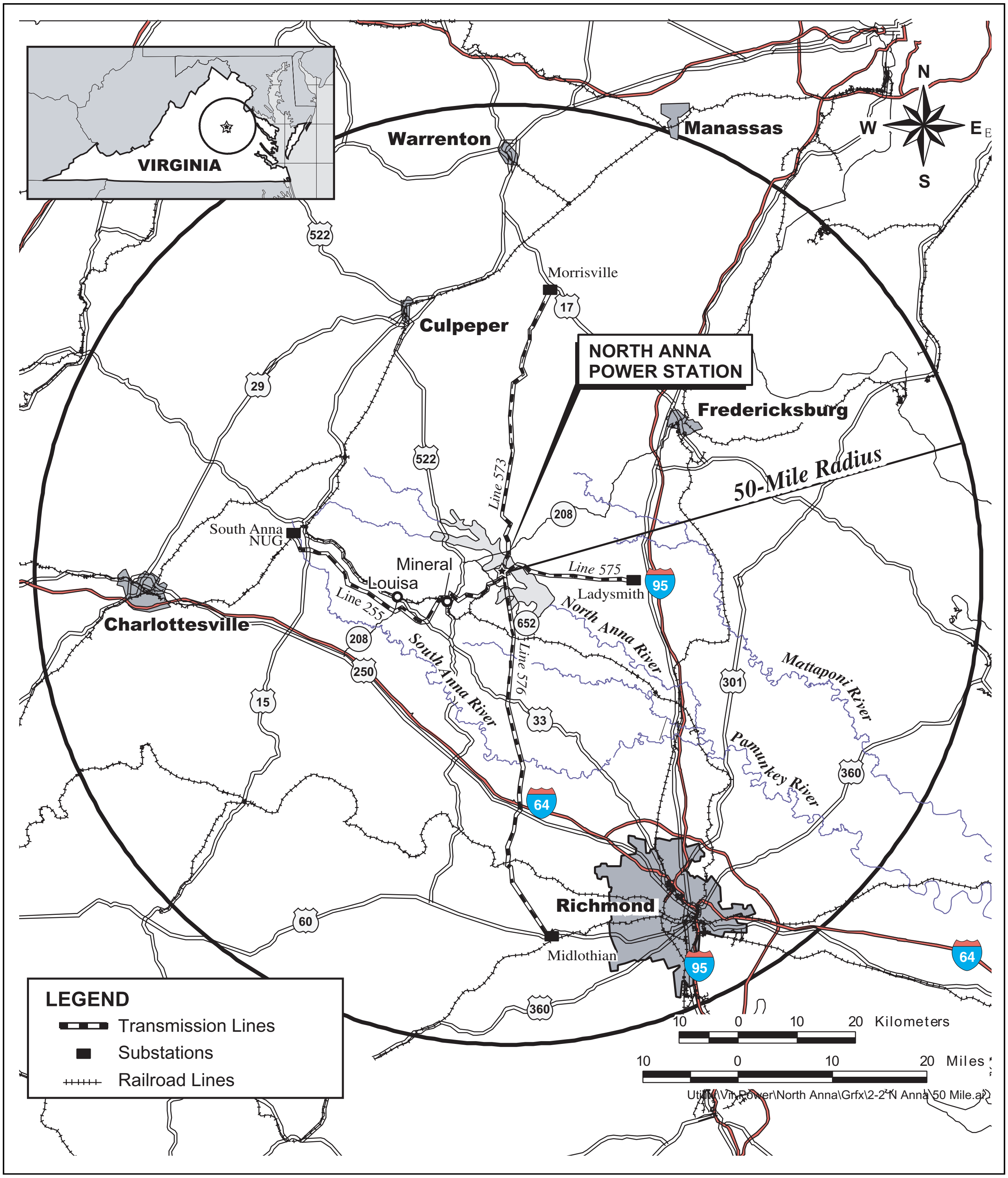

Figure 2.4-1 Lake Anna and the North Anna River

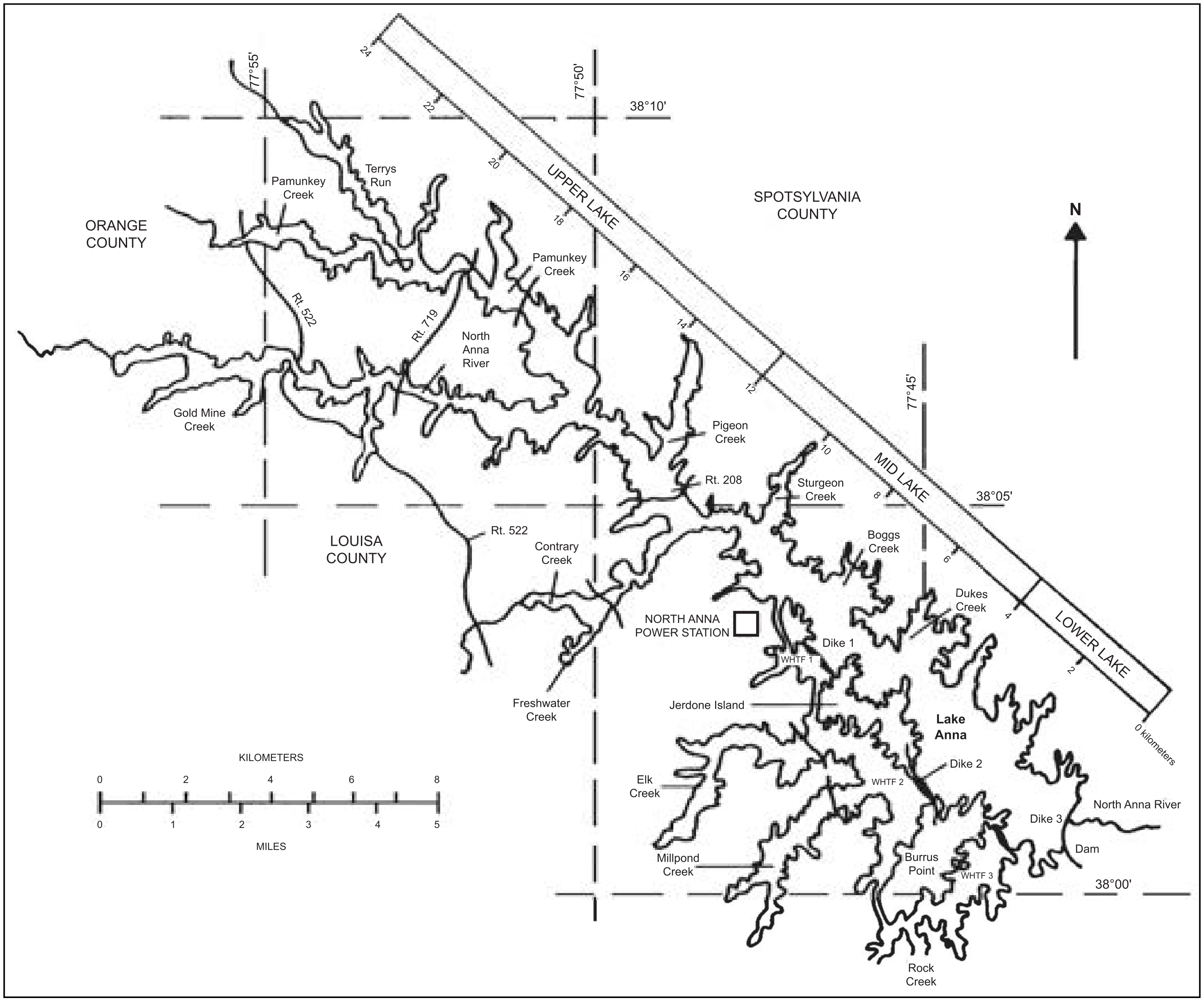

Figure 2.4-2 North Anna River; Northeast Creek; Contrary Creek

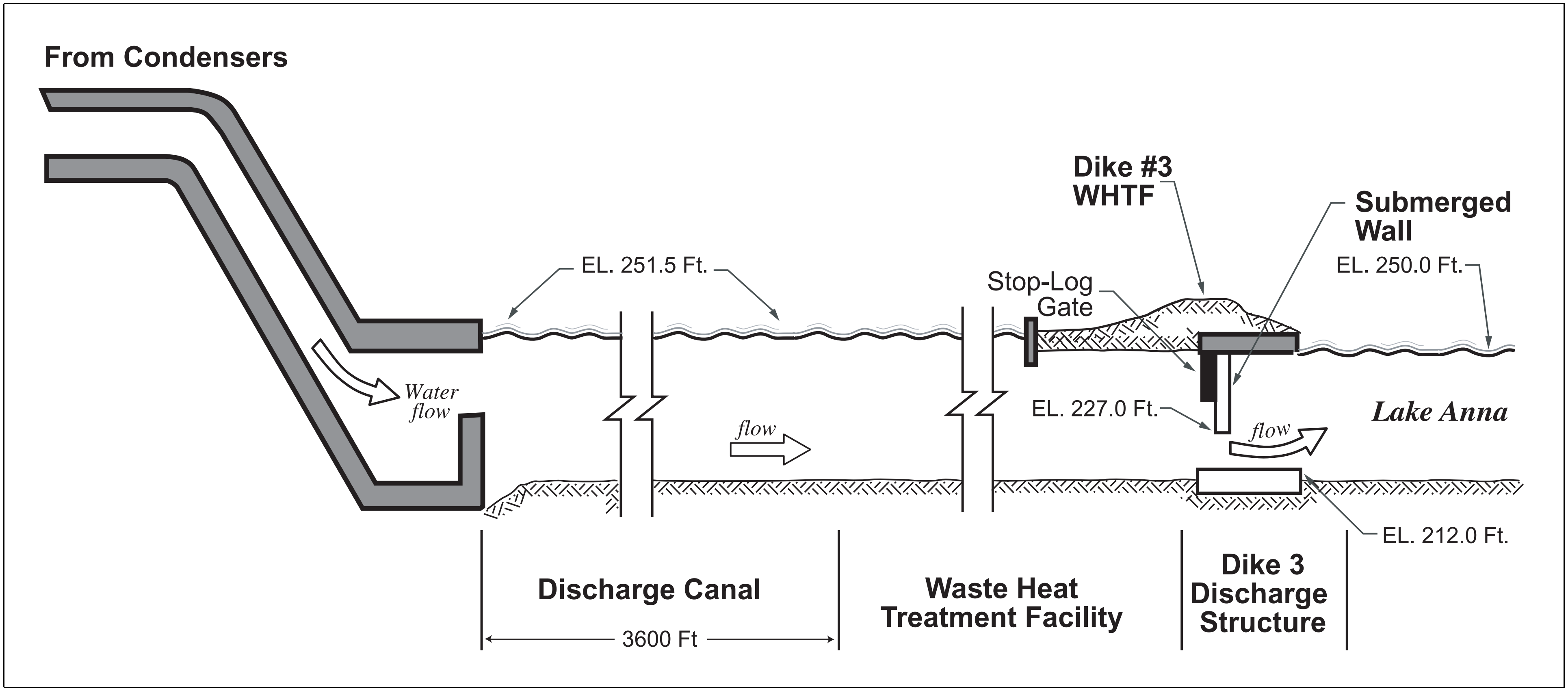

Figure 2.4-3 Schematic Cross-Sectional Diagram of Water-Discharge System at Dike 3 WHTF

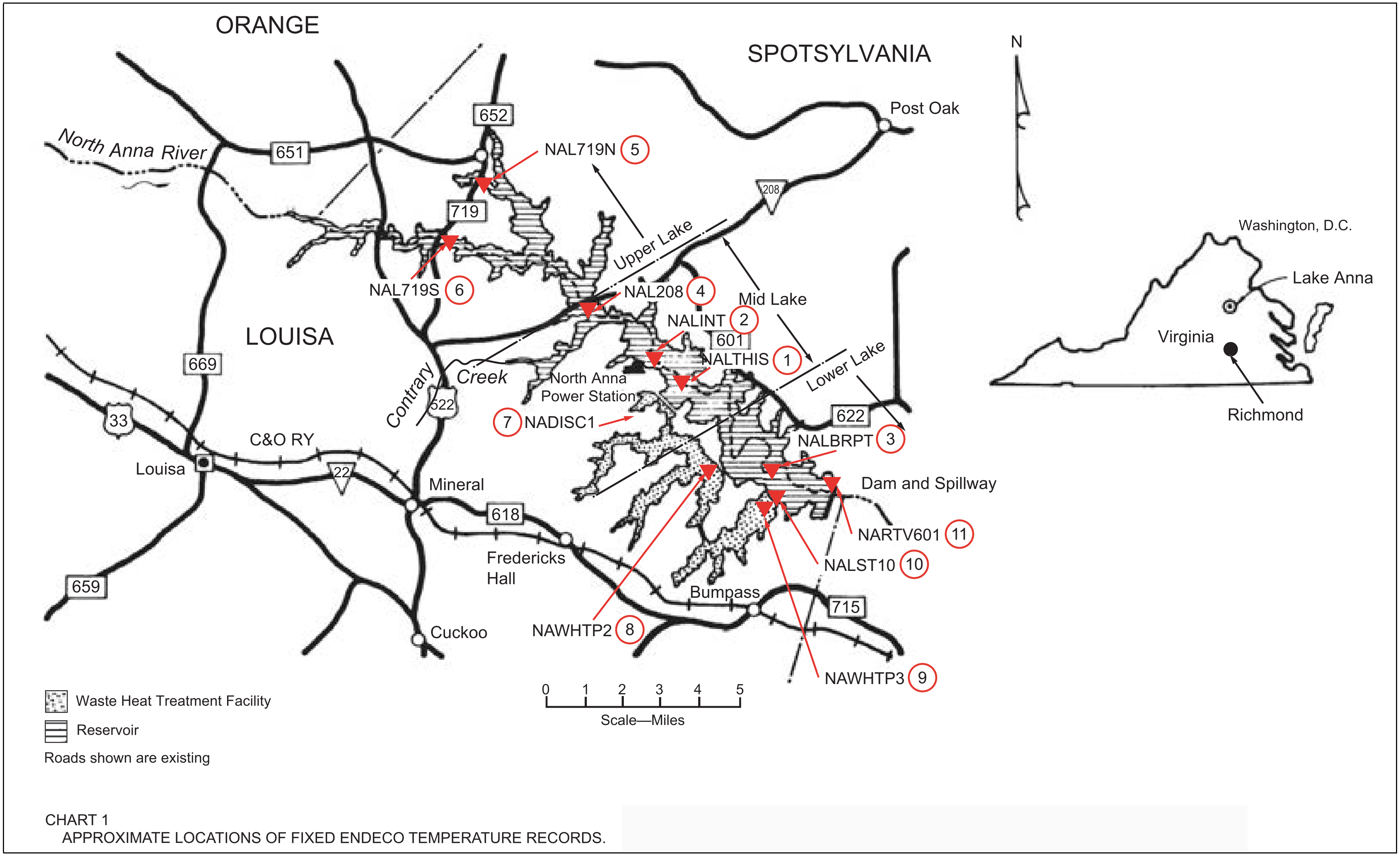

Figure 2.4-4 Location of Temperature Sensors - Lake Anna

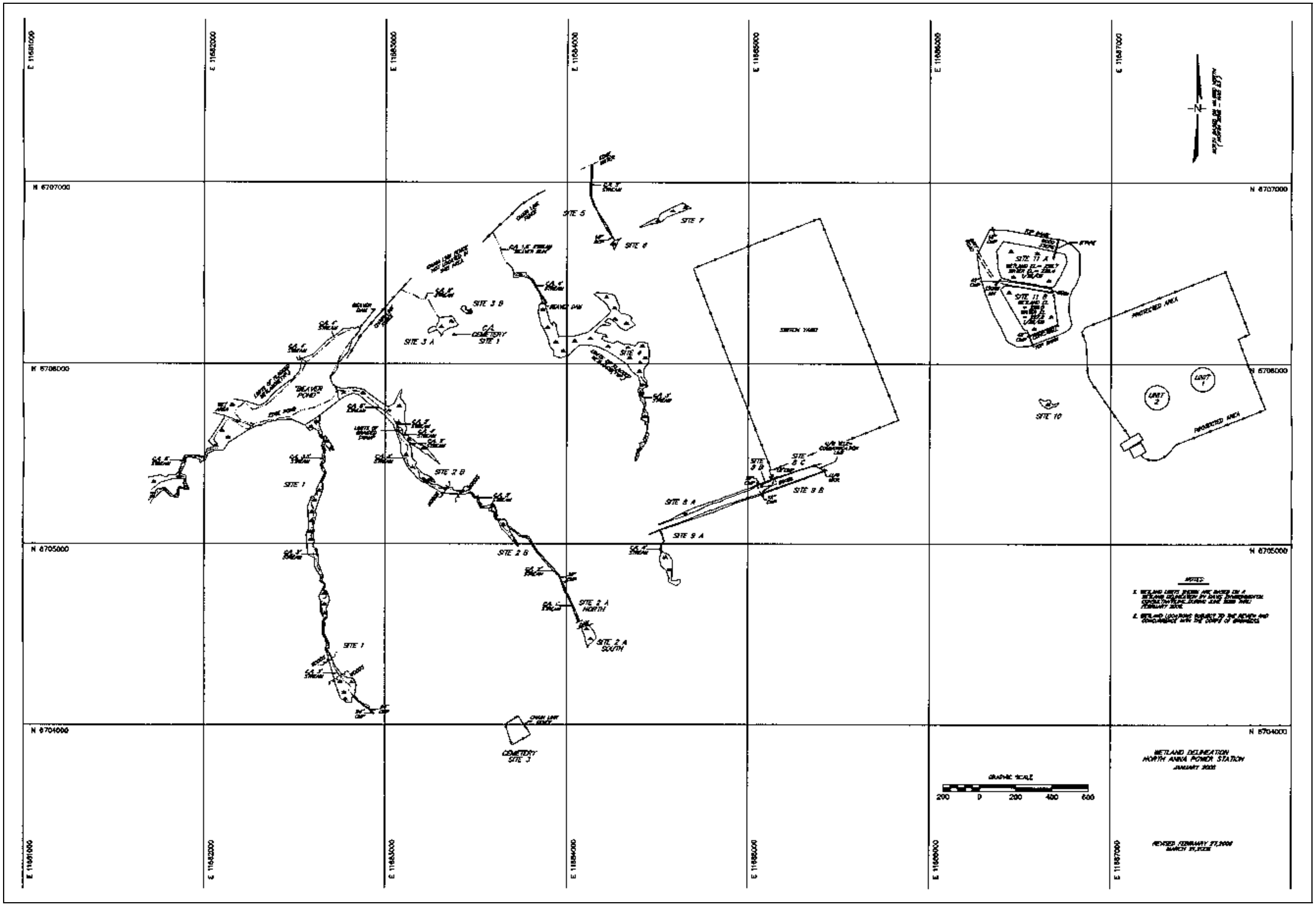

Figure 2.4-5 Overall ESP Site Wetlands Survey

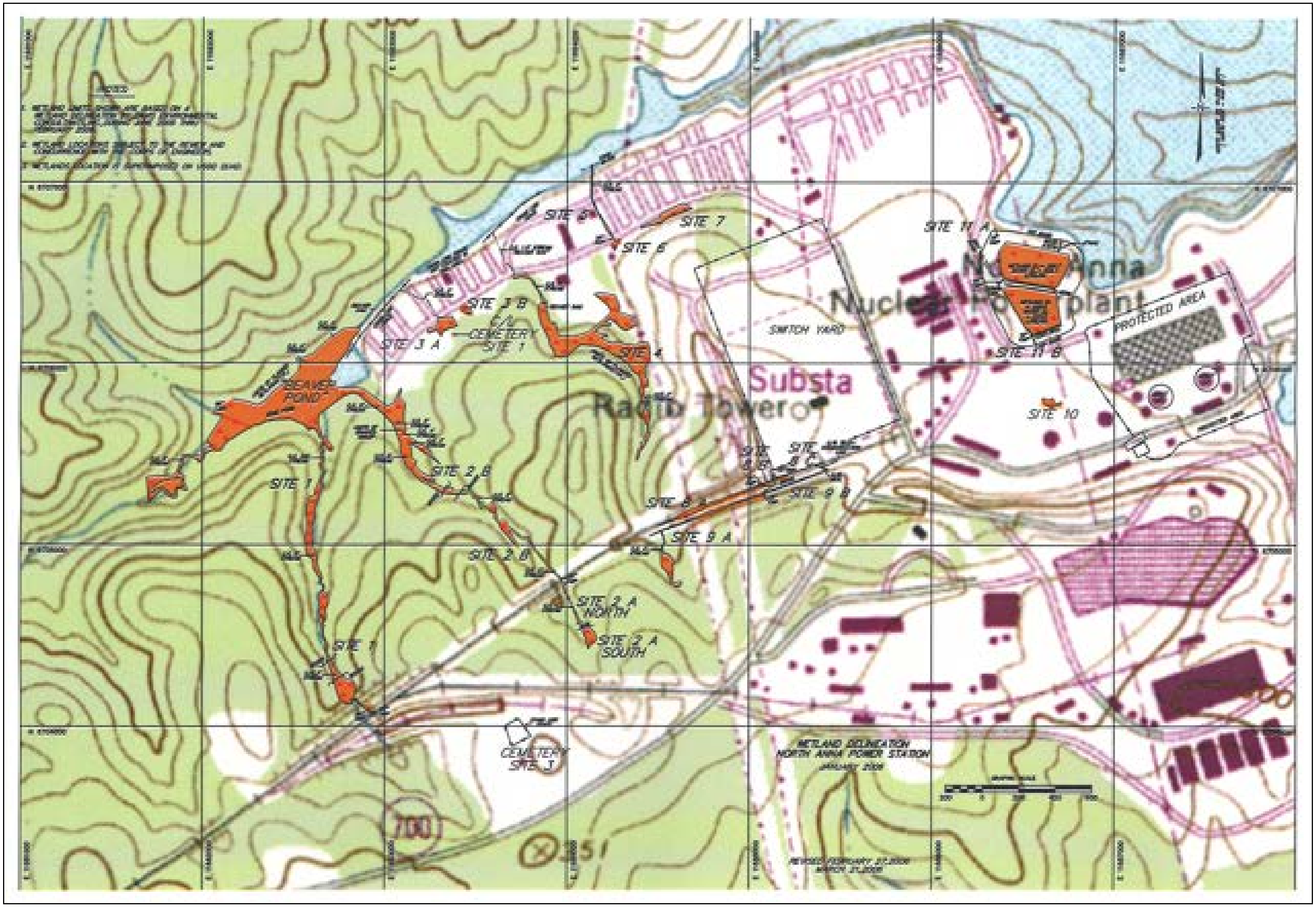

Figure 2.4-6 Sketched ESP Site Wetlands on Topo

2.5 Socioeconomics

This section presents the socioeconomic resources that have the potential to be impacted by the construction, operation, and decommissioning of the new units. The section is divided into four subsections: 1) demographics, 2) community characteristics, 3) historic properties, and 4) environmental justice. These subsections include spatial (e.g., regional, vicinity, and site) and temporal (e.g., 10-year increments of population growth) considerations, where appropriate, as referenced.

2.5.1 Demography

The population distribution surrounding the ESP site, up to an 80-km (50-mi.) radius, has been estimated, based on the most recent U.S. Census Bureau decennial census data (Reference 1). The population distribution encompasses nine concentric rings at 2 km (1.2 mi.), 4 km (2.5 mi.), 6 km (3.7 mi.), 8 km (5.0 mi.), 10 km (6.2 mi.), 16 km (10 mi.), 40 km (24.9 mi.), 60 km (37.3 mi.), and 80 km (50 mi.), and 16 directional sectors. The projected population estimates for Years 2010, 2020, 2030, 2040, and 2065 have been calculated with a formula adopted from the Weldon Cooper Center for Public Service (Reference 2) using the 1990 Census and 2000 Census data as the base.

2.5.1.1 Resident Population Within 16 km (10 miles)

Figure 2.5-1 shows the general locations of the municipalities and other features within 10 miles (16 km) of the ESP site. According to the 2000 Census survey, Mineral, which has a population of 424 located within about 1 square mile (incorporated), is the largest community within 10 miles of the site (Reference 5). As reported in NAPS UFSAR (Reference 4, Section 2.1.3.1), the population in 1990 was 452. Therefore, the population of Mineral has remained constant during the past decade.

The population distribution within 16 km (10 miles) of the site has been computed by overlaying the 2000 Census block points data (the smallest unit of census data) (Reference 1) on the grid shown on Figure 2.5-1, and summing the population of the census block points falling in each of the polar sectors comprising the grid. The census block-point summation and allocation has been accomplished using the Landview 5 (LV5) software, operating directly on census data, and the MARPLOT mapping software (Reference 1). The system can display Census 2000 demographic data, jurisdictional entities, and many statistical entities of the U.S. Census Bureau. It can also calculate Census 2000 population, racial distribution, census block count, and housing unit count within a user-defined radius. Using MARPLOT, the grid system was created as shown on Figure 2.5-1. LV5 was designed to summarize the population distribution and other information, once the user selected an area of interest within the grid system. The entire grid system is evenly divided into 16 directions, each direction consisting of 22.5 degrees.

The population distributions and related information have been recorded on a spreadsheet to tabulate the results at the distances of interest for all sixteen directions. In order to generate more accurate counts, census block points were used in LV5 to calculate population distributions.

Population projections for the area within 10 miles of the ESP site up to 65 years from the 2000 census were developed. The formula used for average annual growth (percentage of growth) is adopted from Reference 2. The Weldon Cooper Center for Public Service group has performed the 2001 provisional population estimates for the Commonwealth of Virginia.

$$\text{Annual Average Growth} = \frac{\text{Log}_{10}\left(\text{Population}_{2000} / \text{Population}_{1990}\right)}{(2000 - 1990) \times 0.4342945}$$

The 1990 population distributions within each county and city considered in Virginia and Maryland were also obtained from the U.S. Census Bureau (Reference 25). The same formula is also used for projection of the transient population up to the year 2065. The 10-mile population distribution for Year 2000 is shown on Figure 2.5-3. The 16-km (10-mile) resident and transient population projections for the years 2010, 2020, 2030, 2040, and 2065 are given in Figure 2.5-4 through Figure 2.5-7.

In 2000, the total population within 16 km (10 mi.) of the ESP site was 15,511. Based on the average annual growth, the estimated population for 2010 is 20,996. This is a projected increase of 35.4 percent. In 2020, an estimated 26,480 people will live within the 16-km (10-mi) radius of the site. This constitutes a 26.1 percent increase from 2010. For each decade, there is a slight downward trend in the percent increase of the population. The growth between 2020 and 2030 is projected to be 20.7 percent and between 2030 and 2040 to be 17.2 percent. Table 2.5-1 presents the population distribution within a 16-km (10-mi) radius of the ESP site for four decades (2000 to 2040).

Table 2.5-2 presents the estimated sex distribution of the population within a 16-km (10-mi) radius of the ESP site. The ratio of men to women is fairly consistent throughout the different concentric rings. The ratio of men to women in Virginia is slightly over 96 men to every 100 women (see Table 2.5-3). The ratio of men to women living within the 16-km (10-mi) radius of the ESP site is about the same: 97 men to every 100 women.

Table 2.5-4 presents the estimated age distribution of the population within a 16-km (10-mi) radius of the ESP site. The number of individuals in the 20-to-24 age group and the 65 and over age group is significantly lower than the rest of the age groups. However, this is typical of the Commonwealth of Virginia as a whole (see Table 2.5-14). The percentage of each age group tends to be very similar across each concentric ring. There appear to be no large groupings of any specific age group.

Table 2.5-6 presents the racial and ethnic distribution of the population within a 16-km (10-mi) radius of the ESP site. The white population is by far the majority within the 0- to 16-km (0- to

10-mi.) radius, with 12,805 people (82.6 percent of the population). However, the percentage of white people living within a given radius changes throughout the entire 16-km (10-mi.) radius from 94.3 percent in the 2-km (1.2-mi.) radius to 76.4 percent in the 8-km (5-mi.) radius to 83.6 percent in the 16-km (10-mi.) radius.

The percentage of black people living within a given radius also changes greatly throughout the entire 16-km (10-mi) radius from 4.8 percent in the 2-km (1.2-mi.) radius to 21.5 percent in the 8-km (5-mi.) radius to 13.5 percent in the 16-km (10-mi.) radius. The overall percentage of black people within the 0- to 16-km (0- to 10-mi.) radius from the site is 14.9 percent (2309 people).

Table 2.5-7 presents the estimated income distribution of the population within a 16-km (10-mi.) radius of the ESP site. Income distribution provided in the 2000 census data set has been recorded only up to Year 1999. Most of the individuals 15 years of age and older earn below $25,000 per year. Within the 0- to 16-km (0- to 10-mi.) radius, an estimated 5404 individuals (approximately 45.7 percent) earn less than $25,000. This is consistent with the overall Virginia numbers within one percent (see Table 2.5-7). The percentage of individuals earning between $50,000 and $75,000, between $75,000 and $100,000, and over $100,000 increases almost consistently throughout the different concentric rings.

Overall, the characteristics of the population within each concentric ring are basically the same.

2.5.1.2 **Resident Population Between 16 km (10 miles) and 80 km (50 miles)**

The 80-km (50-mi.) radius around the ESP site covers thirty counties and four cities in Virginia and one county in Maryland (See Figure 2.5-2). The Town of Louisa is approximately 12 miles to the west of the site. The population of the town has increased from 1088 (Reference 4) to 1400 (Reference 9, Section 2.2.8.5) between 1990 and 2002. About 40 miles south-southwest of the site is Richmond, Virginia, with a population of 197,790 in the Year 2000. About 36 miles west of the ESP site is Charlottesville, Virginia, which has a population of 45,049 according to the 2000 Census. About 22 miles northeast of the ESP site is Fredericksburg, Virginia, with a population of 19,279. The nearest population center with more than 25,000 residents is the City of Charlottesville. The closest point of Fredericksburg is 22 miles to the northeast with a projected 2065 population of about 20,950.

In addition to the thirty counties within Virginia, the 80-km (50-mi.) radius from the ESP site also encompasses Charles County, Maryland. The population distribution within that 80-km (50-mi.) radius for Charles County, which at its closest point is 37 miles northeast from the site, is 9270 based on the 2000 census data.

The 80-km (50-mi.) Year 2000 resident and transient population distribution throughout the four concentric distance rings and the 16 directional sectors is shown on Figure 2.5-8. The resident and transient population projections for the area between 16 and 80 km (10 and 50 mi.) for years 2010, 2020, 2030, 2040, and 2065 are based on the same methodology as the 16-km (10-mi.)

projections. These population projections throughout the four concentric rings and the 16 directional sectors are given in Figure 2.5-9 through Figure 2.5-12A.

The total population within 80 km (50 mi.) of the ESP site is 1,538,156, according to the 2000 Census. Based on the average annual growth, the estimated 2010 population is 1,849,908, which is a projected increase of 20.3 percent. Table 2.5-8 presents the population distribution within an 80-km (50-mi) radius of the site for four decades (2000 to 2040).

In 2020, an estimated 2,161,660 people will live within the 80-km (50-mi) radius. This constitutes a 16.9 percent increase from 2010. For each decade, there is a slight downward trend in the percent increase of the population. The growth between 2020 and 2030 is projected to be 14.4 percent and between 2030 and 2040 to be 12.6 percent.

Table 2.5-9 presents the estimated sex distribution of the population within an 80-km (50-mi.) radius of the ESP site. The population within this 80-km (50-mi.) radius contains about 94 males for every 100 females. This is a bit lower than the overall state of Virginia, which averages slightly over 96 men to every 100 women (See Table 2.5-3).

The estimated sex distribution throughout the 80-km (50-mi.) radius is fairly consistent. The distribution within each concentric ring is basically the same and is very close to the ratio for Virginia as a whole (see Table 2.5-3).

Table 2.5-10 presents the estimated age distribution of the population within an 80-km (50-mi.) radius of the ESP site. The age group with the largest percentage of people is the 25- to 44-year-old age group. The next largest age group is the 0- to 19-year-old age group. This could be based on the fact that most parents are between the ages of 25 and 44, and their children, would be 19 years old and younger.

For each age group, the percentages are fairly consistent, regardless of the size of the population within the specific radius; although, there are a couple of inconsistencies. These inconsistencies include the 0-to-16-km (0-to-10-mi.) radius's 25-to-44 age group (which is lower than the same group in the other concentric circles) and the 0-to-16 km (0-to-10 mi.) radius's 0-to-19 age group (which is higher than the same group in the other concentric circles).

Table 2.5-11 presents the racial and ethnic distribution of the population within an 80-km (50-mi.) radius of the ESP site. The ratio of the white population to the black population within 80-km (50-mile) radius is 3 to 1 (see Table 2.5-12) which is consistent with the ratio of 3.7 to 1 for the Commonwealth of Virginia in its entirety.

The black population increases significantly between the 60-km (37.3-mi.) radius and the 80-km (50-mi.) radius. This increase is due to the population of the City of Richmond. In Richmond, the ratio of white individuals to black individuals is 67 to 100 (see Table 2.5-12).

Table 2.5-13 presents the estimated income distribution of the population within an 80-km (50-mi.) radius of the ESP site. The largest percentage of the population earned less than $25,000 in 1999.

This was consistent with the rest of the state. The distribution of earnings within each concentric ring is fairly consistent throughout the entire 80-km (50-mi.) radius from the ESP site.

The majority of current NAPS employees reside in Henrico, Louisa, Orange, and Spotsylvania counties. Spotsylvania and Louisa counties are two of the fastest growing counties in Virginia. While Virginia as a whole has increased in population by 13.4 percent between 1990 and 2000, Spotsylvania and Louisa counties have increased in population by 45.4 percent and 23.3 percent, respectively. Henrico and Orange counties have also surpassed the Virginia average by increasing in population by 18.6 and 18.9 percent, respectively. However, the City of Richmond decreased in population by 2.5 percent in the same time period.

Table 2.5-3 presents the sex distribution of the population in the counties that contribute most of the current NAPS employees, in comparison to the entire state of Virginia. The counties' sex-distributed populations closely track within one percent. The exceptions are Henrico County and the City of Richmond in which both locations have a larger female population.

Table 2.5-14 presents the age distribution of the population in the counties that contribute most of the current NAPS employees in comparison with the entire state of Virginia. The counties' age-distributed populations closely track within 3 percent. The exceptions are Spotsylvania County's 0-to-19 age group (which is 4.8 percentage points higher than the Virginia average), Orange County's 25-to-44 age group (which is 3.8 percentage points lower than the Virginia average), and Orange County's 65-and-older age group (which is 6 percentage points higher than the Virginia average).

Table 2.5-12 presents the racial and ethnic distribution of the population in the counties that contribute most of the current NAPS employees in comparison with the entire state of Virginia. The counties' racial and ethnic-distributed populations closely track within 5 percent. The exceptions are Orange County's white population group (which is 12.1 percentage points higher than the Virginia average), the City of Richmond's white population group (which is 34 percentage points lower than the Virginia average), Spotsylvania County's white population group (which is 10.6 percentage points higher than the Virginia average), Orange County's black population group (which is 5.8 percentage points lower than the Virginia average), the City of Richmond's black population group (which is 37.6 percentage points higher than the Virginia average), and Spotsylvania County's black population group (which is 7.1 percentage points lower than the Virginia average).

Table 2.5-7 presents the income distribution of the population in the counties that contribute most of the current NAPS employees in comparison with the entire state of Virginia. The counties' income-distributed populations closely track within 4 percent. The exceptions are Henrico County's $1000-$25,000 income group (which is 5.3 percentage points lower than the Virginia average), Louisa County's $1000-$25,000 income group (which is 5.5 percentage points higher than the Virginia average), the City of Richmond's $1000-$25,000 income group (which is 9.8 percentage points higher than the Virginia average), Spotsylvania County's $1000-$25,000 income group (which is 6.3 percentage points lower than the Virginia average), and Henrico County's $25,000-to-$50,000 income group (which is 6.6 percentage points higher than the Virginia average).

The population distributions throughout the 9 concentric rings and the 16 directional sectors extending to a 50-mile radius for the Present Date, Startup Date, and 40-year Date are summarized in Table 2.5-15. The startup date was conservatively assumed to be around Year 2025, based on the assumption that the period of ESP approval is between 2005 and 2025.

2.5.1.3 **Transient Population**

2.5.1.3.1 **Transient Population Within 16 km (10 miles)**

Information concerning transient population for the area has been collected from several sources, because the information is not available from the 2000 census data. The area within 10 miles (16 kilometers) of the ESP site is predominantly rural and is characterized by farmland and wooded tracts of land. Since there are no significant industrial or commercial facilities in the area, and none are anticipated (Reference 4, Section 2.1.3.3), the transient employment population is likely to move out of, rather than into, the area.

Recreational use of Lake Anna, including Lake Anna State Park, is the greatest contributor to transient population in the area. The usage of the lake was estimated from a number of contributing factors including the number of boat ramps, wet slips, campsites, picnic areas, etc. These contributing factors are listed in Table 2.5-16.

An estimate of lake usage on a peak weekend day in the peak summer season has been developed based on representative usage of recreational facilities (e.g., boating, picnicking, camping) provided by the VDCR (Reference 4, Section 2.1.3.3) and the Lake Anna recreational facilities listed in Table 2.5-16. However, residents should have been included in the census data. This estimate does not include use by local residents with their own docks. In addition, many residents without docks keep their boats in marina wet slips or use the boat ramps and are, therefore, included in the lake usage.

There are six marinas in the vicinity of the ESP site. The closest is 1.4 miles north-northeast of the site. The remaining marinas are from 2 to 2.5 miles distant. A survey of several of the marinas indicate that their actual boat launches, per ramp, ranged from 15 to 40 per peak day, which is significantly lower than the number of 80 per day provided by the VDCR as an upper limit, and that the usage per ramp has dropped as new ramps are added. This was attributed to parking space limitations and the fact that the lake usage by recreational boaters may be approaching saturation. A rate of 50 launches per ramp per day was selected as being more representative of Lake Anna conditions.

Based on 50 launches per ramp per day, these marinas and other boat ramps, including those at Lake Anna State Park, could provide access for up to 1450 pleasure craft on Lake Anna. Peak day usage estimates for boats moored in wet slips ranged from 30 to 50 percent. Assuming that all slips are rented, 150 additional boats would be added, bringing the total, excluding boats from private docks, to 1600. The resulting transient population at three persons per boat would be 4800 (Reference 4, Section 2.1.3.3).

The two commercial campgrounds, with a combined total of more than 200 campsites, has been estimated by the Virginia State Department of Conservation and Recreation to contribute about 650 persons to the transient population assuming three persons per campsites. The number of picnickers has been estimated at 450. Since both campsites have boat ramps, significant double counting is likely (Reference 4, Section 2.1.3.3)

Lake Anna State Park provides facilities for picnicking, fishing, boat launching, swimming and biking. The Lake Anna State Park Manager estimated a peak daily attendance of 4372 from June 2002 through August 2002, and an annual attendance of 187,302 between July 1, 2001 and June 30, 2002, based on traffic counts. Double counting is likely as boaters are included in the traffic count.

The resulting estimated total peak daily transient population on Lake Anna (including the WHTF and Lake Anna State Park) is less than 11,270 (see Table 2.5-17). Since use of the WHTF is limited to residents and their guests, there are no public boat ramps. The WHTF transient population, estimated at less than 1,000, is based on one guest for each resident in the polar sectors encompassing the WHTF.

Annual transient population is uncertain because of the dramatic drop in boating on weekdays and during non-summer months. Based on the Lake Anna State Park data, assuming 180 days of operation, the average daily attendance is less than one quarter of the peak daily attendance. Conservatively assuming that the average attendance, excluding the park, is one half the peak daily figure, the total annual attendance would be about 807,300, based on a 180-day season.

Transient population within 16 km of the ESP site combined with the resident population in that area for Year 2000 and for projected years 2010, 2020, 2030, 2040, and 2065 are presented in Figure 2.5-3 through Figure 2.5-7.

2.5.1.3.2 **Transient Population Between 16 km (10 miles) and 80 km (50 miles)**

It is difficult to provide an accurate count of the transient population between 10-mile (16-km) and 50-mile (80-km) concentric circles from the ESP site. There are colleges, schools and hospitals within 50 miles. However, compared to the resident population within the same area, use of these facilities by transient population is expected to be insignificant.

Between 16 km and 80 km of the ESP site, the only major recreational facility that induces a significant amount of transient population is Paramount’s Kings Dominion Amusement Park. Paramount’s Kings Dominion is 35 miles southeast from the site. The park opens from March to November and hosts about 2 to 2.5 million visitors annually. According to the park’s public relations manager, the park could experience slow growth in the future, until it reaches its current maximum capacity of 2.875 million visitors per year (i.e., an additional 15 percent above the current attendance). On average, the park opens to the public about 138 days per year (Reference 6). Using the maximum capacity of the park and the average number of days open, the average daily park visitor count is conservatively estimated to be 20,830.

There is no official count of visitors that come from areas outside the 50-mile radius from the ESP site. However, the majority of the park visitors are expected to come from Richmond and Fredericksburg areas due to their proximity to the park. It is conservatively assumed that 40 percent of the daily park visitors come from areas outside the 50-mile radius. The 8350 park visitors from further than 50 miles are considered transient population and the number is included in the population distribution estimates (See Table 2.5-15).

Transient population between 16 km and 80 km of the ESP site combined with the resident population in that area for Year 2000 and for projected years 2010, 2020, 2030, 2040, and 2065 are presented in Figure 2.5-8 through Figure 2.5-12A.

2.5.1.4 **Migrant Labor**

Migrant laborers are typically members of minority or low-income populations. Because migrant workers travel and can temporarily spend a significant amount of time in an area without being actual residents, they may be unavailable for census counts. Therefore, migrant workers could be under-represented in U.S. Census Bureau minority and low-income population counts.

Migrant workers do not harvest agricultural crops in Louisa County; however, they do re-plant forest land that has been harvested. Over the past 5 years, most completely harvested forestland in Louisa County has been reforested (replanted) or allowed to regenerate naturally. Planting takes place from late January through March and is often done under Virginia Department of Forest contract. Data on the number of migrant workers participating in the planting are not available, but the number is considered to be small. Given the expected small number of migrant workers, and the probability of the population being concentrated in a single location, their temporary domicile would not be long in duration. Therefore, migrant workers would not materially change the population characteristics of any particular census tract within Louisa County.

2.5.1.5 **Population Density**

Given an approved ESP period of 20 years and an assumed ESP approval date of 2005, the startup date of new units is conservatively assumed to be 2025. Assuming an operational period of 40 years for new units, new unit operations could extend until 2065.

Figure 2.5-13 shows the actual cumulative populations in Year 2000 and projected cumulative population in Year 2065 as a function of 10-mile to 50-mile radial distances from the site. On the same figure, population density curves, spanning the same radial distances, are shown for 500 persons per square mile, and of 1000 persons per square mile.

By inspection of the curves for actual population densities of Year 2000 and Year 2065 projections, it is concluded that at the time of initial site approval and within about 5 years thereafter, the population densities, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), would not exceed 500 persons per square mile. The results conform to the guidance in RG 4.7, Regulatory Position C.4 (Reference 7).

Similarly, by inspection and projection of the same curves to account for trends over the lifetime of the new units, it is concluded that the expected population densities, including weighted transient population, averaged over any radial distance out to 30 miles (cumulative population at a distance divided by the area at that distance), would not exceed: 1) 500 persons per square mile at the time of initial operation, and 2) 1000 persons per square mile over the lifetime of new units (Reference 8).

2.5.2 **Community Characteristics**

The region around the ESP site has a medium density population (Reference 9). The permanent workforce at the existing units consists of approximately 850 employees. During planned outages of an existing unit (every 18 months/unit), an additional 700 to 1000 workers are onsite for a period of 30 to 40 days. During construction of the new units, a peak workforce of approximately 5000 would be expected. Depending on the reactor design selected and the scheduling of the installation of the new units, this peak workforce could be onsite for 5 to 7 years. Approximately 720 new employees would be required for the operation of the new units. For planned outages, about the same number of additional workers could be expected for a new unit as is used for an existing unit.

The communities with the greatest potential to be impacted socio-economically by the installation and operation of new units at the ESP site are in Henrico, Louisa, Orange, Hanover, and Spotsylvania Counties, and the City of Richmond because most employees reside in one of these counties. These counties are in central Virginia, which has experienced a steady growth in population and economic activity in the last decade. As presented in Section 2.5.1, the population growth over the last decade has been greatest in Louisa and Spotsylvania Counties. Conversely, the City of Richmond population during this period has declined.

The existing socio-economic situation of the area around the NAPS site has been addressed in detail by the Environmental Report (ER) prepared by Virginia Power as part of its Application for Renewed Operating Licenses for NAPS Units 1 and 2 (Reference 10), and by the Supplemental Environmental Impact Statement (SEIS) prepared by the NRC for the license renewal of NAPS Units 1 and 2 (Reference 11). Although both documents have been prepared within the last two years, the information provided in these documents has been updated when more recent information was available and pertinent to the installation of new units at the ESP site. The following discussion is based primarily on these sources.

2.5.2.1 **Economy**

Information on the population distribution (by county and by distance from the ESP site), including breakdowns by age, sex, race and ethnic background, are presented in Section 2.5.1. Tables on estimated income distribution are also provided, identifying income group by distance from the ESP site and county. These tables include similar information for the Commonwealth of Virginia as a point of comparison in assessing whether the area around the ESP site is similar to the rest of the state. The conclusion is that, in general, there are no great differences in the income distributions between the area around the ESP site and throughout the state as a whole.

Percent unemployment, individual poverty rates, and median household incomes for the five counties of interest and the City of Richmond have been obtained from the Virginia Employment Commission (VEC) website (Reference 12) and include data generated by the U.S. Census Bureau from the 2000 Census (Reference 13). The information is presented in Table 2.5-18.

Similar data for Virginia as a whole are also presented to provide a point of comparison for the local data. The unemployment rates, individual poverty rates, and median household incomes for Charles County in Maryland and for the State of Maryland are also presented in this table, because the 80 km (50 mile) radius that defines the potential area of impact for the new units includes part of Charles County. Furthermore, the history of major construction at NAPS shows that part of the construction work force has originated from Maryland. (Reference 10) The data have been obtained from the Maryland website for the Maryland Department of Labor, Licensing, and Regulation (Reference 14), and includes data generated by the U.S. Census Bureau from the 2000 Census.

Based on Table 2.5-18, the total civilian labor force in the region (November 2002) was 434,366, of which 65,349 were in Charles County, Maryland.

2.5.2.1.1 **Hanover County, Henrico County, and the City of Richmond**

Henrico County, Hanover County, and the City of Richmond are part of the Richmond-Petersburg metropolitan statistical area (MSA), which is home to approximately 1 million people (Reference 15). Of this number, 262,300 people live in Henrico County, 86,320 in Hanover County, and 197,790 in the City of Richmond. The MSA is located approximately 161 km (100 miles) from Washington, D.C. and is the primary economic driving force within an 80-km (50-mile) radius of the ESP site. This MSA has a transportation network of trucking and railroad terminals, interstate highway access to main east-west and north-south corridors, and an international airport. The CSX Corporation headquarters is located in Richmond. The Port of Richmond, the westernmost inland port, has direct access to the Atlantic Ocean, serving both domestic and international markets. A map of the area, taken from the North Anna License Renewal Application (Reference 10), is presented as Figure 2.5-16. Paramount's Kings Dominion, located in Hanover County, is a major tourist attraction for the area.

The Richmond area is headquarters for more than 35 major corporations, including 12 Fortune 1000 companies, of which 6 are Fortune 500 companies, and 3 are Forbes 500 largest companies.

Capital One Financial Corporation is the largest private employer in the area. Service is the largest employment sector in the MSA, followed by retail and wholesale trades, manufacturing, finance, and construction. (Reference 15)

Approximately 45 percent of resident workers in Henrico County commute to jobs outside the county, as compared to almost 64 percent of resident workers in Hanover County and about 40 percent of resident workers in the City of Richmond. The unemployment rate for Henrico County is 3.3 percent, as of November 2002, which is higher than the 2.4 percent for Hanover County and lower than the corresponding rate of 5.8 percent for the City of Richmond. (Reference 12)

2.5.2.1.2 **Louisa County**

Louisa County is in the triangle between Richmond, Fredericksburg, and Charlottesville. Interstate 64 runs east-west through the county, as does a CSX rail line. Louisa County, with a population of 25,627, continues to be a rural community with most of the land forested or under cultivation. There are two incorporated towns in the county, Louisa and Mineral, both of which are within 15 miles of the ESP site. Because the ESP site is located there, Louisa County has benefited economically more from the plant than the other counties that could be impacted by the installation of the new units. Table 2.5-19 lists the top five employers in the county, their product, and the number of employees. The remaining 14 employers have less than 100 employees, with most generally having fewer than 25 employees. (Reference 16)

There has been relatively little growth in industry in the last ten years although there has been significant growth in population. The county is actively pursuing additional industries in an effort to diversify and expand its industrial base. Almost 62 percent of the resident workers in Louisa County commute to jobs outside the county. (Reference 12)

The existing units operations have contributed more than 50 percent of the property taxes paid to Louisa County over the past decade, and, therefore, have allowed the property tax assessment rates to remain below those of neighboring counties. While recognizing the benefits of the existing units, the county is still looking to expand its industrial base so as to become less dependent on one facility.

2.5.2.1.3 **Orange County**

Orange County, with a population of 25,881, has two incorporated towns, Orange and Gordonsville, and one planned, gated residential community, Lake of the Woods. It borders the northwestern extent of Lake Anna and is about 72 miles from Richmond, 75 miles from Washington, D.C., and 25 miles from Charlottesville, the home of the University of Virginia. Agribusiness is the main business sector in Orange County; although, manufacturing has played a significant role for over 80 years. Approximately 97 percent of the land in Orange County is forested, under cultivation, or pasture land. (Reference 17)

Of the 11,925 resident workers in the county, approximately 53 percent commute to jobs outside the county (Reference 12). According to the Chamber of Commerce, there are over 535 businesses and industries in the county, most of which employ fewer than 25 workers, many employing fewer than 10 workers. Major private employers in the county, defined by Orange County as having 25 or more employees, are listed in Table 2.5-20 (Reference 17).

2.5.2.1.4 **Spotsylvania County**

Spotsylvania County, with a population of 90,395, is midway between Washington, D.C. and Richmond. Its southwestern border is the North Anna River, most of which was flooded when Lake Anna was formed as a source of cooling water for the power station.

Economically, the county is more associated with the Washington, D.C. area through commuting patterns of its residents and federal procurement opportunities. Almost 60 percent of the resident workers commute to jobs outside the county. (Reference 12)

Although agriculture and forestry have been important components of the county’s economy, the relative economic importance of these industries has declined over the years as the commercial and industrial base of the county has grown. Additionally, the number of employees in the state, local, or federal government sectors has increased significantly over the last ten years. Major private employers in Spotsylvania (defined by Spotsylvania County to be those with 100 or more employees) are listed in Table 2.5-21 (Reference 18).

In addition to the private employers, the Spotsylvania County Government employs about 600 workers; that is, the county is the second largest employer in the county, second only to Capital One.

2.5.2.2 **Taxes**

In Virginia, counties and towns collect most of their taxes through property taxes and sales taxes. Property taxes include business personal property and individual tangible personal property as well as real estate. business personal property includes such items as office furniture, fixtures, equipment, machinery and tools. (Reference 19)

Annual power station property taxes are paid to Louisa, Orange, and Spotsylvania Counties. Table 2-15 of the SEIS (Reference 11) presents the breakdown of property taxes collected by each county, the amount paid, and the percent of total property taxes that the payment represents. The total budget for each county is also presented for comparison purposes. Data are presented for the period of 1995 to 2000. The preponderance of the property taxes paid for the power station goes to Louisa County, and represents about 46 percent of the total property taxes collected by the county. The other two counties are paid taxes that represent about 1.5 percent of the total property taxes collected by each. Overall, the property taxes paid to Louisa County amounted to about 22.5 percent of the total budget for the county during the 1995–2000 time period. The SEIS points out that the property tax payments would be expected to decline as the existing facility depreciates.

The SEIS also points out that the potential effects of electric utility deregulation within Virginia are not known. However, it is reasonable to conclude that the installation of new units should result in a relative increase in property tax payments even with the depreciation of the existing units.

The SEIS discusses the relatively large increases in the economy of Henrico County over the past two decades due to the increased business investments in the Richmond area, as well as in the economy of Spotsylvania due partly to the large increase in government and other white collar workers who have chosen to live in Spotsylvania. To a lesser extent, Orange and Louisa Counties have benefited from this growth in the economies of Henrico and Spotsylvania Counties. Louisa County has benefited from the growth in second and retirement homes that have been constructed around Lake Anna. Since these homes have generally been upscale, the land values around the lake have increased significantly. Property tax revenues have also risen as a result of this construction as well as with construction of moderately priced houses around the county.

Many of these moderately-priced houses are intended to accommodate workers who commute to the Richmond-Petersburg MSA or to Washington, D.C., or to companies around the Dulles Airport and the Capital Beltway. The Louisa County land use planning document anticipates that such construction would continue at a rate of about 300 new homes per year for the foreseeable future. However, such increases in home building also require to some extent increased expenditures for infrastructure, which would tend to offset the increased property taxes paid to the county. If the current efforts by Louisa County to attract industry are successful and if the numbers of new homes continue to increase, increased property tax revenues as well as increases in sales tax revenues may be sufficient to offset the depreciation of the existing units. However, as is discussed in more detail in Section 5.8.2, new units would result in an increase in property tax revenues that would more than offset any decreases due to the depreciation of the existing units. (Reference 16)

2.5.2.3 Schools and Recreational Areas

Each county and the City of Richmond have a public school system for kindergarten through high school (Reference 13). The numbers at each level of school is dependent on the size of the local population, being greatest in the Richmond-Petersburg MSA. The Richmond-Petersburg MSA also has a number of private schools for grammar through high school education. Higher educational facilities, both public and private, are located in the Richmond-Petersburg MSA and in Spotsylvania, with none located in either Louisa or Orange Counties. However, both Louisa and Orange Counties are in close proximity to such facilities in the areas mentioned and to the University of Virginia in Charlottesville. During previous major construction activities at the NAPS site, the construction workforce did not require relocation of large numbers of workers into the area. Therefore, unless there is a need for relocation of a large number of construction workers into either or both of these counties, the SEIS (Reference 11) conclusion that any impacts on the school systems would be small, also applies to the construction of the new units. This construction-related information is addressed in more detail in Section 4.4.2.

All of the surrounding counties and the City of Richmond have established parks and other recreational areas for their residents. In Louisa and Orange Counties, these areas typically consist of one or two parks plus playing fields at the local schools. However, as is presented in Section 2.5.1.3, the Lake Anna area has become established as a recreational center not only for the local residents of Louisa, Orange, and Spotsylvania Counties, but also for other in-state and out-of-state visitors. The SEIS (Reference 11) conclusion that any impacts on these parks and other recreational areas would be small, generally applies to the construction of new nuclear generating unit(s), so long as there is no relocation of a large number of construction workers into the counties that border the lake.

A potential exists for negative transportation impacts on the number of people from outside the bordering counties who use the lake recreationally. The potential for negative impacts on the numbers of people using Lake Anna during construction of the new facility and suggested mitigation measures to avoid or reduce these impacts is addressed in more detail in Section 4.4.2.

2.5.2.4 **Housing**

Approximately 80 percent of the permanent employees at the NAPS site live in Hanover, Henrico (including the City of Richmond), Louisa, Orange, or Spotsylvania Counties, with the greatest number living in Louisa County. A detailed breakdown, by county and city (Reference 11, Table 2-5) shows that the number of permanent employees living in Louisa, Spotsylvania, and Orange Counties are 237, 186, and 120, respectively.

A breakdown, by county, of housing units by number occupied and vacant in 1990 and 2000, is presented in Table 2-6 of the SEIS (Reference 11). “Vacant” housing is equated to “available” housing. However, a review of the U.S. Census Bureau’s 2000 Census data reveals that there is a further breakdown of the category “vacant” housing, pertinent sections of which are presented in Table 2.5-22.

This detailed breakdown of “vacant” units is not of concern when renewing operating licenses, nor for planned outages of each existing unit. However, the number of “vacant” housing units that are “for seasonal, recreational, or occasional use” is important in relation to construction. In this case, “vacant” units should not automatically be considered to be available to those members of the large construction workforce who decide to relocate to the area during the installation of the new units. This category of “vacant” housing units would not be available for use by the longer-term workforce and could represent an issue associated with the new units, especially if a larger percentage of the workforce decides to relocate to the area around the ESP site for the duration of their work. However, the “for rent” and “for sale” vacant housing units should be considered as available for their use, if needed. Such use would be in competition with the housing demands from the projected population growth in each county and the City of Richmond. This situation is addressed further in Section 4.4.2.

2.5.2.5 **Public Services**

Public services addressed here include water supply, education, and transportation. These services provide a baseline from which construction period impacts and operational impacts can be estimated.

2.5.2.5.1 **Water Supply**

As described in the SEIS, Henrico County buys its water from the City of Richmond whose source of water supply is the James River. Spotsylvania County supplies most residential, commercial, and industrial areas via a public water system that draws from the Ni River. Additional water capacity is being constructed in both Richmond City and Spotsylvania County.

In Louisa and Orange Counties, groundwater is the primary source of water for the residents, excluding the towns of Louisa and Orange. About 80 percent of Louisa County residents and about 90 percent of Orange County residents rely on groundwater.

The residents of these more rural counties normally have individual septic systems rather than access to a sewer system with a publicly owned treatment works (POTW).

The SEIS identifies a concern regarding access to the public water supplies in the towns surrounding the NAPS site, if new employees associated with the new units were to settle in these towns. The SEIS states that there are plans to construct new treatment plants or expand existing facilities in the towns, which would alleviate these concerns.

Table 1-7 of the SEIS presents the projected population growth in 2010 for the surrounding counties and the City of Richmond. For Louisa County and Orange County, the projected growth in population between Years 2000 and 2010 is 4,380 and 3,920, respectively – values that are similar to the numbers being projected for a peak construction workforce brought in to add new units. These projected population growths and their possible impacts on the local infrastructure, including water and sewer services, have been incorporated into the comprehensive land use plans for both counties. The potential impact of construction and operation on the infrastructure of the area, including the water and sewer systems, is considered further in Section 4.4.2 and Section 5.8.2, respectively.

2.5.2.5.2 **Education**

The SEIS provides information on the number of high schools, middle schools, and elementary schools in each surrounding county and incorporated municipality. A review of this information reveals that Louisa and Orange Counties have school systems that could potentially limit the number of students that could be assimilated by their educational systems if a sudden large influx of families were to relocate into these areas. For Louisa County, with one high school, one middle school, and three elementary schools, a large influx of families with children at these levels of education could tax the capacity of these schools. For Orange County, with one high school, one middle school, and five elementary schools, a large influx of families with children in middle or high school could similarly tax the capacity of the school system. This issue is addressed in Section 4.4.2.

2.5.2.5.3 **Transportation**

The area within the 80-km (50-mile) radius of the ESP site is serviced by Interstate 95, running in a north-south direction between Washington, D.C. and Richmond, and Interstate 64, running between Richmond and Charlottesville; as well as numerous Virginia highways and local roads Figure 2.5-16. According to the SEIS, all local roads in the NAPS area carry a level-of-service designation “B.” Designation “B” means that there is stable traffic flow, such that the freedom to select speed is unaffected, but the freedom to maneuver is slightly diminished. The potential impacts during construction and operation, including likely measures that can be implemented to reduce these impacts during each phase, are addressed in Section 4.4.2 and Section 5.8. Of primary concern is the seasonal use of Lake Anna and the resulting traffic on local roads in the vicinity of NAPS.

2.5.2.5.4 **Police, Fire, and Medical Facilities**

The police force of each of the counties within the 80-km (50-mile) radius about the ESP site consists of a County Sheriff who is typically headquartered in the County Seat and who is assisted by Sheriff’s Deputies who patrol the entire area of the county. The Sheriff’s Department also normally dispatches emergency services through the 911 system in each county. The incorporated towns and cities within the counties have their own police force. The more heavily populated areas of Henrico County and the City of Richmond also have a Division of Police.

Volunteer fire departments protect Hanover, Orange, Louisa, and Henrico counties and the City of Richmond as shown in Table 2.5-23. Emergency medical protection is provided in each county by volunteer rescue squads. The County Sheriff’s Department in each county dispatches these volunteer rescue squads. The independent towns in these counties each have their own volunteer fire departments. Both Henrico County and the City of Richmond have more extensive fire departments and EMS units.

Contacts and arrangements made by Virginia Power with local, state, and federal governmental agencies with emergency planning responsibilities are identified in Part 2: Section 13.3.3.

Medical facilities generally consist of local physicians’ offices in the counties. However, there are major medical facilities in Fredericksburg, Charlottesville, Mechanicsville, and the City of Richmond that are readily accessible to the populations of the counties.

2.5.3 **Historic Properties**

The region surrounding the ESP site has been identified as having prehistoric and historic Native American and historic Euro-American resources. To assess known and potential cultural resource sites surrounding the site, surveys have been conducted for items of historic, archaeologic, and geologic interest. The results are included in the application for license renewal (Reference 10).

Reconnaissance-level archaeological and historical investigations were completed for both the site and the lakebed, with few results. A few artifacts were noted in the area, but the investigator identified them as insignificant and determined that no further evaluations were necessary. In addition, records in the Louisa County Historical Society files identified 33 historic-period cemeteries along the river. Many of the cemeteries were avoided by adjusting project boundaries although, some were removed prior to inundation. Five cemeteries are recorded as on or near NAPS site.

The above referenced environmental report concludes that there are no sites or items of historic, archaeologic, or geologic significance within the vicinity of NAPS. The report conclusions are based on the review of available literature and several database sources. In addition to the work that was completed in 1973 (Presented in Section 2.5.3.2) (Reference 20), a cultural resource assessment for the area within 1-mile of the NAPS fence line and the site itself was commissioned by Dominion and completed in 2001. The results are documented in a report prepared by Louis Berger Group, Inc., (Reference 21) the conclusions of which are summarized in Section 2.5.3.2.

Virginia Power consulted with the State Historic Preservation Office (SHPO) regarding NAPS license renewal. No issues were identified as a result of that consultation. Dominion has initiated informal discussions with the SHPO regarding evaluation for an ESP and those discussions would continue throughout the review process.

Should archaeological resources or artifacts be discovered during pre-construction activities, personnel would be instructed to stop work. Dominion would contact the appropriate organization and/or regulatory agency for proper evaluation and designation, in accordance with the existing procedures.

2.5.3.1 Description of Historic Properties near the ESP site

There are three counties in the vicinity of the ESP site. Table 2.5-24 lists each county and the number of known historic places listed on the National Register of Historic Places (NRHP) (Reference 22) within these respective counties.

Of the 60 national historical sites identified in Table 2.5-24, four sites exist within 10 miles of the ESP site. These sites are listed and described in Table 2.5-25.

Figure 2.5-19 locates the NRHP sites near the ESP site.

2.5.3.2 Description of Historic Properties Within the NAPS Site

The Louis Berger Group, Inc. completed a cultural resource assessment (Reference 21) of the NAPS site and a 1-mile-radius surrounding the existing units (study area) during the license renewal project time period, and the assessment included the following activities:

- A background investigation of related information to compile known information about the NAPS study area; and

- The delineation of areas within the study area containing potential archaeological resources.

The investigations were conducted in accordance with the National Historic Preservation Act of 1966, the Archaeological and Historical Preservation Act of 1974, Executive Order 11593, and Title 36 of the Code of Federal Regulations, Part 660-66 and 800 (as appropriate). The field investigations and technical report met the qualifications specified in the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (FR 48:190:44716-44742). The qualifications of the Project Manager and Project Archaeologist who performed the investigations met or exceeded the requirements described in the Secretary of the Interior's Professional Qualifications Standards (FR 48:190:44716-44743).

Examination of archaeological and historical site files at the Virginia Department of Historic Resources' archives has indicated that no recorded cultural resource sites are known to exist at the NAPS site. Similarly, review of historical documentation at the Louisa County Historical Museum, including historic maps dating between 1751 and 1863, have indicated few historic resources in the study area, other than an early road paralleling the south side of the North Anna River, which appears to be near the western boundary of the NAPS site. An unpublished map, based on county deeds from 1765 to 1815, shows the presence of the Jerdones Mill on the North Anna River bank, just upriver from the NAPS site, along with the associated Jerdones Mill Road. The same map shows an Old Mine Road within the North Anna site area.

No extant historic architectural resources have been identified within the study area and no historic architectural resources are present within the NAPS site. There are five architectural resources within a 1.5-mile radius of the NAPS site; however, the report's conclusions state that none of these resources are affected by current or planned activities. As a follow-up to the initial assessment, five known historic-period cemeteries have been recorded, three of which lie within the administrative boundary of the NAPS site (see Figure 2.5-18) and two that are located south of the North Anna Dam where no activities are planned.

Conclusions made in the report include that previously undisturbed lands within the NAPS site boundary have the potential to contain both unrecorded prehistoric and historic archaeological properties. On the basis of this conclusion, the NAPS site has been classified with respect to the potential for discovering archaeological resources. The three classifications are areas with the following:

- No Potential for Archaeological Resources
- Low Potential for Archaeological Resources
- Moderate-to-High Potential for Archaeological Resources

For areas with low and moderate to high potential for containing archaeological resources (see Figure 2.5-17), subsurface testing would be performed, dependent on existing ground conditions, prior to any ground disturbing activities.

2.5.3.3 Transmission Line Rights-of-Way

The NAPS site transmission line rights-of-way (ROW) have been categorized and inventoried and do not cross over any known archaeological or historic sites of significance (Reference 20).

2.5.3.4 Native American Sites

Among the six state-recognized Indian tribes in Virginia, the closest tribal reservations belong to the Pamunkey and Mattaponi Tribes. The Pamunkey Tribe Reservation is approximately 53 miles southeast of the ESP site and was confirmed to the Tribe in 1658 by the Governor, the Council, and the General Assembly of Virginia. The Mattaponi Indian Reservation, also established in 1658, is approximately 62 miles southeast of the ESP site. There are no known Native American cultural or religious tribal resources that exist within the NAPS site.

2.5.4 Environmental Justice

Federal agencies must identify and address, as applicable to their actions, disproportionately high and adverse human health or environmental impacts of its activities on minority or low-income populations. The NRC has committed to undertake environmental justice reviews in consideration of the NEPA of 1969 and the 1997 Council of Environmental Quality (CEQ) guidance.

For the purpose of the ESP environmental justice review, the geographic distribution of minority and low-income populations within 80 km (50 miles) of the ESP site have been determined, employing data from the 2000 Census and applying the following definitions from Appendix D of LIC-203 (Reference 23):

A minority population or low-income population exists if either of the following criteria are met:

1. A “minority population” is considered to be present if: 1) The minority population in the census block group or environmental impact site exceeds 50 percent, or 2) the minority population percentage of the environmental impact area is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for the comparative analysis, for example, the county or State, or

2. A “low-income population” is considered to be present if: 1) the low-income population in the census block group or environmental impact area exceeds 50 percent, or 2) the percentage of households below the poverty level in an environmental impact area is significantly greater (typically at least 20 percentage points) than the low-income population percentage in the geographic area chosen for the comparative analysis.

For this review, the percentage of any minority or low-income population within census tracts that could potentially be affected by the installation of new units has been calculated and compared to the corresponding percentage of minority or low-income populations within the entire Commonwealth of Virginia or State of Maryland (for Charles County, MD) as appropriate, to determine if they exceed the State values for each category by at least 20 percent. All census tracts with at least 50 percent of their area within the 80-km (50-mile) radius around the ESP site are included in the analysis.

Using the Census Bureau's LandView 5 software and 2000 Census data for the region of interest (ROI) (Reference 24), the distributions of minority populations and low-income populations were developed. The results are shown on Figure 2.5-14 and Figure 2.5-15, respectively.

Generally, the minority populations are found in the sectors to the east through the southwest about the ESP site. There is a black minority population within Louisa County about 20 km southwest, and a similar size black minority population in the southeastern part of Caroline County, where it borders Hanover and King William Counties. About 60 to 80 km to the east and southeast of the site, there are large black minority populations in King and Queen, Essex, and Westmoreland Counties. These three counties are only partially within the area defined by the 80-km radius.

A large, black minority population exists in the City of Richmond and adjoining parts of Henrico County (60 to 80 km southeast of the site). To the south-southwest about 44 km distant, there is a small, black minority population in the northern part of Powhatan County. Another large, black minority population exists in the northern part of Buckingham County, about 60 to 80 km south-southwest of the site.

Charlottesville, approximately 58 km west of the site, contains small populations of minority Asians and blacks. Small, black minority populations also exist to the northeast in Fredericksburg and Stafford County, and a small Hispanic minority population is in Prince William County about 80 km northeast.

A small, low-income population exists, about 60 to 80 km south-southeast of the site, in the City of Richmond. Another, small, low-income population exists in Charlottesville.

The potential for disproportionate human health or environmental impacts on minority or low-income populations associated with the construction and operation of new units is evaluated and presented in Section 4.4.3 and Section 5.8.3, respectively. The potential impacts on minority and low-income populations at alternative sites are part of the more global evaluation of the environmental impacts associated with locating a new nuclear generating station that is presented in Section 9.3.

Section 2.5 References

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Table 2.5-1 Population Distribution from 2000 to 2040 Within 16-km (10-mi) of the ESP Site

Year	0 to 2 km (0–1.2 mi.)	2 to 4 km (1.2–2.5 mi.)	4 to 6 km (2.5–3.7 mi.)	6 to 8 km (3.7–5.0 mi.)	8 to 10 km (5.0–6.2 mi.)	10 to 16 km (6.2–10 mi.)	Total
2000	210	717	1394	1351	2218	9621	15,511
2010*	263	943	1884	1837	2986	13,083	20,996
2020*	316	1169	2375	2322	3753	16,545	26,480
2030*	369	1395	2865	2808	4521	20,007	31,965
2040*	422	1621	3355	3293	5288	23,469	37,449

* All populations in this year are estimates.

Table 2.5-2 Estimated Sex Distribution of Population in 2000 Within 16-km (10-mi.) of the ESP Site

	0 to 2 km (0–1.2 mi.)		2 to 4 km (1.2–2.5 mi.)		4 to 6 km (2.5–3.7 mi.)		6 to 8 km (3.7–5.0 mi.)		8 to 10 km (5.0–6.2 mi.)		10 to 16 km (6.2–10 mi.)	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Male	104	49.5	350	48.8	687	49.3	665	49.2	1,092	49.2	4,738	49.2
Female	106	50.5	367	51.2	707	50.7	686	50.8	1,126	50.8	4,883	50.8
Total	210	—	717	—	1394	—	1351	—	2218	—	9621	—

Table 2.5-3 Sex Distribution of Population in the Major Employee-Contributing Counties and Virginia

	Henrico		Louisa		Orange		City of Richmond		Spotsylvania		Virginia	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Male	122,922	46.9	12,611	49.2	12,524	48.4	92,068	46.5	44,532	49.3	3,471,895	49.0
Female	139,378	53.1	13,016	50.8	13,357	51.6	105,722	53.5	45,863	50.7	3,606,620	51.0
Total	262,300	—	25,627	—	25,881	—	197,790	—	90,395	—	7,078,515	--

Table 2.5-4 Estimated Age Distribution of Population in 2000 Within 16-km (10-mi.) of the ESP Site

Age Group	0 to 2 km (0–1.2 mi.)		2 to 4 km (1.2–2.5 mi.)		4 to 6 km (2.5–3.7 mi.)		6 to 8 km (3.7–5.0 mi.)		8 to 10 km (5.0–6.2 mi.)		10 to 16 km (6.2–10 mi.)	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
0–19	53	27.6	200	28.8	412	29.8	394	29.8	656	29.5	2885	29.9
20–24	8	4.2	36	5.2	64	4.6	66	5.0	110	4.9	471	4.9
25–44	62	32.3	220	31.7	434	31.4	420	31.8	694	31.2	3,000	31.1
45–64	46	24.0	171	24.6	333	24.1	318	24.1	536	24.1	2,294	23.8
65+	23	12.0	68	9.8	140	10.1	124	9.4	229	10.3	991	10.3

Table 2.5-5 Estimated Income Distribution of Population Within 16-km (10-mi) of the ESP Site (for ages greater than 15)

Income Group*	0 to 2 km (0–1.2 mi.)		2 to 4 km (1.2–2.5 mi.)		4 to 6 km (2.5–3.7 mi.)		6 to 8 km (3.7–5.0 mi.)		8 to 10 km (5.0–6.2 mi.)		10 to 16 km (6.2–10 mi.)	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
$0	18	12.3	65	12.6	119	11.4	114	11.2	189	11.1	822	11.1
$1–$25	75	51.4	249	48.3	482	46.0	465	45.6	789	46.5	3,344	45.2
$25–$50	40	27.4	143	27.7	297	28.3	297	29.1	480	28.3	2,127	28.7
$50–$75	9	6.2	43	8.3	103	9.8	98	9.6	166	9.8	742	10.0
$75–$100	2	1.4	9	1.7	26	2.5	27	2.6	42	2.5	197	2.7
$100+	2	1.4	7	1.4	21	2.0	18	1.8	32	1.9	168	2.3
Total	146	—	516	—	1,048	—	1,019	—	1,698	—	7,400	—

* All incomes are in thousands of dollars.

Table 2.5-6 Racial & Ethnic Distribution of Population in 2000 Within 16-km (10-mi.) of the ESP Site

Race Group	0 to 2 km (0–1.2 mi.)		2 to 4 km (1.2–2.5 mi.)		4 to 6 km (2.5–3.7 mi.)		6 to 8 km (3.7–5.0 mi.)		8 to 10 km (5.0–6.2 mi.)		10 to 16 km (6.2–10 mi.)	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
White	198	94.3	615	85.8	1,171	84.0	1,032	76.4	1,748	78.8	8,041	83.6
Black	10	4.8	83	11.6	187	13.4	290	21.5	437	19.7	1,302	13.5
Indian	2	1.0	1	0.1	7	0.5	5	0.4	2	0.1	41	0.4
Asian	0	0.0	2	0.3	15	1.1	1	0.1	9	0.4	57	0.6
Hawaiian	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0	4	0.0
Other	0	0.0	1	0.1	1	0.1	4	0.3	0	0.0	24	0.2
Multi	0	0.0	15	2.1	13	0.9	19	1.4	21	0.9	152	1.6
Hispanic	2	1.0	10	1.4	12	0.9	5	0.4	14	0.6	92	1.0
Total*	210	—	717	—	1,394	—	1,351	—	2,218	—	9,621	—

* Total does not include Hispanic category.

Table 2.5-7 Income Distribution of Population in the Major Employee-Contributing Counties and Virginia (For Ages Greater Than 15)

Race Group	Henrico		Louisa		Orange		City of Richmond		Spotsylvania		Virginia	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
$0	17,410	8.4	2,319	11.3	2,364	11.3	15,444	9.6	7,468	11.0	594,604	10.6
< $25	85,966	41.4	10,678	52.2	10,312	49.1	90,896	56.5	27,350	40.4	2,627,798	46.7
$25 - $50	67,249	32.4	5,360	26.2	5,762	27.5	37,779	23.5	20,517	30.3	1,449,617	25.8
$50 - $75	21,065	10.1	1,429	7.0	1,693	8.1	9,216	5.7	8,299	12.3	521,861	9.3
$75- $100	7,515	3.6	360	1.8	373	1.8	3,128	1.9	2,189	3.2	208,019	3.7
$100+	8,502	4.1	314	1.5	484	2.3	4,346	2.7	1,843	2.7	221,729	3.9
Total	207,707	—	20,460	—	20,988	—	160,809	—	67,666	—	5,623,628	—

*All incomes are in thousands of dollars.

Table 2.5-8 Population Distribution from 2000 to 2040 Within 80-km (50-mi) of the ESP Site

Year	0 to 16 km (0–10 mi.)	16 to 40 km (10–24.9 mi.)	40 to 60 km (24.9–37.3 mi.)	60 to 80 km (37.3–50 mi.)	Total
2000	15,511	185,456	487,842	849,347	1,538,156
2010*	20,996	239,813	604,455	984,645	1,849,908
2020*	26,480	294,169	721,067	1,119,943	2,161,660
2030*	31,965	348,526	837,680	1,255,241	2,473,411
2040*	37,449	402,883	954,292	1,390,539	2,785,163

* All populations in this year are estimates.

Table 2.5-9 Estimated Sex Distribution of Population in 2000 Within 80-km (50-mi.) of the ESP Site

	0 to 16 km (0–10 mi.)		16 to 40 km (10–24.9 mi.)		40 to 60 km (24.9–37.3 mi.)		60 to 80 km (37.3–50 mi.)		Total	
	Number	%	Number	%	Number	%	Number	%	Number	%
Male	7,636	49.2	90,484	48.8	236,507	48.5	411,186	48.4	745,813	48.5
Female	7,875	50.8	94,972	51.2	251,335	51.5	438,168	51.6	792,350	51.2
Total	15,511	—	185,456	—	487,842	—	849,354	—	1,538,163	—

Table 2.5-10 Estimated Age Distribution of Population in 2000 Within 80-km (50-mi) of the ESP Site

Age Group	0 to 16 km (0–10 mi.)		16 to 40 km (10–24.9 mi.)		40 to 60 km (24.9–37.3 mi.)		60 to 80 km (37.3–50 mi.)		Total	
	Number	%	Number	%	Number	%	Number	%	Number	%
0 to 19	4,600	29.8	53,939	29.1	138,057	28.3	246,080	29.0	442,676	28.8
20 to 24	755	4.9	11,006	5.9	27,944	5.7	59,135	7.0	98,840	6.4
25 to 44	4,830	31.2	56,643	30.5	157,037	32.2	270,643	32.0	489,153	31.8
45 to 64	3,698	23.9	43,210	23.3	111,462	22.8	190,145	22.4	348,515	22.7
65+	1,575	10.2	20,640	11.1	53,355	10.9	83,352	9.8	158,922	10.3
Total*	15,458	—	185,438	—	487,855	—	849,355	—	1,538,106	—

* Differences in totals are due to calculation round-off.

Table 2.5-11 Racial & Ethnic Distribution of Population in 2000 Within 80-km (50-mi) of the Site

Race Group	0 to 16 km (0–10 mi.)		16 to 40 km (10–24.9 mi.)		40 to 60 km (24.9–37.3 mi.)		60 to 80 km (37.3–50 mi.)		Total	
	Number	%	Number	%	Number	%	Number	%	Number	%
White	12,805	82.6	146,841	79.2	392,074	80.4	543,709	64.0	1,095,429	71.2
Black	2309	14.9	31,687	17.1	69,776	14.3	253,248	29.8	357,020	23.2
Indian	58	0.4	607	0.3	1452	0.3	2972	0.3	5,089	0.3
Asian	84	0.5	1,767	1.0	12,632	2.6	18,690	2.2	33,173	2.2
Hawaiian	5	0.0	66	0.0	202	0.0	555	0.1	828	0.1
Other	30	0.2	1,744	0.9	4,257	0.9	14,282	1.7	20,313	1.3
Multi	220	1.4	2,744	1.5	7,449	1.5	15,891	1.9	26,304	1.7
Hispanic	135	0.9	4,276	2.3	11,285	2.3	31,374	3.7	47,070	3.1
Total*	15,511	—	185,456	—	487,842	—	849,347	—	1,538,156	—

* Total does not include Hispanic category.

Table 2.5-12 Racial and Ethnic Distribution of Population in the Major Employee-Contributing Counties and Virginia

Race Group	Henrico		Louisa		Orange		City of Richmond		Spotsylvania		Virginia	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
White	180,761	68.9	19,617	76.5	21,833	84.4	75,744	38.3	74,924	82.9	5,120,110	72.3
Black	64,805	24.7	5530	21.6	3566	13.8	113,108	57.2	11,255	12.5	1,390,293	19.6
Indian	920	0.4	108	0.4	53	0.2	479	0.2	288	0.3	21,172	0.3
Asian	9451	3.6	64	0.3	88	0.3	2471	1.2	1243	1.4	261,025	3.7
Hawaiian	82	0.0	3	0.0	5	0.0	157	0.1	45	0.1	3946	0.1
Other	2562	1.0	46	0.2	102	0.4	2948	1.5	941	1.0	138,900	2.0
Multi	3719	1.4	259	1.0	234	0.9	2883	1.5	1699	1.9	143,069	2.0
Hispanic	5946	2.3	182	0.7	330	1.3	5074	2.6	2536	2.8	329,540	4.7
Total*	262,300	—	25,627	—	25,881	—	197,790	—	90,395	—	7,078,515	—

* Total does not include Hispanic category.

Table 2.5-13 Estimated Income Distribution of Population Within 80-km (50-mi) of the ESP Site (For Ages Greater Than 15)

Income Group[a]	0 to 16 km (0–10 mi.)		16 to 40 km (10–24.9 mi.)		40 to 60 km (24.9–37.3 mi.)		60 to 80 km (37.3–50 mi.)		Total	
	Number	%	Number	%	Number	%	Number	%	Number	%
$0	1327	11.2	15,406	10.6	36,982	9.7	67,138	10.1	120,853	10.0
$1–$25	5404	45.7	66,395	45.9	163,203	42.8	297,535	44.7	532,537	44.2
$25 - $50	3384	28.6	40,735	28.1	113,734	29.8	186,066	28.0	343,919	28.6
$50 - $75	1161	9.8	14,365	9.9	39,156	10.3	66,472	10.0	121,154	10.1
$75-$100	303	2.6	4,013	2.8	14,533	3.8	23,955	3.6	42,804	3.6
$100+	248	2.1	3,874	2.7	14,151	3.7	24,112	3.6	42,385	3.5
Total	11,827	—	144,788	—	381,759	—	665,278	—	1,203,652	—

a. All incomes are in thousands of dollars.

Table 2.5-14 Age Distribution of Population in the Major Employee-Contributing Counties and Virginia

Age Group	Henrico		Louisa		Orange		City of Richmond		Spotsylvania		Virginia	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
0 to 19	69,875	26.6	6,787	26.5	6,499	25.1	50,724	25.6	29,131	32.2	1,937,086	27.4
20 to 24	15,380	5.9	1,159	4.5	1,134	4.4	18,386	9.3	4,603	5.1	480,574	6.8
25 to 44	86,166	32.9	7,656	29.9	7,184	27.8	62,712	31.7	29,062	32.2	2,237,655	31.6
45 to 64	58,278	22.2	6,710	26.2	6,620	25.6	39,839	20.1	20,073	22.2	1,630,867	23.0
65+	32,601	12.4	3,315	12.9	4,444	17.2	26,129	13.2	7,526	8.3	792,333	11.2
Total	262,300	—	25,627	—	25,881	—	197,790	—	90,395	—	7,078,515	—

Table 2.5-15 Population Distribution Table

	Distances (km)								
Sectors	**0–2**	**2–4**	**4–6**	**6–8**	**8–10**	**10–16**	**16–40**	**40–60**	**60–80**
North									
Present Date (2002)	0	25	125	149	254	262	9,688	11,808	32,461
Startup Date (2025)	0	49	246	293	498	512	14,710	15,276	41,822
40-year Date (2040)	0	65	324	386	656	676	17,985	17,537	47,926
North-Northeast									
Present Date (2002)	20	93	19	131	170	856	14,662	34,780	133,414
Startup Date (2025)	38	181	36	256	333	1,676	28,608	63,124	209,729
40-year Date (2040)	51	239	48	338	439	2,211	37,704	81,610	259,500
Northeast									
Present Date (2002)	2	10	262	187	142	784	81,323	63,006	60,243
Startup Date (2025)	4	19	512	365	278	1,535	137,973	117,941	93,921
40-year Date (2040)	6	25	676	482	366	2,025	174,918	153,768	115,885
East-Northeast									
Present Date (2002)	0	37	80	25	0	1,432	13,493	8,733	18,066
Startup Date (2025)	0	73	156	49	0	2,804	25,376	12,790	24,452
40-year Date (2040)	0	96	206	65	0	3,698	33,126	15,436	28,616
East									
Present Date (2002)	0	87	49	50	158	741	8,123	2,193	4,565
Startup Date (2025)	0	171	96	98	310	1,450	11,234	2,872	5,824
40-year Date (2040)	0	225	127	130	408	1,912	13,262	3,315	6,644
East-Southeast									
Present Date (2002)	0	16	187	206	77	724	7,305	4,783	9,717
Startup Date (2025)	0	32	365	404	152	1,372	9,609	6426	12,800
40-year Date (2040)	0	42	482	532	200	1,794	11,111	7498	14,811
Southeast									
Present Date (2002)	0	136	15	40	42	485	5,537	40,418	68,717
Startup Date (2025)	0	205	22	60	63	782	9,249	66,451	106,438
40-year Date (2040)	0	251	27	73	77	976	11,669	83,429	131,038

Table 2.5-15 Population Distribution Table

	Distances (km)								
Sectors	**0–2**	**2–4**	**4–6**	**6–8**	**8–10**	**10–16**	**16–40**	**40–60**	**60–80**
South-Southeast									
Present Date (2002)	39	12	52	71	125	717	8,239	220,811	374,800
Startup Date (2025)	58	17	79	107	188	1,089	13,731	304,881	447,880
40-year Date (2040)	71	21	96	131	229	1,332	17,312	359,710	495,541
South									
Present Date (2002)	61	2	128	13	119	487	6,648	17,891	48,351
Startup Date (2025)	92	3	193	19	180	734	10,192	29,482	73,642
40-year Date (2040)	112	4	235	23	220	896	12,503	37,042	90,136
South-Southwest									
Present Date (2002)	0	37	0	243	25	314	6,366	6,531	7,437
Startup Date (2025)	0	55	0	366	38	474	9,173	10,313	11,488
40-year Date (2040)	0	67	0	447	46	578	11,003	12,780	14,130
Southwest									
Present Date (2002)	10	30	13	0	140	963	3,280	3,852	6,072
Startup Date (2025)	16	46	19	0	212	1,453	4,955	6,814	8,750
40-year Date (2040)	19	56	23	0	258	1,773	6,047	8,746	10,496
West-Southwest									
Present Date (2002)	0	14	65	121	322	866	6,142	16,351	8,600
Startup Date (2025)	0	21	98	183	486	1,308	9,814	31,685	13,010
40-year Date (2040)	0	25	119	224	594	1,596	12,208	41,685	15,886
West									
Present Date (2002)	85	117	2	46	141	271	4,655	33,491	78,028
Startup Date (2025)	128	177	3	69	213	409	7,021	44,190	100,553
40-year Date (2040)	156	216	4	85	260	499	8,565	51,167	115,244
West-Northwest									
Present Date (2002)	0	95	168	50	213	276	6,980	14,230	12,016
Startup Date (2025)	0	144	254	76	322	476	10,028	22,879	19,679
40-year Date (2040)	8	175	310	93	393	607	12,017	28,519	24,676

Table 2.5-15 Population Distribution Table

	Distances (km)								
Sectors	**0–2**	**2–4**	**4–6**	**6–8**	**8–10**	**10–16**	**16–40**	**40–60**	**60–80**
Northwest									
Present Date (2002)	0	26	229	53	423	475	7,582	9,939	3,231
Startup Date (2025)	0	39	346	95	828	909	10,658	11,573	3,675
40-year Date (2040)	0	48	422	123	1,093	1,192	12,665	12,638	3,965
North-Northwest									
Present Date (2002)	4	25	99	63	19	660	6,304	22,349	10,688
Startup Date (2025)	6	49	194	124	36	1,292	9,018	32,677	13,930
40-year Date (2040)	8	65	256	163	48	1,704	10,787	39,412	16,044
Annual Total									
Present Date (2002)	221	762	1,492	1,448	2,372	10,313	196,327	511,165	876,407
Startup Date (2025)	343	1,282	2,620	2,565	4,137	18,276	321,348	779,373	1,187,592
40-year Date (2040)	422	1,621	3,355	3,293	5,288	23,469	402,883	954,292	1,390,539

Cumulative Total	**0–80 km**
Present Date (2002)	1,600,506
Startup Date (2025)	2,317,535
40-year Date (2040)	2,785,163

Table 2.5-16 Lake Anna Recreational Facilities

Facility	Distance	Number of Wet Slips	Number of Ramps	Camp Sites
Marinas				
Anna Point	2.3 miles NNW	25	1	—
Dukes Creek	2.2 miles E	55	5	—
High Point	2.3 miles NNW	50	4	—
Lake Anna	1.4 miles NNE	160	2	—
Rocky Branch	2.3 miles NNE	—	4	—
Sturgeon Creek	2 miles N	36	5	—
Public Landings				
Christopher Run Campground	6 miles WNW	—	1	152
Hunters Landing	6.6 miles NW	—	1	—
Lake Anna Campground	2.5 miles NW	—	1	61
Lake Anna Landing	9 miles NW	—	1	—
Lake Anna State Park	4.3 miles NNW	—	2	—
Pleasants Landing	5.6 miles SE	—	1	—
Sullivan's Landing	8 miles NW	—	1	—
Total		326	29	213

Source: Reference 4, Table 2.1-1.
Note: "—"means no data was reported in source.

Table 2.5-17 Tourist Attractions, Parks and Recreational Areas

Facility	Location	Annual Usage	Peak Daily Usage *	Comments
Lake Anna Recreational Usage	1.4 Mi, NNE	530,000	5900 **	Annual usage based on 180 days at 2,950 people per day.
Waste Heat Treatment Facility	—	90,000	<1,000	Peak daily usage based on doubling the resident population in cooling lagoon sectors (one guest per resident). Annual usage based on 180 days at 500 people per day.
Lake Anna State Park	2.8 Mi, NNW	187,300	4370	Annual use was 187,300 between July 1, 2001 and June 2002. Park closed in winter. Use includes occupants of boats launched at the park.
Paramount's Kings Dominion Amusement Park	35 Mi, SE	2,875,000	20,835	Annual use was 2 to 2.5 million between March and November. Add 15% to calculate maximum capacity. Park closed in winter.

* Peak daily usage is based on a peak weekend day during the summer.

** This number is based on an average of 3 persons per boat, campsite and picnic area.

Table 2.5-18 Employment and Income Statistics by State, County, and City

	Work Force (November 2002)[a]	Unemployment (% November 2002)[a]	Poverty (% Estimated 1999)[b]	Median Household Income (1999)[b]
Hanover County	50,114	2.4	4.2	$58,082
Henrico	147,138	3.3	6.7	$47,903
Louisa	10,577	5.3	9.0	$38,177
Orange	12,364	3.9	8.9	$41,285
City of Richmond	100,290	5.8	17.9	$30,169
Spotsylvania	48,534	2.2	5.5	$55,534
Commonwealth of Virginia	3,773,075	3.6	9.0	$44,848
State of Maryland	2,908,759	3.9	8.0	$49,781
Charles County, MD	65,349	2.8	6.5	$57,408

a. Virginia Employment Commission; Maryland Department of Labor, Licensing and Regulation.

b. 2000 Census Data.

Table 2.5-19 Major Employers in Louisa County, Virginia

Employer	Product	Number of Employees
Dominion Energy	Power Generation	1500
Kloeckner-Pentaplast	Rigid PVC	630
Klearfold, Inc.	Plastic Packing	176
Tradewinds of Virginia	Wood Products	130
Tri-Dim	Filters	100

Table 2.5-20 Major Private Employers in Orange County, Virginia

Employer	Product	Employees
Von Holtzbrinck Publishing Svcs.	Book Distribution Center	305
American Woodmark Corp.	Cabinet Components	300
American Press, Inc.	Printer of Periodicals and Catalogs	250
RIDGID Products	Plumbing/Drain Equipment	211

Table 2.5-20 Major Private Employers in Orange County, Virginia

Employer	Product	Employees
A, B, &C Group	Direct Marketing	138
Battlefield Farms, Inc.	Bedding and Holiday Plants	80
General Shale	Brick	80
Klockner/Intertrans Carrier Co.	Motor Carrier/Distribution Center	72
Elcotel/Technology Service Group	Telephones and Parts	70
Zamma Corp.	Molding and Furniture Components	45
Central Virginia Newspapers, Inc.	Newspaper Publishing and Printing	34
MSAG Data Consultants, Inc.	Computer Mapping/Data	26
Atlantic Research Corp.	Rocket Propulsion Systems	25

Table 2.5-21 Major Private Employers in Spotsylvania County, Virginia

Employer	Product	Employees
Capital One	Call Center	1200
CVS Pharmacy	Distribution Center	450
General Products Company	Manufacturing	375
Diversified Mailing Services	Commercial Mailing Service	300
General Motors	Manufacturing	300
Sheridan Books	Printing	250
Rappahannock Electric Cooperative	Electric Service	250
Printpack Inc.	Flexible	180
Kaeser Compressors, Inc.	Air Compressors	175
Simmons USA	Bedding	130
E-OIR Measurements, Inc.	Sensor Technology Firm	125
Walter Grinders	Tool Grinding Machines	120
National Coach Works	Charter Motor Coach Services	115
United Parcel Service	Package Delivery/Pickup Service	110
A. Smith Bowman Distillery	Manufacturer of Distilled Spirits	100
Carlisle Motion Control	Manufacturer of Brake Lining	100
The Shockey Precast Group	Manufacturer of Precast Concrete	100

Table 2.5-22 Vacant Housing Units by County During 2000

County	Total Vacant	For Rent	For Sale Only	For Seasonal, Recreational, or Occasional Use	Remainder of Vacant Units
Henrico	4449	1970	806	454	1219
Louisa	1910	73	124	1226	487
Orange	1204	116	170	484	434
Spotsylvania	2021	359	449	564	649
Richmond City	7733	3113	849	249	3522

Table 2.5-23 Regional Fire Stations and Emergency Service Centers

Hanover County	**Orange County**	**Louisa County**
Henry Vol. Fire	Barboursville Fire Department	Louisa Vol. Fire
Mechanicsville Vol. Fire	Gordonsville Fire Department	Mineral Vol. Fire
Eastern Hanover Vol. Fire	Orange Fire Department	Bumpass Vol. Fire
Black Creek Vol. Fire	Lake of the Woods Fire Department	Holly Grove Vol. Fire
Farrington Vol. Fire	Mine Run Fire Department	Locust Creek Vol. Fire
Hanover County Vol. Fire	Rapidan Fire Department	Trevillians Vol. Fire
Beaverdam Vol. Fire	Lake of the Woods Rescue Squad	Zion Crossroad Vol. Fire
Hanover Industrial Airpark Fire	Orange County Rescue Squad	Louisa Rescue
Montpelier Vol. Fire		Mineral Rescue
Rockville Vol. Fire	**Henrico County**	Holly Grove Rescue
Ashland Vol. Fire & Rescue	5 Fire Stations & Fire Medic Units	Lake Anna Rescue
West Hanover Vol. Fire & Rescue	15 Fire Stations	
East Hanover Rescue	Fire Rescue 33 (Tuckahoe #1 VRS)	**City of Richmond**
Ashcake Rescue	Fire Rescue 34 (Tuckahoe #2 VRS)	21 Fire Companies
Emergency Operations Center	Fire Rescue 32 (Lakeside VRS)	EMS Headquarters
	Fire Rescue 31 (Henrico VRS)	

Table 2.5-24 Historic Sites in Counties Near the ESP Site

County	Number of Listed Historic Sites
Louisa	13
Spotsylvania	15
Hanover	32
Total	60

Table 2.5-25 Historic Sites within the Vicinity

Historic Site	County	Approximate Distance from ESP site	National Register of Historic Places (NRHP) Number
Andrew’s Tavern	Spotsylvania	4 miles	88-136
DESCRIPTION: Samuel Andrews built Andrews Tavern in 1815. The site is currently a private residence. The building’s craftsmanship, combined with its hall and parlor plan, make it a model of the Federal provincial architecture of Piedmont Virginia. The property retains a high degree of integrity, in both its buildings and setting. During its 186 years, Andrews Tavern has served as a post office, tavern, polling place, school, store, militia site, and residence. **SIGNIFICANCE:** Event, Architecture/Engineering **NOTE:** Spotsylvania Board of Supervisors removed Andrews Tavern from the historic properties register at the request of the property owner in mid-2001. It remains on the Virginia and National listings.			
Cuckoo House	Louisa	9 miles	54-16
DESCRIPTION: Captain Henry Pendleton erected the present building in 1781 on the site of an old tavern. Some are of the opinion that part of the present structure is a portion of the old Cuckoo Tavern. The home is built of brick laid in the common bond, the plan of architecture being the shape of the letter “T.” Cuckoo was originally the site of an old tavern, known at one time as King’s Ordinary and afterwards known as Cuckoo Tavern. Jack Jouett was the “other rider” the night of famous Paul Revere’s ride to warn the Virginia General Assembly that the British were coming. It was from the Cuckoo Tavern that Jouett rode to Charlottesville to warn the Virginia General Assembly of the British approach. The tavern was the stopping place for the aristocrats. **SIGNIFICANCE:** Architecture/Engineering, Event			
Jerdone Castle	Louisa	7 miles	54-45
DESCRIPTION: It is estimated that John Jerdone erected the structure in the early 1750’s. The house is a rectangular frame building, with a lean-to on the East side. It is one and one-half stories. An addition to the house was made in the 1850’s. **SIGNIFICANCE:** Architecture/Engineering, Person			
Prospect Hill	Spotsylvania	9 miles	88-56
DESCRIPTION: The Holladay family has owned The Prospect Hill property since 1798. The name Prospect Hill is believed to be attributed to the extraordinary view of the surrounding country from the property site. The main house was erected in 1812. The frame structure has two stories and an attic. Waller Holladay, scholar and a poet, was educated as a lawyer; but did not practice long. He is closely linked to Thomas Jefferson and Edmund and John Randolph (of Roanoke). The home had been raided by Union soldiers. **SIGNIFICANCE:** Event, Architecture/Engineering, Person			

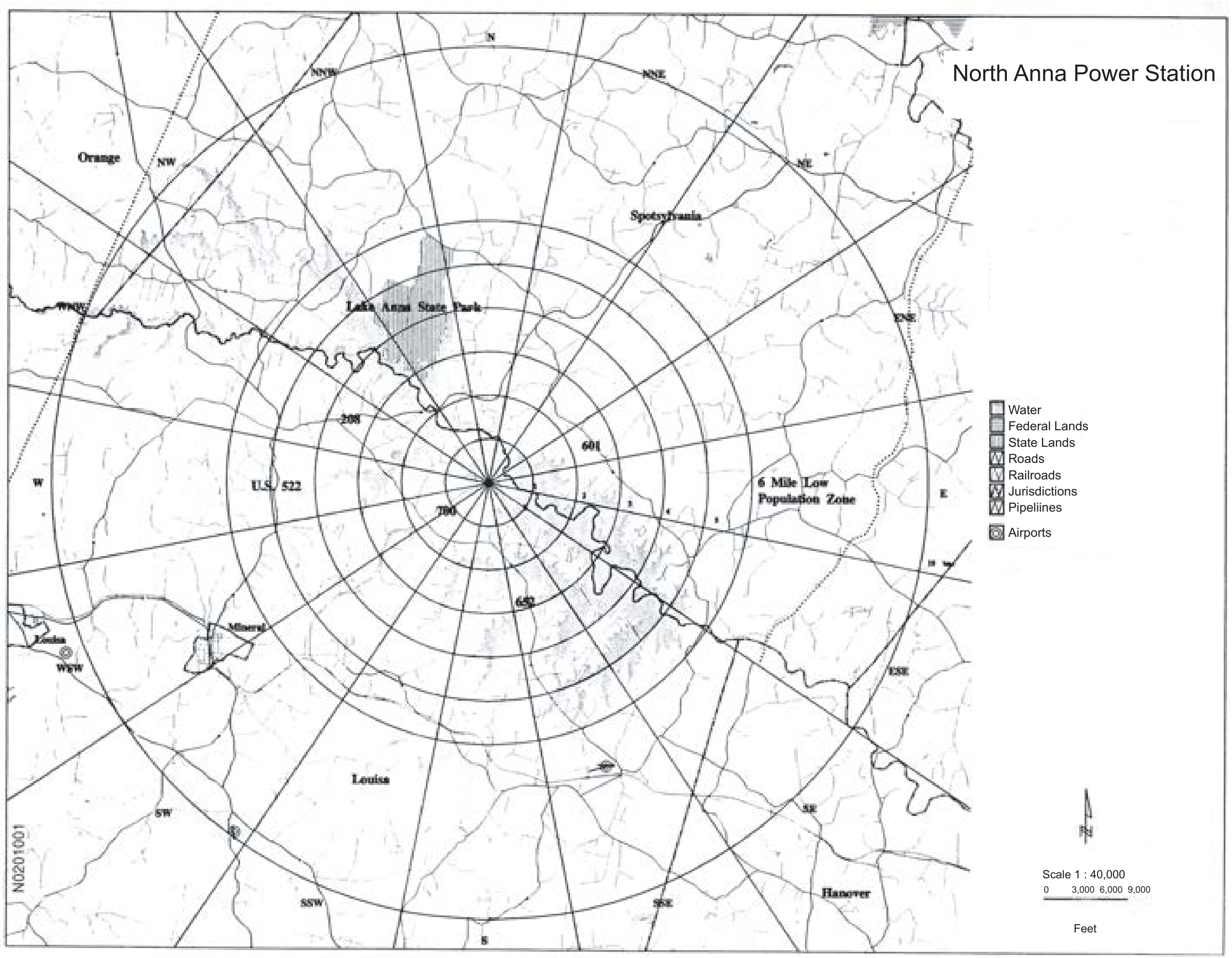


Figure 2.5-1 10-Mile Surrounding Area

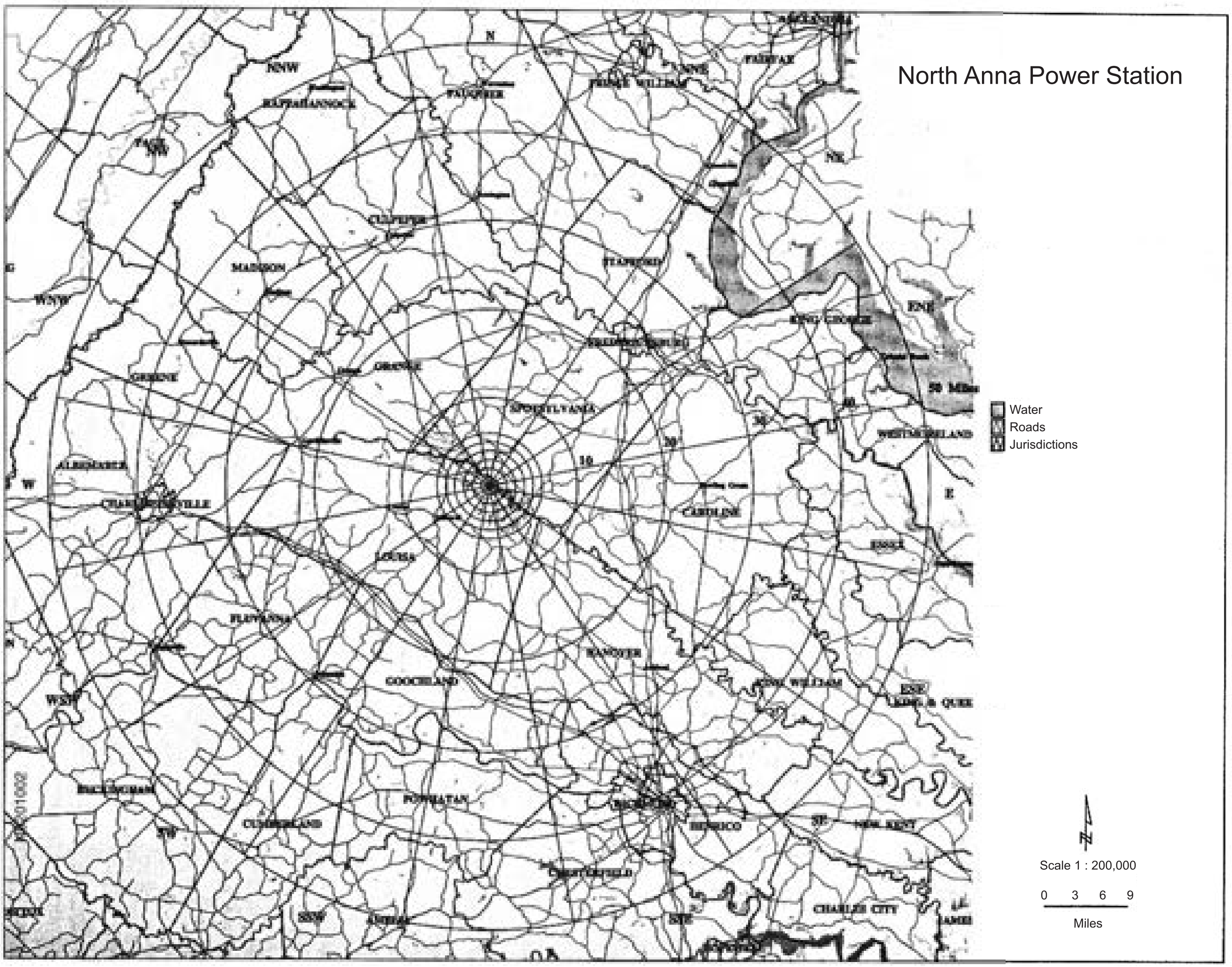
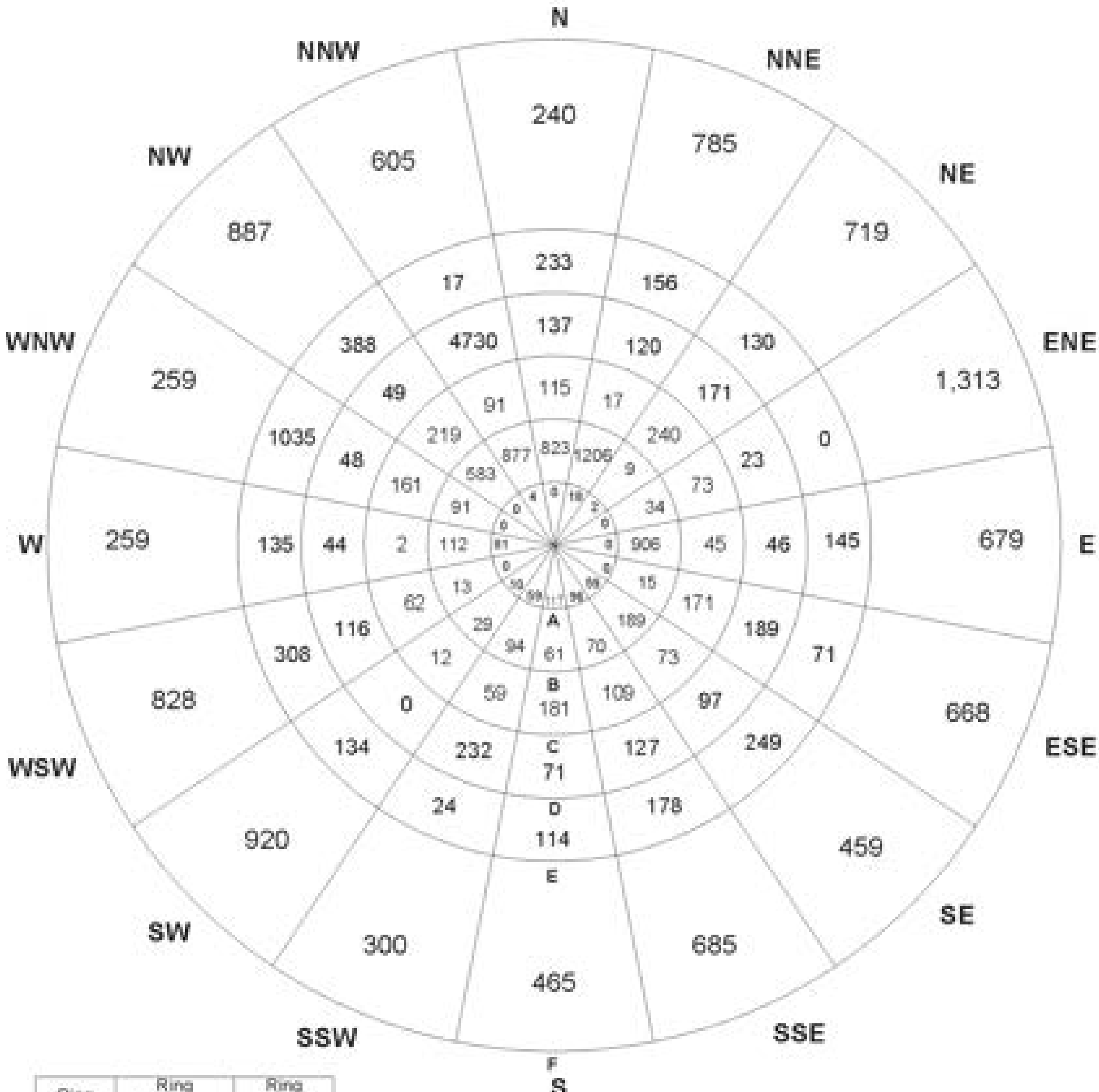
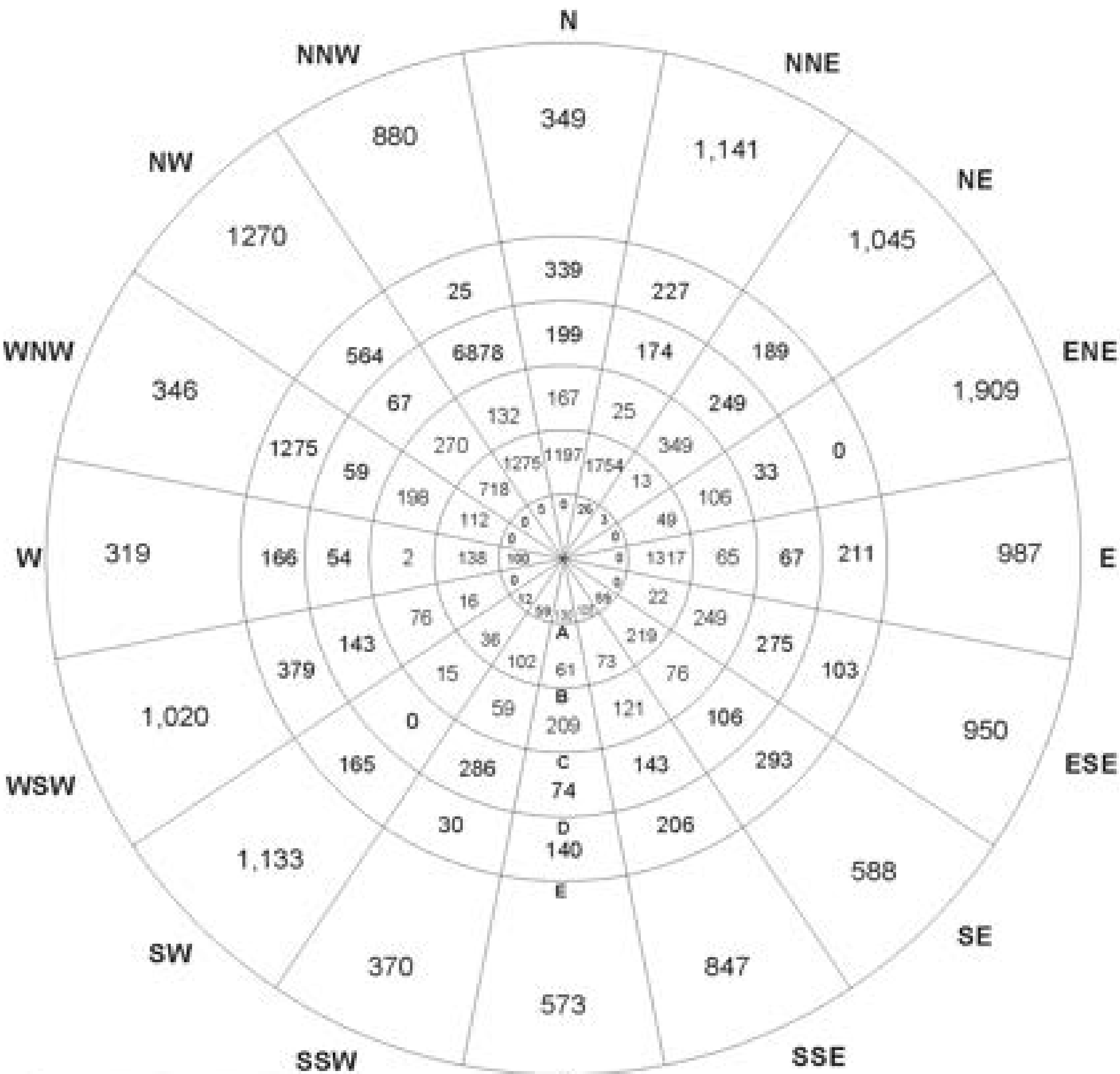


Figure 2.5-2 50-Mile Surrounding Area



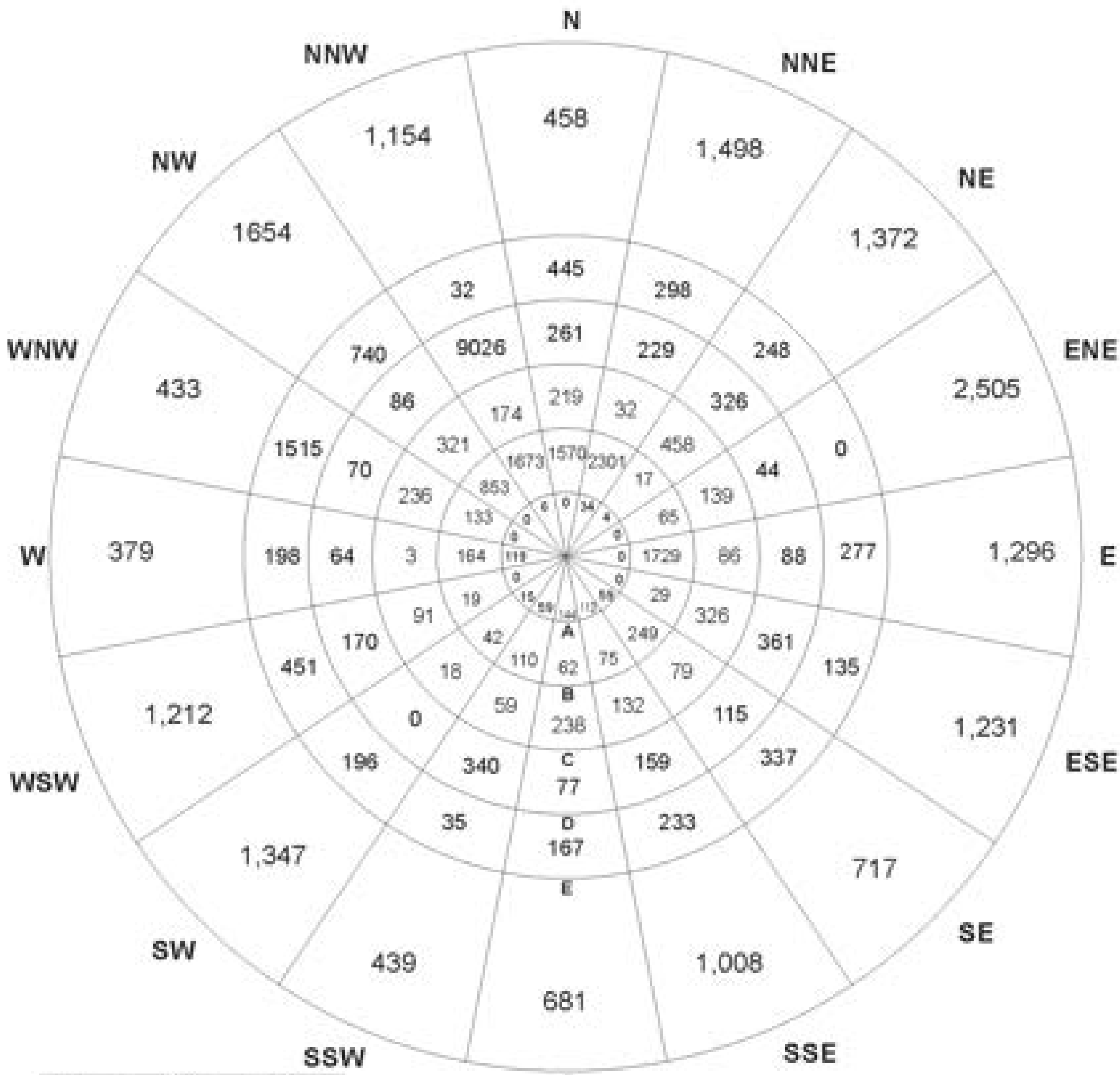
Ring	Ring Kilometers	Ring Miles
A	0 - 2	0 - 1.24
B	2 - 4	1.24 - 2.5
C	4 - 6	2.5 - 3.73
D	6 - 8	3.73 - 5.0
E	8 - 10	5.0 - 6.2
F	10 - 16	6.2 - 10.0

Figure 2.5-3 16-Kilometer (10-Mile) Resident and Transient Population Distribution–2000



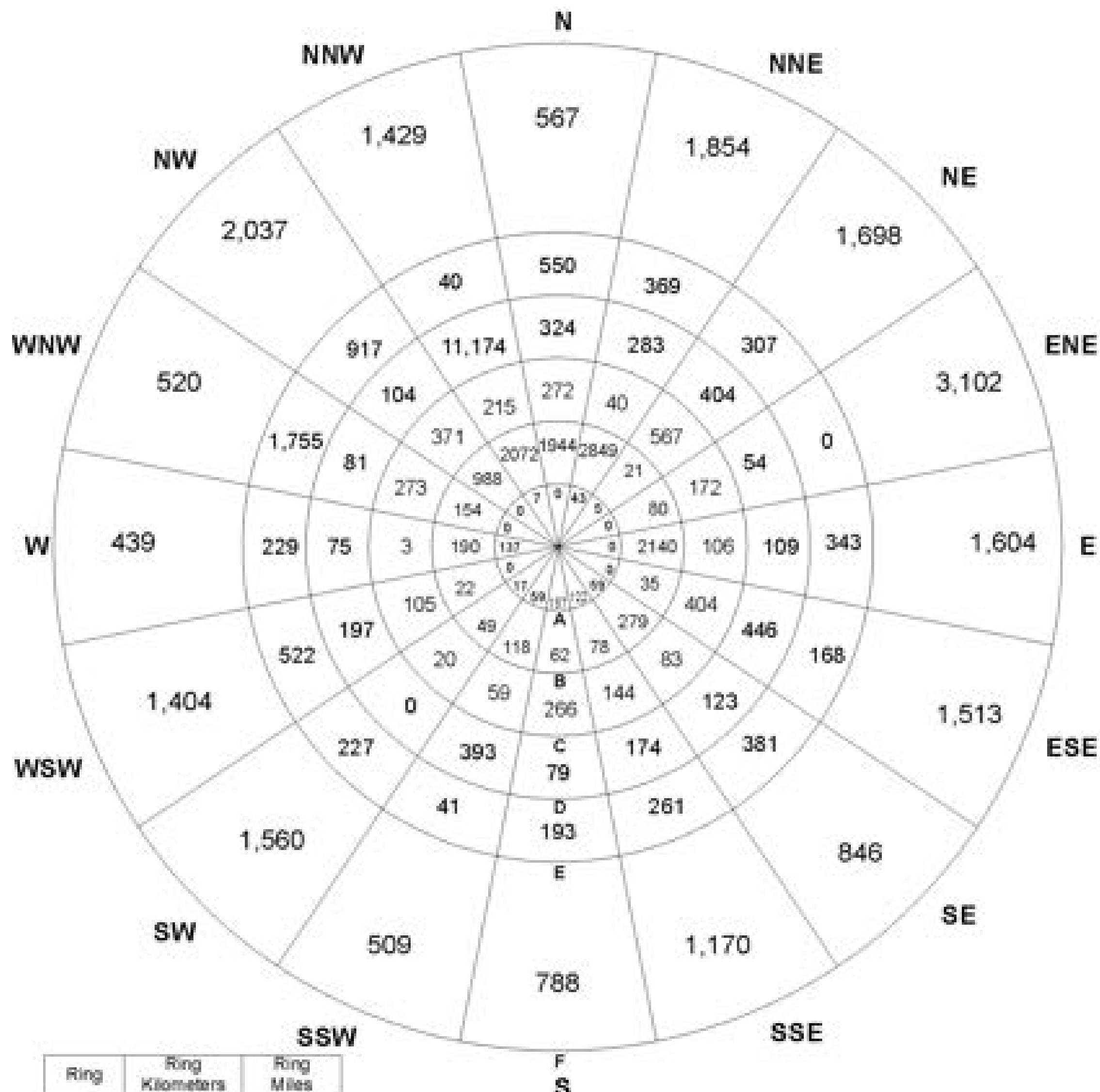
Ring	Ring Kilometers	Ring Miles
A	0 - 2	0 - 1.24
B	2 - 4	1.24 - 2.5
C	4 - 6	2.5 - 3.73
D	6 - 8	3.73 - 5.0
E	8 - 10	5.0 - 6.2
F	10 - 16	6.2 - 10.0

Figure 2.5-4 16-Kilometer (10-Mile) Resident and Transient Population Distribution–2010



Ring	Ring Kilometers	Ring Miles
A	0 - 2	0 - 1.24
B	2 - 4	1.24 - 2.5
C	4 - 6	2.5 - 3.73
D	6 - 8	3.73 - 5.0
E	8 - 10	5.0 - 6.2
F	10 - 16	6.2 - 10.0

Figure 2.5-5 16-Kilometer (10-Mile) Resident and Transient Population Distribution–2020



Ring	Ring Kilometers	Ring Miles
A	0 - 2	0 - 1.24
B	2 - 4	1.24 - 2.5
C	4 - 6	2.5 - 3.73
D	6 - 8	3.73 - 5.0
E	8 - 10	5.0 - 6.2
F	10 - 16	6.2 - 10.0

Figure 2.5-6 16-Kilometer (10-Mile) Resident and Transient Population Distribution–2030

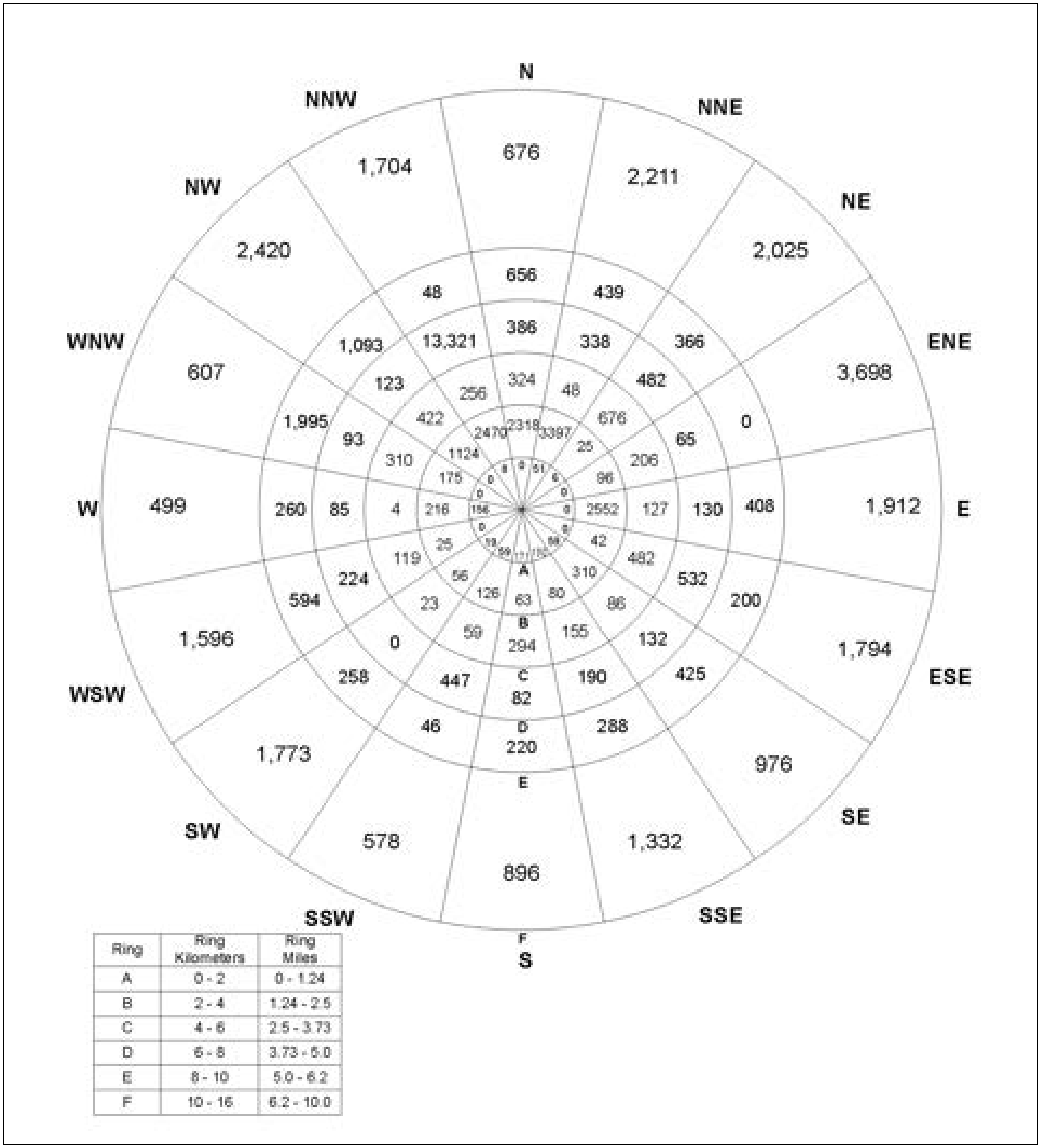
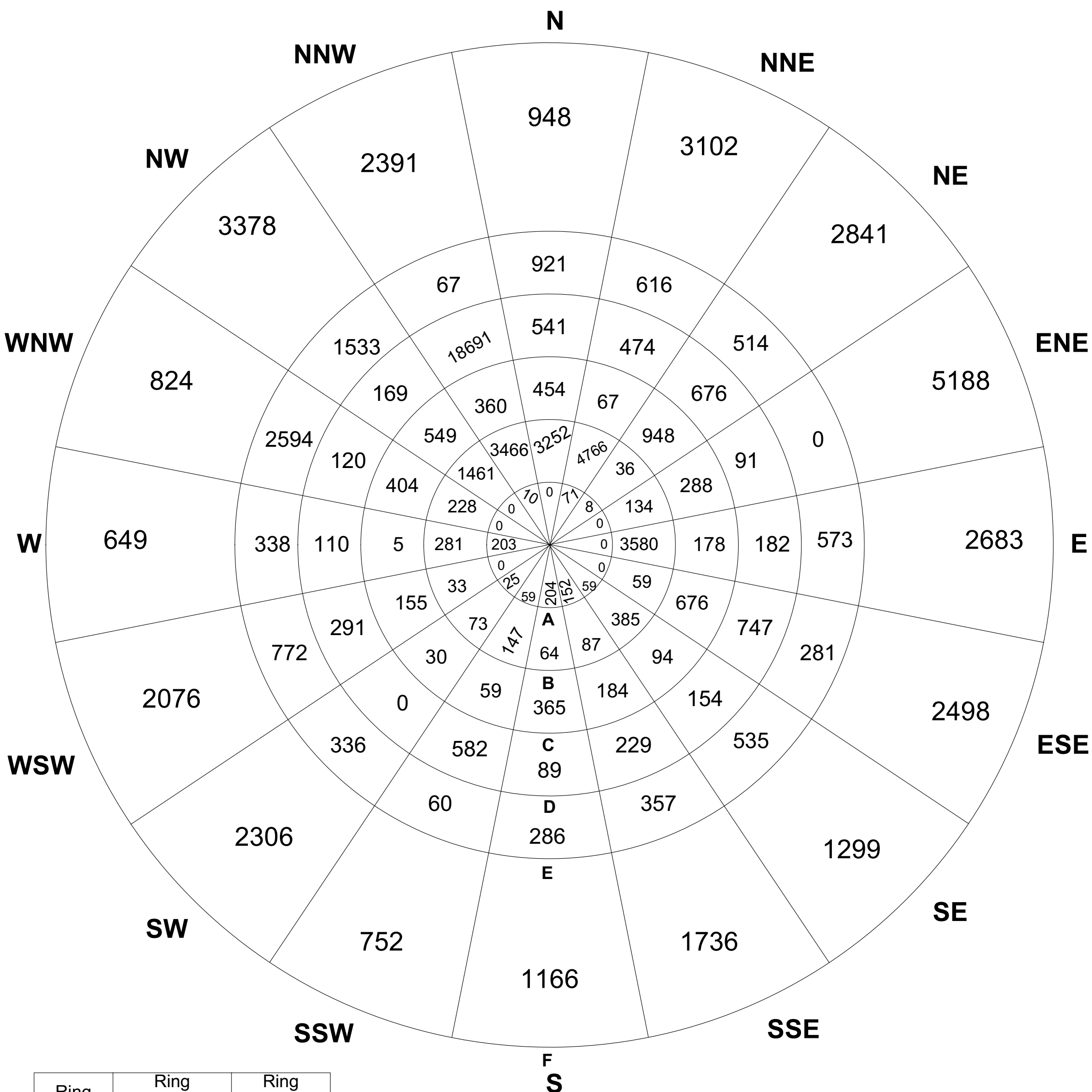
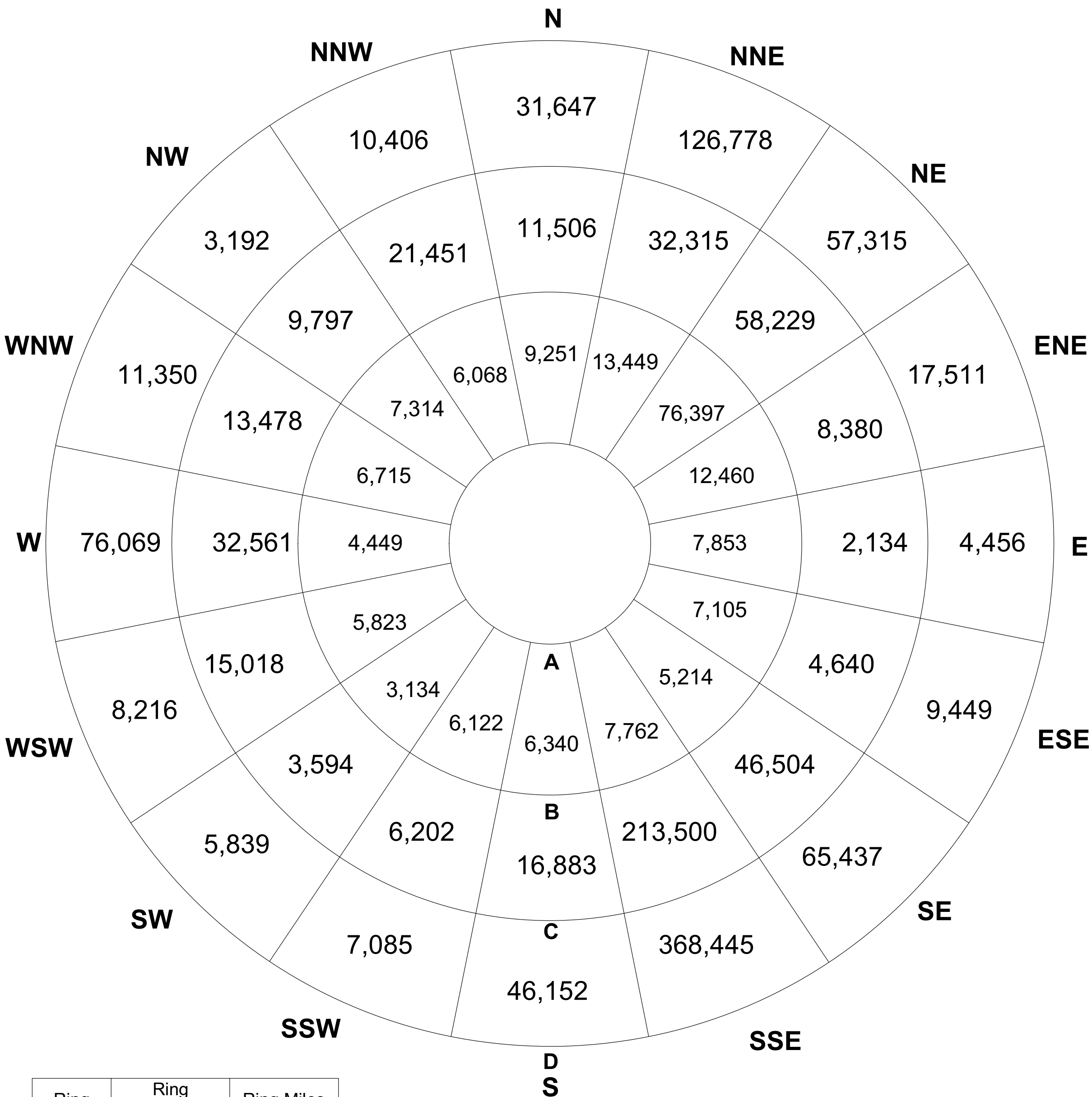


Figure 2.5-7 16-Kilometer (10-Mile) Resident and Transient Population Distribution–2040



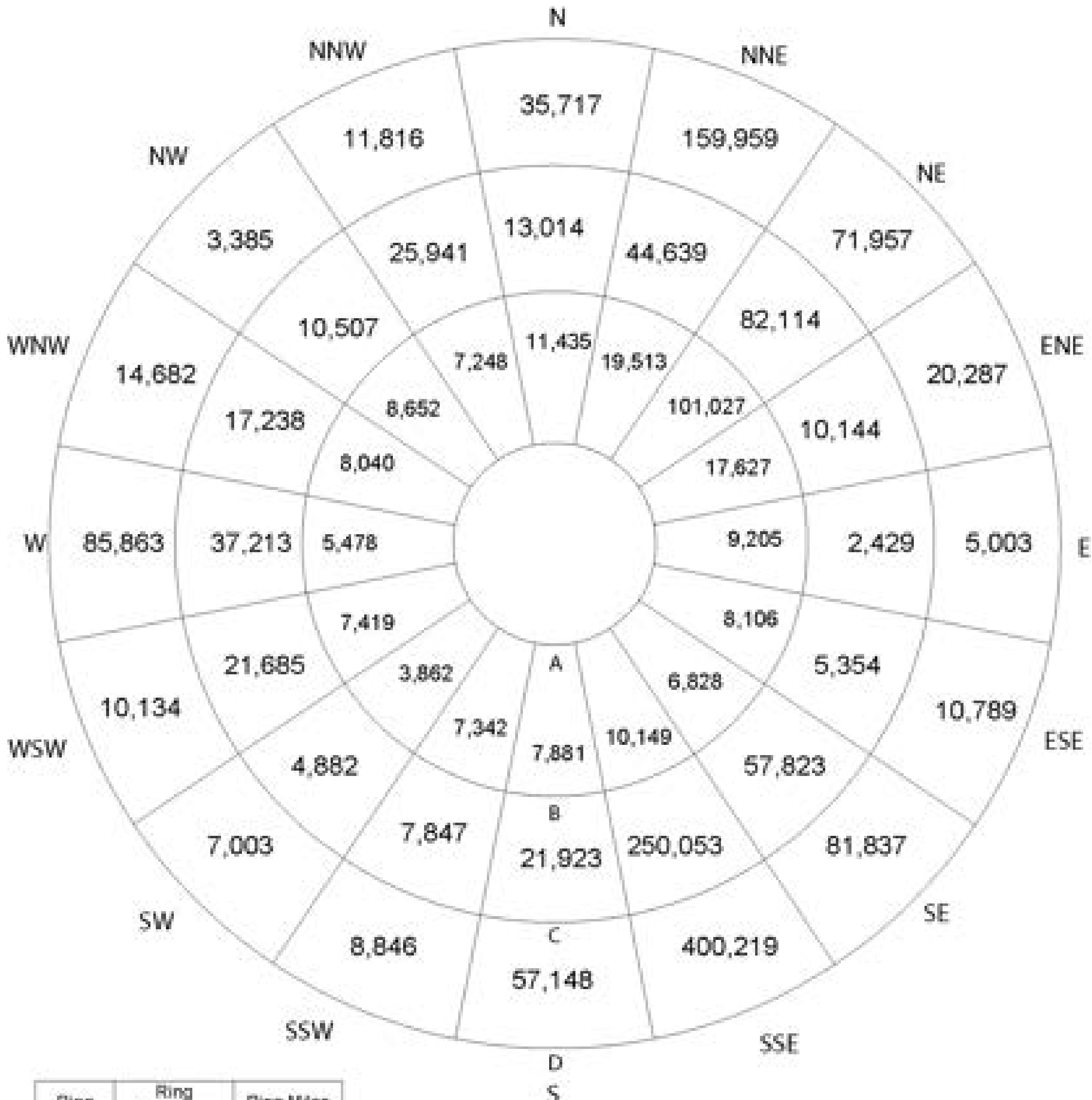
Ring	Ring Kilometers	Ring Miles
A	0 - 2	0 - 1.24
B	2 - 4	1.24 - 2.5
C	4 - 6	2.5 - 3.73
D	6 - 8	3.73 - 5.0
E	8 - 10	5.0 - 6.2
F	10 - 16	6.2 - 10.0

Figure 2.5-7A 16-Kilometer (10-Mile) Resident and Transient Population Distribution–2065



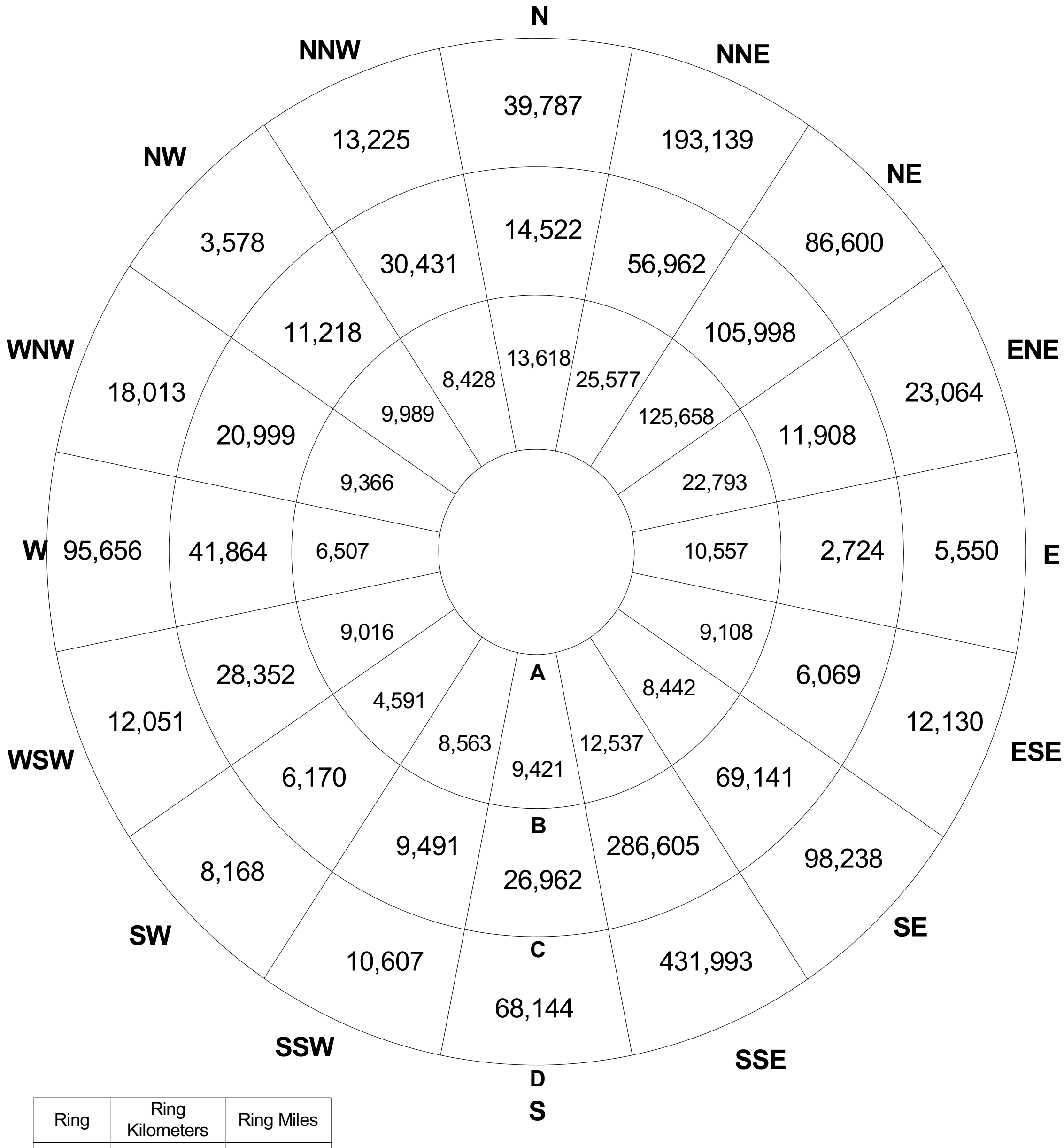
Ring	Ring Kilometers	Ring Miles
A	0 - 16	0 - 10
B	16 - 40	10 - 24.9
C	40 - 60	24.9 - 37.3
D	60 - 80	37.3 - 50

Figure 2.5-8 80-Kilometer (50-Mile) Resident and Transient Population Distribution–2000



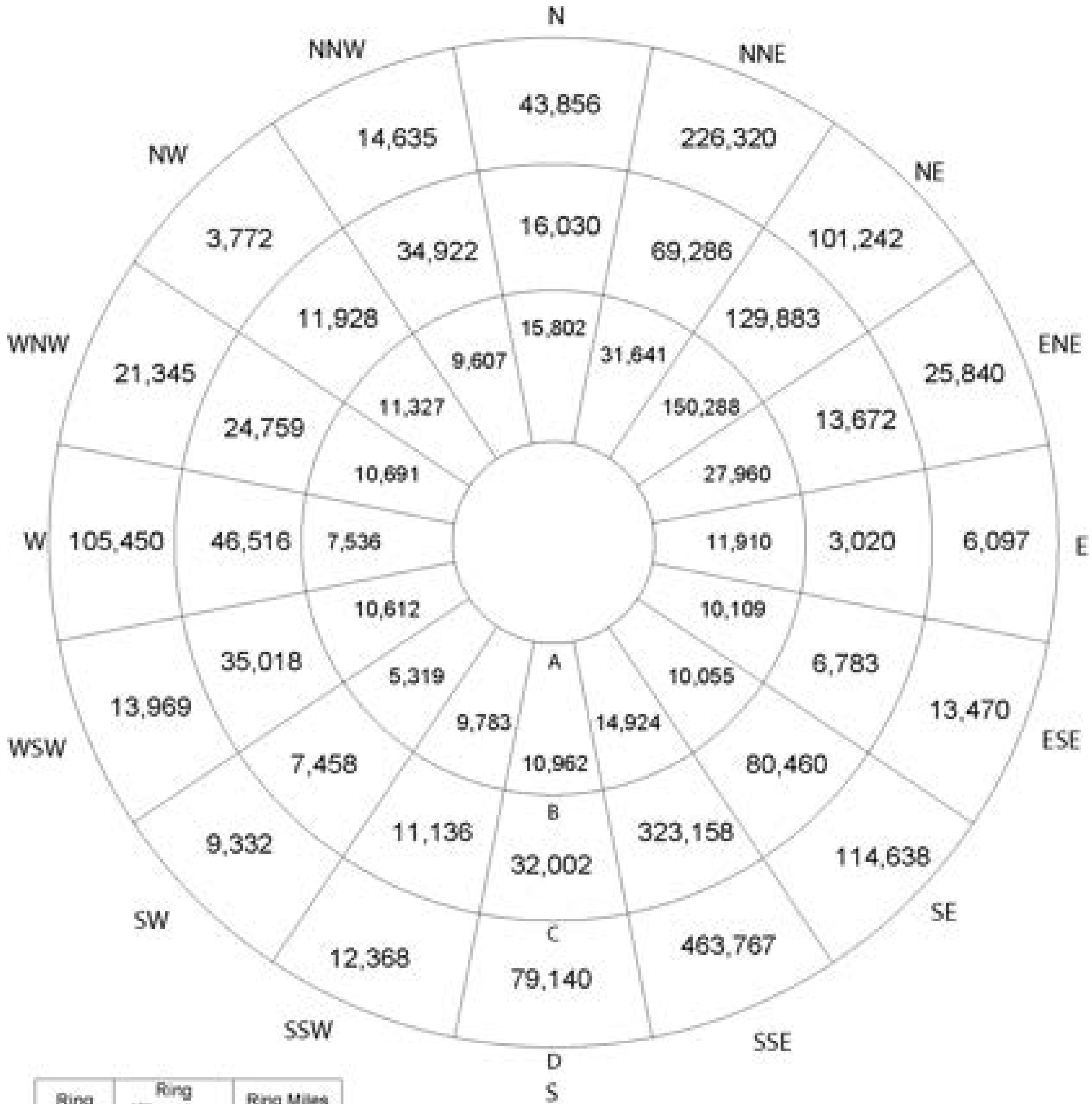
Ring	Ring Kilometers	Ring Miles
A	0 - 16	0 - 10
B	16 - 40	10 - 24.9
C	40 - 60	24.9 - 37.3
D	60 - 80	37.3 - 50

Figure 2.5-9 80-Kilometer (50-Mile) Resident and Transient Population Distribution–2010



Ring	Ring Kilometers	Ring Miles
A	0 - 16	0 - 10
B	16 - 40	10 - 24.9
C	40 - 60	24.9 - 37.3
D	60 - 80	37.3 - 50

Figure 2.5-10 80-Kilometer (50-Mile) Resident and Transient Population Distribution–2020



Ring	Ring Kilometers	Ring Miles
A	0 - 16	0 - 10
B	16 - 40	10 - 24.9
C	40 - 60	24.9 - 37.3
D	60 - 80	37.3 - 50

Figure 2.5-11 80-Kilometer (50-Mile) Resident and Transient Population Distribution–2030

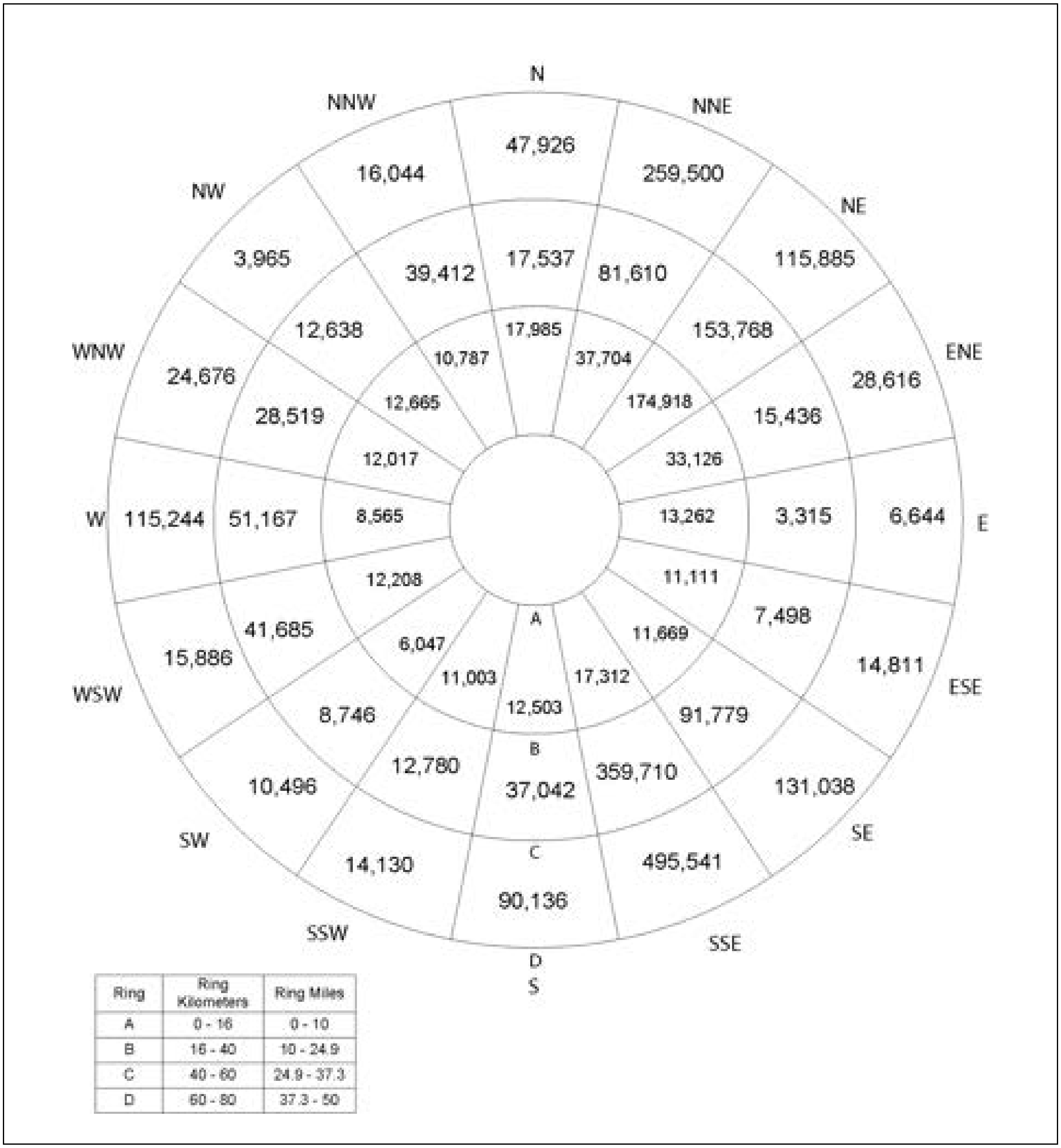
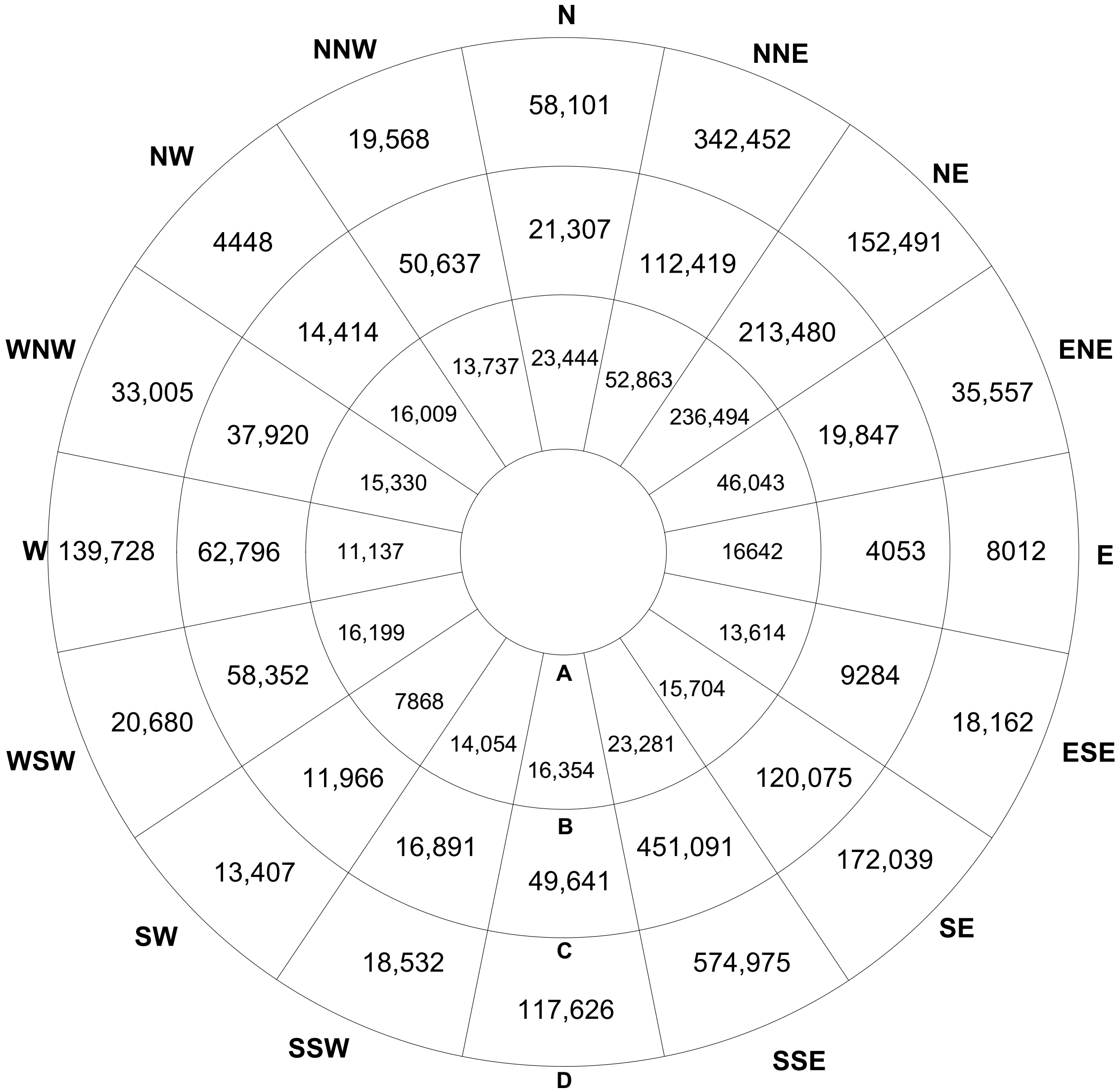


Figure 2.5-12 80-Kilometer (50-Mile) Resident and Transient Population Distribution–2040



Ring	Ring Kilometers	Ring Miles
A	0 - 16	0 - 10
B	16 - 40	10 - 24.9
C	40 - 60	24.9 - 37.3
D	60 - 80	37.3 - 50

Figure 2.5-12A 80-Kilometer (50-Mile) Resident and Transient Population Distribution–2065

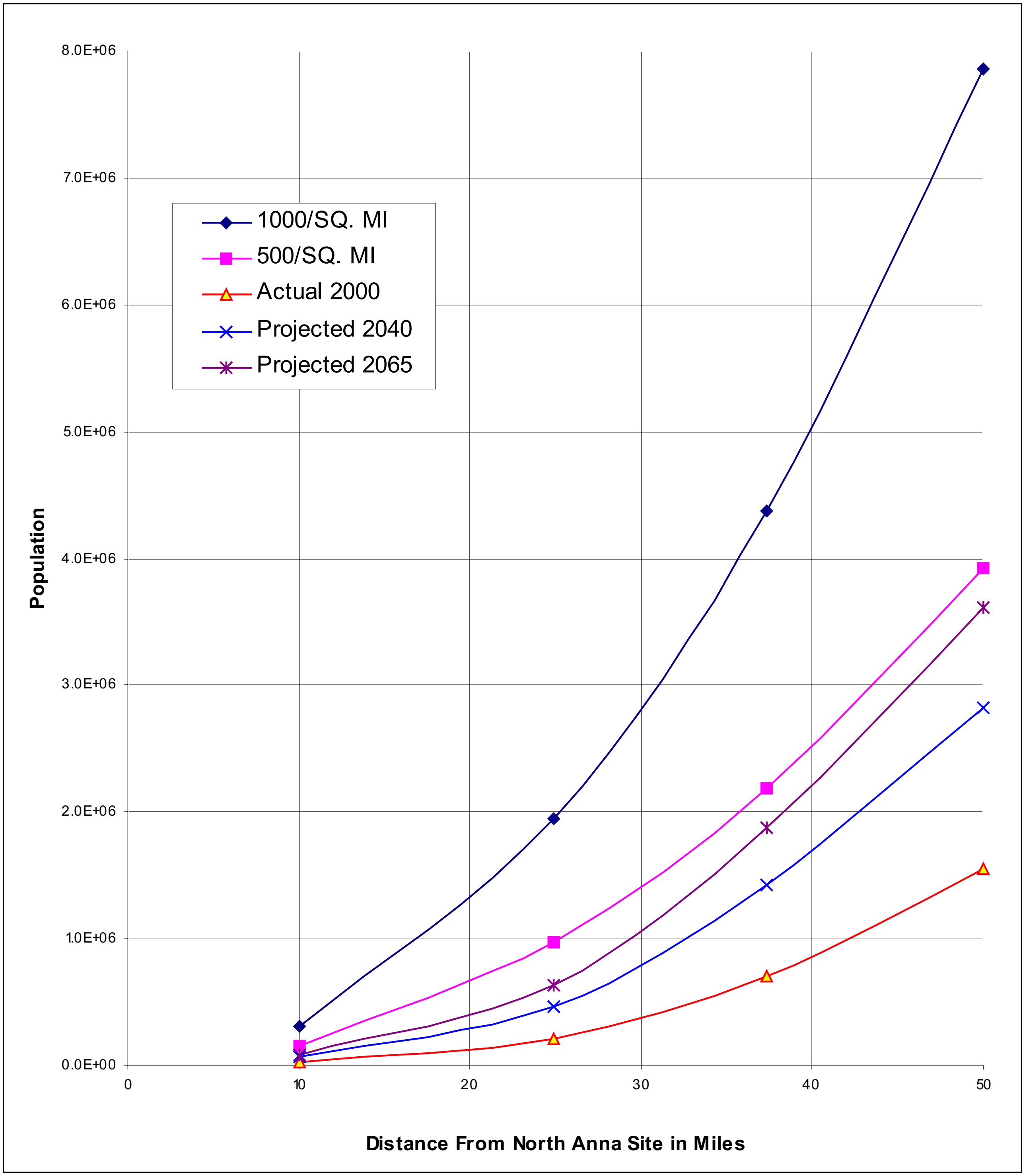


Figure 2.5-13 Population Density

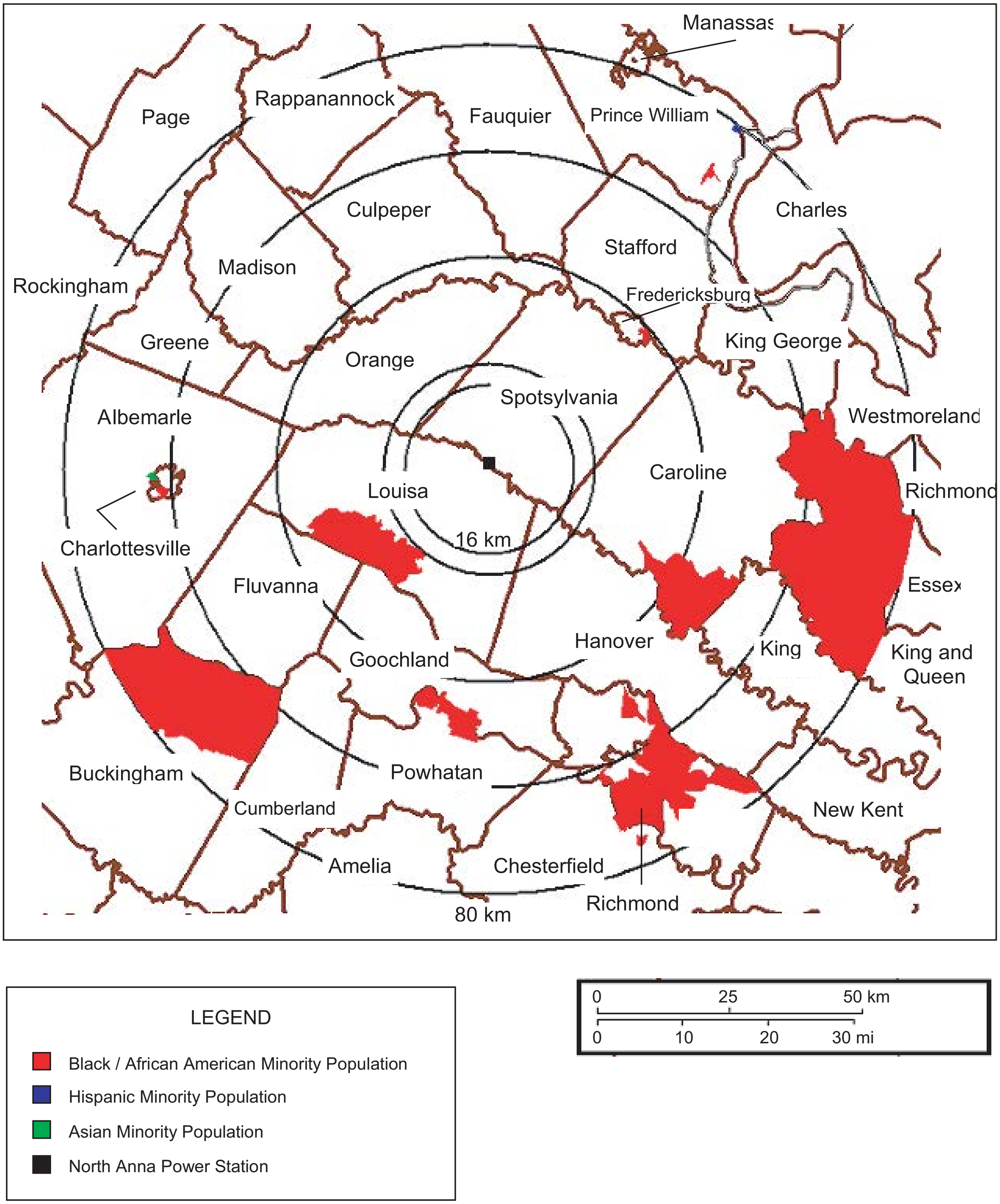


Figure 2.5-14 Minority Population

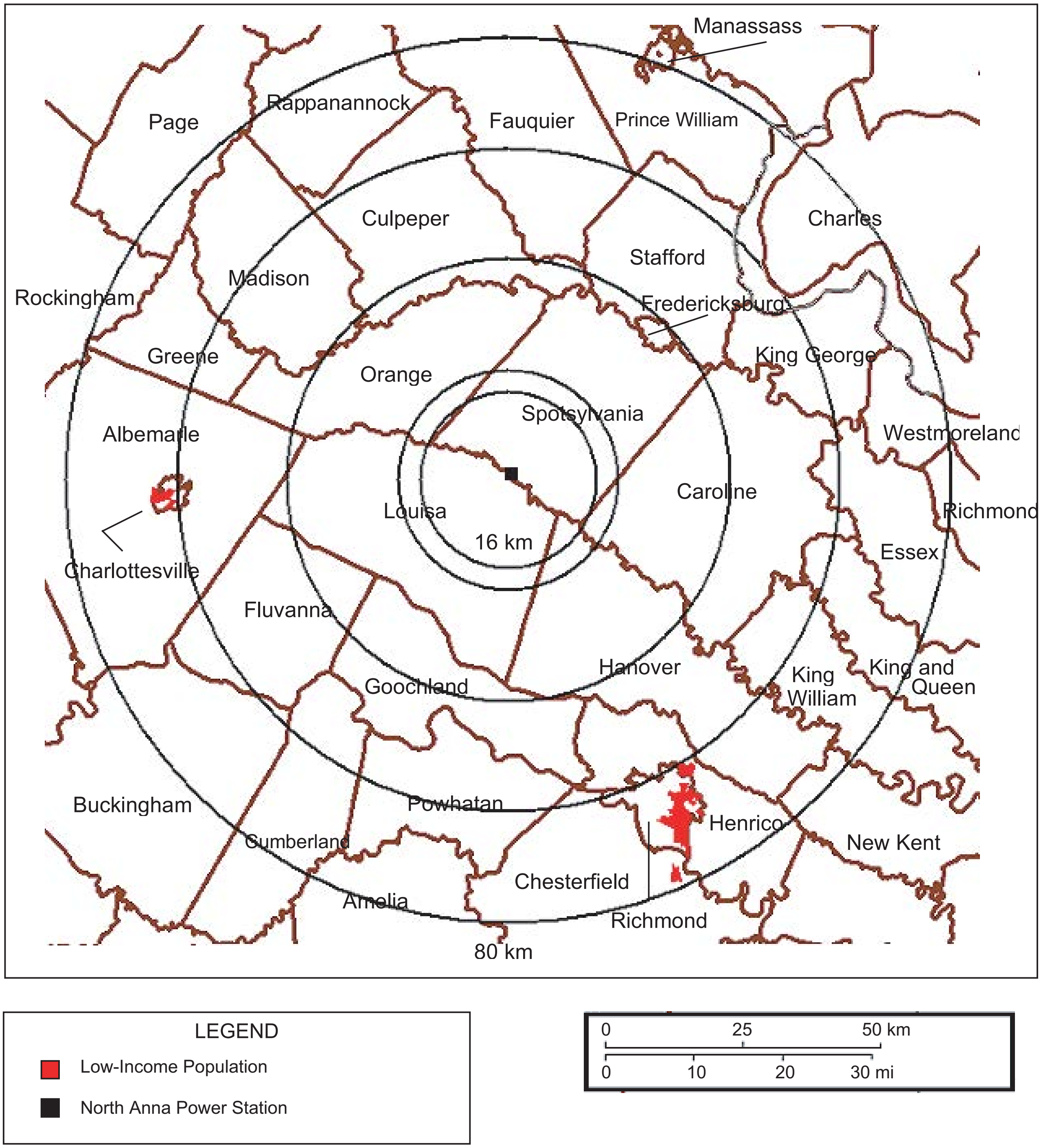


Figure 2.5-15 Low-Income Population

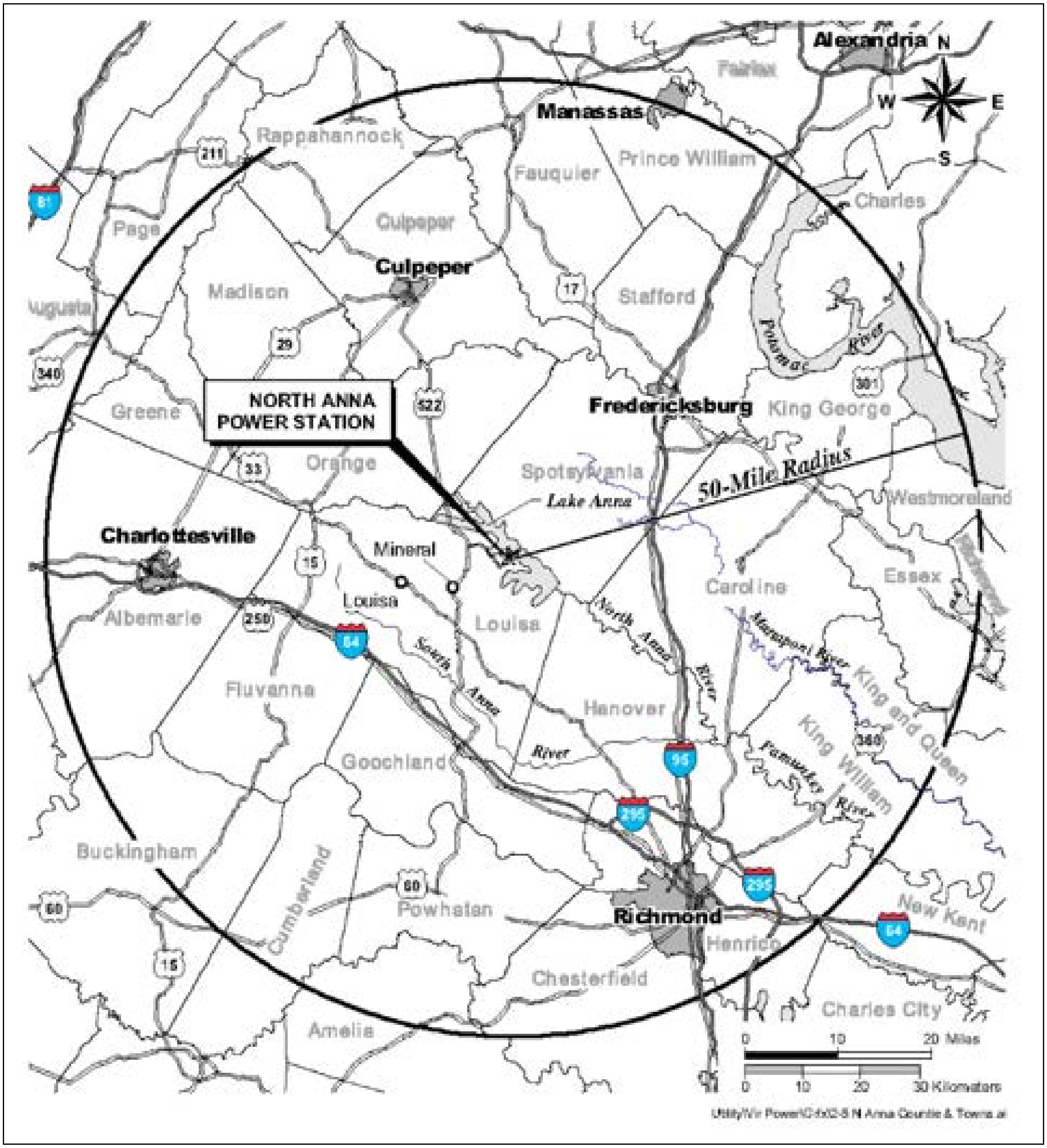


Figure 2.5-16 50-Mile Vicinity Map Showing Counties and Important Towns and Cities

Source: North Anna Power Station, Units 1 and 2 Application for Renewed Operating Licenses Appendix E – Environmental Report, Figure 2-5

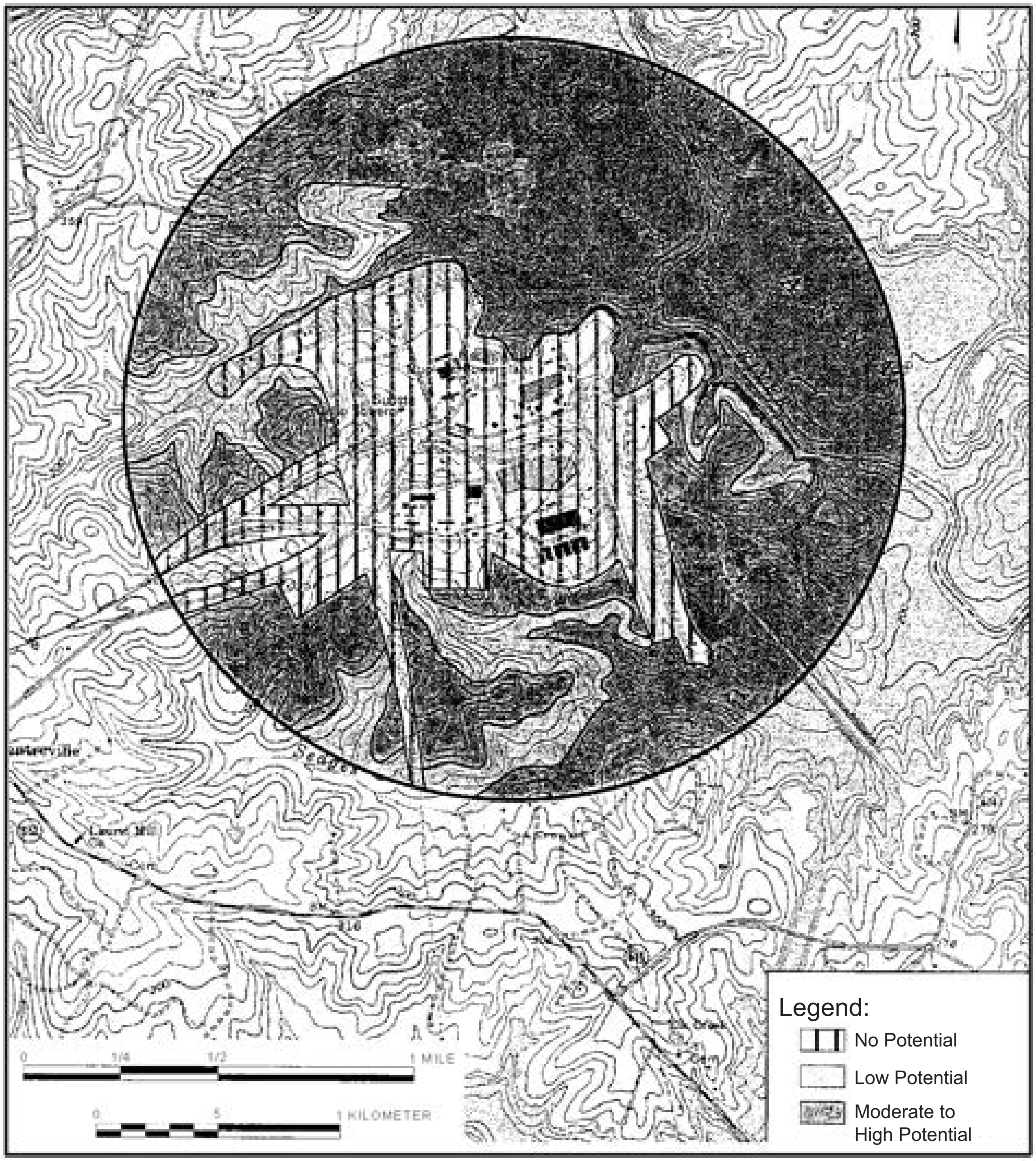


Figure 2.5-17 Area Potentials for Yielding Archeological Resources Within the Study Area

Source: Cultural Resources Assessment, Louis Berger Group, 2001 (Reference 21)

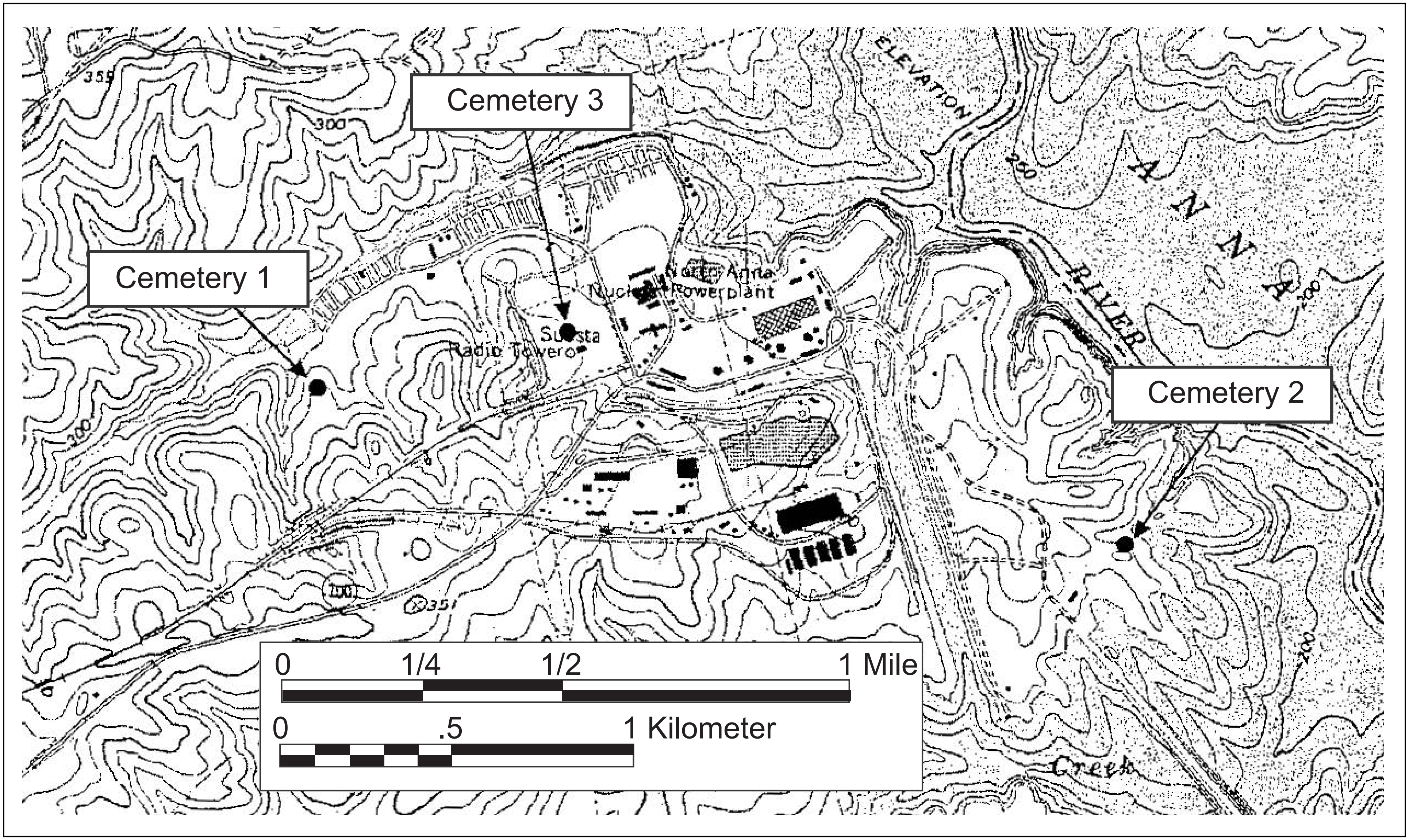


Figure 2.5-18 Cemeteries Within the NAPS Site Boundary

Source: Cultural Resources Assessment, Louis Berger Group, 2001 (Reference 21)

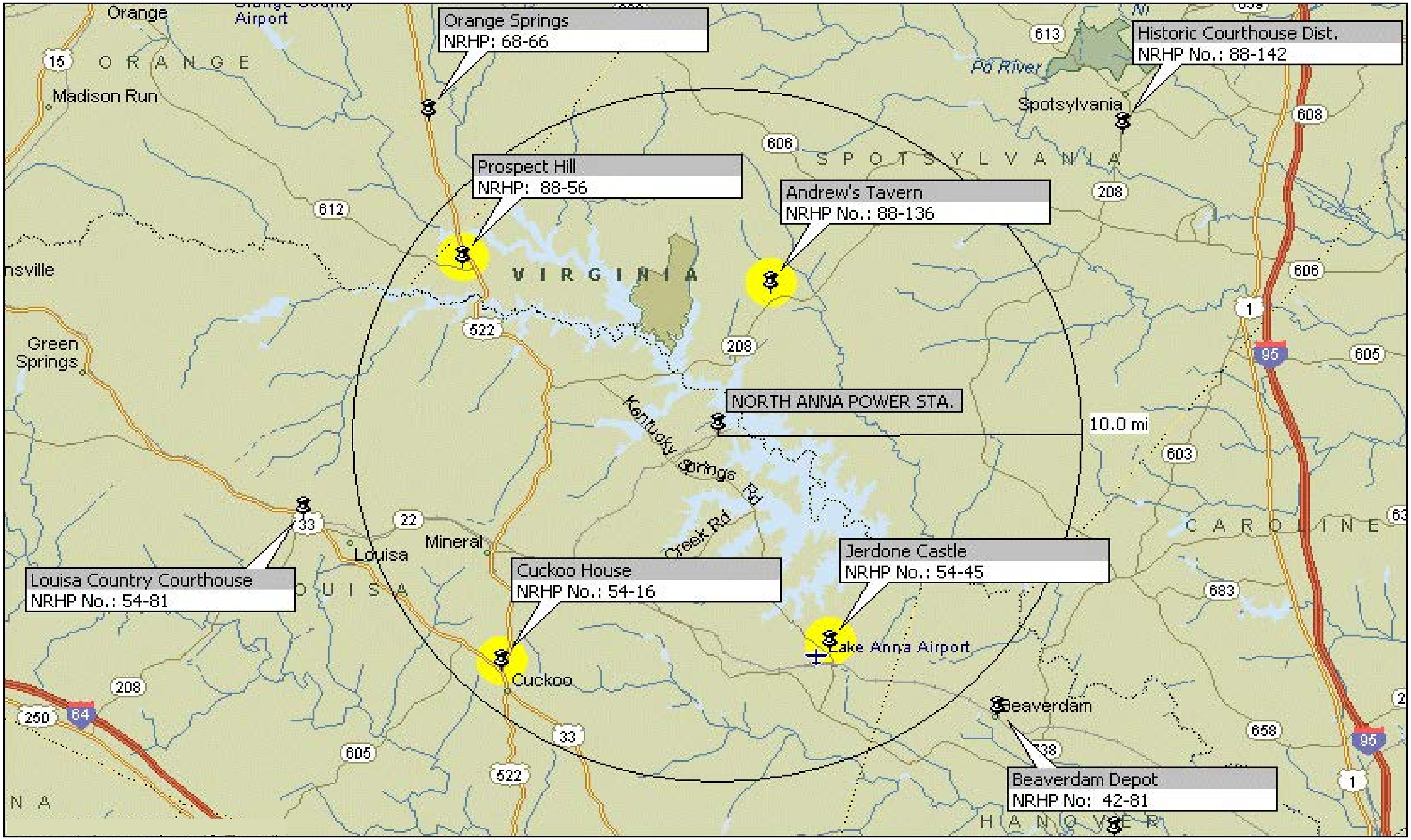


Figure 2.5-19 Location of Historic Sites in the Vicinity of NAPS

2.6 Geology

The following sections summarize geological, seismological, and geotechnical conditions at the ESP site. These conditions and utilization of the ESP site for new units are then evaluated for potential environmental impacts. The information is subdivided into three categories, corresponding to the subject conditions. The geological, seismological, and geotechnical information has been developed in accordance with the guidance provided in RG 4.2 (Reference 1).

The geological, seismological, and geotechnical information presented in this section is based on reviews of previous reports prepared for the existing units and the abandoned Units 3 and 4, geologic literature, and the results of a subsurface investigation performed in late 2002 (Part 2: Appendix 2.5.4B) as part of the ESP application activities. Previous NAPS site-specific reports reviewed include the UFSAR for the existing units (Reference 2) and the ISFSI Safety Analysis Report (Reference 3). Reports prepared by Dames and Moore for licensing of the existing units (Reference 4) and the abandoned Units 3 and 4 (Reference 5) (Reference 6) were also reviewed.

Geological and geotechnical investigations conducted for the existing units and for the abandoned Units 3 and 4 included over 100 borings to depths ranging from 20 to 175 feet (Reference 4) (Reference 5). Test pits were excavated in the area of abandoned Units 3 and 4, and detailed field geologic mapping was performed (Reference 6). During the foundation excavation for abandoned Units 3 and 4, the rock comprising the excavation walls and floor was mapped (Reference 7). As part of the ESP subsurface investigation program, seven borings, eight cone penetrometer tests, two seismic cone penetrometer tests, and cross-hole and down-hole seismic tests were performed. The data obtained by the ESP investigation are presented in Part 2: Appendix 2.5.4B. Field and aerial reconnaissance geologic mapping was also performed as part of the ESP seismicity investigation program.

2.6.1 Geological Conditions

2.6.1.1 Physiography

The ESP site lies within the Piedmont Physiographic Province (Figure 2.6-1). The Piedmont Province is a rolling hilly area that extends from its boundary with the Coastal Plain Province on the east to the Blue Ridge Province on the west. Elevations range from about 800 to 1500 feet along the western border of the Province and slope eastward to elevations of about 200 feet at its eastern border (Reference 8).

The ESP site is located within the Piedmont Upland section (referred to as subprovince in some publications) of the Piedmont Province, approximately 15 miles west of the Coastal Plain Province (Figure 2.6-1). Topography in the vicinity of the ESP site is characteristic of the Piedmont Upland section with a gently undulating surface varying in elevation from about 200 to 500 feet (Figure 2.6-2). The ESP site is surrounded by forest and brushwood-covered land interspersed with an occasional farm and is well dissected by streams (Reference 2). Slopes in the region typically range from 2 to 5 percent with steeper slopes ranging from 7 to 10 percent along the lower tributaries of some of the larger streams.

2.6.1.2 Stratigraphy

The Piedmont Upland section is underlain by Late Precambrian and Paleozoic age crystalline rocks, which are overlain by Cenozoic age residual soils. The crystalline rocks consist of deformed and metamorphosed sedimentary, igneous, and volcanic rocks, intruded by mafic dikes and granitic plutons (Reference 9). The rocks belong to a number of northeast trending lithotectonic belts, bounded by low-angle thrust faults (Paleozoic in age), and are interpreted to have formed along the shore and offshore of ancestral North America. The lithotectonic belts are: the Goochland-Raleigh belt; the Carolina and Eastern Slate belts; the Charlotte, Milton and Chopawamsic belts; and the Western/Inner Piedmont belt (Reference 10) (Figure 2.6-3).

The ESP site is located in the Chopawamsic belt. The Chopawamsic belt is bounded on the west and east by the Chopawamsic and Spotsylvania thrust faults, respectively, and is interpreted to be a volcanic-arc that was accreted to ancestral North America. The belt is comprised of the Chopawamsic Formation and the Ta River Metamorphic Suite, which are overlain unconformably by the Quantico Formation and intruded by rocks of the Falmouth Intrusive Suite (Figure 2.6-4 and Figure 2.6-5). The Chopawamsic Formation and Ta River Metamorphic suite have been assigned to the Cambrian and/or Ordovician Periods (Reference 11) and the Quantico Formation and Falmouth Intrusive Suite have been assigned to the Ordovician and Carboniferous Periods, respectively (Reference 12).

The ESP site is underlain by rocks of the Ta River Metamorphic Suite, which extend thousands of feet below the ground surface (Reference 13). The main rock encountered in borings completed during previous subsurface investigations at the NAPS site and in borings completed as part of the ESP subsurface investigation is a gneiss. The gneiss is generally described as a gray to dark gray:

- quartz gneiss with some biotite quartz gneiss, and
- hornblende gneiss, biotite quartz gneiss, and quartz gneiss.

The gneiss is moderately to intensely jointed and contains layers of quartz, pegmatite, chlorite, and clay. The upper part of the gneiss (averaging about 30 feet thick) is highly weathered and fractured, becoming less weathered and fractured with increasing depth.

Residual soil overlying the gneiss consists predominantly of saprolite. The saprolite is derived from weathering of the underlying bedrock and retains many of the structural and mineraological features of the bedrock. The saprolite extends to the top of the rock from which it was derived; however, the contact between the saprolite and sound rock may be gradational and not well defined. The saprolite at the site generally consists of micaceous clayey, silty, fine to coarse sand with some to many relict rock fragments and in some areas of the site it extends to a depth of about 100 feet below the ground surface.

2.6.1.3 **Faults**

Seven bedrock faults (Paleozoic in age) have been mapped within 5 miles of the ESP site (Figure 2.6-4 and Figure 2.6-5). Two of the faults, the Spotsylvania and Chopawamsic, are major thrust faults that separate lithotectonic belts within the Piedmont Province. The Long Branch and Sturgeon Creek faults are thrust faults, and the remaining three unnamed faults are designated as faults “a”, “b”, and “c” on Figure 2.6-4 and Figure 2.6-5.

2.6.2 **Seismological Conditions**

2.6.2.1 **Tectonic Setting**

The northeast trending, fault-bounded belts comprising the Piedmont Physiographic Province (Paleozoic in age) are defined essentially on the basis of rock type and metamorphic grade. The faults that separate the belts are low-angle thrust faults created by large-scale detachment and northwest thrusting of rocks along a basal decollement. Below the decollement are rocks that form the North American basement complex. The basal decollement is a nearly horizontal blind thrust fault that dips gently southeast and is at a depth of approximately 3 to 6 miles below the ground surface (Reference 14) (Reference 15). The low-angle thrust faults rise from the basal decollement and either terminate in the subsurface or extend to the ground surface. Also located in the Piedmont Province are a number of Mesozoic age grabens and half-grabens (“Triassic basins”) that are bounded on their western side by normal faults. The normal faults are considered to be either listric into the Paleozoic thrust faults or penetrate into the North American basement complex (Reference 16).

2.6.2.2 **Seismic Sources**

Seismic activity in the Piedmont Province is generally considered to originate in the North American basement. Geologic structures considered to be responsible for earthquake activity in the province are the basal decollement and associated thrust structures and the normal faults and intrusions associated with rifting that occurred during Mesozoic time (Reference 17).

2.6.2.2.1 **Seismic Source Zones**

The region (200-mile radius) encompasses two areas where seismic sources have been delineated. These areas have been designated as seismic source zones and consist of the Central Virginia seismic source zone and the Giles County seismic source zone (Reference 18) (Figure 2.6-6).

The CVSZ is an area of persistent, low-level seismicity. The zone is about 75 miles long and 90 miles wide and seismicity ranges in depth from about 2 to 11 miles below the ground surface

(Reference 19). The ESP site lies within the zone, near its northern boundary (Reference 18). Seismic sources within the CVSZ vary from place to place. In the central and western parts of the zone, seismicity is considered to be attributed to west-dipping reflectors (interfaces between media of different elastic properties that reflect seismic waves) that form the roof of a detached antiform. In the eastern part of the zone, seismicity is considered to be related to intrusions that have created an extensive near-vertical dike swarm (Reference 20). Given the depth distribution of 2 to 11 miles and broad spatial distribution of seismicity, however, it is difficult to uniquely attribute the seismicity to any known geologic structure, and earthquakes are considered to occur within the upper portion of the North American basement complex or within thrust fault bounded crust above the basal decollement. The largest historical earthquake to occur in this zone occurred in Goochland County on December 23, 1875, about 30 miles southwest of the ESP site. It had a body-wave magnitude (m_b) of 5 (Reference 21) and a Modified Mercalli Intensity (MMI) of VII. Isoseismal maps indicate that the ESP site would have experienced a shaking intensity of MMI V (Reference 22).

The Giles County seismic zone is located in Giles County, Virginia, near its southwestern border with West Virginia. The zone is about 25 miles long, 6 miles wide and seismicity ranges in depth from 3 to 16 miles below the ground surface (Reference 23) (Reference 24). The ESP site is about 150 miles northeast of this zone (Reference 18). The source of seismicity within the Giles County seismic zone is considered to be due to normal faulting within the North American basement complex (Reference 16) (Reference 24). The largest known earthquake to occur in Virginia and the second largest earthquake to occur in the southeastern United States occurred in this zone on May 31, 1897. It had a magnitude m_b of 5.8 and an intensity MMI of VIII (Reference 25). Isoseismal maps indicate that the ESP site would have experienced a shaking intensity of MMI V (Reference 22) from this earthquake.

2.6.2.2.2 **Tectonic Sources (Faults)**

The Spotsylvania and Chopawamsic thrust faults bound the eastern and western margins of the Chopawamsic belt, respectively. They have been mapped over significant distances within the Piedmont Province (Reference 12). The Spotsylvania thrust fault is about 4.5 miles southeast of the site and juxtaposes rocks of the Ta River Metamorphic Suite against rocks of the Goochland belt. It is a fault zone, rather than a single fault, having a width of approximately 1.5 miles (Reference 13) (Reference 26) and a length of over 300 miles (Reference 11). The Chopawamsic thrust fault is about 4.5 miles northwest of the site and separates rocks of the Chopawamsic Formation from rocks of the Western Piedmont belt. Interpretations indicate that this structure extends for a distance of over 45 miles (Reference 27).

The Long Branch thrust fault is about 2 miles west of the site and separates rocks of the Quantico Formation from rocks of the Chopawamsic Formation and Ta River Metamorphic Suite. The fault has been mapped for over 45 miles and along its length it is locally displaced by smaller faults (Reference 12) (Reference 13).

The Sturgeon Creek fault is about 1 mile west of the site and displaces the fault contact between the Quantico Formation and the Ta River Metamorphic Suite. It has been mapped for a distance of about 10 miles (Reference 13).

Unnamed fault ("a") extends directly through the NAPS site. The fault was found in the Ta River Metamorphic Suite during the foundation excavation for abandoned Units 3 and 4. The fault was investigated by Dames and Moore (Reference 6) and the results were presented to the U.S. Atomic Energy Commission (Reference 28). The results of the investigation indicate that movement occurred along the fault approximately 200 million years ago and that movement has not occurred since, or at least not within the last one million years, given the relatively undisturbed thickness of residual soil overlying the fault. The results of the investigation also concluded that the fault is of limited extent (Reference 6), although subsequent interpretation has extended the fault north and south for a total distance of about 7 miles (Reference 26) (Reference 29). Aerial reconnaissance, field reconnaissance and air photo interpretation carried out for this ESP application, however, did not reveal any evidence for existence of the fault over this distance. Bedrock exposures that are poor to non-existent along the entire 7-mile length of the postulated fault trace, and a lack of geomorphic expression do not support this extension of the fault.

Unnamed faults "b" and "c" are located east of the Long Branch thrust fault, approximately 1 and 4 miles west and north of the ESP site, respectively Figure 2.6-4. The longer of the two faults ("b") juxtaposes rocks of the Quantico Formation against rocks of the Ta River Metamorphic and Falmouth Intrusive Suites. It is about 16 miles long, is offset by the Sturgeon Creek fault and is truncated at its northern end by the unnamed fault "c." This fault juxtaposes rocks of the Quantico Formation against rocks of the Falmouth Suite.

2.6.3 **Geotechnical Conditions**

For geotechnical purposes, the subsurface materials at the NAPS site were initially classified into the following five categories (Reference 4):

- I Residual clays and clayey silts
- IIA Saprolite (rock fragments less than 10 percent of volume of overall mass)
- IIB Saprolite (rock fragments 10 to 50 percent of soil mass)
- III Weathered Rock (rock fragments more than 50 percent of volume of mass)
- IV Parent Rock (slightly weathered to fresh rock below zone of soil and rock fragments)

In addition to these five categories, a sixth category termed Zone III-IV, representing a slightly to moderately weathered rock, was subsequently added to further describe the soil and rock with regard to engineering properties (Reference 2) (Reference 4) (Reference 5). The engineering properties for Zones IIA, IIB, III, III-IV, and IV, based on the previous and ESP field investigation and laboratory testing programs, are presented in Table 2.6-1.

Bedrock at the ESP site exhibits various degrees of weathering that affects its engineering behavior and properties. Zone III bedrock is generally a poor quality rock, with an average rock quality designation (RQD) value of 20 percent, while Zone III-IV and IV bedrock is typically a good to excellent quality rock, with average RQD values of 50 and 95 percent, respectively.

While the saprolite at the ESP site has the relict structure of the parent bedrock, its engineering properties typically resemble those of a soil. It exhibits certain aspects that are characteristic of both cohesive and cohesionless soils. Zone IIA saprolite has been classified as silty sand (SM), clayey sand (SC), and high and low plasticity silt and clay (MH, ML, CH, and CL). Zone IIB saprolite has been classified as mainly silty sand (SM). Standard penetration test (SPT) N-values for the Zone IIA saprolite indicates medium dense conditions, while SPT N-values for the Zone IIB saprolite indicates very dense conditions. The presence of mica in the saprolite (about 5 to 20 percent) contributes to high void ratios, high compressibilities, and low compacted densities (Reference 30). Therefore, due to the potential for excessive settlement of the Zone IIA saprolite, as occurred beneath the Units 1 and 2 SWR, no safety-related structures would be founded on the Zone IIA saprolite without ground improvement.

2.6.4 **Environmental Impact Evaluation**

2.6.4.1 **Geological Impacts**

2.6.4.1.1 **Zones of Alteration, Weathering, and Structural Weakness**

Occasional zones of severely weathered and fractured rock have been identified in the weathered and unweathered gneiss at the ESP site (Reference 4) (Reference 5) (Reference 7) (Part 2: Appendix 2.5.4B). The zones are typically 0.5 to 1 foot thick and contain quartz, clay, and iron oxides. Because of the tendency for zones of severely weathered rock to weather further upon exposure, where encountered in excavations for plant structures and judged to have a potential for impact on the stability of the foundation, they would be removed from the face of the excavation and replaced with cement grout. As a result, no adverse environmental impacts due to the effects of inadequate bearing capacity of the foundation rock mass resulting from the presence of weathered and fractured rock are anticipated for the ESP site.

2.6.4.1.2 **Effects of Human Activity**

Massive sulfide and gold deposits have been mined from rocks of the Chopawamsic belt in the vicinity of the ESP site. The deposits have been mined predominantly in and around the town of Mineral, approximately 7 miles west of the site. Mined deposits within a 5-mile radius of the site have been designated the Allah Cooper, Sulfur, Cofer and Old Dominion (Reference 31) (Reference 32) (Reference 33) (Reference 34). Published documentation of these mining activities indicate that the ESP site has not been nor would it be affected by these mining activities. As a result, no adverse environmental impacts due to the effects of mining activities are anticipated for the ESP site.

2.6.4.1.3 Construction Groundwater Control

Groundwater at the ESP site generally occurs at depths ranging from about 6 to 58 feet below the present day ground surface, with the exception of the area of the abandoned Units 3 and 4 excavation where groundwater is within about 2 feet of the ground surface. Groundwater levels at the site are such that foundation excavations extending below the water table during plant construction are likely to require temporary dewatering. Any dewatering that may be required would be performed in a manner that minimizes drawdown effects on the surrounding environment. As a result, no adverse environmental impacts due to dewatering are anticipated for the ESP site.

2.6.4.1.4 Unforeseen Geologic Features

Evaluation of the ESP site's geology indicates that no conditions are present that could potentially produce an adverse environmental impact associated with plant construction or operation. The ESP site has not been adversely affected by human activity with respect to the development of natural resources or groundwater withdrawal, nor are any such future activities expected to produce adverse effects at or beyond the site.

2.6.4.2 Seismological Impacts

2.6.4.2.1 Ground Shaking

The upper-bound maximum earthquake magnitude estimate, developed for the Central Virginia and Giles County Seismic Source Zones, ranges from m_b 6.6 to 7.2 (Reference 18). The two largest earthquakes to occur in the ESP site region are the 1875 Goochland County and 1897 Giles County earthquakes with intensities of MMI VII and VIII, respectively. Isoseismal maps indicate that the ESP site would have experienced a shaking intensity of MMI V from these two earthquakes (Reference 22). There is no physical evidence at the site, such as fissuring, liquefaction, landsliding, or lurching, to suggest that the surficial sediments or the underlying bedrock were disturbed by ground shaking during these events.

Damaging earthquake ground shaking is not expected to occur at the ESP site during the life of the new units. However, safety-related structures, systems, and components would be designed to accommodate the maximum horizontal ground accelerations determined for the ESP site. Therefore, adverse environmental impacts resulting from the effects of ground shaking on plant structures would be small.

2.6.4.2.2 Surface Fault Rupture

The seven bedrock faults mapped within the vicinity of the ESP site are not considered to be capable tectonic sources, as defined in RG 1.165, Appendix A (Reference 35). The faults are considered to be old structures that formed during Pre-Cambrian and Paleozoic time, and no deformational or geomorphic features indicative of potential Quaternary activity have been associated with them. No historical seismic activity has been reported as being associated with any of the faults (Reference 23) (Reference 36). Therefore, the resulting environmental impacts of potential surface fault rupture would be small.

2.6.4.3 Geotechnical Impacts

2.6.4.3.1 Settlement

Settlement at the ESP site is only a consideration for structures founded directly on the Zone IIA saprolite. Larger than expected settlement was initially recorded beneath the existing units SWR pumphouse, which is founded on about 65 feet of Zone IIA saprolite, mainly micaceous sand and silt. The settlement was considered to be a result of the weight of the pumphouse itself and the 30 feet of embankment fill built up around it.

The potential for excessive settlement of the Zone IIA saprolite makes it unsuitable, in its natural state, for the support of any safety-related structures due to the possibility of adverse environmental impacts that could result from damage to the structure during plant operation. The Zone IIA saprolite may be used to support safety-related structures if ground improvement methods are used and assuming adequate bearing capacity strengths can be achieved.

2.6.4.3.2 Slope Stability

The only existing slope at the NAPS site with a potential to affect the safety of the new units is the 55-foot high, 2H:1V slope that presently exists between abandoned Units 3 and 4 and the existing units SWR. Static long-term analyses of modification of the existing slope using the computer program SLOPE/W produced a factor of safety in excess of the minimum 1.5 required. Pseudo-static analyses using horizontal and vertical seismic accelerations developed in support of this ESP application produced a factor of safety less than the minimum acceptable value of 1.1. However, when the pseudo-static analyses were run with the seismic input modified to conform to the reductions given by Seed (Reference 37), the computed factor of safety against slope failure is in excess of 1.1.

The Seed reductions are considered reasonable and valid, and the slope is considered to have an adequate factor of safety against failure during the ESP design seismic event.

A new slope may be excavated to the west of the existing SWR to accommodate ultimate heat sinks for the new units. This slope would have the same configuration and composition as the existing slope. The analytical conclusions for the existing slope would apply to the new slope, i.e., the new slope would be stable under seismic and long-term static conditions. If analysis during detailed engineering indicates unacceptable factors of safety against slope failure, modifications would be employed to ensure adequate slope stability.

Based on the preceding discussion, slope failure and the potential environmental implications associated with damage to the facility are not an issue for the new units.

2.6.4.3.3 Liquefaction

Liquefaction of site soils during an earthquake event could affect the safety of the new units by causing foundation bearing failures and excessive settlement and slope failure. Liquefaction can occur when all of the following criteria are met:

- Design ground acceleration is high.
- Soil is saturated.
- Soils are sands or silty sands in a loose to medium dense condition.

At the ESP site, the first criterion is met, and the second criterion applies in many areas of the ESP site. However, the third criterion, involving the type and density of the soil, is less clearly applicable. The Zone IIB soils are extremely dense and the Zone III weathered rock has over 50 percent rock fragments. Neither of these materials meets the loose or medium dense criterion and neither has liquefaction potential.

The only soil at the NAPS site with the gradation and relative density attributes than can potentially result in liquefaction is the Zone IIA saprolite. However, the structure, fabric, and mineralogy of this saprolite substantially reduces its potential for liquefaction. No evidence of liquefaction has been reported at the NAPS site. The possibility of isolated liquefaction effects in localized zones at the site may exist, although the fabric and structure of the soil are considered to minimize such effects. To avoid these zones, structures associated with the new units would not be sited above them, or ground improvement measures would be implemented to mitigate any liquefaction effects. As a result, no adverse environmental impacts associated with possible liquefaction effects at the ESP site are anticipated.

2.6.4.3.4 Excavation

a. **Excavation in Soil and Rock**

Temporary excavations in soil would have slopes no steeper than 1.5H:1V and would be performed in accordance with OSHA regulations. Where there is insufficient space to slope the excavations, vertical cuts would be supported with sheet pile, soldier piles and lagging or other suitable methods. For large excavations, this support may be supplemented by the use of tiebacks that are angled down and anchored, where possible, into bedrock. Temporary excavations into bedrock would be vertical, except where the structure of the rock dips into the excavation, in which case the excavation would be carried out parallel to the dip of the structure (about 1H:1V). The potential for the failure of temporary excavation slopes and walls during construction at the ESP site would be minimized and, therefore, environmental impacts associated with the failure of temporary excavation slopes are anticipated.

b. **Excavation Techniques**

Excavations in the soils at the ESP site are expected to be achieved using conventional excavating equipment. Excavation in the Zone III rock would likely require the use of powerful but conventional earthmoving equipment. Excavation in Zone III-IV and Zone IV rock would likely require the use of blasting techniques followed by removal using appropriate earthmoving equipment. To ensure the integrity of the foundation rock, the stability of the excavated slopes, and to limit the blasting impact on surrounding structures and the environment, controlled blasting techniques, such as pre-splitting use of delays, minimizing blast size, etc., would be utilized. Monitoring of the blast vibrations would be performed to determine blast magnitudes on existing structures and equipment in and around the NAPS site. No adverse environmental impacts resulting from excavation methods or the use of heavy construction equipment are anticipated during construction at the ESP site.

Alternatives to blasting for the excavation of rock at the ESP site would be reviewed and considered prior to selection of the final excavation method. The alternative excavation methods to be considered would likely include thermal lance, plasma gun, pile driver and expandable metal slug, drilling and expansive grout, hydraulic splitter, hoe ram, diamond wire saw, trenching machine, and water jet.

c. **Disposal of Excavated Material**

Excavated material would be disposed of either within the NAPS site boundary or at an offsite disposal area. Whether at or off the site, the disposal area would be identified and approval for the intended purpose obtained in advance of the start of construction. The area would be a stable area, not prone to slumping or sliding, and isolated from waterways or streams. Methods such as re-vegetation and erosion control measures would be used to mitigate the potential for the erosion of material at the disposal site. The topsoil would be removed to accommodate disposal of the material and would be used to cover and re-vegetate the stockpile at the completion of construction. No adverse environmental impacts from the disposal of excavated material are anticipated at or in the area or vicinity of the ESP site.

2.6.4.3.5 **Backfill**

a. **Backfill Material**

Backfill at the ESP site would be a sound, well-graded granular material – either a sandy gravel or a gravelly sand – with less than 10 percent passing the No. 200 sieve. Although a large amount of saprolite would be excavated for the project, the saprolite would not be used as structural fill to support plant structures. An onsite testing laboratory would be established and operated by qualified soils technicians under the direction of a civil or geotechnical engineer to control the quality of the backfill. As a result, no adverse environmental impacts due to the use of poor quality backfill material or the improper placement and compaction of backfill are anticipated at the ESP site.

b. **Source of Backfill**

Backfill material would either be imported or produced at the ESP site. If imported, materials such as dense graded Aggregate (e.g. Size 21A or 21B, as specified by the Virginia

Department of Transportation Road and Bridge Specifications (Reference 38)) would be considered suitable. If the material is produced at the ESP site, a crushing, screening and blending plant would be set up to produce crushed rock to the required gradation specifications for use as structural fill. This would not adversely affect natural resources at or in the vicinity of the ESP site and as a result, no environmental impacts are anticipated.

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Table 2.6-1 Summary of Geotechnical Engineering Properties

Stratum	IIA		IIB	III	III-IV	IV
	Coarse-grained	Fine-grained				
Description	**Saprolite**	**Saprolite**	**Saprolite w/10 to 50% Core Stone**	**Moderately to Highly Weathered Quartz Gneiss w/Biotite**	**Slightly to Moderately Weathered Quartz Gneiss w/Biotite**	**Fresh to Slightly Weathered Quartz Gneiss w/Biotite**
Rock properties						
Recovery,%	-	-	-	60	90	100
RQD,%	-	-	-	20	50	95
Unconfined compressive strength, ksi	-	-	-	0.6	4	12
USCS symbol	SP, SM, SC	ML, CL, MH, CH	Mainly SM	-	-	-
Range of fines content,%	15 to 45	-	-	-	-	-
Natural moisture content, w,%	-	26	-	-	-	-
Undrained shear strength, c_u, ksf	-	2.0	-	-	-	-
Effective cohesion, c′, ksf	0.25	0.5	-	-	-	-
Effective friction angle, ϕ', degrees	30	25	40	-	-	-
Total unit weight, γ, pcf	125		130	145	163	163
SPT N-value, N_{60}, blows/ft	20		100	-	-	-
Shear and compression wave velocity						
Shear wave velocity range, ft/sec	600 to 1350		-	-	-	4000 to 8000
Shear wave velocity average, ft/sec	950		1600	2000	3300	6300
Compression wave velocity average, ft/sec	2100		3500	4500	7400	14,000
Elastic and shear moduli						
Elastic modulus (high strain), E_{hs}	1200 ksf		3500 ksf	120 ksi	1000 ksi	3750 ksi
Elastic modulus (low strain), E_{ls}	9500 ksf		28,000 ksf	300 ksi	1000 ksi	3750 ksi
Shear modulus (high strain), G_{hs}	450 ksf		1300 ksf	50 ksi	375 ksi	1400 ksi

Table 2.6-1 Summary of Geotechnical Engineering Properties

Stratum	IIA		IIB	III	III-IV	IV
	Coarse-grained	Fine-grained				
Description	Saprolite	Saprolite	Saprolite w/10 to 50% Core Stone	Moderately to Highly Weathered Quartz Gneiss w/Biotite	Slightly to Moderately Weathered Quartz Gneiss w/Biotite	Fresh to Slightly Weathered Quartz Gneiss w/Biotite
Shear modulus (low strain), G_{ls}	3500 ksf		10,000 ksf	125 ksi	375 ksi	1400 ksi
Consolidation characteristics						
Recompression ratio, RR	0.015		-	-	-	-
Coeff. of secondary compression, C_α	0.0008		-	-	-	-
Coeff. of subgrade reaction, k_1, kcf	230		1,500	-	-	-
Coefficient of sliding against concrete	0.35		0.45	0.6	0.65	0.7
Poisson's ratio, μ (high strain)	0.35		0.3	0.33	0.33	0.33
Static earth pressure coefficients						
Active, K_a	0.33		0.22	-	-	-
Passive, K_p	3.0		4.6	-	-	-
At-rest, K_o	0.5		0.36	-	-	-
Hydraulic conductivity, cm/sec	5×10^{-4}		-	-	-	-

Note:"-" denotes no design parameter given.

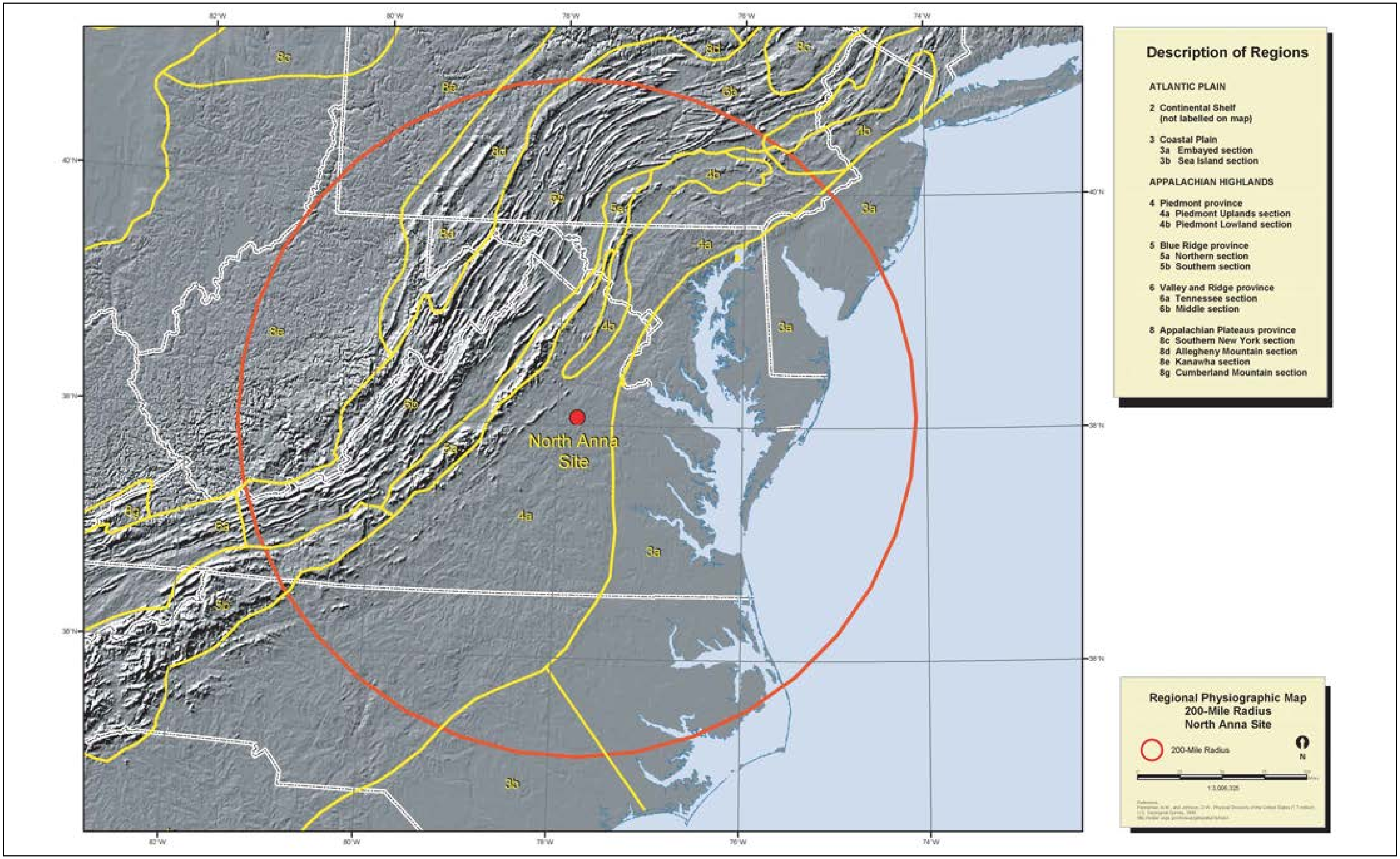


Figure 2.6-1 Regional Physiographic Map (200-Mile Radius)

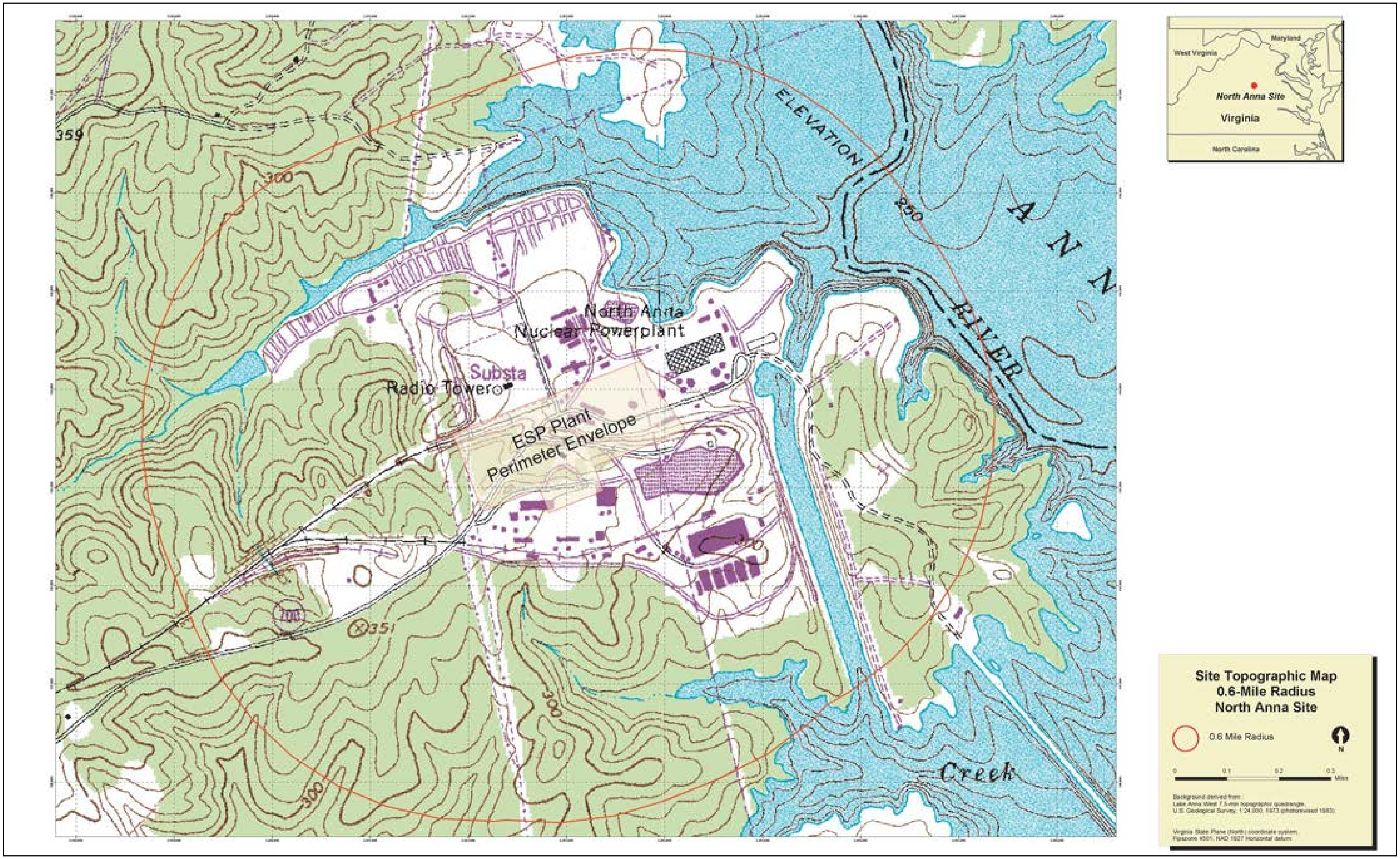


Figure 2.6-2 Site Topographic Map (0.6-Mile Radius)

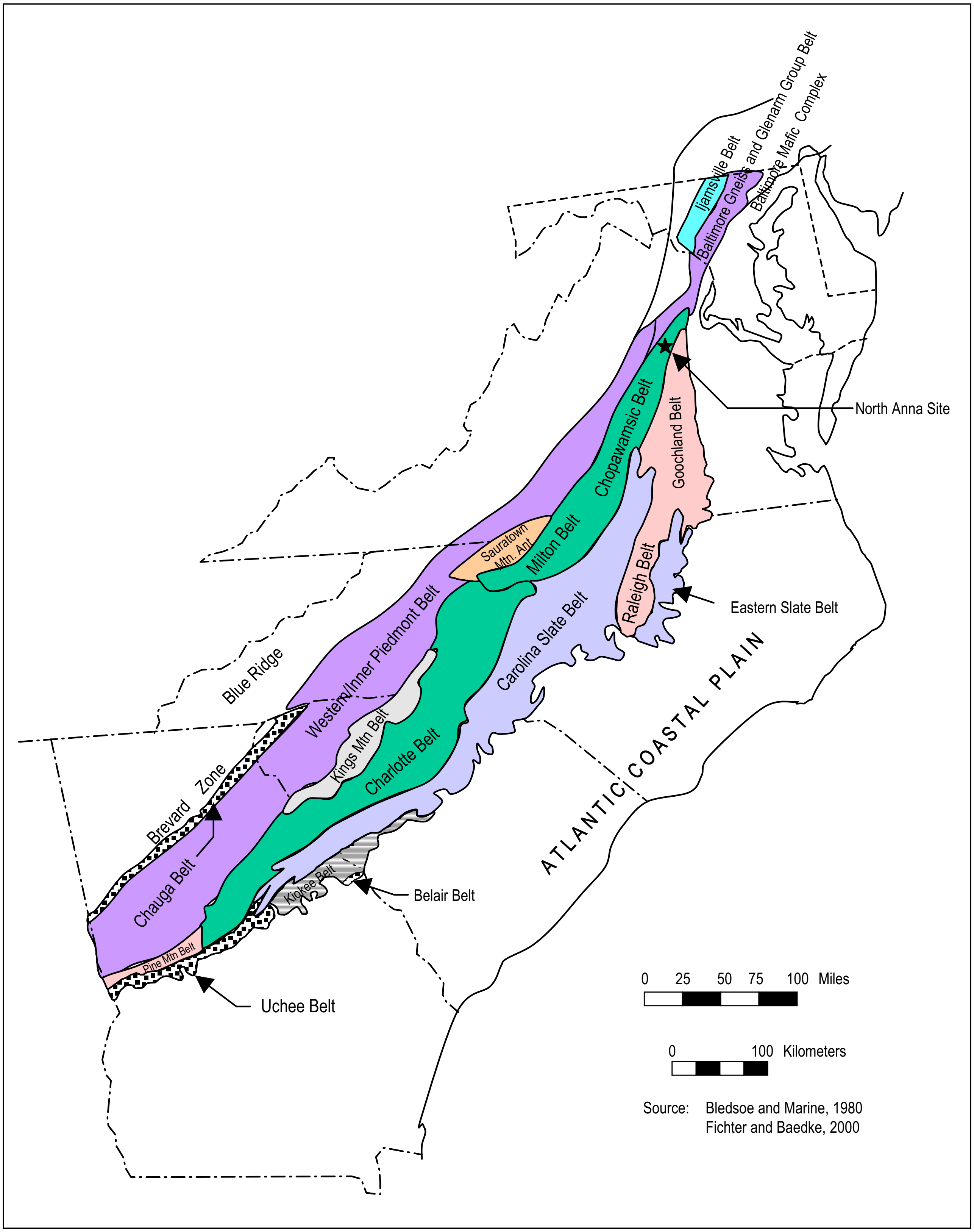


Figure 2.6-3 Lithotectonic Belts of the Piedmont Province

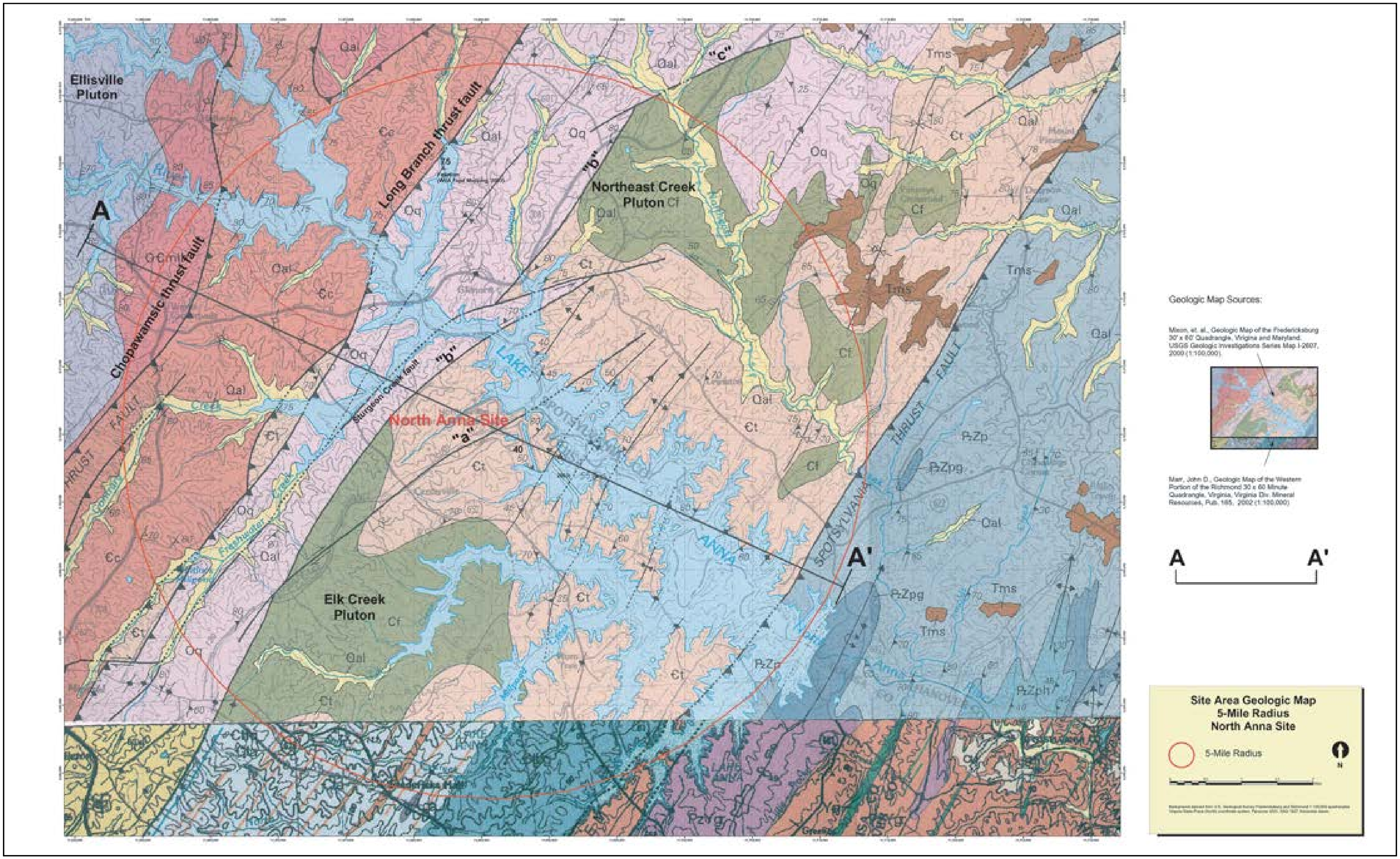


Figure 2.6-4 Site Area Geologic Map (5-Mile Radius) (Sheet 1 of 2)

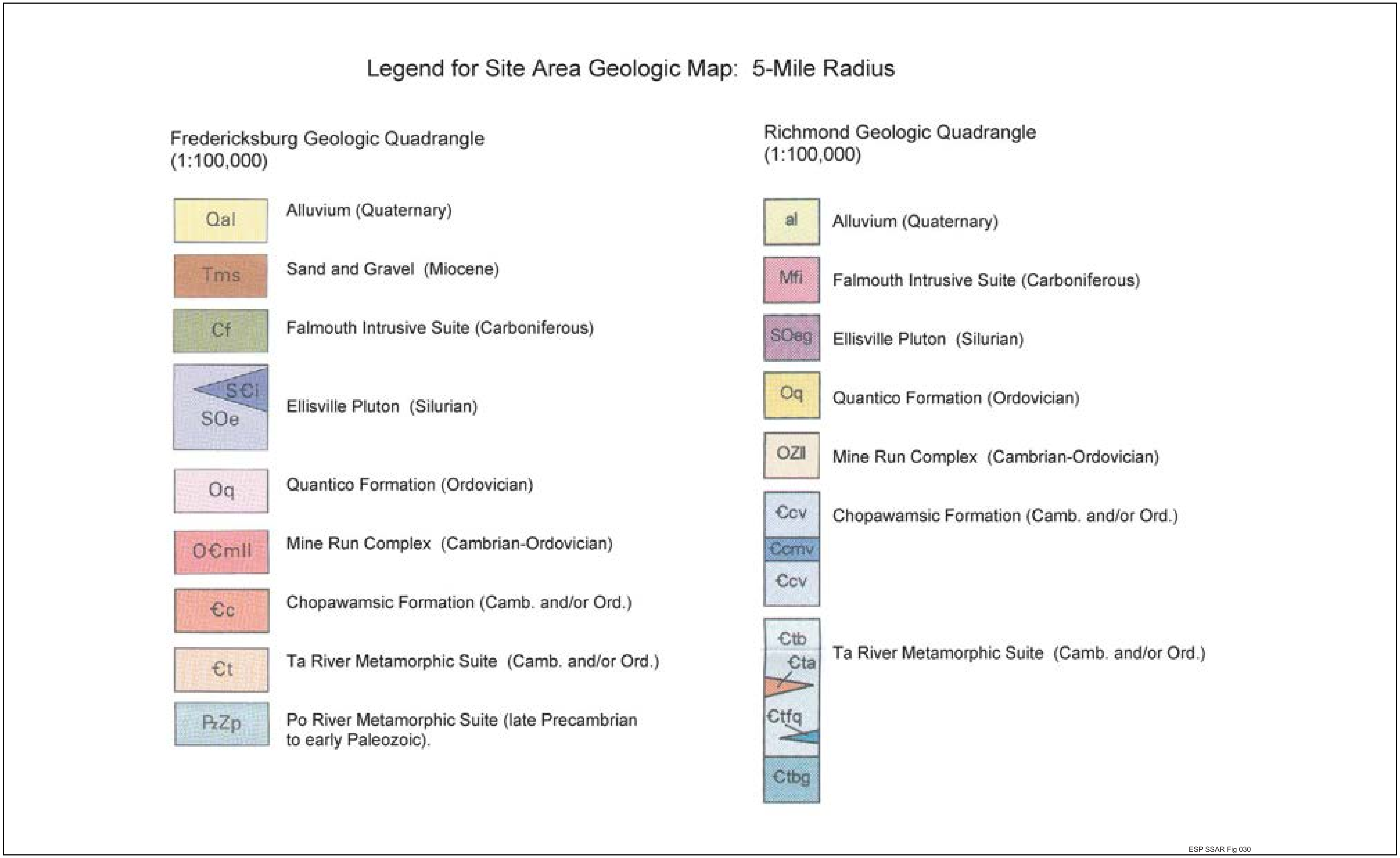
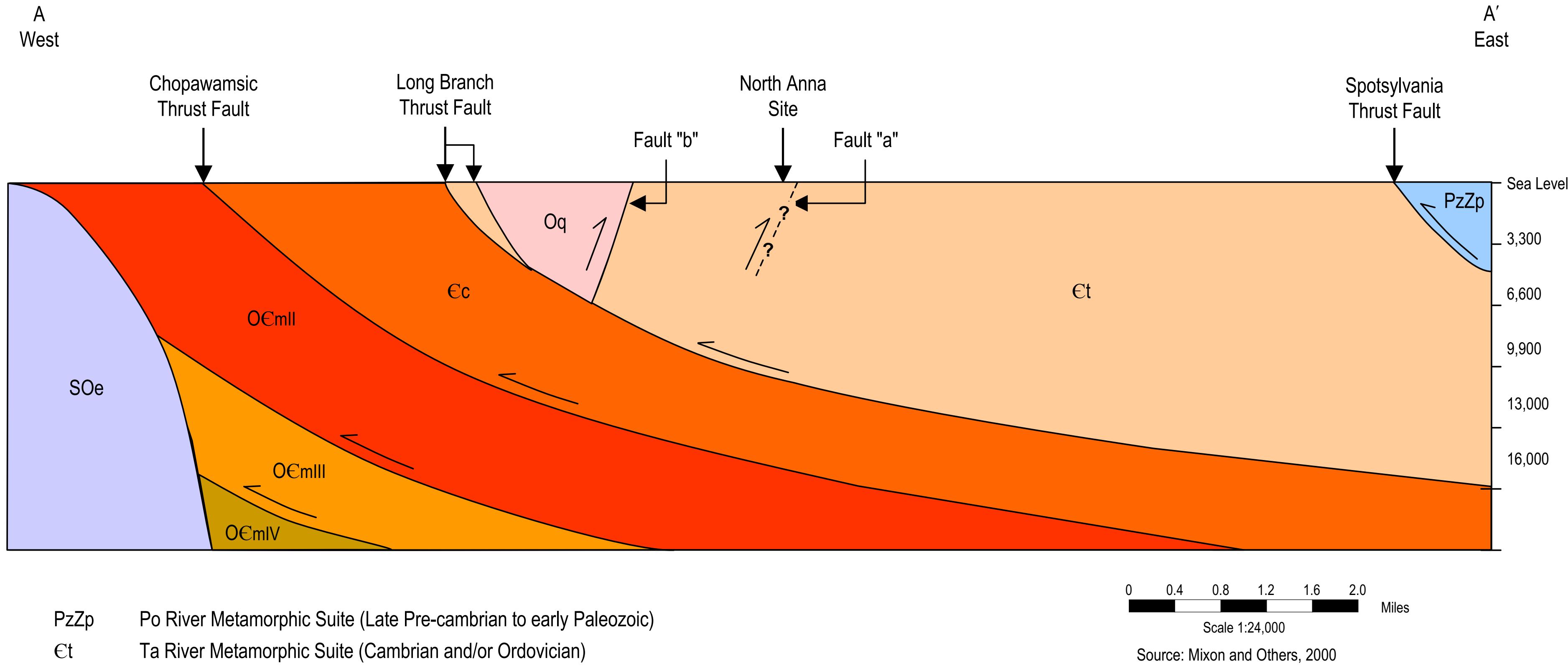


Figure 2.6-4 Site Area Geologic Map (5-Mile Radius) (Sheet 2 of 2)



PzZp	Po River Metamorphic Suite (Late Pre-cambrian to early Paleozoic)
Єt	Ta River Metamorphic Suite (Cambrian and/or Ordovician)
Єc	Chopawamsic Formation (Cambrian and/or Ordovician)
OЄmII	Melange Zone II (Cambrian and/or Ordovician)
OЄmIII	Melange Zone III (Cambrian and/or Ordovician)
OЄmIV	Melange Zone IV (Cambrian and/or Ordovician)
Oq	Quantico Formation (Ordovician)
SOe	Ellisville Pluton (Silurian)

Figure 2.6-5 Site Area Geologic Cross Section (5-Mile Radius)

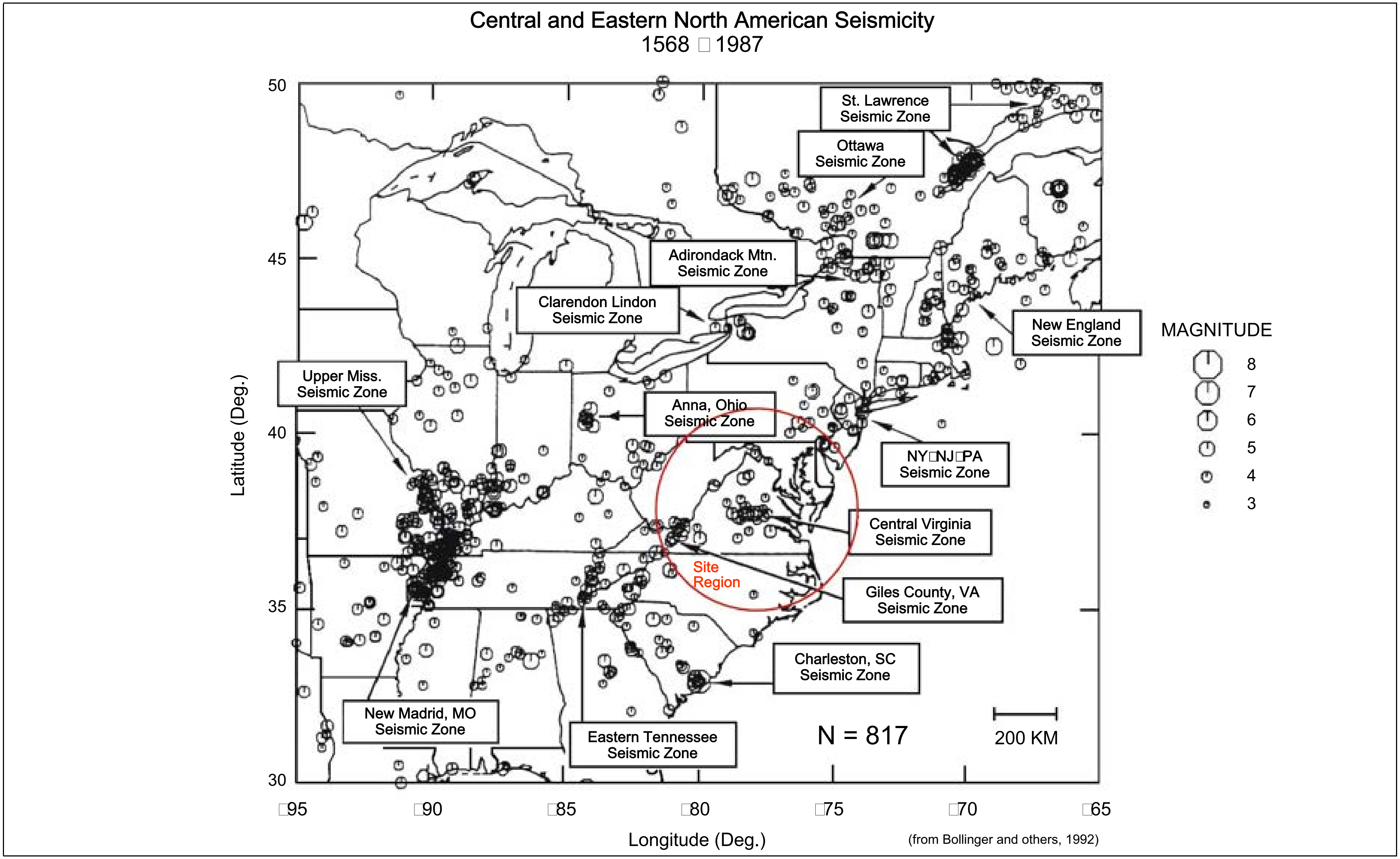


Figure 2.6-6 Seismic Source Zones and Seismicity in Central and Eastern North America

2.7 Meteorology and Air Quality

This section describes the general climate of the ESP site and the regional meteorological conditions used as the basis for design and operational conditions of the new units. This section also provides meteorological information that has been used to evaluate construction and operational impacts.

2.7.1 General Climate

The description of the site general climate is based on regional climatological and meteorological information primarily collected for Richmond, Virginia, and supplemented by the meteorological information collected at the NAPS site. In addition, observations taken at NWS cooperative network stations in the ESP site have been used to supplement the data from Richmond and the NAPS site.

2.7.1.1 General Description

The climate in the Piedmont region of Virginia, where the ESP site is located, is classified as modified continental. Summers are warm and humid and winters are generally mild. The Blue Ridge Mountains to the west act as a partial barrier to outbreaks of cold, continental air in winter. The mountains also tend to channel winds along a general north-south orientation. Temperatures in the site region rarely exceed 100°F or fall below 0°F. (Reference 1)

Based on 30 years of data (1961–1990), the area around the site receives an annual average rainfall of approximately 43.2 inches. Rainfall is fairly well distributed throughout the entire year, with the exception of July and August, when thunderstorm activity raises monthly totals to about 5.0 inches (Reference 1). Tropical cyclones can also contribute substantially to the precipitation totals and to extreme precipitation events.

The 60-year climatological records show that the monthly average snowfall of 4 inches or more occurs only in January. Snow usually remains on the ground only 1 or 2 days at a time. Richmond averages about 16.3 inches of snow a year (Reference 1).

In general, during light wind conditions, the local environmental conditions predominate, resulting in a channeling effect of winds such that the airflow patterns follow the topographical contour lines of the region. Lake Anna has a moderating effect with respect to extreme temperatures in the immediate vicinity of the site. During periods of temperature inversions or light wind conditions, the local dispersion conditions can be somewhat restricted (Reference 2, Section 2.3.1.2.1).

The existing units' Meteorological Monitoring Program began operations in 1971. The system was upgraded in 1978 in accordance with the criteria of RG 1.23 (Reference 2, Section 2.3.3.2.5.1). Data collected by the existing units' meteorological monitoring system is representative of long-term site meteorological conditions. However, long-term regional climatological data are considered more suitable for use for estimates of climatological extremes. Therefore, design and operating basis conditions (probable maximum precipitation, tornado parameters, snow load, ice thickness, etc.) are based primarily on regional climatological data.

2.7.1.2 Winds

The climatological data indicate that while Richmond's prevailing wind is southerly on an annual basis, there are 6 months when the prevailing wind direction is northerly. The annual average wind speed is 7.9 mph. The monthly average wind speed is slightly lower during the summer season. The monthly average wind speed is highest during late winter and early spring. The maximum 2-minute average wind speed is 46 mph, while the maximum 5-second wind speed is 60 mph.

Based on the data collected from 1974 to 1987 (see Table 2.7-7), the average wind speed is 6.3 mph. Similar to Richmond, the average onsite summer wind speed (5.4 mph) is also lower than those during other seasons (Reference 2, Section 2.3).

2.7.1.3 Temperature

Annual average temperature is 58.2°F in Richmond, based on an 81-year period of record for that station, while the monthly average temperature ranges from the high 30s in January to the high 70s in July. Extreme temperatures recorded in Richmond range from a maximum of 105°F to a minimum of –12°F (Reference 1).

The annual average temperature onsite is 55.8°F, the monthly average temperature ranges from 33.6°F in February to 75.0F° in July (Reference 2, Section 2.3).

2.7.1.4 Atmospheric Moisture

Annual average relative humidity in Richmond is 70 percent. The early morning relative humidity is highest during August and September, with an average of 90 percent. Heavy fog conditions with visibility less than 0.25 mile are infrequent, on average occurring 27.2 days per year (Reference 1).

2.7.1.5 Precipitation

Annual precipitation in Richmond is about 43 inches, based on the 1961 to 1990 period. For the 64-year period (1938–2001), the maximum annual precipitation of 61.3 inches was measured in 1975. During the same period, the minimum annual precipitation of 22.9 inches occurred in 1941 (Reference 1) (Reference 3).

On average, about 48 percent of the annual precipitation at Richmond occurs from May through September each year. Generally, July has the highest amount of precipitation. The normal monthly totals range from about 3 to 5 inches. On average, there are about 11 days per year with precipitation greater than 1.0 inch. The maximum 24-hour precipitation was about 8.8 inches (August 1955). This event was associated with the remnants of Hurricane Connie as presented in Section 2.7.3.4.

Snowfall normally occurs from November through March, with an annual average of 16.3 inches for the 1961 to 1990 period. The monthly maximum snowfall measured in the region was 29.8 inches in Charlottesville in March 1960 (Reference 21). The maximum 24-hour snowfall observed in Richmond was 21.6 inches in January 1940. Annually, there are 4.3 days with snowfall greater than 1.0 inch. (Reference 1)

2.7.2 Regional Air Quality

2.7.2.1 Background Air Quality

The ESP site is in Louisa County, Virginia, which is within the Northeastern Virginia Intrastate AQCR. This region is designated as in attainment or unclassified for all criteria pollutants except $PM_{2.5}$ as noted below. The City of Richmond is within the State Capital Intrastate AQCR. This AQCR is also designated as attainment or unclassified for all criteria pollutants (40 CFR 81.347). Criteria pollutants are those for which NAAQSs have been established, such as SO_2, PM_{10}, $PM_{2.5}$, CO, Ozone, NO_2, and lead (Reference 42). Attainment areas are areas where the ambient air quality levels are better than EPA-designated ambient air quality standards.

The Commonwealth of Virginia is also subject to a revised 8-hour ozone standard and a new ambient air quality standard for $PM_{2.5}$, both promulgated by the EPA in July 1997 (Reference 5) (Reference 6). $PM_{2.5}$ refers to particles with an aerodynamic diameter less than or equal to 2.5 nominal micrometers. The EPA is taking steps to implement the new standard but has not yet designated the non-attainment areas for $PM_{2.5}$. Currently, Louisa County is designated as in attainment for both the ozone 1-hour and 8-hour standards.

The EPA has designated Class I Areas as areas with pristine air quality, such as wilderness areas, national parks, and Indian Reservations. There are two Class I Areas in Virginia: James River Face Wilderness and Shenandoah National Park, in which visibility is an important issue (Reference 7). The Shenandoah National Park is located closer to the ESP site (42 miles away) than is the James River Face Wilderness.

2.7.2.2 Projected Air Quality

VDEQ regulates airborne emissions at the NAPS site. Virginia Power holds an Exclusionary General Permit from VDEQ under Title 9 of the Virginia Administrative Code for all non-radiological airborne emissions resulting from plant operations. These emission sources at the NAPS site include two auxiliary boilers, four emergency diesel generators (3840 HP each), and a blackout generator (4640 HP). No air emission monitoring is performed at the site. Compliance under the Exclusionary General Permit is based on fuel sulfur content and fuel consumption records. Annual operation of the auxiliary boilers and the diesel generators is limited under the permit to 3000 and 500 hours, respectively. Under the terms of the permit, Virginia Power provides VDEQ with emissions update information and compliance certification annually (Reference 8).

The number of new unit-related non-radiological emission sources (i.e., auxiliary boilers, emergency diesel generators or station blackout generators, and cooling towers) on the ESP site is unknown at this time. However, these new emission sources would be regulated under the VDEQ air regulations. If Dominion decides to build the new units, Dominion would provide the required emissions update information to VDEQ. These future non-radiological emission sources would not be expected to cause significant impacts to ambient air quality or to visibility in Class I areas. New unit sources such as emergency and station blackout generators would only be operated for short time periods during tests or in the event of a loss of station power. In addition, the distances between the ESP site and the Class I areas are relatively long.

2.7.2.3 Inversion and High Air Pollution Potential

In the ESP site region, the annual frequency of occurrence of low-level inversions or isothermal layers based at or below 500 feet in elevation is approximately 30 percent according to Hosler (Reference 9). Seasonally, the greatest frequencies of inversions occur during the fall and winter (34 percent and 33 percent, respectively). Spring and summer have the lowest inversion frequencies (about 28 percent of the time for each season). Most of these inversions are nocturnal in nature, generated through nighttime cooling.

The mean maximum mixing height depth (MMMD) is another indication of the restriction to atmospheric dilution at a site. The mixing depth is the distance above the ground in which relatively free vertical mixing occurs in the atmosphere (Reference 10). According to Holzworth, the annual afternoon MMMD value for the ESP site region is about 4900 feet (Reference 11). The seasonal afternoon MMMD values for the ESP site during fall and winter are about 4600 feet and 3300 feet, respectively. Shallow mixing depths have a greater frequency of occurrence during the fall and winter seasons: fall and winter have a higher frequency of inversions. The actual effect of the mixing height on pollutants emitted within the mixing depth is determined by the actual hourly mixing heights.

2.7.3 Severe Weather

2.7.3.1 Thunderstorms, Hail, and Lightning

Based on a 65-year period of record, Richmond averages 36 thunderstorm-days per year. July has the highest frequency of occurrence, about 8 days, on average (Reference 1).

Hail can occur at any time of the year and is associated with well-developed thunderstorms, but has been observed primarily during the spring and summer months. The latest version of the Climate Atlas of the United States (Reference 40), published by the NCDC in 2002 and developed from observations made over the 30-year period of record from 1961 to 1990, indicates that Louisa and Spotsylvania Counties can expect, on average, hail with diameters greater than or equal to 0.75 inch about one day per year. The occurrence of hailstorms with hail greater than or equal to 1.0 inch in diameter averages less than one day per year.

However, the annual mean number of days with hail 0.75 inch or greater is slightly higher in nearby southern and eastern Hanover County (just to the southeast of the ESP site), eastern Goochland County (south of the ESP site) and Henrico County (also southeast of the ESP site), ranging from one to two days per year. Similarly, hailstorms with hail 1.0 inch or greater occur about one day per year on average. The NCDC cautions that hailstorm events are point observations and somewhat dependent on population density.

While no hailstorms of note have been recorded in some years, multiple events have been observed in other years including four in Louisa County during 1998 and three in Spotsylvania County during 1993, both with diameters up to 1.75 inches (Reference 41). Therefore, the slightly higher annual mean number of hail days may be a more representative frequency for the relatively less-populated ESP site area.

In terms of extreme hailstorm events, softball size hail (about 4.5 inches in diameter) has been observed in recent years at two locations in the general ESP site area (Reference 41) - on June 4, 2002 at Free Union, just northwest of Charlottesville in Albemarle County (about 42 miles west of the ESP site) and on May 4, 1996 at Lignum in central Culpeper County (about 28 miles north-northwest of the ESP site).

The mean frequency of lightning strikes to earth can be estimated using a method reported by EPRI (Reference 13). The EPRI formula assumes a relationship between the average number of thunderstorm-days per year (T) and the number of lightning strikes to earth per square mile per year (N).

$$N = 0.31\ T$$

As indicated previously, there are 36 thunderstorm-days per year, on average, at Richmond (Reference 1). Consequently, the number of lightning strokes to earth per square mile is about 11.2 per year. The ESP site plant envelope area is approximately 0.068 mi^2. Using this area as the potential reactor area, the annual average number of lightning strokes in the reactor area can be calculated as follows:

$$11.2/mi^2/year \times 0.068\ mi^2 = 0.76 \text{ lightning strokes per year at the ESP site}$$

2.7.3.2 Tornadoes and Severe Winds

Based on the period of record, 1953-1999 (Reference 14), Virginia ranks 28th in the U.S. for average annual number of tornadoes.

During the period from January 1950 through December 2003, a total of 235 tornadoes were reported within a 2-degree square area around the ESP site (Reference 12). This averages 4.35 tornadoes per year within this area, which includes counties in Virginia, West Virginia, and Maryland, and the District of Columbia. Among those 235 tornadoes, 204 occurred in Virginia, 29 in Maryland, 2 in the District of Columbia, and none in West Virginia. For the same period of record, the tornado intensities, based on the Fujita-Pearson Tornado Scale, and the number of tornado occurrences in the entire Commonwealth of Virginia are presented in Table 2.7-2.

During the 54-year period (1950–2003), 433 tornadoes were reported in Virginia (Reference 12). This is equivalent to about 8 tornadoes per year. In Louisa County and the immediately adjacent four-county area (Hanover, Spotsylvania, Caroline, and Orange counties), 7 tornadoes were reported in Louisa County, 5 in Hanover County, 5 in Spotsylvania County, 8 in Orange County, and 5 in Caroline County. No F3 or higher intensity tornadoes were reported in Louisa or Spotsylvania counties.

As discussed in the Technical Basis for Regional Tornado Criteria (WASH-1300) (Reference 36), according to statistical methods proposed by Thom, the probability of a tornado striking a point within a given area may be estimated as follows (Reference 15):

$$P = \frac{z \times t}{A}$$

where:

P = the mean probability per year
z = the mean path area of a tornado
t = the mean number of tornadoes per year
A = the area of concern

The Event Record Details provided in the Storm Events report list the path length and path width of each specific tornado (Reference 12). For tornado events within the 2-degree square area around the ESP site, according to the available recorded data, the calculated mean tornado path length is 3.1 miles and the calculated mean path width is 116.7 yards. These values yield a z value of 0.2056 square mile. Using a 2-degree square area as a basis for A and a value of 4.35 tornadoes per year yields an annual probability of 5.94×10^{-5}, or a recurrence interval of 16,835 years. The strike probability, multiplied by the intensity probability yields the total probability that a tornado of a certain strength will strike a certain area.

According to American National Standard ANSI A58.1-1982, the operating basis wind velocity at 33 feet (10 meters) above ground level in the ESP site area associated with a 100-year return period is 64 miles per hour (Reference 38). Values for other recurrence intervals are listed in Table 2.7-3 (Reference 38). The fastest-mile-wind speed is defined as the passage of one mile of wind with the highest speed for the day. The fastest-mile-wind speed at Richmond (68 miles per hour) was recorded at that station in October 1954 (Reference 17). The 3-second gust wind speed that represents a 100-year return period is 96 mph at 10 meters above ground. This wind speed was determined in accordance with the guidance in Reference 37.

2.7.3.3 Heavy Snow and Ice Storms

Frozen precipitation typically occurs in the form of hail (already discussed in Section 2.7.3.1), snow, sleet and freezing rain. The frequency of occurrence of these types of weather events in the ESP site area are based on the latest version of the Climate Atlas of the United States (Reference 40).

The data indicate that the occurrence of snowfalls greater than or equal to 1 inch in the ESP site area ranges from about three to five days per year. However, the frequency of such snow events increases to the west and northwest of the ESP site in far western Louisa County, north-central Fluvanna County, and much of Albemarle and Orange Counties, ranging between 6 and 10 days per year. In general, these differences can be attributed to topographic effects.

On the other hand, the frequency of snowstorms of greater magnitude is similar over the ESP site area because the weather systems that produce such events often affect fairly large areas. On average, the data indicate that daily snowfall totals greater than or equal to thresholds of 5 and 10 inches occur less than one day per year.

Freezing rain falls as a liquid but freezes upon impact forming a glaze on the ground or other exposed objects whose temperature is typically near or below 32°F (0°C). It frequently occurs during the transition from winter rains to ice pellets (sleet) or snow and vice versa depending on the characteristics of the air mass. The Climate Atlas indicates that freezing precipitation events occur, on average, about six to ten days per year in the ESP site area.

2.7.3.4 Tropical Cyclones

On average, a tropical cyclone, or its remnants, can be expected to impact some part of the Commonwealth of Virginia each year (Reference 20). Tropical cyclones include not only hurricanes and tropical storms, but systems classified as tropical depressions, sub-tropical depressions and extra-tropical storms, among others.

This characterization considers all “tropical cyclones” (rather than systems classified only as hurricanes or tropical storms) because storm classifications are generally downgraded once landfall occurs and the system weakens although it may still result in significant rainfall events as it travels through the site region.

A comprehensive database of historical tropical cyclone tracks (i.e., currently extending from 1851 through 2003), available through the NOAA’s Coastal Services Center and based on information compiled by the National Hurricane Center (Reference 39), indicates that a total of 55 tropical cyclone centers or storm tracks have passed within a 100-nautical mile radius of the North Anna ESP site. Storm classifications and respective frequencies of occurrence over this period of record are as follows:

- Hurricanes - Category 3 (1), Category 2 (1), and Category 1 (5)
- Tropical Storms - 27

- Tropical Depressions - 13
- Subtropical Depressions - 1
- Extra-Tropical Storms - 7

Tropical cyclones are responsible for at least two separate record rainfall events in the North Anna ESP site area. In August 1969, Hurricane Camille, a tropical depression by the time it passed through the area within 100-nautical miles of the site, resulted in a record 24-hour (daily) rainfall total of 11.18 inches at the nearby Louisa observation station (see Section 2.7.4.1.5). The Louisa station is part of the National Weather Service's cooperative climatological network.

In August 1955, Hurricane Connie passed within about 120 nautical miles of the site at its closest approach. Although not included in the count of tropical cyclones above, Connie, then classified as a tropical storm, was responsible for the current record 24-hour (daily) rainfall total at Richmond Byrd International Airport (i.e., 8.79 inches) (see Section 2.7.1.5).

2.7.4 **Local Meteorology**

Data acquired from the NCDC (in Asheville, NC) have been used to determine the normal, means, and extremes of temperature, precipitation, relative humidity, and fog applicable to the ESP site. The 2001 Richmond Local Climatological Data (Reference 1) provides detailed climatological data for this first-order station. Climatological summaries for other stations in the area also provide supplemental information (Reference 21 through Reference 25).

The approximate distance and direction of the Richmond NWS station and at other nearby locations in the NWS' network of cooperative observing stations in the ESP site area are provided in Table 2.7-1:

Table 2.7-1 NWS and Cooperative Observing Stations Near the ESP Site

Station	Distance (miles)	Direction
Partlow 3WNW	5	East
Louisa	12	West
Piedmont Research Station	21	Northwest
Fredericksburg Nat'l Park	26	Northeast
Charlottesville 2W	40	West
Richmond	46	Southeast

The closest station, Partlow 3WNW, was closed on December 31, 1976 (Reference 26); therefore, recent data are not available from this station.

Besides using data from the nearby meteorological and climatological observing stations, data collected from the existing units' meteorological monitoring system was also used to characterize local meteorological conditions. The onsite primary meteorological tower is about 1750 feet east-northeast from the Unit 1 containment building (see Figure 2.7-1 and Figure 2.7-2). Based on proximity, the meteorological parameters (i.e., wind speed and wind direction) collected by the tower are representative of the ESP site. Consequently, they are appropriate for use in describing local meteorological conditions.

2.7.4.1 **Normal and Extreme Values of Meteorological Parameters**

A summary of normal and extremes of available temperature, precipitation, relative humidity, and fog are presented for Richmond in Table 2.7-4. Climatological means for Richmond and stations in the site region are presented in Table 2.7-5. Monthly temperature means for other applicable stations are presented in Table 2.7-6.

2.7.4.1.1 **Wind Direction, Wind Speed and Wind Persistence**

The distribution of wind direction and speed is an important consideration when evaluating transport conditions relevant to site diffusion climatology. The topographic features of the site region and/or the general circulation of the atmosphere (i.e., movement of pressure systems and location of semi-permanent zones) are factors in influencing the wind direction within the site region. For the ESP site, the prevailing wind is from the south-southwest during the summer season and from the northwest and north during the winter season. These wind directions are due primarily to the location of the Bermuda High off the eastern coast of the United States during the summer season, and the development of a cold high-pressure zone over the eastern portion of the United States during the winter season.

However, the topographic features of the ESP site region, in conjunction with the movement of pressure systems and the location of the semi-permanent pressure zones, have a definite influence on the wind direction distribution. The Blue Ridge Mountains, which are oriented in a south-southwest to north-northeast direction, are approximately 40 to 50 miles northwest of the ESP site. Consequently, the prevailing winds during the summer season are from the south and south-southwest because of the channeling effect created by the presence of the Blue Ridge Mountains. Additionally, the Blue Ridge Mountains act as a barrier to the prevailing westerly winds at the surface; but even more so, they act as a barrier to the movement of low-pressure cells from the Gulf of Mexico region to the northeast portion of the United States. Consequently, low-pressure cells that are generated in the Gulf are frequently forced to move toward the east on the back (west) side of the Blue Ridge Mountains, therefore, resulting in a southerly flow of air in the ESP site region instead of a southeasterly or easterly wind.

Topographic features also have a definite influence with respect to the wind direction during periods of light winds. Usually, during episodes of near calm, the pressure gradient is weak and there is no organization in the general circulation. However, due to topographic effects such as the presence of

Lake Anna, the airflow typically follows the contour lines of the land. Air is channeled along Lake Anna and the North Anna River Valley during light wind conditions. If there is a sufficient temperature gradient between the ambient air over the lake and surrounding land, a weak lake breeze could form. However, the lake breeze would affect only the area in the immediate vicinity of the lake (less than 1 mile) (Reference 2, Section 2.3.2.2.1.1).

The seasonal and annual average distributions of wind direction based on data collected at the existing units' primary tower are presented in Figure 2.7-3 through Figure 2.7-12 for the lower (33 ft) and upper (159 ft) levels (Reference 2). Winds occur on an annual basis along a north-south orientation with a general westerly component. Wind direction distributions based on the lower level data are similar to those based on the upper level data. However, the upper level data indicate a more distinct north-south orientation of wind flows. Wind data at Richmond show a south-southwest/north orientation that is similar to the general wind flow at the ESP site (Reference 1).

Wind direction distributions show seasonal variations. The frequencies of northerly and southerly winds are generally equivalent during the fall season. Winds from the northwest and south-southwest sectors characterize wind flows during the winter. During the spring season, the wind flow is predominantly from the northwest at the lower level. During the summer months, the predominant wind is from the south-southwest.

Atmospheric dilution is directly proportional to the wind speed (other factors remaining constant). The seasonal and annual mean wind speeds for the ESP site are presented in Table 2.7-7. As indicated in the table, mean wind speeds show seasonal variations.

The mean annual wind speeds at the ESP site are 6.3 mph and 8.6 mph at the lower and upper tower level, respectively. The annual frequencies of calm are 0.37 and 0.75 percent for the lower and upper tower levels, respectively (Reference 2, Section 2.3.2.2.1.1).

Wind persistence is important when considering potential effects of a radiological release. It is defined as a continuous flow from a given direction or range of directions. Wind persistence roses for meteorological data collected at the NAPS site are presented in Figure 2.7-13 through Figure 2.7-22. The maximum 22.5-degree range direction persistence episodes recorded at NAPS during the period of record from the data for the lower level was a 26-hour wind from the north. The maximum persistence period at the upper level was 33 hours from the west-northwest. In general, extreme persistence periods (greater than 18 hours) at the ESP site are associated with moderately high winds and relatively low or moderate turbulence (Reference 2, Section 2.3.2.2.1.2).

2.7.4.1.2 **Atmospheric Stability**

Atmospheric stability, as applied in this report, is determined by the delta T method defined by the NRC (Reference 2, Section 2.3.3.2).

The seasonal and annual frequencies of stability classes and associated wind speeds for the ESP site are presented in Table 2.7-8. The vertical stability data, based on delta T site measurements, indicate the predominance of neutral and slightly stable conditions (Reference 2, Section 2.3.2.2.1.1).

Extremely unstable conditions (Stability Class A) are more frequent and extremely stable conditions (Stability Class G) are less frequent during the summer than during the winter. This situation is attributed to the greater solar heating of the surface during the summer and the large-scale restrictive dilution conditions (presented in Section 2.7.2.3) that generally occur during the winter. Also, ground snow cover is conducive to the formation of stable (or inversion) conditions.

Instrumentation is available in the main control room of the existing units by which personnel can identify atmosphere stability. The existing units' Emergency Plan Implementing Procedures identify station-specific instructions and appropriate temperature values for determining RG 1.23, Table 2 atmospheric stability classifications. This stability classification method allows for the rapid assessment of pertinent meteorological parameters by control room personnel in the event of an accidental release of radioactive material to the atmosphere.

2.7.4.1.3 **Temperature**

Ambient temperature at the ESP site is measured by the primary tower at the 33-foot level, and differential temperature is measured between the 33-foot and 158.9-foot levels. The annual onsite average temperature, as reported in Reference 2, is 55.8°F, while the annual average temperature in Richmond is 58.3°F, based on the period of record from September 16, 1971 to September 15, 1972. A higher annual average for Richmond is expected because the ESP site is in a rural area, which tends to have slightly lower average temperature than large cities that are influenced by the heat-island effect. In addition, the presence of Lake Anna would also moderate the site temperature.

The annual average temperature measured in Louisa (Reference 23) is 56.1°F, based on the long-term climatological record for that station. Similarly, the nearby Partlow 3WNW station, located in southern Spotsylvania County, has a long-term annual average temperature of 55.2°F. (Reference 25)

2.7.4.1.4 **Atmospheric Moisture**

The relative humidity data collected in Richmond is described in Section 2.7.1.4. These data are representative of the ESP site area due to its similar exposure to the Atlantic shore.

Based on 24-year (1973–1996) records, the 0.4 percent, 1 percent, and 2 percent wet-bulb temperatures measured in Richmond are 79°F, 78°F, and 77°F, respectively (Reference 43). Wet bulb temperature is used for cooling system-modeling studies.

2.7.4.1.5 Precipitation

As stated in Section 2.7.1.5, the annual precipitation in Richmond is about 43 inches. This annual total is representative of conditions at the ESP site. Based on a 30-year (1951–1980) period, the annual precipitation recorded in Louisa averages 42.08 inches (Reference 23). The annual precipitation in Partlow 3WNW (1952–1971) is about 42.2 inches (Reference 25). In Louisa, the maximum 24-hour precipitation is 11.18 inches (August 1969), while the maximum monthly precipitation is about 16.3 inches (August 1969). The Richmond monthly average precipitation ranges from about 3 to 5 inches (Reference 1), while in Louisa, the monthly averages range from about 3 to 4.5 inches (Reference 23).

In Louisa, the annual snowfall averages about 20 inches (Reference 23). The Partlow 3WNW annual snowfall averages 18.6 inches (Reference 25). These values are slightly higher than the average value of 16.3 inches measured in Richmond. The maximum monthly snowfall measured in Louisa (32.2 inches) is also slightly higher than 28.5 inches measured in Richmond (Reference 1) or 29.8 inches measured in Charlottesville 2W (Reference 21).

2.7.4.1.6 Fog

The closest available fog data for the ESP site area are from the NWS observations at Richmond International Airport in Richmond. The local climatological data for Richmond through 2001 indicate an average of 27.2 days per year of heavy fog based on 73 years of records (Reference 1). Heavy fog is defined by the NWS as fog that reduces visibility to one-quarter of a mile or less. The frequency of fog conditions at the ESP site would be expected to be somewhat different from Richmond. The ESP site is characterized by gentle rolling terrain that rises to an average height of 50 to 150 feet above Lake Anna’s level. Low regions at the site and in the vicinity of the lake would be expected to have a higher frequency of fog occurrences attributed to the accumulation of relatively cool surface air due to drainage flows from higher elevations when compared to the relatively flat region of the Richmond airport.

2.7.4.1.7 Topographical Description and Potential Modifications

The ESP site and exclusion area (approximately 1803 acres) is in the northeastern portion of Virginia in Louisa County along the North Anna River. The site region is characterized by gently rolling terrain that rises to an average height of 50 to 150 feet above Lake Anna’s level and is cut by the North Anna River. The topography in the site region is characteristic of the Central Piedmont Plateau, which has a gently undulating surface that varies from 200 to 500 feet above sea level. Figure 2.7-23 and Figure 2.7-24 present the topographic features of the site. Section 2.7.4.1.1 presents how the topographic features of the site influence wind direction distribution.

Lake Anna, which extends approximately 17 miles along the old North Anna riverbed, was formed by damming up the North Anna River about 5 miles southeast of the site. As described in Section 2.3.1, the North Anna Reservoir and the WHTF, which together form Lake Anna, cover a surface area of about 13,000 acres and contain approximately 305,000 acre-feet of water.

Because of the gently rolling terrain, there is cold air drainage into low-lying areas at night. Some wind channeling along Lake Anna is expected during low-wind-speed conditions. This same effect also occurred in the natural lowland area before the lake was developed.

The ESP site for the new Units 3 and 4 is immediately west of the existing units. The primary topographic influences on local meteorological conditions at the ESP site are Lake Anna and the North Anna River Valley. During construction of the new units, a portion of the currently undeveloped area of the ESP site would be cleared of existing vegetation and subsequently graded to accommodate the new units and their ancillary structures. No large-scale cut and fill activities would be needed in the area of the ESP Plant Parameter Envelope to accommodate the new units since a large portion of the area to be developed is already relatively level. Undulating surfaces in the area of the planned cooling towers would be leveled to accommodate the towers. Therefore, the expected terrain modifications associated with development of the new nuclear power plant(s) at the ESP site would be limited to the existing NAPS site and would not significantly impact terrain features around the Lake and/or Valley, nor significantly alter the site's existing gently undulating surface that is characteristic of its location in the Piedmont region of Virginia.

2.7.5 **Short-Term Diffusion Estimates**

2.7.5.1 **Basis**

To evaluate potential health effects for DBAs, NUREG-1555, Section 7.1 requires the applicant to account for the 50 percentile χ/Q values at appropriate distances from the effluent release points (Reference 27). The NRC-sponsored PAVAN computer code (Reference 28) was used to generate these overall site, 50 percentile χ/Q values.

Recent readily available site meteorological data (1996–1998) were used for a quantitative evaluation of the hypothetical accident at the ESP site. Onsite data provide representative measurements of local dilution conditions appropriate to the ESP site and are reasonable representative of long-term conditions. The use of the recent 3-year data for dispersion analyses involving accidental releases in this ESP application is consistent with the approach used in the license renewal application for the existing units (Reference 29) and also satisfies the requirement of RG 4.7 (Reference 30). These 3-year combined joint frequency distributions of wind direction, wind speed, and atmospheric stability recorded at the NAPS site are presented in Table 2.7-9.

The PAVAN program implements the guidance provided in RG 1.145 (Reference 31) and performs the following calculation procedures. The code computes χ/Q values at the EAB and LPZ for each combination of wind speed and atmospheric stability for each of the 16 downwind direction sectors. Because the ground level release scenario provides a bounding case, elevated releases were not evaluated. The χ/Q values for each sector are then ranked in descending order, and an associated cumulative frequency distribution is derived based on the frequency distribution of wind speed and stabilities for that sector. The χ/Q values are also ranked independent of wind direction into a cumulative frequency distribution for the entire site.

The PAVAN model was configured to calculate offsite χ/Q values assuming both wake-credit allowed and wake-credit not-allowed. As described in Section 2.1, the EAB is the perimeter of a 5000-foot-radius circle from the center of the abandoned Unit 3 containment. There are no residential areas in the EAB. The PPE indicates that the highest expected structure would be about 234 feet above grade level. Therefore, the closest EAB is more than 10 building heights away from the boundary of the plant envelope developed for the ESP site. As a result, the entire EAB is located beyond the wake influence zone that would be induced by a containment building. The LPZ is a 6-mile-radius circle centered at the Unit 1 containment building. Because it is located further away from the plant site than the EAB, the "wake-credit not allowed" scenario of the PAVAN results was used for the χ/Q analysis at the EAB and LPZ.

To be conservative, the shortest distances between the ESP plant envelope boundaries to the 5000-ft-radius circle for each downwind sector were entered as input to calculate the χ/Q values at the EAB (see Table 2.7-10). Similarly, the shortest distance from the ESP plant envelope area boundary to the LPZ was entered as input to calculate the X/Q values at the LPZ. With respect to the ESP site, the shortest distance between the ESP site plant envelope boundary and the LPZ is 8843 m (about 5.5 mi.) measured from the southwest of the plant envelope area.

2.7.5.2 PAVAN Modeling Results

Based on the PAVAN-generated ordered χ/Q values (see Table 2.7-11 and Table 2.7-12), the 50-percentile overall site χ/Q values calculated by the model at the EAB and LPZ are 3.34E-05 and 2.17E-06, respectively.

2.7.6 Long-Term (Routine) Diffusion Estimates

2.7.6.1 Basis

The NRC-sponsored, computer code designated XOQDOQ (Reference 32) was used to estimate χ/Q values due to routine releases. The XOQDOQ model implements the assumptions outlined in RG 1.111 (Reference 33). A straight-line trajectory was assumed between the release point and all receptors by the XOQDOQ model.

The primary function of the XOQDOQ computer code, obtained from RSICC (Reference 34), is to calculate annual χ/Q values and annual average relative deposition D/Q values, at interested receptors (i.e., EAB, LPZ, nearest milk cow, residence, garden, meat animal, etc.). The program assumes the material released to the atmosphere to be a Gaussian distribution around the plume centerline. In estimating concentrations for longer time periods, the Gaussian distribution is assumed to be evenly distributed within the directional sector.

Input data and assumptions used in the XOQDOQ modeling are presented below.

- Meteorological Data: Three-year combined (1996–1998) onsite joint frequency distribution of wind speed, wind direction and atmospheric stability.
- Type of Release: Ground level
- Wind Sensor Height: 33 ft
- Vertical Temperature Difference: 33 ft–158.9 ft
- Number of Wind Speed Categories: 7
- Release Height: 33 ft (default height)
- Minimum Building Cross-Sectional Area: 2250 m^2
- Distances from the release point to the site boundary, and the nearest milk cow, vegetable garden, milk goat, and meat animal: See Table 2.7-13.

For dispersion analysis, a smaller cross-sectional area usually results in higher ground level concentrations. To be conservative, the minimum building cross-sectional area of 2250 m^2 was used to evaluate building downwash effect.

When compared to the elevated releases, ground level releases usually produce higher pollutant concentrations for receptors located at ground level. Therefore, ground level releases were conservatively assumed in the χ/Q analysis. Distances from the Unit 1 containment building to various interested receptors (nearest residence, garden, meat animal, site boundary, and vegetable garden) for each directional sector are provided in Reference 35, Appendix C. Because the plant envelope area for the ESP site is an area (not a point), the shortest distances from any point of the plant envelope to the interested receptors were re-calculated for each directional sector. The results are presented in Table 2.7-13. The maximum annual χ/Q (no decay) value at the EAB (0.88 mile to the ESE of the plant envelope) is 3.70×10^{-6} sec/m^3. The maximum annual average χ/Q value calculated for the nearest residence (0.96 mile to the NNE of the plant envelope) is 2.4×10^{-6} sec/m^3. The maximum annual χ/Q for the nearest vegetable garden (0.94 mile to the NE of the plant envelope) is 2.0×10^{-6} sec/m^3. Finally, the maximum annual χ/Q for the nearest meat animal (1.37 miles to the SE of the plant envelope) is 1.4×10^{-6} sec/m^3.

Table 2.7-14 summarizes the maximum χ/Q and D/Q values predicted by the XOQDOQ model for the sensitive receptors due to routine releases. Table 2.7-15 summarizes the maximum annual average χ/Q and D/Q values at distances between 0.25 and 50 miles and for various segment boundaries.

Detailed annual average χ/Q and D/Q estimates generated by the XOQDOQ model for the interested receptors and at distances between 0.25 mile to 50 miles, as well as for various segment boundaries, are also presented. Table 2.7-16 represents χ/Q estimates at the specific points of interest. Table 2.7-17 lists χ/Q estimates at downwind distances between 0.25 and 50 miles. Table 2.7-18 contains χ/Q estimates that include radioactive decay with a half-life of 2.26 days for short-lived noble gases. Table 2.7-19 contains χ/Q estimates that include radioactive decay with a half-life of 8 days for all iodines released to the atmosphere. Finally, Table 2.7-20 contains estimates of long-term average D/Q at downwind distances between 0.25 and 50 miles.

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Table 2.7-2 Summary of Virginia Tornado Intensities

Tornado Intensity (Fujita Tornado Scale)	**Number of Occurrences** (January 1950–December 2003)
F0	120
F1	184
F2	72
F3	29
F4	2
F5	0
Non-Classified	26
Total	433

Notes: Scale	Wind Speed (mph)
F0	40–72
F1	73–112
F2	113–157
F3	158–206
F4	207–260
F5	261–318

Source: Storm Events for Virginia, 01/01/1950 through 12/31/2003, NCDC, NOAA. (Reference 12)

Table 2.7-3 Extreme 1-Mile Wind Passage at Richmond, Virginia

Probability	**Speed (mph)**	**Recurrence Interval (years)**
0.04	56	25
0.02	60	50
0.01	64	100

Source: ANSI A58.1, American National Standard: Minimum Design Loads for Building and Other Structures, ANSI, 1982. (Reference 38)

Table 2.7-4 Richmond Climatological Data

NORMALS, MEANS, AND EXTREMES

RICHMOND, VA

LATITUDE: 37° 30' 40" N | LONGITUDE: 77° 19' 24" W | ELEVATION (FT): GRND: 164 BARO: 167 | TIME ZONE: EASTERN (UTC + 5) | WBAN: 13740

	ELEMENT	POR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE °F	NORMAL DAILY MAXIMUM	30	45.7	49.2	59.5	70.0	77.8	85.1	88.4	87.1	80.9	70.7	61.1	50.2	68.8
	MEAN DAILY MAXIMUM	81	47.4	50.3	58.9	69.3	77.6	85.1	88.3	86.5	80.8	70.6	60.4	50.0	68.8
	HIGHEST DAILY MAXIMUM	72	80	83	93	96	100	104	105	102	103	99	86	81	105
	YEAR OF OCCURRENCE		1950	1932	1938	1990	1941	1952	1977	1983	1954	1941	1993	1998	JUL 1977
	MEAN OF EXTREME MAXS.	81	69.4	71.2	80.2	87.8	91.1	96.0	97.5	95.9	93.1	85.5	77.8	70.1	84.6
	NORMAL DAILY MINIMUM	30	25.7	28.1	36.3	44.6	54.2	62.7	67.5	66.4	59.0	46.5	37.9	29.9	46.6
	MEAN DAILY MINIMUM	81	28.4	30.0	36.6	45.4	54.7	63.5	68.0	66.6	60.1	47.8	38.4	30.9	47.5
	LOWEST DAILY MINIMUM	72	-12	-10	11	23	31	40	51	46	35	21	10	-1	-12
	YEAR OF OCCURRENCE		1940	1936	1960	1985	1956	1967	1965	1934	1974	1962	1933	1942	JAN 1940
	MEAN OF EXTREME MINS.	81	10.2	14.2	21.6	30.9	41.0	51.1	57.8	55.6	45.4	32.4	22.7	14.6	33.1
	NORMAL DRY BULB	30	35.7	38.7	48.0	57.3	66.0	73.9	78.0	76.8	70.0	58.6	49.6	40.1	57.7
	MEAN DRY BULB	81	38.0	40.1	47.8	57.4	66.2	74.3	78.2	76.6	70.5	59.2	49.5	40.4	58.2
	MEAN WET BULB	17	34.0	36.7	41.9	50.5	59.4	67.3	71.5	66.0	63.6	53.7	44.9	36.8	52.2
	MEAN DEW POINT	17	27.0	29.1	33.9	43.0	54.3	63.2	68.1	63.1	59.9	48.7	38.6	30.0	46.6
	NORMAL NO. DAYS WITH:														
	MAXIMUM ≥ 90°	30	0.0	0.0	0.1	0.8	2.3	8.7	13.8	11.0	4.1	0.3	0.0	0.0	41.1
	MAXIMUM ≤ 32°	30	4.3	1.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	7.6
	MINIMUM ≤ 32°	30	23.0	19.5	10.8	2.3	0.1	0.0	0.0	0.0	0.0	2.1	9.4	19.2	86.4
	MINIMUM ≤ 0°	30	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
H/C	NORMAL HEATING DEG. DAYS	30	908	736	527	241	61	0	0	0	23	233	462	772	3963
	NORMAL COOLING DEG. DAYS	30	0	0	0	10	92	270	403	366	173	34	0	0	1348
RH	NORMAL (PERCENT)	30	68	66	63	61	70	72	75	77	77	74	69	69	70
	HOUR 01 LST	30	75	73	72	73	83	86	88	90	90	86	79	76	81
	HOUR 07 LST	30	79	78	78	76	81	83	86	90	90	89	84	80	83
	HOUR 13 LST	30	56	53	49	45	52	54	57	58	57	52	51	55	53
	HOUR 19 LST	30	65	62	57	53	63	66	69	74	77	75	68	68	66
S	PERCENT POSSIBLE SUNSHINE	46	54	58	62	66	65	69	68	66	65	63	59	54	62
W/O	MEAN NO. DAYS WITH:														
	HEAVY FOG(VISBY≤1/4 MI)	73	2.7	2.1	1.7	1.6	1.8	1.5	2.0	2.4	2.9	3.3	2.3	2.8	27.1
	THUNDERSTORMS	65	0.2	0.4	1.6	2.4	5.3	6.6	8.2	6.2	2.9	1.0	0.6	0.2	35.6
CLOUDINESS	MEAN:														
	SUNRISE-SUNSET (OKTAS)	1			5.6		5.6	3.2							
	MIDNIGHT-MIDNIGHT (OKTAS)	1			5.6										
	MEAN NO. DAYS WITH:														
	CLEAR	1	2.0	1.0	9.0		9.0	10.0							
	PARTLY CLOUDY	1		1.0	5.0		4.0	8.0							
	CLOUDY	1	7.0	4.0	10.0		8.0	1.0							
PR	MEAN STATION PRESSURE(IN)	28	29.91	29.89	29.85	29.81	29.81	29.81	29.83	29.86	29.89	29.92	29.92	29.93	29.87
	MEAN SEA-LEVEL PRES. (IN)	17	30.12	30.11	30.05	29.99	30.00	29.99	30.01	30.04	30.08	30.12	30.14	30.14	30.07
WINDS	MEAN SPEED (MPH)	43	8.3	8.7	9.3	9.2	7.9	7.5	7.1	6.6	7.0	7.2	7.7	7.9	7.9
	PREVAIL.DIR(TENS OF DEGS)	26	01	01	36	19	19	20	19	19	36	36	19	36	19
	MAXIMUM 2-MINUTE:														
	SPEED (MPH)	6	38	39	37	46	41	45	33	44	40	37	36	40	46
	DIR. (TENS OF DEGS)		31	23	22	33	30	26	29	36	01	10	16	15	33
	YEAR OF OCCURRENCE		2000	1997	1996	1999	1997	2000	1999	1996	1999	1996	1999	1996	APR 1999
	MAXIMUM 5-SECOND:														
	SPEED (MPH)	6	48	49	49	56	60	55	44	59	53	46	46	48	60
	DIR. (TENS OF DEGS)		31	26	22	25	28	27	29	32	08	10	16	16	28
	YEAR OF OCCURRENCE		2000	1997	1996	1998	1996	2000	1999	2000	1996	1996	1999	1996	MAY 1996
PRECIPITATION	NORMAL (IN)	30	3.24	3.16	3.61	2.96	3.84	3.62	5.03	4.40	3.34	3.53	3.17	3.26	43.16
	MAXIMUM MONTHLY (IN)	64	7.97	5.97	8.65	7.31	8.87	9.24	18.87	14.10	16.60	9.39	7.64	7.07	18.87
	YEAR OF OCCURRENCE		1978	1979	1984	1987	1972	1938	1945	1955	1999	1971	1959	1973	JUL 1945
	MINIMUM MONTHLY (IN)	64	0.64	0.48	0.94	0.64	0.87	0.38	0.51	0.52	0.26	0.01	0.17	0.40	0.01
	YEAR OF OCCURRENCE		1981	1978	1966	1963	1965	1980	1983	1943	1978	2000	2001	1980	OCT 2000
	MAXIMUM IN 24 HOURS (IN)	64	3.31	2.67	3.43	2.97	3.08	4.61	5.73	8.79	6.52	6.50	4.07	3.16	8.79
	YEAR OF OCCURRENCE		1962	1979	1992	1987	1981	1963	1969	1955	1999	1961	1956	1958	AUG 1955
	NORMAL NO. DAYS WITH:														
	PRECIPITATION ≥ 0.01	30	10.4	9.4	10.2	9.0	10.7	9.6	10.4	9.5	7.6	7.0	8.0	9.1	110.9
	PRECIPITATION ≥ 1.00	30	0.8	0.7	0.8	0.6	1.0	0.9	1.4	1.3	1.0	1.2	0.8	0.7	11.2
SNOWFALL	NORMAL (IN)	30	5.8	5.5	2.4	0.1	0.0	0.0	0.0	0.0	0.0	T	0.3	2.2	16.3
	MAXIMUM MONTHLY (IN)	62	28.5	21.4	19.7	2.0	T	0.0	0.0	0.0	0.0	T	7.3	12.5	28.5
	YEAR OF OCCURRENCE		1940	1983	1960	1940	1994					1979	1953	1958	JAN 1940
	MAXIMUM IN 24 HOURS (IN)	62	21.6	16.8	12.1	2.0	T	0.0	0.0	0.0	0.0	T	7.3	7.5	21.6
	YEAR OF OCCURRENCE		1940	1983	1962	1940	1994					1979	1953	1966	JAN 1940
	MAXIMUM SNOW DEPTH (IN)	77	18	20	13	1	0	0	0	0	0	0	6	9	20
	YEAR OF OCCURRENCE		1922	1922	1980	1964							1938	1958	FEB 1922
	NORMAL NO. DAYS WITH:														
	SNOWFALL ≥ 1.0	30	1.5	1.4	0.6	0.*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	4.3

Source: Richmond, Virginia, Local Climatological Data, Annual Summary with Comparative Data 2001, NCDC, NOAA.

Table 2.7-5 Mean Annual Meteorological Data for Stations in the Site Region

Location	Mean Annual Temperature (°F)	Mean Annual Precipitation (in.)	Mean Annual Snowfall (in.)
Charlottesville	56.8	45.72	24.2
Fredericksburg	56.2	40.99	17.7
Louisa	56.3	41.62	19.9
Piedmont Research Station	55.9	38.68	22.0
Partlow	55.2	42.24	18.6

Source: Reference 21 through Reference 25.

Table 2.7-6 Comparison of Mean Temperature Data for North Anna, Richmond, Partlow, and Louisa (°F) (September 16, 1971–September 15, 1972)

Month	North Anna	Richmond	Partlow	Louisa
January (1972)	36.6	40.7	37.6	39.5
February (1972)	33.6	37.6	35.5	36.2
March (1972)	43.0[a]	47.2	45.1	46.3[a]
April (1972)	54.7[a]	56.2	54.1	55.0
May (1972)	62.4	64.6	62.4	62.1
June (1972)	68.3	70.1	69.5	68.1
July (1972)	75.0	77.1	77.0	74.8
August (1972)	72.9	75.2	73.1	72.8
September (16-30, 1971; 1-15, 1972)	68.2[a]	69.6	([b])	([b])
October (1971)	62.8	64.6	63.9	63.0[a]
November (1971)	45.8[a]	48.5	46.6[a]	47.1
December (1971)	46.3[a]	48.0	46.8	46.2

Source: Reference 2

a. One or more days of data missing.

b. Data not available.

Table 2.7-7 North Anna Mean Wind Speeds (mph) 1974-1987

Elevation	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)	Winter (Dec, Jan, Feb)	Annual
Upper Level	9.6	7.5	8.3	9.2	8.6
Lower Level	7.1	5.4	5.9	6.6	6.3

Source: Reference 2

Table 2.7-8 North Anna Vertical Stability (∆T) and Low-Level Wind Speed Distribution 1974-1987

	Vertical Stability Categories						
Period	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Spring							
Frequency (%)	20.04	5.41	4.86	29.87	24.18	7.92	7.71
Wind Speed (mph)	(8.6)	(8.4)	(8.6)	(7.9)	(6.3)	(4.0)	(2.9)
Summer							
Frequency (%)	25.33	5.38	5.10	29.52	27.21	6.42	1.44
Wind Speed (mph)	(6.1)	(6.2)	(6.2)	(5.7)	(4.3)	(3.2)	(2.9)
Fall							
Frequency (%)	21.28	4.16	4.25	28.71	25.57	10.26	6.14
Wind Speed (mph)	(6.9)	(7.1)	(7.4)	(6.8)	(4.9)	(3.4)	(3.2)
Winter							
Frequency (%)	13.39	4.82	4.85	35.10	27.55	8.09	6.60
Wind Speed (mph)	(7.6)	(7.8)	(8.2)	(7.4)	(5.6)	(3.5)	(2.8)
Annual							
Frequency (%)	20.00	4.91	4.74	30.69	26.08	8.22	5.46
Wind Speed (MPH)	(7.2)	(7.4)	(7.6)	(7.0)	(5.2)	(3.5)	(3.0)

Source: Reference 2

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)													
Frequency	**Calm**	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
							Stability Class A – by ΔT								
N	0	0	2	2	5	3	6	17	19	19	12	5	0	0	90
NNE	0	0	0	0	2	3	5	6	14	4	1	2	0	0	37
NE	0	0	0	2	2	1	4	5	8	3	6	2	0	0	33
ENE	0	0	0	0	2	3	1	10	16	3	0	1	0	0	36
E	0	0	1	2	3	2	22	15	4	5	1	0	0	0	55
ESE	0	0	0	2	4	7	19	26	6	5	0	0	0	0	69
SE	0	0	0	0	1	4	18	26	2	0	0	0	0	0	51
SSE	0	0	0	2	6	2	18	39	1	0	0	0	0	0	68
S	0	0	0	2	3	8	33	113	10	1	0	0	0	0	170
SSW	0	0	0	0	5	5	24	107	73	12	0	1	0	0	227
SW	0	0	0	0	3	3	15	35	50	20	9	1	0	0	136
WSW	0	0	0	0	0	1	11	40	40	12	3	4	0	0	111
W	0	0	0	0	1	4	7	52	55	28	8	3	0	0	158
WNW	0	0	0	1	4	4	19	46	39	36	30	7	0	0	186
NW	0	0	1	2	13	8	41	78	54	26	16	11	3	0	253
NNW	0	0	0	3	12	14	24	20	22	13	18	14	3	0	143
Total	0	0	4	18	66	72	267	635	413	187	104	51	6	0	1823

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)													
Frequency	Calm	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
Stability Class B – by ΔT															
N	0	0	0	0	0	1	3	22	10	3	8	9	0	0	56
NNE	0	0	0	1	0	1	5	8	8	3	1	0	0	0	27
NE	0	0	0	0	0	1	4	9	8	5	1	1	0	0	29
ENE	0	0	0	0	1	4	6	10	4	3	0	0	0	0	28
E	0	0	0	1	2	4	12	12	6	2	0	0	0	0	39
ESE	0	0	0	1	1	3	20	30	2	1	1	0	0	0	59
SE	0	0	0	0	0	1	10	13	4	0	0	0	0	0	28
SSE	0	0	0	0	1	0	7	18	1	0	0	0	0	0	27
S	0	0	0	0	2	3	18	39	6	3	0	0	0	0	71
SSW	0	0	0	1	0	2	16	48	40	15	15	8	0	0	145
SW	0	1	0	0	1	1	4	18	26	11	4	3	0	0	69
WSW	0	0	0	0	0	0	4	16	16	9	3	4	0	0	52
W	0	0	0	0	0	1	2	14	11	7	6	1	0	0	42
WNW	0	0	0	0	1	1	5	20	21	13	9	4	2	0	76
NW	0	0	0	2	3	6	18	14	19	25	21	8	8	8	132
NNW	0	0	0	1	4	3	8	23	16	20	19	14	5	0	113
Total	0	1	0	7	16	32	142	314	198	120	88	52	15	8	993

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)												
Frequency	**Calm**	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
							Stability Class C– by ∆T							
N	0	0	0	5	5	1	14	17	28	28	28	11	1	0	138
NNE	0	0	0	0	3	1	7	9	9	10	8	0	0	0	47
NE	0	0	0	2	5	3	3	8	5	3	4	0	0	0	33
ENE	0	0	0	1	3	1	10	17	12	6	0	0	0	0	50
E	0	0	0	0	6	7	13	18	8	3	1	0	0	0	56
ESE	0	0	0	3	3	12	31	48	13	3	5	1	0	0	119
SE	0	0	0	0	2	9	20	22	4	0	0	0	0	0	57
SSE	0	0	0	1	0	3	10	10	1	0	0	0	0	0	25
S	0	0	0	0	4	5	34	30	7	1	0	0	0	0	81
SSW	0	0	0	0	0	5	18	72	28	17	11	4	0	0	155
SW	0	0	0	1	1	4	8	35	28	18	14	10	0	0	119
WSW	0	0	0	0	0	0	7	17	8	6	6	4	0	0	48
W	0	0	0	1	4	3	5	14	17	7	4	3	0	0	58
WNW	0	0	0	4	6	2	10	21	17	15	11	1	2	0	89
NW	0	0	1	1	7	2	14	28	26	29	9	19	5	12	153
NNW	0	0	1	0	7	10	22	32	32	39	15	18	2	3	181
Total	0	0	2	19	56	68	226	398	243	185	116	71	10	15	1409

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)													
Frequency	**Calm**	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
							Stability Class D– by ΔT								
N	2	0	10	33	51	57	176	460	406	263	86	56	6	2	1608
NNE	0	0	6	23	55	53	173	358	233	122	42	16	5	0	1086
NE	0	0	5	14	52	56	139	290	179	87	23	5	7	1	858
ENE	0	1	7	28	45	54	119	227	138	66	21	7	4	0	717
E	0	2	11	31	60	41	138	230	171	63	20	9	11	0	787
ESE	0	0	6	12	34	32	98	185	115	43	21	2	1	0	549
SE	0	2	7	9	22	21	79	224	59	14	4	0	0	0	441
SSE	0	2	6	13	25	25	56	89	15	2	1	0	0	0	234
S	0	1	5	32	55	75	167	199	38	14	2	0	0	0	588
SSW	1	2	9	39	64	63	176	352	175	91	48	12	0	0	1032
SW	1	2	17	36	51	47	140	266	176	64	41	32	2	0	875
WSW	0	1	13	20	16	21	44	100	102	63	18	4	0	0	402
W	0	4	7	28	31	16	40	67	55	36	17	3	0	0	304
WNW	1	0	3	22	31	32	70	107	74	69	34	25	8	2	478
NW	0	2	2	25	48	59	96	158	119	92	43	27	15	3	689
NNW	0	0	8	25	46	49	147	264	221	141	76	58	7	3	1045
Total	5	19	122	390	686	701	1858	3576	2276	1230	497	256	66	11	11693

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)												
Frequency	Calm	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
							Stability Class E– by ∆T								
N	2	3	14	27	16	16	31	62	28	24	6	9	3	0	241
NNE	1	7	10	21	23	11	29	54	29	9	3	4	3	0	204
NE	1	6	17	20	23	18	31	41	16	9	2	4	3	4	195
ENE	0	9	11	20	19	20	23	43	7	2	0	0	0	1	155
E	2	8	11	13	26	21	53	38	13	1	1	3	0	1	191
ESE	1	6	13	22	35	24	53	72	21	6	6	0	0	0	259
SE	0	4	17	36	28	31	96	131	21	1	1	1	1	0	368
SSE	0	5	17	39	38	50	96	58	10	5	5	0	0	0	323
S	1	14	54	94	115	117	244	185	58	22	1	0	0	0	905
SSW	4	11	67	132	125	85	157	280	145	33	8	1	0	0	1048
SW	1	9	45	102	101	72	133	229	120	50	12	5	0	0	879
WSW	1	11	39	69	56	40	46	97	69	10	1	2	0	0	441
W	1	13	45	81	111	80	105	141	38	18	5	0	0	0	638
WNW	0	11	30	85	99	93	143	107	45	24	10	10	1	0	658
NW	1	9	26	50	80	49	69	51	18	15	6	1	1	0	376
NNW	0	3	22	30	34	25	42	44	21	7	2	7	1	0	238
Total	16	129	438	841	929	752	1351	1633	659	236	69	47	13	6	7119

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)													
Frequency	**Calm**	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
							Stability Class F– by ∆T								
N	1	3	5	4	1	5	1	0	0	0	0	0	0	0	20
NNE	0	1	7	3	6	0	3	2	1	0	0	0	0	0	23
NE	1	4	7	3	4	3	2	0	0	1	0	0	0	0	25
ENE	2	2	7	9	4	2	4	0	0	0	0	0	0	0	30
E	1	6	15	15	4	3	10	2	0	0	0	0	0	2	58
ESE	1	4	5	7	10	5	9	5	1	0	1	0	0	3	51
SE	0	6	8	8	6	5	8	3	0	0	1	0	0	0	45
SSE	0	1	10	12	6	10	4	1	0	0	2	0	0	0	46
S	0	7	10	36	31	20	12	1	0	0	0	0	0	0	117
SSW	1	4	17	55	55	30	28	10	0	0	0	0	0	0	200
SW	0	8	23	37	26	21	27	20	5	0	0	0	0	0	167
WSW	1	8	20	49	36	8	9	10	2	2	0	0	0	0	145
W	2	12	38	75	85	74	109	26	0	0	0	0	0	0	421
WNW	2	12	37	99	101	66	62	36	1	0	3	0	0	0	419
NW	0	6	24	37	44	20	16	10	1	0	0	0	0	0	158
NNW	2	7	14	7	5	4	5	5	0	0	0	0	0	0	49
Total	14	91	247	456	424	276	309	131	11	3	7	0	0	5	1974

Table 2.7-9   1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)												
Frequency	**Calm**	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
						Stability Class G – by ΔT									
N	3	7	5	5	3	2	0	0	0	0	0	0	0	0	25
NNE	1	6	5	3	1	0	0	0	0	0	0	0	0	0	16
NE	2	5	4	4	1	0	0	0	0	0	0	0	0	0	16
ENE	0	4	5	3	3	0	0	0	0	0	0	0	0	0	15
E	1	6	11	9	2	0	0	0	0	0	0	0	0	0	29
ESE	0	1	7	7	4	0	0	0	0	0	0	0	0	0	19
SE	0	1	2	5	6	4	1	0	0	0	0	0	0	0	19
SSE	0	2	1	2	1	2	0	1	0	0	0	0	0	0	9
S	0	0	1	2	1	3	0	0	0	0	0	0	0	0	7
SSW	0	1	1	1	4	2	5	0	0	0	0	0	0	0	14
SW	1	1	6	6	4	4	5	1	0	0	0	0	0	0	28
WSW	1	2	10	7	6	1	0	0	0	0	0	0	0	0	27
W	0	6	16	31	27	8	9	2	0	0	0	0	0	0	99
WNW	0	5	39	120	117	57	40	5	0	0	0	0	0	0	383
NW	3	15	45	89	86	38	17	3	1	0	0	0	0	0	297
NNW	4	14	25	19	10	3	0	0	0	0	0	0	0	0	75
Total	16	76	183	313	276	124	77	12	1	0	0	0	0	0	1078

Table 2.7-9 1996–1998 NAPS Meteorological Data (33-ft Level)

Sector	Class	Wind Speed (m/s)												
Frequency	**Calm**	0.34-0.50	0.51-0.75	0.76-1.0	1.01-1.25	1.26-1.5	1.51-2.0	2.01-3.0	3.01-4.0	4.01-5.0	5.01-6.0	6.01-8.0	8.01-10	>10.0	Total
						Total Observations – All Stability Categories								
N	8	13	36	76	81	85	231	578	491	337	140	90	10	2	2178
NNE	2	14	28	51	90	69	222	437	294	148	55	22	8	0	1440
NE	4	15	33	45	87	82	183	353	216	108	36	12	10	5	1189
ENE	2	16	30	61	77	84	163	307	177	80	21	8	4	1	1031
E	4	22	49	71	103	78	248	315	202	74	23	12	11	3	1215
ESE	2	11	31	54	91	83	230	366	158	58	34	3	1	3	1125
SE	0	13	34	58	65	75	232	419	90	15	6	1	1	0	1009
SSE	0	10	34	69	77	92	191	216	28	7	8	0	0	0	732
S	1	22	70	166	211	231	508	567	119	41	3	0	0	0	1939
SSW	6	18	94	228	253	192	424	869	461	168	82	26	0	0	2821
SW	3	21	91	182	187	152	332	604	405	163	80	51	2	0	2273
WSW	3	22	82	145	114	71	121	280	237	102	31	18	0	0	1226
W	3	35	106	216	259	186	277	316	176	96	40	10	0	0	1720
WNW	3	28	109	331	359	255	349	342	197	157	97	47	13	2	2289
NW	4	32	99	206	281	182	271	342	238	187	95	66	32	23	2058
NNW	6	24	70	85	118	108	248	388	312	220	130	111	18	6	1844
Total	51	316	996	2044	2453	2025	4230	6699	3801	1961	881	477	110	45	26089

Table 2.7-10 Shortest Distances from the ESP Plant Envelope Boundary to the EAB

Downwind Direction	Distance (ft)	Distance (m)
N	4521	1378
NNE	4589	1399
NE	4697	1432
ENE	4835	1474
E	4707	1435
ESE	4660	1420
SE	4266	1300
SSE	3562	1086
S	3131	954
SSW	2877	877
SW	2860	872
WSW	2838	865
W	2860	872
WNW	2959	902
NW	3242	988
NNW	3822	1165

Table 2.7-11   PAVAN Results for χ/Q Values at the EAB

Plant Name: North Anna ESP
Data Period: 1996–1998 JFD
Type of Release: Ground-Level Release
Source of Data: Onsite
Comments: Data period: 1/1/96 - 12/31/98
Program: PAVAN, 10/76, 8/79 Revision, Implementation of RG 1.145
Site Exclusion Boundary Calculations:

Five Percent Overall Site Limit.
Building wake credit is not included.
Correction factors used in the annual average calculations.

Below are printed the ordered values of χ/Q and the frequency with which that value is reached or exceeded.
The top number is the χ/Q. The middle number is the frequency normalized to this sector.
The third number is the frequency with respect to all time.

Meteorological Instrumentation
Wind Sensors Height: 32.8 ft
ΔT Heights: 32.8 ft–158.9 ft

0	9.211E-04	9.140E-04	9.090E-04	8.847E-04	8.381E-04	8.101E-04	7.256E-04	6.790E-04	6.263E-04	6.215E-04
	0.001	0.004	0.005	0.006	0.007	0.008	0.013	0.013	0.029	0.071
	0.00095	0.00360	0.00454	0.00574	0.00713	0.00827	0.01275	0.01325	0.02858	0.07075
0	6.181E-04	6.142E-04	6.099E-04	6.050E-04	6.016E-04	6.016E-04	5.848E-04	5.832E-04	5.755E-04	5.699E-04
	0.094	0.111	0.112	0.114	0.118	0.119	0.120	0.120	0.121	0.148
	0.09374	0.11097	0.11183	0.11413	0.11796	0.11857	0.11969	0.12013	0.12070	0.14753
0	5.680E-04	5.639E-04	5.628E-04	5.527E-04	5.508E-04	5.499E-04	5.334E-04	4.934E-04	4.808E-04	4.617E-04
	0.169	0.170	0.176	0.176	0.180	0.182	0.183	0.237	0.238	0.246
	0.16885	0.17018	0.17573	0.17638	0.18021	0.18185	0.18304	0.23670	0.23803	0.24569
0	4.471E-04	4.177E-04	4.175E-04	4.147E-04	4.143E-04	4.121E-04	4.114E-04	4.091E-04	4.011E-04	4.002E-04
	0.247	0.305	0.324	0.331	0.389	0.408	0.446	0.450	0.477	0.482
	0.24709	0.30459	0.32376	0.33142	0.38892	0.40808	0.44641	0.45025	0.47708	0.48178

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	3.977E-04	3.913E-04	3.863E-04	3.834E-04	3.827E-04	3.799E-04	3.776E-04	3.758E-04	3.739E-04	3.720E-04
	0.497	0.501	0.520	0.524	0.547	0.566	0.570	0.581	0.589	0.595
	0.49711	0.50095	0.52011	0.52395	0.54694	0.56611	0.56984	0.58134	0.58901	0.59479
0	3.672E-04	3.665E-04	3.635E-04	3.627E-04	3.627E-04	3.590E-04	3.560E-04	3.539E-04	3.533E-04	3.437E-04
	0.602	0.614	0.618	0.628	0.651	0.653	0.656	0.657	0.662	0.664
	0.60246	0.61377	0.61790	0.62810	0.65110	0.65267	0.65591	0.65734	0.66168	0.66367
0	3.290E-04	3.269E-04	3.240E-04	3.132E-04	3.123E-04	3.107E-04	3.090E-04	3.078E-04	3.041E-04	3.008E-04
	0.759	0.786	0.788	0.799	0.802	0.851	0.863	0.867	0.871	0.897
	0.75949	0.78633	0.78783	0.79933	0.80164	0.85147	0.86296	0.86680	0.87063	0.89746
0	2.850E-04	2.833E-04	2.785E-04	2.765E-04	2.754E-04	2.743E-04	2.727E-04	2.721E-04	2.651E-04	2.644E-04
	0.917	0.919	1.091	1.118	1.137	1.222	1.249	1.272	1.291	1.295
	0.91663	.91889	1.09138	1.11821	1.13737	1.22170	1.24853	1.27153	1.29070	1.29453
0	2.620E-04	2.609E-04	2.601E-04	2.575E-04	2.575E-04	2.568E-04	2.557E-04	2.556E-04	2.552E-04	2.529E-04
	1.297	1.301	1.303	1.452	1.455	1.482	1.483	1.506	1.567	1.583
	1.29749	1.30132	1.30267	1.45216	1.45487	1.48171	1.48307	1.50607	1.56740	1.58273
0	2.506E-04	2.505E-04	2.493E-04	2.492E-04	2.486E-04	2.472E-04	2.472E-04	2.469E-04	2.467E-04	2.467E-04
	1.602	1.613	1.652	1.698	1.709	1.713	1.744	1.745	1.817	1.863
	1.60190	1.61340	1.65173	1.69772	1.70922	1.71306	1.74372	1.74456	1.81739	1.86338
0	2.441E-04	2.421E-04	2.418E-04	2.407E-04	2.406E-04	2.402E-04	2.337E-04	2.321E-04	2.309E-04	2.302E-04
	1.898	1.952	1.982	1.998	2.024	2.055	2.078	2.082	2.090	2.091
	1.89788	1.95154	1.98221	1.99754	2.02437	2.05504	2.07803	2.08228	2.08995	2.09146

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	2.280E-04	2.203E-04	2.203E-04	2.203E-04	2.180E-04	2.177E-04	2.142E-04	2.123E-04	2.107E-04	2.088E-04
	2.103	2.114	2.137	2.138	2.192	2.200	2.208	2.223	2.230	2.571
	2.10296	2.11446	2.13745	2.13806	2.19173	2.19955	2.20789	2.22322	2.22953	2.57067
0	2.088E-04	2.083E-04	2.074E-04	2.057E-04	2.045E-04	2.027E-04	2.023E-04	1.988E-04	1.983E-04	1.974E-04
	2.577	2.584	2.618	2.687	2.699	2.737	2.741	2.768	2.776	2.814
	2.57721	2.58376	2.61825	2.68725	2.69875	2.73708	2.74135	2.76818	2.77584	2.81417
0	1.962E-04	1.957E-04	1.931E-04	1.927E-04	1.917E-04	1.914E-04	1.900E-04	1.879E-04	1.870E-04	1.847E-04
	2.815	2.819	3.279	3.291	3.314	3.433	3.440	3.456	3.482	3.486
	2.81545	2.81929	3.27925	3.29075	3.31375	3.43257	3.44024	3.45557	3.48240	3.48623
0	1.836E-04	1.814E-04	1.813E-04	1.799E-04	1.782E-04	1.768E-04	1.751E-04	1.712E-04	1.686E-04	1.671E-04
	3.502	3.594	3.624	3.625	3.644	3.648	3.656	3.694	3.759	4.089
	3.50157	3.59356	3.62422	3.62493	3.64410	3.64793	3.65560	3.69393	3.75909	4.08873
0	1.662E-04	1.659E-04	1.648E-04	1.646E-04	1.645E-04	1.644E-04	1.636E-04	1.635E-04	1.627E-04	1.614E-04
	4.231	4.246	4.334	4.365	4.376	4.522	4.545	4.572	4.614	4.721
	4.23055	4.24589	4.33404	4.36471	4.37621	4.52186	4.54486	4.57169	4.61386	4.72118
0	1.604E-04	1.602E-04	1.591E-04	1.586E-04	1.578E-04	1.571E-04	1.565E-04	1.558E-04	1.545E-04	1.539E-04
	4.760	4.836	4.875	4.878	4.913	4.914	4.930	4.979	5.428	5.435
	4.75951	4.83617	4.87450	4.87834	4.91283	4.91419	4.92952	4.97935	5.42782	5.43548
0	1.534E-04	1.531E-04	1.520E-04	1.503E-04	1.498E-04	1.496E-04	1.481E-04	1.469E-04	1.461E-04	1.456E-04
	5.451	5.554	5.600	5.604	5.612	5.635	5.688	5.742	5.744	5.786
	5.45082	5.55431	5.60031	5.60414	5.61180	5.63480	5.68846	5.74213	5.74381	5.78597

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	1.451E-04	1.434E-04	1.433E-04	1.420E-04	1.416E-04	1.416E-04	1.408E-04	1.407E-04	1.393E-04	1.392E-04
	5.809	5.811	5.853	5.887	5.937	6.002	6.006	6.007	6.009	6.154
	5.80897	5.81074	5.85290	5.88740	5.93723	6.00239	6.00622	6.00710	6.00863	6.15428
0	1.389E-04	1.382E-04	1.377E-04	1.376E-04	1.375E-04	1.371E-04	1.361E-04	1.343E-04	1.326E-04	1.322E-04
	6.155	6.163	6.167	6.209	6.213	6.236	6.377	6.378	6.397	6.409
	6.15514	6.16281	6.16664	6.20881	6.21264	6.23564	6.37746	6.37817	6.39733	6.40883
0	1.308E-04	1.304E-04	1.288E-04	1.284E-04	1.284E-04	1.278E-04	1.276E-04	1.265E-04	1.253E-04	1.253E-04
	6.428	6.436	6.654	6.738	6.876	6.892	6.922	7.133	7.137	7.156
	6.42800	6.43566	6.65415	6.73847	6.87646	6.89179	6.92246	7.13328	7.13711	7.15627
0	1.250E-04	1.246E-04	1.246E-04	1.236E-04	1.233E-04	1.224E-04	1.223E-04	1.221E-04	1.216E-04	1.210E-04
	7.168	7.172	7.551	7.693	7.980	7.984	7.992	8.069	8.092	8.218
	7.16777	7.17161	7.55108	7.69290	7.98038	7.98421	7.99187	8.06853	8.09153	8.21802
0	1.209E-04	1.203E-04	1.201E-04	1.191E-04	1.188E-04	1.179E-04	1.168E-04	1.167E-04	1.159E-04	1.147E-04
	8.237	8.318	8.506	8.509	8.574	8.601	8.686	8.747	8.770	8.774
	8.23719	8.31768	8.50550	8.50933	8.57450	8.60133	8.68565	8.74698	8.76998	8.77381
0	1.139E-04	1.129E-04	1.129E-04	1.126E-04	1.121E-04	1.119E-04	1.102E-04	1.090E-04	1.088E-04	1.085E-04
	8.793	8.801	8.804	8.812	8.820	8.843	8.946	8.962	9.130	9.149
	8.79298	8.80064	8.80448	8.81214	8.81981	8.84280	8.94630	8.96163	9.13028	9.14945
0	1.068E-04	1.062E-04	1.052E-04	1.052E-04	1.044E-04	1.044E-04	1.037E-04	1.029E-04	1.027E-04	1.023E-04
	9.157	9.295	9.395	9.399	9.464	9.502	9.517	9.563	9.682	9.694
	9.15711	9.29510	9.39476	9.39859	9.46376	9.50209	9.51742	9.56341	9.68224	9.69374

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	1.014E-04	1.012E-04	9.988E-05	9.969E-05	9.942E-05	9.935E-05	9.887E-05	9.871E-05	9.866E-05	9.784E-05
	9.732	9.943	9.970	10.357	10.391	10.395	10.495	10.702	11.028	11.047
	9.73207	9.94288	9.96972	10.35685	10.39135	10.39518	10.49484	10.70182	11.02763	11.04680
0	9.765E-05	9.758E-05	9.750E-05	9.709E-05	9.683E-05	9.657E-05	9.633E-05	9.626E-05	9.609E-05	9.586E-05
	11.120	11.131	11.139	11.396	11.583	11.737	11.852	11.940	12.078	12.097
	11.11962	11.13112	11.13879	11.39560	11.58342	11.73674	11.85173	11.93989	12.07788	12.09705
0	9.568E-05	9.552E-05	9.470E-05	9.465E-05	9.445E-05	9.443E-05	9.396E-05	9.348E-05	9.171E-05	9.134E-05
	12.132	12.247	12.254	12.427	12.442	12.615	12.618	12.752	12.902	12.906
	12.13155	12.24654	12.25420	12.42669	12.44202	12.61451	12.61834	12.75250	12.90198	12.90582
0	9.070E-05	9.067E-05	8.908E-05	8.894E-05	8.842E-05	8.814E-05	8.755E-05	8.693E-05	8.663E-05	8.558E-05
	12.982	13.013	13.163	13.193	13.301	13.362	13.534	13.623	13.642	13.718
	12.98248	13.01314	13.16263	13.19330	13.30062	13.36195	13.53444	13.62259	13.64176	13.71842
0	8.493E-05	8.431E-05	8.395E-05	8.308E-05	8.239E-05	8.222E-05	8.173E-05	8.157E-05	8.137E-05	8.069E-05
	13.826	13.941	13.987	14.240	14.320	14.604	14.623	14.646	14.723	14.872
	13.82575	13.94074	13.98673	14.23971	14.32021	14.60385	14.62302	14.64602	14.72268	14.87216
0	8.022E-05	8.008E-05	7.965E-05	7.947E-05	7.892E-05	7.828E-05	7.790E-05	7.706E-05	7.602E-05	7.491E-05
	14.914	14.945	14.949	14.956	15.148	15.275	15.367	15.497	15.512	15.547
	14.91433	14.94499	14.94882	14.95649	15.14814	15.27463	15.36662	15.49695	15.51228	15.54678
0	7.403E-05	7.345E-05	7.282E-05	7.164E-05	7.126E-05	7.121E-05	7.098E-05	7.082E-05	7.078E-05	7.074E-05
	15.907	15.968	16.474	16.800	16.946	16.953	17.344	17.655	17.774	17.946
	15.90708	15.96841	16.47437	16.80018	16.94583	16.95350	17.34447	17.65494	17.77377	17.94625

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	7.060E-05	7.004E-05	6.999E-05	6.977E-05	6.954E-05	6.878E-05	6.803E-05	6.716E-05	6.674E-05	6.670E-05
	17.954	18.383	18.422	18.425	18.636	18.901	18.962	19.092	19.104	19.200
	17.95392	18.38322	18.42155	18.42538	18.63620	18.90068	18.96201	19.09233	19.10383	19.19966
0	6.623E-05	6.540E-05	6.500E-05	6.426E-05	6.422E-05	6.419E-05	6.380E-05	6.336E-05	6.323E-05	6.316E-05
	19.219	19.223	19.257	19.295	19.391	19.437	19.449	19.453	19.560	19.698
	19.21882	19.22266	19.25715	19.29548	19.39131	19.43731	19.44880	19.45264	19.55996	19.69795
0	6.314E-05	6.313E-05	6.297E-05	6.262E-05	6.255E-05	6.244E-05	6.240E-05	6.231E-05	6.211E-05	6.179E-05
	20.005	20.070	20.097	20.292	20.369	20.376	20.476	20.714	20.718	20.821
	20.00459	20.06976	20.09659	20.29207	20.36873	20.37640	20.47606	20.71370	20.71754	20.82103
0	6.166E-05	6.143E-05	6.117E-05	6.103E-05	6.089E-05	6.052E-05	6.050E-05	6.031E-05	6.016E-05	6.006E-05
	21.239	21.258	21.308	21.396	21.446	21.768	21.806	21.971	22.082	22.117
	21.23883	21.25800	21.30783	21.39598	21.44581	21.76779	21.80612	21.97094	22.08210	22.11659
0	5.993E-05	5.973E-05	5.961E-05	5.938E-05	5.933E-05	5.923E-05	5.915E-05	5.897E-05	5.895E-05	5.893E-05
	22.201	22.504	22.531	22.722	22.929	23.370	23.378	23.489	23.696	23.703
	22.20092	22.50373	22.53056	22.72221	22.92920	23.37000	23.37766	23.48882	23.69580	23.70347
0	5.872E-05	5.852E-05	5.842E-05	5.836E-05	5.825E-05	5.822E-05	5.795E-05	5.788E-05	5.773E-05	5.750E-05
	23.715	23.826	24.029	24.401	24.880	24.919	25.122	25.133	25.168	25.179
	23.71497	23.82613	24.02928	24.40108	24.88021	24.91854	25.12169	25.13319	25.16769	25.17919
0	5.737E-05	5.731E-05	5.703E-05	5.697E-05	5.679E-05	5.666E-05	5.635E-05	5.597E-05	5.591E-05	5.537E-05
	25.455	25.835	25.842	25.854	26.241	26.666	26.747	26.870	26.873	26.896
	25.45517	25.83464	25.84231	25.85381	26.24094	26.66641	26.74690	26.86956	26.87339	26.89639

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	5.509E-05	5.502E-05	5.442E-05	5.363E-05	5.341E-05	5.336E-05	5.308E-05	5.304E-05	5.261E-05	5.225E-05
	27.015	27.230	27.253	27.491	27.586	27.763	28.131	28.150	28.338	28.445
	27.01522	27.22987	27.25286	27.49051	27.58634	27.76266	28.13063	28.14979	28.33761	28.44494
0	5.218E-05	5.140E-05	5.093E-05	5.069E-05	4.995E-05	4.994E-05	4.982E-05	4.969E-05	4.968E-05	4.943E-05
	28.663	29.166	29.258	29.269	29.311	29.392	29.472	29.495	29.618	29.629
	28.66342	29.16555	29.25754	29.26904	29.31120	29.39170	29.47219	29.49519	29.61785	29.62935
0	4.936E-05	4.894E-05	4.875E-05	4.855E-05	4.834E-05	4.816E-05	4.785E-05	4.776E-05	4.735E-05	4.732E-05
	30.078	30.174	30.323	30.649	30.653	30.814	30.898	31.255	31.393	31.669
	30.07781	30.17364	30.32313	30.64893	30.65277	30.81376	30.89808	31.25455	31.39254	31.66852
0	4.723E-05	4.722E-05	4.698E-05	4.694E-05	4.596E-05	4.585E-05	4.567E-05	4.454E-05	4.447E-05	4.421E-05
	31.776	32.082	32.094	32.098	32.266	32.420	32.496	32.864	33.052	33.508
	31.77584	32.08249	32.09398	32.09782	32.26647	32.41979	32.49645	32.86442	33.05224	33.50837
0	4.395E-05	4.378E-05	4.347E-05	4.313E-05	4.273E-05	4.273E-05	4.243E-05	4.224E-05	4.211E-05	4.204E-05
	33.589	34.651	35.314	35.341	35.525	35.540	35.559	35.563	35.590	35.812
	33.58886	34.65061	35.31373	35.34056	35.52454	35.53988	35.55904	35.56287	35.58971	35.81202
0	4.198E-05	4.162E-05	4.120E-05	4.078E-05	4.042E-05	4.034E-05	3.982E-05	3.981E-05	3.974E-05	3.946E-05
	36.188	36.226	36.230	36.326	36.333	36.337	36.345	36.383	36.594	36.858
	36.18766	36.22599	36.22982	36.32565	36.33332	36.33715	36.34482	36.38315	36.59396	36.85844
0	3.915E-05	3.914E-05	3.900E-05	3.828E-05	3.788E-05	3.780E-05	3.778E-05	3.768E-05	3.746E-05	3.727E-05
	36.904	37.579	37.824	37.943	38.139	38.158	38.277	39.147	39.450	41.443
	36.90444	37.57906	37.82437	37.94320	38.13868	38.15784	38.27667	39.14677	39.44958	41.44276

Table 2.7-11 PAVAN Results for χ/Q Values at the EAB

0	3.727E-05	3.702E-05	3.698E-05	3.692E-05	3.662E-05	3.654E-05	3.641E-05	3.599E-05	3.582E-05	3.561E-05
	41.477	42.413	43.785	43.789	43.984	44.045	44.647	44.666	45.214	45.441
	41.47725	42.41251	43.78474	43.78857	43.98406	44.04539	44.64717	44.66634	45.21446	45.44061
0	3.558E-05	3.549E-05	3.541E-05	3.536E-05	3.521E-05	3.450E-05	3.439E-05	3.418E-05	3.416E-05	3.405E-05
	46.150	46.660	47.062	47.066	47.070	47.081	47.257	47.269	47.338	48.047
	46.14972	46.65952	47.06199	47.06582	47.06965	47.08115	47.25747	47.26897	47.33796	48.04708
0	3.358E-05	3.354E-05	3.341E-05	3.335E-05	3.319E-05	3.319E-05	3.312E-05	3.294E-05	3.291E-05	3.279E-05
	48.576	48.603	49.676	50.240	50.274	51.616	51.903	53.666	54.559	54.970
	48.57603	48.60287	49.67612	50.23957	50.27407	51.61563	51.90311	53.66631	54.55940	54.96954
0	3.250E-05	3.245E-05	3.237E-05	3.201E-05	3.190E-05	3.178E-05	3.168E-05	3.157E-05	3.156E-05	3.152E-05
	55.211	56.089	56.629	56.687	56.809	56.813	56.852	57.032	57.473	57.695
	55.21102	56.08878	56.62924	56.68674	56.80939	56.81323	56.85156	57.03171	57.47251	57.69483
0	3.148E-05	3.138E-05	3.136E-05	3.130E-05	3.122E-05	3.090E-05	3.087E-05	3.068E-05	3.059E-05	3.045E-05
	57.756	58.615	58.634	59.006	59.067	59.094	59.650	59.903	60.117	60.198
	57.75616	58.61476	58.63392	59.00573	59.06705	59.09388	59.64967	59.90265	60.11730	60.19780
0	3.031E-05	3.029E-05	3.026E-05	3.024E-05	3.012E-05	3.002E-05	2.989E-05	2.981E-05	2.980E-05	2.936E-05
	60.225	60.800	60.803	60.976	60.999	61.467	61.926	61.938	62.084	62.202
	60.22463	60.79958	60.80342	60.97590	60.99890	61.46653	61.92649	61.93799	62.08365	62.20247
0	2.934E-05	2.904E-05	2.873E-05	2.871E-05	2.868E-05	2.847E-05	2.817E-05	2.809E-05	2.805E-05	2.795E-05
	62.287	63.843	64.107	64.272	64.399	64.479	64.483	64.648	64.740	64.778
	62.28680	63.84301	64.10749	64.27231	64.39880	64.47929	64.48312	64.64793	64.73993	64.77826

Table 2.7-12 PAVAN Results for χ/Q Values at the LPZ

Plant Name: North Anna ESP
Data Period: 1996–1998 JFD
Type of Release: Ground-Level Release
Source of Data: Onsite
Comments: Data period: 1/1/96 - 12/31/98
Program: PAVAN, 10/76, 8/79 Revision, Implementation of RG 1.145
Low Population Zone Calculations:

Five Percent Overall Site Limit.
Building wake credit is not included.
Correction factors used in the annual average calculations.

Below are printed the ordered values of χ/Q and the frequency with which that value is reached or exceeded.
The top number is the χ/Q. The middle number is the frequency normalized to this sector.
The third number is the frequency with respect to all time.

Meteorological Instrumentation
Wind Sensors Height: 32.8 ft
ΔT Heights: 32.8 ft–158.9 ft

0	1.237E-04	8.410E-05	5.981E-05	5.607E-05	4.205E-05	4.067E-05	3.364E-05	2.803E-05	2.711E-05	2.701E-05
	.061	.353	.406	1.108	2.307	2.656	3.714	4.190	5.136	5.198
	.06133	.35264	.40630	1.10775	2.30749	2.65629	3.71421	4.18951	5.13627	5.19759
0	2.102E-05	2.033E-05	1.837E-05	1.776E-05	1.627E-05	1.492E-05	1.356E-05	1.256E-05	1.225E-05	1.017E-05
	5.493	7.241	7.735	7.781	9.406	9.410	10.468	10.487	12.166	13.350
	5.49274	7.24060	7.73506	7.78106	9.40626	9.41009	10.46801	10.48718	12.16604	13.35045
0	9.185E-06	8.543E-06	7.847E-06	7.348E-06	6.341E-06	6.123E-06	5.695E-06	5.303E-06	4.592E-06	4.550E-06
	16.574	16.647	17.149	20.710	20.752	23.634	24.102	24.114	29.292	29.319
	16.57403	16.64686	17.14898	20.70987	20.75204	23.63448	24.10211	24.11361	29.29204	29.31887
0	4.271E-06	3.417E-06	3.375E-06	2.848E-06	2.668E-06	2.482E-06	2.206E-06	2.136E-06	1.880E-06	1.493E-06
	30.814	33.443	39.703	42.390	44.915	44.935	45.839	52.961	53.226	66.932
	30.81375	33.44321	39.70255	42.38952	44.91549	44.93466	45.83926	52.96103	53.22552	66.93244

Table 2.7-12 PAVAN Results for χ/Q Values at the LPZ

0	1.410E-06	1.245E-06	1.151E-06	1.128E-06	1.026E-06	9.388E-07	9.339E-07	7.932E-07	7.471E-07	6.366E-07
	67.113	67.120	75.844	75.894	75.917	80.632	80.705	82.610	82.824	82.828
	67.11259	67.12025	75.84424	75.89405	75.91705	80.63168	80.70450	82.60951	82.82416	82.82799
0	6.226E-07	5.949E-07	4.759E-07	4.670E-07	4.327E-07	4.244E-07	3.183E-07	3.113E-07	2.546E-07	2.335E-07
	83.089	84.070	84.323	85.189	85.231	85.247	85.342	86.868	87.182	88.114
	83.08863	84.06989	84.32287	85.18914	85.23130	85.24663	85.34245	86.86799	87.18228	88.11370
0	2.122E-07	1.868E-07	1.592E-07	1.557E-07	1.167E-07	1.061E-07	9.339E-08	8.490E-08	7.958E-08	6.366E-08
	88.512	89.221	90.789	91.234	91.506	95.143	95.182	95.239	97.581	98.758
	88.51231	89.22141	90.78912	91.23375	91.50589	95.14342	95.18176	95.23925	97.58121	98.75794
0	5.305E-08	3.979E-08	3.183E-08	2.894E-08						
	99.494	99.889	99.969	100.000						
	99.49386	99.88866	99.96915	99.99981						

Table 2.7-13 ESP Application Nearby Sensitive Receptors

	Nearest Resident		Nearest Site Boundary		Milk* Cow	Meat Animal		Milk* Goat	Veg. Garden 500 ft^2	
Sector	(mile)	(km)	(mile)	(km)		(mile)	(km)		(mile)	(km)
N	1.48	2.38	0.87	1.40		2.18	3.51		1.78	2.86
NNE	0.96	1.54	0.88	1.42		1.56	2.51		1.66	2.67
NE	0.94	1.51	0.90	1.45		1.44	2.32		0.94	1.51
ENE	2.18	3.51	0.91	1.47		2.58	4.15		2.18	3.51
E	1.38	2.22	0.89	1.43		3.58	5.76		1.38	2.22
ESE	1.77	2.85	0.88	1.42		None	None		3.57	5.74
SE	1.37	2.20	0.83	1.34		1.37	2.20		1.37	2.20
SSE	0.91	1.46	0.73	1.17		2.71	4.36		1.21	1.95
S	1.01	1.63	0.62	0.99		None	None		1.11	1.79
SSW	1.1	1.77	0.57	0.92		1.90	3.06		1.50	2.41
SW	2.78	4.47	0.54	0.87		None	None		2.78	4.47
WSW	1.22	1.96	0.55	0.88		1.22	1.96		1.52	2.45
W	1.30	2.09	0.54	0.87		4.20	6.76		4.80	7.72
WNW	0.98	1.58	0.56	0.90		3.98	6.40		None	None
NW	0.88	1.42	0.62	0.99		None	None		0.98	1.58
NNW	0.93	1.50	0.72	1.16		1.93	3.11		1.13	1.82

Note: No milk cow or goats within a 5-mile radius of the NAPS.
Source: Reference 35.

Table 2.7-14 XOQDOQ Predicted Maximum χ/Q and D/Q Values at Specific Points of Interest

Type of Location	Direction from Site	Distance (miles)	χ/Q (No Decay)	χ/Q (2.26 Day Decay)	χ/Q (8 Day Decay)	D/Q
Residence	NNE	0.96	2.4E-06	2.4E-06	2.1E-06	7.2E-09
EAB	ESE	0.88	3.7E-06	3.7E-06	3.3E-06	1.2E-08 [a]
Meat Animal	SE	1.37	1.4E-06	1.4E-06	1.2E-06	3.1E-09 [b]
Veg. Garden	NE	0.94	2.0E-06	2.0E-06	1.8E-06	6.0E-09

Notes:
χ/Q – sec/m^3
D/Q – 1/m^2

a. direction = south

b. direction = north-northeast

Table 2.7-15 XOQDOQ Predicted Maximum Annual Averages (Ground-Level Release)

No Decay Undepleted

	Distance in Miles From the Site										
ESE	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
χ/Q (s/m^3)	2.685E-5	8.740E-6	4.697E-6	3.103E-6	1.742E-6	1.163E-6	8.527E-7	6.634E-7	5.373E-7	4.482E-7	3.822E-7
	Distance in Miles From the Site										
ESE	5.00	7.50	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
χ/Q (s/m^3)	3.317E-7	1.934E-7	1.325E-7	7.833E-8	5.418E-8	4.079E-8	3.239E-8	2.668E-9	2.257E-8	1.948E-8	1.709E-8
	Segment Boundaries in Miles From the Site										
ESE	0.5 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 – 20	20 - 30	30 - 40	40 - 50	
χ/Q (s/m^3)	4.887E-6	1.787E-6	8.596E-7	5.394E-7	3.831E-7	1.971E-7	7.964E-8	4.100E-8	2.675E-8	1.951E-8	
2.26 Day Decay, Undepleted											
	Distance in Miles From the Site										
ESE	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
χ/Q (s/m^3)	2.681E-5	8.712E-6	4.674E-6	3.083E-6	1.725E-6	1.148E-6	8.388E-7	6.504E-7	5.251E-7	4.365E-7	3.711E-7
	Distance in Miles From the Site										
ESE	5.00	7.50	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
χ/Q (s/m^3)	3.210E-7	1.841E-7	1.241E-7	7.095E-8	4.750E-8	3.462E-8	2.662E-8	2.124E-8	1.740E-8	1.455E-8	1.237E-8
	Segment Boundaries in Miles From the Site										
ESE	0.5 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 – 20	20 - 30	30 - 40	40 - 50	
χ/Q (s/m^3)	4.864E-6	1.770E-6	8.458E-7	5.272E-7	3.719E-7	1.878E-7	7.233E-8	3.485E-8	2.131E-8	1.459E-8	

Table 2.7-15 XOQDOQ Predicted Maximum Annual Averages (Ground-Level Release)

8.0 Day Decay, Depleted

	Distance in Miles From the Site										
ESE	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
χ/Q (s/m^3)	2.540E-5	7.974E-6	4.180E-6	2.711E-6	1.475E-6	9.592E-7	6.875E-7	5.240E-7	4.166E-7	3.415E-7	2.866E-7
	Distance in Miles From the Site										
ESE	5.00	7.50	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
χ/Q (s/m^3)	2.450E-7	1.344E-7	8.739E-8	4.735E-8	3.047E-8	2.153E-8	1.614E-8	1.261E-8	1.015E-8	8.357E-9	7.007E-9
	Segment Boundaries in Miles From the Site										
ESE	0.5 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 - 20	20 - 30	30 - 40	40 - 50	
χ/Q (s/m^3)	4.370E-6	1.521E-6	6.945E-7	4.187E-7	2.874E-7	1.381E-7	4.874E-8	2.176E-8	1.268E-8	8.388E-9	
Relative Deposition/Area											
	Distance in Miles from Site										
NNE	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
D/Q (1/m^2)	6.2570E-8	2.116E-8	1.086E-8	6.671E-9	3.326E-9	2.017E-9	1.364E-9	9.882E-10	7.514E-10	5.920E-10	4.793E-10
	Distance in Miles from Site										
NNE	5.00	7.50	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
D/Q (1/m^2)	3.964E-10	1.943E-10	1.219E-10	6.161E-11	3.729E-11	2.500E-11	1.792E-11	1.345E-11	1.046E-11	8.355E-12	6.820E-12
	Segment Boundaries in Miles From the Site										
NNE	0.5 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 - 20	20 - 30	30 - 40	40 - 50	
D/Q (1/m^2)	1.129E-8	3.487E-9	1.388E-9	7.583E-10	4.820E-10	2.070E-10	6.420E-10	2.544E-11	1.359E-11	8.410E-12	

Table 2.7-16 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Specific Points of Interest (1996-98 Meteorological Data)

Ground-Level Release - No Purge Releases

			χ/Q (sec/m^3)						χ/Q (sec/m^3)			
Dir. From Site	**Type of Location**	**Dist. (Mile)**	**No Decay Undepleted**	**2.26 Day Decay Undepleted**	**8.0 Day Decay Depleted**	**D/Q (1/m^2)**	**Type of Location**	**Dist. (Mile)**	**No Decay Undepleted**	**2.26 Day Decay Undepleted**	**8.0 Day Decay Depleted**	**D/Q (1/m^2)**
S	Residences	1.01	1.10E-06	1.10E-06	9.40E-07	5.00E-09	S. B.	0.62	2.40E-06	2.40E-06	2.10E-06	1.20E-08
SSW	Residences	1.1	7.50E-07	7.50E-07	6.50E-07	2.90E-09	S. B.	0.57	2.10E-06	2.10E-06	1.90E-06	8.70E-09
SW	Residences	2.78	1.60E-07	1.60E-07	1.30E-07	4.80E-10	S. B.	0.54	2.10E-06	2.10E-06	1.90E-06	7.80E-09
WSW	Residences	1.22	5.40E-07	5.30E-07	4.60E-07	1.70E-09	S. B.	0.54	1.90E-06	1.90E-06	1.70E-06	6.70E-09
W	Residences	1.3	6.00E-07	5.90E-07	5.10E-07	1.80E-09	S. B.	0.54	2.30E-06	2.30E-06	2.10E-06	8.00E-09
WNW	Residences	0.98	8.00E-07	7.90E-07	7.00E-07	2.70E-09	S. B.	0.56	1.90E-06	1.90E-06	1.80E-06	7.00E-09
NW	Residences	0.88	9.70E-07	9.70E-07	8.60E-07	3.00E-09	S. B.	0.61	1.70E-06	1.70E-06	1.50E-06	5.40E-09
NNW	Residences	0.93	7.70E-07	7.70E-07	6.80E-07	2.00E-09	S. B.	0.72	1.10E-06	1.10E-06	1.00E-06	3.00E-09
N	Residences	1.48	9.70E-07	9.60E-07	8.20E-07	2.30E-09	S. B.	0.87	2.20E-06	2.20E-06	1.90E-06	5.80E-09
NNE	Residences	0.96	2.40E-06	2.40E-06	2.10E-06	7.20E-09	S. B.	0.88	2.70E-06	2.70E-06	2.40E-06	8.30E-09
NE	Residences	0.94	2.00E-06	2.00E-06	1.80E-06	6.00E-09	S. B.	0.9	2.10E-06	2.10E-06	1.90E-06	6.40E-09
ENE	Residences	2.18	3.50E-07	3.50E-07	2.90E-07	7.50E-10	S. B.	0.92	1.30E-06	1.30E-06	1.10E-06	3.40E-09
E	Residences	1.38	1.30E-06	1.30E-06	1.10E-06	2.30E-09	S. B.	0.89	2.60E-06	2.50E-06	2.30E-06	5.00E-09
ESE	Residences	1.77	1.40E-06	1.40E-06	1.20E-06	2.00E-09	S. B.	0.88	3.70E-06	3.70E-06	3.30E-06	6.70E-09
SE	Residences	1.37	1.40E-06	1.40E-06	1.20E-06	2.90E-09	S. B.	0.83	2.80E-06	2.80E-06	2.50E-06	6.70E-09
SSE	Residences	0.91	1.30E-06	1.30E-06	1.20E-06	5.10E-09	S. B.	0.72	1.90E-06	1.90E-06	1.70E-06	7.50E-09

Note: S. B. – Site Boundary; M. A. – Meat Animal; V. G. – Vegetable Garden

Table 2.7-16 Long-Term Average χ/Q (sec/m³) for Routine Releases at Specific Points of Interest (1996-98 Meteorological Data)

Ground-Level Release - No Purge Releases

Dir. From Site	Type of Location	Dist. (Mile)	χ/Q (sec/m³) No Decay Undepleted	χ/Q (sec/m³) 2.26 Day Decay Undepleted	χ/Q (sec/m³) 8.0 Day Decay Depleted	D/Q (1/m²)	Type of Location	Dist. (Mile)	χ/Q (sec/m³) No Decay Undepleted	χ/Q (sec/m³) 2.26 Day Decay Undepleted	χ/Q (sec/m³) 8.0 Day Decay Depleted	D/Q (1/m²)
S	M. A.	-	-	-	-	-	V. G.	1.11	9.30E-07	9.20E-07	8.10E-07	4.30E-09
SSW	M. A.	1.9	3.20E-07	3.20E-07	2.70E-07	1.10E-09	V. G.	1.5	4.60E-07	4.60E-07	3.90E-07	1.70E-09
SW	M. A.	-	-	-	-	-	V. G.	2.78	1.60E-07	1.60E-07	1.30E-07	4.80E-10
WSW	M. A.	1.22	5.40E-07	5.30E-07	4.60E-07	1.70E-09	V. G.	1.52	3.80E-07	3.80E-07	3.20E-07	1.20E-09
W	M. A.	4.2	1.00E-07	1.00E-07	7.70E-08	2.30E-10	V. G.	4.8	8.40E-08	8.20E-08	6.20E-08	1.80E-10
WNW	M. A.	3.98	9.50E-08	9.30E-08	7.30E-08	2.40E-10	V. G.	None	-	-	-	-
NW	M. A.	None	-	-	-	-	V. G.	0.98	8.20E-07	8.20E-07	7.20E-07	2.50E-09
NNW	M. A.	1.93	2.50E-07	2.50E-07	2.10E-07	5.60E-10	V. G.	1.13	5.70E-07	5.70E-07	4.90E-07	1.40E-09
N	M. A.	2.18	5.40E-07	5.30E-07	4.40E-07	1.20E-09	V. G.	1.78	7.30E-07	7.30E-07	6.10E-07	1.70E-09
NNE	M. A.	1.56	1.10E-06	1.10E-06	9.50E-07	3.10E-09	V. G.	1.66	1.00E-06	1.00E-06	8.60E-07	2.80E-09
NE	M. A.	1.44	1.00E-06	1.00E-06	8.90E-07	2.90E-09	V. G.	0.94	2.00E-06	2.00E-06	1.80E-06	6.00E-09
ENE	M. A.	2.58	2.80E-07	2.70E-07	2.20E-07	5.60E-10	V. G.	2.18	3.50E-07	3.50E-07	2.90E-07	7.50E-10
E	M. A.	3.58	3.40E-07	3.40E-07	2.70E-07	4.40E-10	V. G.	1.38	1.30E-06	1.30E-06	1.10E-06	2.30E-09
ESE	M. A.	None	-	-	-	-	V. G.	3.57	5.20E-07	5.10E-07	4.10E-07	5.90E-10
SE	M. A.	1.37	1.40E-06	1.40E-06	1.20E-06	2.90E-09	V. G.	1.37	1.40E-06	1.40E-06	1.20E-06	2.90E-09
SSE	M. A.	2.71	2.60E-07	2.50E-07	2.10E-07	7.70E-10	V. G.	1.21	8.60E-07	8.60E-07	7.40E-07	3.10E-09

Note: S. B. – Site Boundary; M. A. – Meat Animal; V. G. – Vegetable Garden

Table 2.7-17 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles No Decay, Undepleted

Ground Level Release - No Purge Releases

Annual Average χ/Q (sec/m^3) **Distance in Miles from the Site**

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	9.892E-06	3.343E-06	1.737E-06	1.099E-06	5.804E-07	3.710E-07	2.630E-07	1.990E-07	1.573E-07	1.285E-07	1.076E-07
SSW	7.733E-06	2.642E-06	1.380E-06	8.743E-07	4.630E-07	2.965E-07	2.105E-07	1.594E-07	1.262E-07	1.031E-07	8.641E-08
SW	6.892E-06	2.360E-06	1.235E-06	7.838E-07	4.158E-07	2.667E-07	1.896E-07	1.437E-07	1.139E-07	9.320E-08	7.815E-08
WSW	6.435E-06	2.194E-06	1.149E-06	7.299E-07	3.879E-07	2.491E-07	1.773E-07	1.346E-07	1.067E-07	8.740E-08	7.334E-08
W	7.894E-06	2.665E-06	1.399E-06	8.926E-07	4.777E-07	3.083E-07	2.203E-07	1.678E-07	1.335E-07	1.096E-07	9.221E-08
WNW	6.843E-06	2.320E-06	1.217E-06	7.739E-07	4.128E-07	2.660E-07	1.899E-07	1.446E-07	1.150E-07	9.437E-08	7.937E-08
NW	6.822E-06	2.367E-06	1.253E-06	7.999E-07	4.290E-07	2.776E-07	1.988E-07	1.517E-07	1.209E-07	9.942E-08	8.374E-08
NNW	5.763E-06	2.029E-06	1.080E-06	6.897E-07	3.706E-07	2.402E-07	1.723E-07	1.316E-07	1.050E-07	8.641E-08	7.284E-08
N	1.469E-05	5.213E-06	2.778E-06	1.771E-06	9.494E-07	6.142E-07	4.399E-07	3.357E-07	2.675E-07	2.200E-07	1.853E-07
NNE	1.868E-05	6.567E-06	3.500E-06	2.234E-06	1.198E-06	7.757E-07	5.558E-07	4.242E-07	3.382E-07	2.782E-07	2.344E-07
NE	1.523E-05	5.352E-06	2.854E-06	1.826E-06	9.817E-07	6.364E-07	4.564E-07	3.487E-07	2.782E-07	2.290E-07	1.930E-07
ENE	9.350E-06	3.256E-06	1.748E-06	1.126E-06	6.118E-07	3.995E-07	2.881E-07	2.211E-07	1.771E-07	1.463E-07	1.237E-07
E	1.774E-05	6.092E-06	3.305E-06	2.154E-06	1.188E-06	7.835E-07	5.696E-07	4.400E-07	3.543E-07	2.940E-07	2.497E-07
ESE	2.685E-05	8.740E-06	4.697E-06	3.103E-06	1.742E-06	1.163E-06	8.527E-07	6.634E-07	5.373E-07	4.482E-07	3.822E-07
SE	1.932E-05	6.168E-06	3.268E-06	2.151E-06	1.202E-06	8.001E-07	5.855E-07	4.548E-07	3.678E-07	3.064E-07	2.611E-07
SSE	1.049E-05	3.458E-06	1.807E-06	1.158E-06	6.243E-07	4.053E-07	2.910E-07	2.225E-07	1.776E-07	1.463E-07	1.234E-07

Table 2.7-17 Long-Term Average χ/Q (sec/m³) for Routine Releases at Distances Between 0.25 to 50 Miles No Decay, Undepleted

Ground Level Release - No Purge Releases

Annual Average χ/Q (sec/m³) **Distance in Miles from the Site**

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	9.185E-08	5.021E-08	3.285E-08	1.820E-08	1.203E-08	8.748E-09	6.752E-09	5.430E-09	4.499E-09	3.814E-09	3.291E-09
SSW	7.380E-08	4.043E-08	2.649E-08	1.469E-08	9.713E-09	7.062E-09	5.450E-09	4.381E-09	3.629E-09	3.076E-09	2.653E-09
SW	6.680E-08	3.671E-08	2.412E-08	1.342E-08	8.899E-09	6.484E-09	5.013E-09	4.037E-09	3.348E-09	2.841E-09	2.453E-09
WSW	6.274E-08	3.459E-08	2.277E-08	1.272E-08	8.461E-09	6.180E-09	4.788E-09	3.863E-09	3.209E-09	2.727E-09	2.358E-09
W	7.905E-08	4.398E-08	2.916E-08	1.646E-08	1.103E-08	8.108E-09	6.314E-09	5.116E-09	4.267E-09	3.638E-09	3.156E-09
WNW	6.805E-08	3.789E-08	2.514E-08	1.422E-08	9.558E-09	7.041E-09	5.493E-09	4.458E-09	3.723E-09	3.177E-09	2.759E-09
NW	7.188E-08	4.017E-08	2.672E-08	1.515E-08	1.018E-08	7.497E-09	5.847E-09	4.743E-09	3.960E-09	3.379E-09	2.932E-09
NNW	6.257E-08	3.506E-08	2.336E-08	1.327E-08	8.922E-09	6.572E-09	5.126E-09	4.158E-09	3.471E-09	2.961E-09	2.570E-09
N	1.591E-07	8.890E-08	5.911E-08	3.347E-08	2.246E-08	1.652E-08	1.286E-08	1.042E-08	8.691E-09	7.407E-09	6.422E-09
NNE	2.012E-07	1.126E-07	7.492E-08	4.248E-08	2.854E-08	2.100E-08	1.637E-08	1.327E-08	1.108E-08	9.446E-09	8.194E-09
NE	1.658E-07	9.287E-08	6.186E-08	3.512E-08	2.362E-08	1.739E-08	1.357E-08	1.101E-08	9.187E-09	7.837E-09	6.802E-09
ENE	1.065E-07	6.033E-08	4.050E-08	2.325E-08	1.575E-08	1.167E-08	9.148E-09	7.451E-09	6.242E-09	5.342E-09	4.650E-09
E	2.158E-07	1.239E-07	8.400E-08	4.888E-08	3.344E-08	2.496E-08	1.968E-08	1.611E-08	1.356E-08	1.165E-08	1.017E-08
ESE	3.317E-07	1.934E-07	1.325E-07	7.833E-08	5.418E-08	4.079E-08	3.239E-08	2.668E-08	2.257E-08	1.948E-08	1.709E-08
SE	2.264E-07	1.317E-07	9.011E-08	5.318E-08	3.676E-08	2.767E-08	2.198E-08	1.810E-08	1.531E-08	1.322E-08	1.160E-08
SSE	1.061E-07	5.969E-08	3.991E-08	2.281E-08	1.545E-08	1.144E-08	8.972E-09	7.312E-09	6.130E-09	5.250E-09	4.573E-09

Table 2.7-17 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles No Decay, Undepleted

Ground Level Release - No Purge Releases

χ/Q (sec/m^3) for each segment **Segment Boundaries in Miles from the Site**

Direction From Site	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	1.810E-06	6.025E-07	2.662E-07	1.583E-07	1.080E-07	5.175E-08	1.871E-08	8.825E-09	5.453E-09	3.823E-09
SSW	1.436E-06	4.804E-07	2.130E-07	1.269E-07	8.669E-08	4.165E-08	1.510E-08	7.124E-09	4.400E-09	3.083E-09
SW	1.285E-06	4.313E-07	1.918E-07	1.145E-07	7.841E-08	3.780E-08	1.379E-08	6.540E-09	4.053E-09	2.848E-09
WSW	1.195E-06	4.022E-07	1.794E-07	1.073E-07	7.358E-08	3.559E-08	1.306E-08	6.232E-09	3.878E-09	2.733E-09
W	1.455E-06	4.946E-07	2.228E-07	1.342E-07	9.249E-08	4.519E-08	1.687E-08	8.170E-09	5.135E-09	3.646E-09
WNW	1.265E-06	4.278E-07	1.921E-07	1.156E-07	7.962E-08	3.893E-08	1.458E-08	7.093E-09	4.473E-09	3.184E-09
NW	1.299E-06	4.441E-07	2.010E-07	1.215E-07	8.399E-08	4.124E-08	1.551E-08	7.553E-09	4.760E-09	3.386E-09
NNW	1.117E-06	3.836E-07	1.741E-07	1.055E-07	7.306E-08	3.598E-08	1.358E-08	6.620E-09	4.173E-09	2.967E-09
N	2.872E-06	9.831E-07	4.447E-07	2.689E-07	1.859E-07	9.126E-08	3.428E-08	1.664E-08	1.046E-08	7.422E-09
NNE	3.619E-06	1.241E-06	5.618E-07	3.399E-07	2.351E-07	1.155E-07	4.349E-08	2.116E-08	1.332E-08	9.465E-09
NE	2.952E-06	1.016E-06	4.613E-07	2.796E-07	1.936E-07	9.529E-08	3.595E-08	1.752E-08	1.104E-08	7.854E-09
ENE	1.807E-06	6.318E-07	2.910E-07	1.779E-07	1.240E-07	6.179E-08	2.375E-08	1.175E-08	7.475E-09	5.353E-09
E	3.413E-06	1.223E-06	5.748E-07	3.558E-07	2.503E-07	1.266E-07	4.982E-08	2.511E-08	1.616E-08	1.167E-08
ESE	4.887E-06	1.787E-06	8.596E-07	5.394E-07	3.831E-07	1.971E-07	7.964E-08	4.100E-08	2.675E-08	1.951E-08
SE	3.416E-06	1.234E-06	5.904E-07	3.693E-07	2.617E-07	1.343E-07	5.409E-08	2.782E-08	1.815E-08	1.324E-08
SSE	1.885E-06	6.456E-07	2.941E-07	1.785E-07	1.238E-07	6.122E-08	2.334E-08	1.152E-08	7.336E-09	5.260E-09

Table 2.7-18 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles 2.260-Day Decay, Undepleted

Ground Level Release - No Purge Releases

Annual Average χ/Q (sec/m^3) **Distance in Miles from the Site**

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	9.882E-06	3.336E-06	1.732E-06	1.094E-06	5.768E-07	3.679E-07	2.603E-07	1.964E-07	1.550E-07	1.263E-07	1.055E-07
SSW	7.724E-06	2.636E-06	1.375E-06	8.704E-07	4.598E-07	2.938E-07	2.081E-07	1.572E-07	1.241E-07	1.013E-07	8.462E-08
SW	6.884E-06	2.355E-06	1.231E-06	7.800E-07	4.128E-07	2.641E-07	1.873E-07	1.417E-07	1.120E-07	9.140E-08	7.644E-08
WSW	6.427E-06	2.189E-06	1.145E-06	7.262E-07	3.849E-07	2.466E-07	1.750E-07	1.325E-07	1.048E-07	8.560E-08	7.164E-08
W	7.884E-06	2.658E-06	1.394E-06	8.880E-07	4.739E-07	3.051E-07	2.174E-07	1.651E-07	1.310E-07	1.073E-07	9.001E-08
WNW	6.834E-06	2.315E-06	1.213E-06	7.700E-07	4.097E-07	2.633E-07	1.875E-07	1.423E-07	1.129E-07	9.244E-08	7.754E-08
NW	6.814E-06	2.361E-06	1.248E-06	7.960E-07	4.258E-07	2.748E-07	1.963E-07	1.494E-07	1.187E-07	9.741E-08	8.183E-08
NNW	5.755E-06	2.023E-06	1.075E-06	6.859E-07	3.675E-07	2.375E-07	1.698E-07	1.294E-07	1.029E-07	8.446E-08	7.099E-08
N	1.467E-05	5.198E-06	2.767E-06	1.762E-06	9.415E-07	6.074E-07	4.338E-07	3.301E-07	2.623E-07	2.151E-07	1.807E-07
NNE	1.866E-05	6.550E-06	3.486E-06	2.222E-06	1.189E-06	7.675E-07	5.484E-07	4.175E-07	3.319E-07	2.723E-07	2.288E-07
NE	1.521E-05	5.339E-06	2.843E-06	1.816E-06	9.740E-07	6.298E-07	4.505E-07	3.432E-07	2.731E-07	2.242E-07	1.885E-07
ENE	9.337E-06	3.247E-06	1.741E-06	1.120E-06	6.065E-07	3.949E-07	2.840E-07	2.173E-07	1.735E-07	1.429E-07	1.205E-07
E	1.772E-05	6.073E-06	3.289E-06	2.140E-06	1.177E-06	7.738E-07	5.608E-07	4.318E-07	3.466E-07	2.868E-07	2.427E-07
ESE	2.681E-05	8.712E-06	4.674E-06	3.083E-06	1.725E-06	1.148E-06	8.388E-07	6.504E-07	5.251E-07	4.365E-07	3.711E-07
SE	1.929E-05	6.149E-06	3.253E-06	2.137E-06	1.191E-06	7.898E-07	5.761E-07	4.460E-07	3.595E-07	2.985E-07	2.535E-07
SSE	1.048E-05	3.450E-06	1.800E-06	1.152E-06	6.194E-07	4.010E-07	2.871E-07	2.189E-07	1.743E-07	1.432E-07	1.204E-07

Table 2.7-18 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles 2.260-Day Decay, Undepleted

Ground Level Release - No Purge Releases

Annual Average χ/Q (sec/m^3)	Distance in Miles from the Site										
Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	8.989E-08	4.859E-08	3.144E-08	1.702E-08	1.100E-08	7.823E-09	5.903E-09	4.641E-09	3.760E-09	3.117E-09	2.630E-09
SSW	7.211E-08	3.904E-08	2.528E-08	1.368E-08	8.832E-09	6.268E-09	4.723E-09	3.707E-09	2.999E-09	2.481E-09	2.091E-09
SW	6.518E-08	3.538E-08	2.295E-08	1.245E-08	8.048E-09	5.717E-09	4.310E-09	3.384E-09	2.737E-09	2.265E-09	1.908E-09
WSW	6.112E-08	3.325E-08	2.160E-08	1.175E-08	7.604E-09	5.407E-09	4.078E-09	3.203E-09	2.591E-09	2.144E-09	1.806E-09
W	7.696E-08	4.223E-08	2.761E-08	1.516E-08	9.882E-09	7.064E-09	5.351E-09	4.219E-09	3.423E-09	2.840E-09	2.398E-09
WNW	6.631E-08	3.644E-08	2.386E-08	1.314E-08	8.600E-09	6.169E-09	4.688E-09	3.706E-09	3.015E-09	2.508E-09	2.122E-09
NW	7.006E-08	3.865E-08	2.537E-08	1.401E-08	9.174E-09	6.583E-09	5.003E-09	3.955E-09	3.218E-09	2.677E-09	2.265E-09
NNW	6.081E-08	3.359E-08	2.206E-08	1.217E-08	7.957E-09	5.697E-09	4.320E-09	3.408E-09	2.766E-09	2.295E-09	1.938E-09
N	1.547E-07	8.524E-08	5.588E-08	3.077E-08	2.008E-08	1.436E-08	1.088E-08	8.579E-09	6.961E-09	5.774E-09	4.873E-09
NNE	1.959E-07	1.081E-07	7.096E-08	3.916E-08	2.561E-08	1.835E-08	1.392E-08	1.099E-08	8.934E-09	7.421E-09	6.272E-09
NE	1.614E-07	8.924E-08	5.865E-08	3.242E-08	2.122E-08	1.522E-08	1.157E-08	9.140E-09	7.433E-09	6.179E-09	5.226E-09
ENE	1.035E-07	5.772E-08	3.818E-08	2.128E-08	1.400E-08	1.007E-08	7.667E-09	6.067E-09	4.938E-09	4.107E-09	3.473E-09
E	2.091E-07	1.182E-07	7.888E-08	4.449E-08	2.950E-08	2.135E-08	1.632E-08	1.296E-08	1.058E-08	8.819E-09	7.474E-09
ESE	3.210E-07	1.841E-07	1.241E-07	7.095E-08	4.750E-08	3.462E-08	2.662E-08	2.124E-08	1.740E-08	1.455E-08	1.237E-08
SE	2.191E-07	1.253E-07	8.436E-08	4.816E-08	3.222E-08	2.348E-08	1.805E-08	1.440E-08	1.180E-08	9.866E-09	8.385E-09
SSE	1.032E-07	5.726E-08	3.774E-08	2.096E-08	1.379E-08	9.931E-09	7.568E-09	5.995E-09	4.886E-09	4.069E-09	3.446E-09

Table 2.7-18 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles 2.260-Day Decay, Undepleted

Ground Level Release - No Purge Releases

χ/Q (sec/m^3) for each segment **Segment Boundaries in Miles from the Site**

Direction From Site	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	1.805E-06	5.989E-07	2.634E-07	1.559E-07	1.059E-07	5.015E-08	1.755E-08	7.903E-09	4.666E-09	3.127E-09
SSW	1.431E-06	4.773E-07	2.106E-07	1.249E-07	8.492E-08	4.027E-08	1.410E-08	6.334E-09	3.727E-09	2.490E-09
SW	1.280E-06	4.284E-07	1.895E-07	1.126E-07	7.670E-08	3.647E-08	1.283E-08	5.776E-09	3.402E-09	2.272E-09
WSW	1.191E-06	3.993E-07	1.771E-07	1.054E-07	7.188E-08	3.426E-08	1.209E-08	5.461E-09	3.220E-09	2.151E-09
W	1.450E-06	4.909E-07	2.199E-07	1.317E-07	9.029E-08	4.345E-08	1.558E-08	7.130E-09	4.239E-09	2.849E-09
WNW	1.261E-06	4.247E-07	1.897E-07	1.135E-07	7.780E-08	3.748E-08	1.350E-08	6.225E-09	3.723E-09	2.515E-09
NW	1.295E-06	4.409E-07	1.985E-07	1.194E-07	8.209E-08	3.973E-08	1.439E-08	6.642E-09	3.974E-09	2.685E-09
NNW	1.113E-06	3.805E-07	1.717E-07	1.034E-07	7.121E-08	3.451E-08	1.250E-08	5.749E-09	3.424E-09	2.302E-09
N	2.860E-06	9.753E-07	4.386E-07	2.637E-07	1.813E-07	8.762E-08	3.160E-08	1.450E-08	8.621E-09	5.792E-09
NNE	3.605E-06	1.231E-06	5.544E-07	3.336E-07	2.295E-07	1.111E-07	4.020E-08	1.851E-08	1.105E-08	7.444E-09
NE	2.941E-06	1.008E-06	4.554E-07	2.745E-07	1.890E-07	9.169E-08	3.327E-08	1.536E-08	9.183E-09	6.198E-09
ENE	1.800E-06	6.265E-07	2.869E-07	1.744E-07	1.208E-07	5.920E-08	2.180E-08	1.016E-08	6.094E-09	4.118E-09
E	3.397E-06	1.212E-06	5.660E-07	3.482E-07	2.433E-07	1.209E-07	4.547E-08	2.151E-08	1.301E-08	8.842E-09
ESE	4.864E-06	1.770E-06	8.458E-07	5.272E-07	3.719E-07	1.878E-07	7.233E-08	3.485E-08	2.131E-08	1.459E-08
SE	3.401E-06	1.223E-06	5.810E-07	3.610E-07	2.541E-07	1.280E-07	4.912E-08	2.364E-08	1.445E-08	9.890E-09
SSE	1.878E-06	6.407E-07	2.902E-07	1.752E-07	1.208E-07	5.880E-08	2.150E-08	1.002E-08	6.022E-09	4.081E-09

Table 2.7-19 Long-Term Average χ/Q (sec/m³) for Routine Releases at Distances Between 0.25 to 50 Miles 8.000-Day Decay, Depleted

Ground Level Release - No Purge Releases

Annual Average χ/Q (sec/m³) **Distance in Miles from the Site**

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	9.360E-06	3.051E-06	1.547E-06	9.606E-07	4.921E-07	3.065E-07	2.124E-07	1.575E-07	1.223E-07	9.819E-08	8.091E-08
SSW	7.316E-06	2.411E-06	1.228E-06	7.643E-07	3.924E-07	2.448E-07	1.699E-07	1.261E-07	9.799E-08	7.876E-08	6.495E-08
SW	6.521E-06	2.154E-06	1.100E-06	6.851E-07	3.524E-07	2.202E-07	1.530E-07	1.137E-07	8.845E-08	7.115E-08	5.872E-08
WSW	6.088E-06	2.002E-06	1.023E-06	6.380E-07	3.287E-07	2.057E-07	1.431E-07	1.064E-07	8.285E-08	6.670E-08	5.508E-08
W	7.468E-06	2.432E-06	1.245E-06	7.802E-07	4.048E-07	2.546E-07	1.778E-07	1.327E-07	1.036E-07	8.364E-08	6.924E-08
WNW	6.474E-06	2.117E-06	1.083E-06	6.764E-07	3.498E-07	2.196E-07	1.533E-07	1.143E-07	8.924E-08	7.202E-08	5.962E-08
NW	6.454E-06	2.160E-06	1.115E-06	6.992E-07	3.636E-07	2.292E-07	1.605E-07	1.200E-07	9.385E-08	7.588E-08	6.290E-08
NNW	5.452E-06	1.851E-06	9.612E-07	6.028E-07	3.140E-07	1.983E-07	1.390E-07	1.040E-07	8.145E-08	6.591E-08	5.468E-08
N	1.390E-05	4.756E-06	2.473E-06	1.548E-06	8.044E-07	5.070E-07	3.549E-07	2.653E-07	2.076E-07	1.678E-07	1.391E-07
NNE	1.767E-05	5.993E-06	3.115E-06	1.952E-06	1.015E-06	6.404E-07	4.485E-07	3.354E-07	2.625E-07	2.123E-07	1.760E-07
NE	1.441E-05	4.884E-06	2.541E-06	1.596E-06	8.319E-07	5.254E-07	3.683E-07	2.757E-07	2.159E-07	1.747E-07	1.450E-07
ENE	8.845E-06	2.971E-06	1.556E-06	9.843E-07	5.183E-07	3.297E-07	2.324E-07	1.748E-07	1.374E-07	1.116E-07	9.283E-08
E	1.679E-05	5.558E-06	2.941E-06	1.882E-06	1.006E-06	6.465E-07	4.594E-07	3.477E-07	2.748E-07	2.241E-07	1.873E-07
ESE	2.540E-05	7.974E-06	4.180E-06	2.711E-06	1.475E-06	9.592E-07	6.875E-07	5.240E-07	4.166E-07	3.415E-07	2.866E-07
SE	1.828E-05	5.628E-06	2.909E-06	1.879E-06	1.018E-06	6.601E-07	4.721E-07	3.592E-07	2.852E-07	2.335E-07	1.958E-07
SSE	9.928E-06	3.156E-06	1.608E-06	1.012E-06	5.291E-07	3.346E-07	2.348E-07	1.759E-07	1.379E-07	1.116E-07	9.268E-08

Table 2.7-19 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles 8.000-Day Decay, Depleted

Ground Level Release - No Purge Releases

Annual Average χ/Q (sec/m^3) **Distance in Miles from the Site**

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	6.805E-08	3.507E-08	2.180E-08	1.110E-08	6.849E-09	4.687E-09	3.426E-09	2.620E-09	2.071E-09	1.679E-09	1.389E-09
SSW	5.465E-08	2.822E-08	1.756E-08	8.952E-09	5.520E-09	3.776E-09	2.758E-09	2.108E-09	1.665E-09	1.349E-09	1.115E-09
SW	4.945E-08	2.561E-08	1.597E-08	8.170E-09	5.050E-09	3.461E-09	2.531E-09	1.937E-09	1.532E-09	1.242E-09	1.027E-09
WSW	4.642E-08	2.411E-08	1.507E-08	7.733E-09	4.793E-09	3.291E-09	2.411E-09	1.848E-09	1.463E-09	1.188E-09	9.832E-10
W	5.848E-08	3.065E-08	1.929E-08	9.997E-09	6.243E-09	4.312E-09	3.175E-09	2.443E-09	1.941E-09	1.581E-09	1.313E-09
WNW	5.036E-08	2.642E-08	1.664E-08	8.645E-09	5.416E-09	3.751E-09	2.768E-09	2.134E-09	1.698E-09	1.385E-09	1.152E-09
NW	5.319E-08	2.801E-08	1.769E-08	9.211E-09	5.771E-09	3.996E-09	2.949E-09	2.272E-09	1.808E-09	1.475E-09	1.226E-09
NNW	4.627E-08	2.442E-08	1.544E-08	8.051E-09	5.043E-09	3.491E-09	2.574E-09	1.983E-09	1.577E-09	1.285E-09	1.067E-09
N	1.176E-07	6.193E-08	3.908E-08	2.032E-08	1.270E-08	8.781E-09	6.467E-09	4.976E-09	3.953E-09	3.219E-09	2.672E-09
NNE	1.489E-07	7.846E-08	4.956E-08	2.581E-08	1.616E-08	1.118E-08	8.243E-09	6.348E-09	5.048E-09	4.113E-09	3.417E-09
NE	1.227E-07	6.473E-08	4.094E-08	2.135E-08	1.338E-08	9.264E-09	6.834E-09	5.267E-09	4.190E-09	3.416E-09	2.839E-09
ENE	7.876E-08	4.200E-08	2.676E-08	1.410E-08	8.894E-09	6.191E-09	4.586E-09	3.546E-09	2.829E-09	2.312E-09	1.925E-09
E	1.595E-07	8.619E-08	5.543E-08	2.959E-08	1.884E-08	1.320E-08	9.835E-09	7.639E-09	6.119E-09	5.017E-09	4.191E-09
ESE	2.450E-07	1.344E-07	8.739E-08	4.735E-08	3.047E-08	2.153E-08	1.614E-08	1.261E-08	1.015E-08	8.357E-09	7.007E-09
SE	1.672E-07	9.154E-08	5.941E-08	3.214E-08	2.067E-08	1.461E-08	1.095E-08	8.553E-09	6.884E-09	5.669E-09	4.753E-09
SSE	7.849E-08	4.159E-08	2.639E-08	1.385E-08	8.732E-09	6.079E-09	4.505E-09	3.485E-09	2.783E-09	2.276E-09	1.897E-09

Table 2.7-19 Long-Term Average χ/Q (sec/m^3) for Routine Releases at Distances Between 0.25 to 50 Miles 8.000-Day Decay, Depleted

Ground Level Release - No Purge Releases

χ/Q (sec/m^3) for each segment **Segment Boundaries in Miles from the Site**

Direction From Site	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	1.620E-06	5.137E-07	2.155E-07	1.231E-07	8.127E-08	3.650E-08	1.159E-08	4.759E-09	2.641E-09	1.688E-09
SSW	1.285E-06	4.095E-07	1.724E-07	9.870E-08	6.523E-08	2.936E-08	9.340E-09	3.834E-09	2.125E-09	1.356E-09
SW	1.150E-06	3.676E-07	1.552E-07	8.907E-08	5.897E-08	2.663E-08	8.518E-09	3.513E-09	1.952E-09	1.248E-09
WSW	1.070E-06	3.428E-07	1.451E-07	8.343E-08	5.531E-08	2.505E-08	8.057E-09	3.340E-09	1.862E-09	1.193E-09
W	1.302E-06	4.214E-07	1.802E-07	1.043E-07	6.952E-08	3.179E-08	1.039E-08	4.372E-09	2.461E-09	1.588E-09
WNW	1.132E-06	3.645E-07	1.554E-07	8.985E-08	5.986E-08	2.739E-08	8.987E-09	3.802E-09	2.149E-09	1.391E-09
NW	1.163E-06	3.784E-07	1.626E-07	9.447E-08	6.315E-08	2.902E-08	9.566E-09	4.050E-09	2.289E-09	1.481E-09
NNW	9.996E-07	3.267E-07	1.408E-07	8.198E-08	5.489E-08	2.528E-08	8.356E-09	3.538E-09	1.997E-09	1.291E-09
N	2.569E-06	8.375E-07	3.596E-07	2.089E-07	1.397E-07	6.416E-08	2.111E-08	8.902E-09	5.012E-09	3.234E-09
NNE	3.238E-06	1.057E-06	4.544E-07	2.642E-07	1.767E-07	8.126E-08	2.680E-08	1.133E-08	6.394E-09	4.132E-09
NE	2.642E-06	8.654E-07	3.732E-07	2.173E-07	1.455E-07	6.703E-08	2.216E-08	9.389E-09	5.304E-09	3.432E-09
ENE	1.616E-06	5.381E-07	2.353E-07	1.382E-07	9.317E-08	4.340E-08	1.460E-08	6.269E-09	3.570E-09	2.322E-09
E	3.052E-06	1.041E-06	4.646E-07	2.763E-07	1.879E-07	8.880E-08	3.055E-08	1.336E-08	7.687E-09	5.037E-09
ESE	4.370E-06	1.521E-06	6.945E-07	4.187E-07	2.874E-07	1.381E-07	4.874E-08	2.176E-08	1.268E-08	8.388E-09
SE	3.055E-06	1.050E-06	4.771E-07	2.866E-07	1.964E-07	9.408E-08	3.311E-08	1.476E-08	8.602E-09	5.690E-09
SSE	1.687E-06	5.500E-07	2.379E-07	1.388E-07	9.304E-08	4.303E-08	1.436E-08	6.157E-09	3.509E-09	2.286E-09

Table 2.7-20 Long-Term Average D/Q ($1/m^2$) for Routine Releases at Distances Between 0.25 to 50 Miles

Ground Level Release - No Purge Releases

******************** Relative Deposition per Unit Area (M**-2) at Fixed Points By Downwind Sectors ********************

Distances in Miles

Direction From Site	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	4.819E-08	1.630E-08	8.367E-09	5.138E-09	2.561E-09	1.553E-09	1.050E-09	7.611E-10	5.787E-10	4.559E-10	3.691E-10
SSW	3.194E-08	1.080E-08	5.546E-09	3.405E-09	1.698E-09	1.030E-09	6.961E-10	5.045E-10	3.836E-10	3.022E-10	2.446E-10
SW	2.633E-08	8.902E-09	4.571E-09	2.807E-09	1.399E-09	8.486E-10	5.738E-10	4.158E-10	3.161E-10	2.491E-10	2.016E-10
WSW	2.286E-08	7.732E-09	3.970E-09	2.438E-09	1.215E-09	7.371E-10	4.983E-10	3.611E-10	2.746E-10	2.163E-10	1.751E-10
W	2.691E-08	9.101E-09	4.673E-09	2.869E-09	1.430E-09	8.676E-10	5.866E-10	4.251E-10	3.232E-10	2.546E-10	2.061E-10
WNW	2.495E-08	8.438E-09	4.333E-09	2.660E-09	1.326E-09	8.044E-10	5.439E-10	3.941E-10	2.997E-10	2.361E-10	1.911E-10
NW	2.242E-08	7.583E-09	3.893E-09	2.391E-09	1.192E-09	7.229E-10	4.887E-10	3.542E-10	2.693E-10	2.122E-10	1.718E-10
NNW	1.628E-08	5.504E-09	2.826E-09	1.735E-09	8.652E-10	5.247E-10	3.548E-10	2.571E-10	1.955E-10	1.540E-10	1.247E-10
N	4.309E-08	1.457E-08	7.481E-09	4.594E-09	2.290E-09	1.389E-09	9.391E-10	6.805E-10	5.175E-10	4.077E-10	3.300E-10
NNE	6.257E-08	2.116E-08	1.086E-08	6.671E-09	3.326E-09	2.017E-09	1.364E-09	9.882E-10	7.514E-10	5.920E-10	4.793E-10
NE	5.046E-08	1.706E-08	8.761E-09	5.379E-09	2.682E-09	1.627E-09	1.100E-09	7.969E-10	6.059E-10	4.774E-10	3.865E-10
ENE	2.720E-08	9.199E-09	4.723E-09	2.900E-09	1.446E-09	8.769E-10	5.929E-10	4.296E-10	3.267E-10	2.574E-10	2.084E-10
E	3.824E-08	1.293E-08	6.640E-09	4.077E-09	2.033E-09	1.233E-09	8.335E-10	6.040E-10	4.593E-10	3.618E-10	2.929E-10
ESE	5.097E-08	1.724E-08	8.849E-09	5.434E-09	2.709E-09	1.643E-09	1.111E-09	8.050E-10	6.121E-10	4.822E-10	3.904E-10
SE	4.574E-08	1.547E-08	7.942E-09	4.877E-09	2.431E-09	1.475E-09	9.970E-10	7.225E-10	5.493E-10	4.328E-10	3.504E-10
SSE	4.085E-08	1.381E-08	7.092E-09	4.355E-09	2.171E-09	1.317E-09	8.902E-10	6.451E-10	4.905E-10	3.865E-10	3.129E-10

Table 2.7-20 Long-Term Average D/Q ($1/m^2$) for Routine Releases at Distances Between 0.25 to 50 Miles

Ground Level Release - No Purge Releases

******************** Relative Deposition per Unit Area (M**-2) at Fixed Points By Downwind Sectors ********************

Distance in Miles

Direction From Site	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	3.053E-10	1.496E-10	9.388E-11	4.745E-11	2.872E-11	1.926E-11	1.380E-11	1.036E-11	8.056E-12	6.435E-12	5.252E-12
SSW	2.024E-10	9.917E-11	6.222E-11	3.145E-11	1.904E-11	1.276E-11	9.145E-12	6.867E-12	5.339E-12	4.265E-12	3.481E-12
SW	1.668E-10	8.174E-11	5.129E-11	2.592E-11	1.569E-11	1.052E-11	7.538E-12	5.660E-12	4.401E-12	3.515E-12	2.869E-12
WSW	1.449E-10	7.099E-11	4.454E-11	2.251E-11	1.363E-11	9.136E-12	6.547E-12	4.916E-12	3.822E-12	3.053E-12	2.492E-12
W	1.705E-10	8.356E-11	5.243E-11	2.650E-11	1.604E-11	1.075E-11	7.706E-12	5.786E-12	4.499E-12	3.594E-12	2.933E-12
WNW	1.581E-10	7.748E-11	4.861E-11	2.457E-11	1.487E-11	9.971E-12	7.145E-12	5.365E-12	4.171E-12	3.332E-12	2.720E-12
NW	1.421E-10	6.962E-11	4.369E-11	2.208E-11	1.336E-11	8.961E-12	6.421E-12	4.821E-12	3.749E-12	2.994E-12	2.444E-12
NNW	1.031E-10	5.054E-11	3.171E-11	1.603E-11	9.701E-12	6.504E-12	4.661E-12	3.500E-12	2.721E-12	2.174E-12	1.774E-12
N	2.730E-10	1.338E-10	8.394E-11	4.243E-11	2.568E-11	1.722E-11	1.234E-11	9.264E-12	7.203E-12	5.754E-12	4.697E-12
NNE	3.964E-10	1.943E-10	1.219E-10	6.161E-11	3.729E-11	2.500E-11	1.792E-11	1.345E-11	1.046E-11	8.355E-12	6.820E-12
NE	3.197E-10	1.567E-10	9.830E-11	4.968E-11	3.007E-11	2.016E-11	1.445E-11	1.085E-11	8.435E-12	6.738E-12	5.500E-12
ENE	1.724E-10	8.446E-11	5.300E-11	2.679E-11	1.621E-11	1.087E-11	7.789E-12	5.849E-12	4.548E-12	3.633E-12	2.965E-12
E	2.423E-10	1.187E-10	7.451E-11	3.766E-11	2.279E-11	1.528E-11	1.095E-11	8.223E-12	6.393E-12	5.107E-12	4.168E-12
ESE	3.229E-10	1.583E-10	9.929E-11	5.019E-11	3.038E-11	2.037E-11	1.459E-11	1.096E-11	8.520E-12	6.806E-12	5.555E-12
SE	2.898E-10	1.420E-10	8.912E-11	4.504E-11	2.726E-11	1.828E-11	1.310E-11	9.835E-12	7.647E-12	6.108E-12	4.986E-12
SSE	2.588E-10	1.268E-10	7.957E-11	4.022E-11	2.434E-11	1.632E-11	1.170E-11	8.782E-12	6.828E-12	5.454E-12	4.452E-12

Table 2.7-20 Long-Term Average D/Q ($1/m^2$) for Routine Releases at Distances Between 0.25 to 50 Miles

Ground Level Release - No Purge Releases

********************* Relative Deposition per Unit Area (M**-2) at Fixed Points By Downwind Sectors ********************

Segment Boundaries in Miles

Direction From Site	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	8.694E-09	2.686E-09	1.069E-09	5.841E-10	3.712E-10	1.594E-10	4.944E-11	1.960E-11	1.046E-11	6.477E-12
SSW	5.762E-09	1.780E-09	7.084E-10	3.871E-10	2.460E-10	1.057E-10	3.277E-11	1.299E-11	6.936E-12	4.293E-12
SW	4.749E-09	1.467E-09	5.839E-10	3.191E-10	2.028E-10	8.710E-11	2.701E-11	1.071E-11	5.717E-12	3.538E-12
WSW	4.125E-09	1.274E-09	5.071E-10	2.771E-10	1.761E-10	7.565E-11	2.346E-11	9.298E-12	4.965E-12	3.073E-12
W	4.855E-09	1.500E-09	5.969E-10	3.262E-10	2.073E-10	8.905E-11	2.761E-11	1.094E-11	5.844E-12	3.617E-12
WNW	4.502E-09	1.391E-09	5.534E-10	3.024E-10	1.922E-10	8.256E-11	2.560E-11	1.015E-11	5.419E-12	3.354E-12
NW	4.045E-09	1.250E-09	4.973E-10	2.718E-10	1.727E-10	7.420E-11	2.301E-11	9.119E-12	4.870E-12	3.014E-12
NNW	2.937E-09	9.072E-10	3.610E-10	1.973E-10	1.254E-10	5.386E-11	1.670E-11	6.619E-12	3.535E-12	2.188E-12
N	7.773E-09	2.402E-09	9.557E-10	5.222E-10	3.319E-10	1.426E-10	4.421E-11	1.752E-11	9.357E-12	5.792E-12
NNE	1.129E-08	3.487E-09	1.388E-09	7.583E-10	4.820E-10	2.070E-10	6.420E-11	2.544E-11	1.359E-11	8.410E-12
NE	9.103E-09	2.812E-09	1.119E-09	6.115E-10	3.887E-10	1.669E-10	5.177E-11	2.052E-11	1.096E-11	6.782E-12
ENE	4.908E-09	1.516E-09	6.033E-10	3.297E-10	2.095E-10	9.001E-11	2.791E-11	1.106E-11	5.907E-12	3.656E-12
E	6.899E-09	2.132E-09	8.482E-10	4.635E-10	2.946E-10	1.265E-10	3.924E-11	1.555E-11	8.305E-12	5.140E-12
ESE	9.195E-09	2.841E-09	1.130E-09	6.177E-10	3.926E-10	1.686E-10	5.230E-11	2.073E-11	1.107E-11	6.851E-12
SE	8.252E-09	2.550E-09	1.015E-09	5.544E-10	3.524E-10	1.514E-10	4.693E-11	1.860E-11	9.934E-12	6.149E-12
SSE	7.369E-09	2.277E-09	9.059E-10	4.950E-10	3.146E-10	1.351E-10	4.191E-11	1.661E-11	8.870E-12	5.490E-12

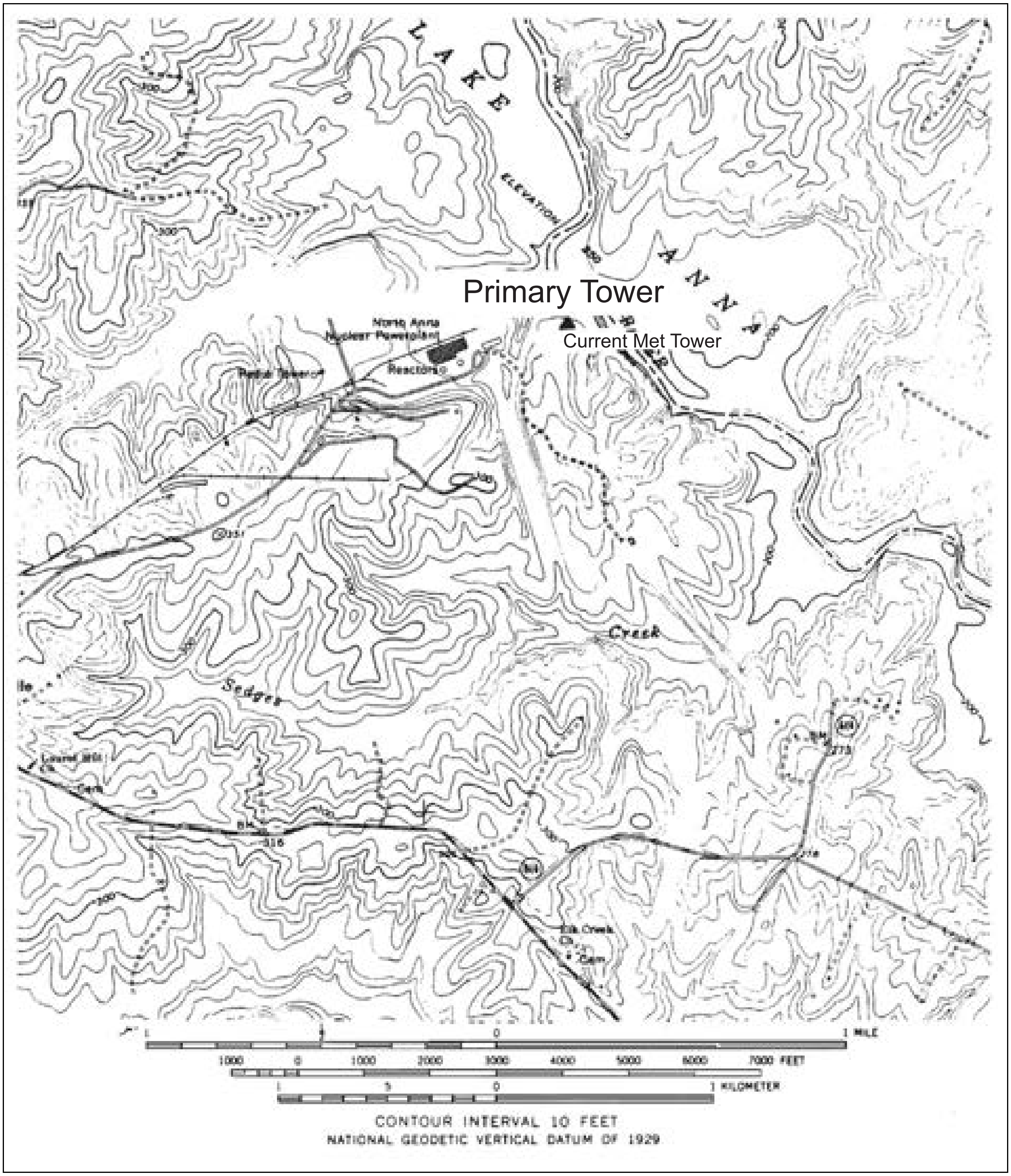
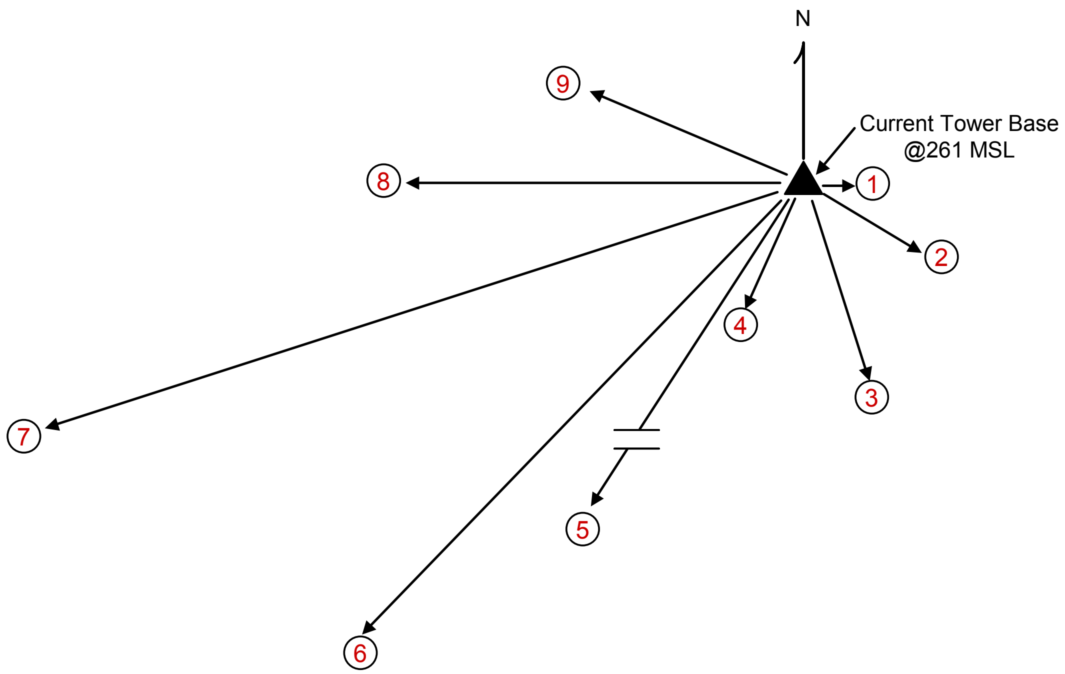


Figure 2.7-1   Location of Meteorological Tower



		Approximated Directions and Distances	
1	Basketball Backboard	095°	100'
2	30 x 50 Pavilion	122°	222'
3	20 x 30 Pavilion	160°	294'
4	Softball Backstop	200°	203'
5	Nearest Contiguous Tree Line		>500'
6	Training Center	205°	740'
7	Unit 1 Containment	250°	1750'
8	Original Tower	272°	1020'
9	Back-up Tower	–	–

Figure 2.7-2 Location of Meteorological Tower Relative to Local Ground Features

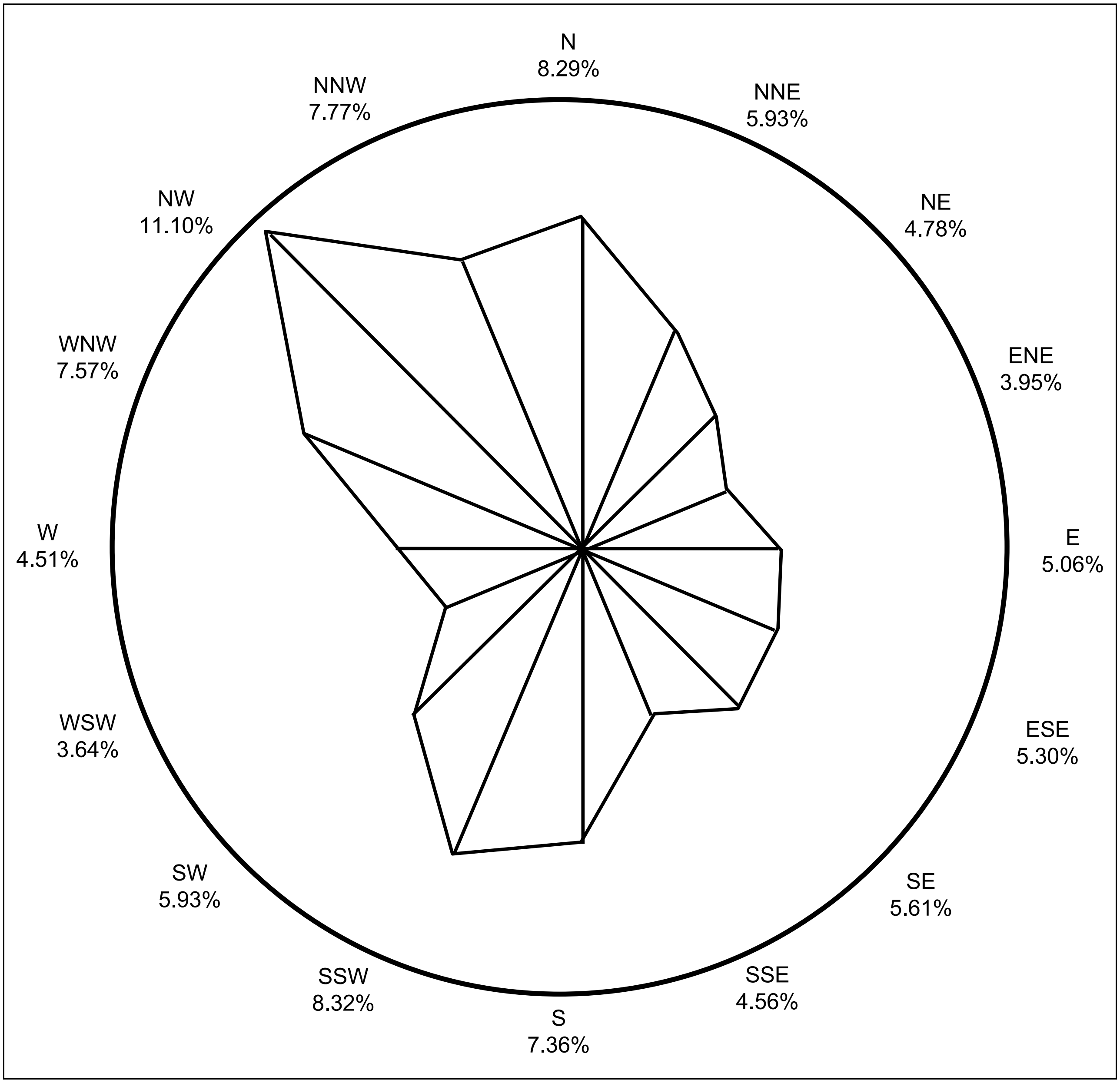


Figure 2.7-3 North Anna Seasonal Wind Direction Roses: Low-Level Winds: 1974–1987: Season = Spring

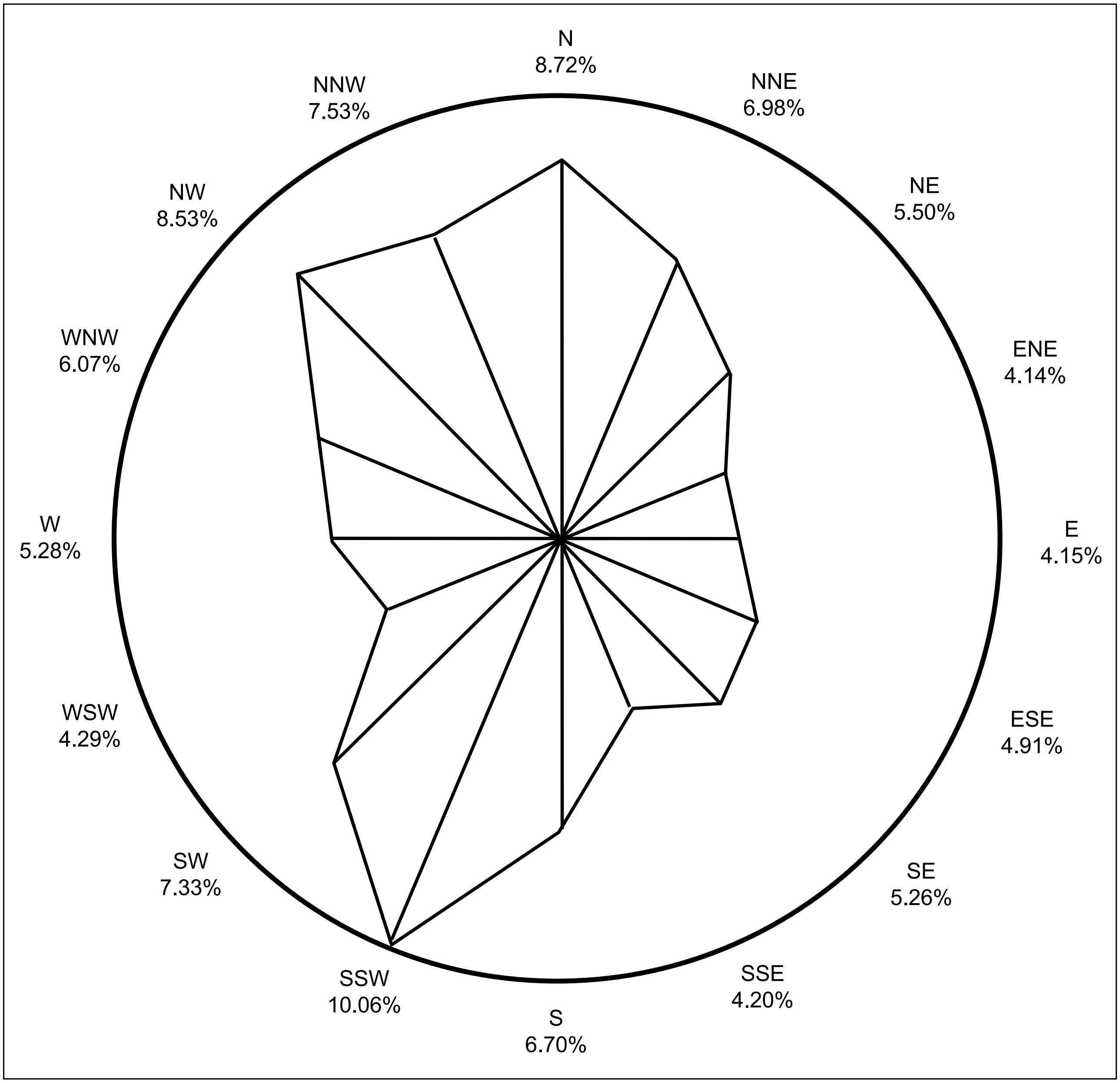


Figure 2.7-4 North Anna Seasonal Wind Direction Roses: High-Level Winds: 1974–1987: Season = Spring

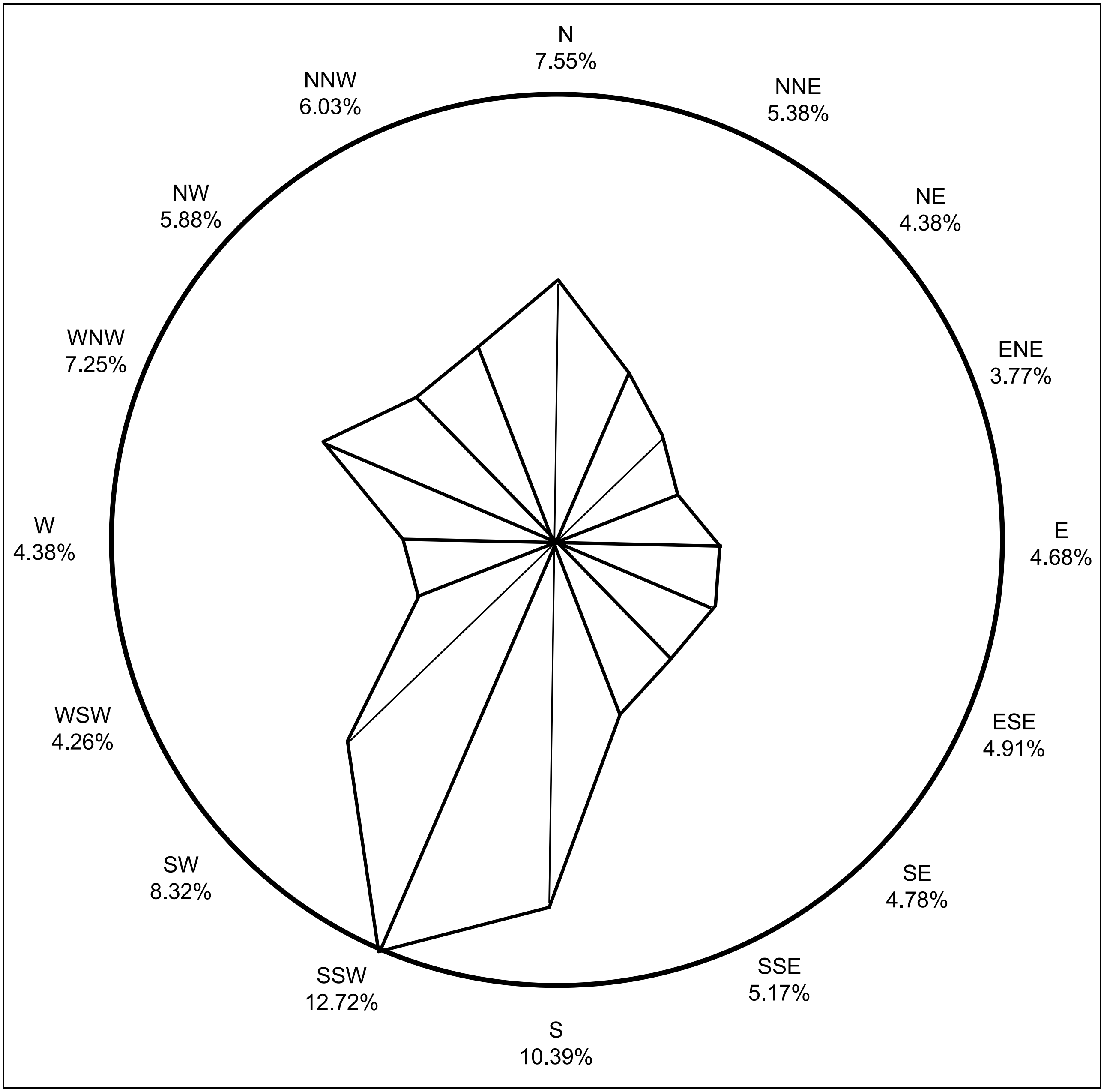


Figure 2.7-5 North Anna Seasonal Wind Direction Roses: Low-Level Winds: 1974–1987: Season = Summer

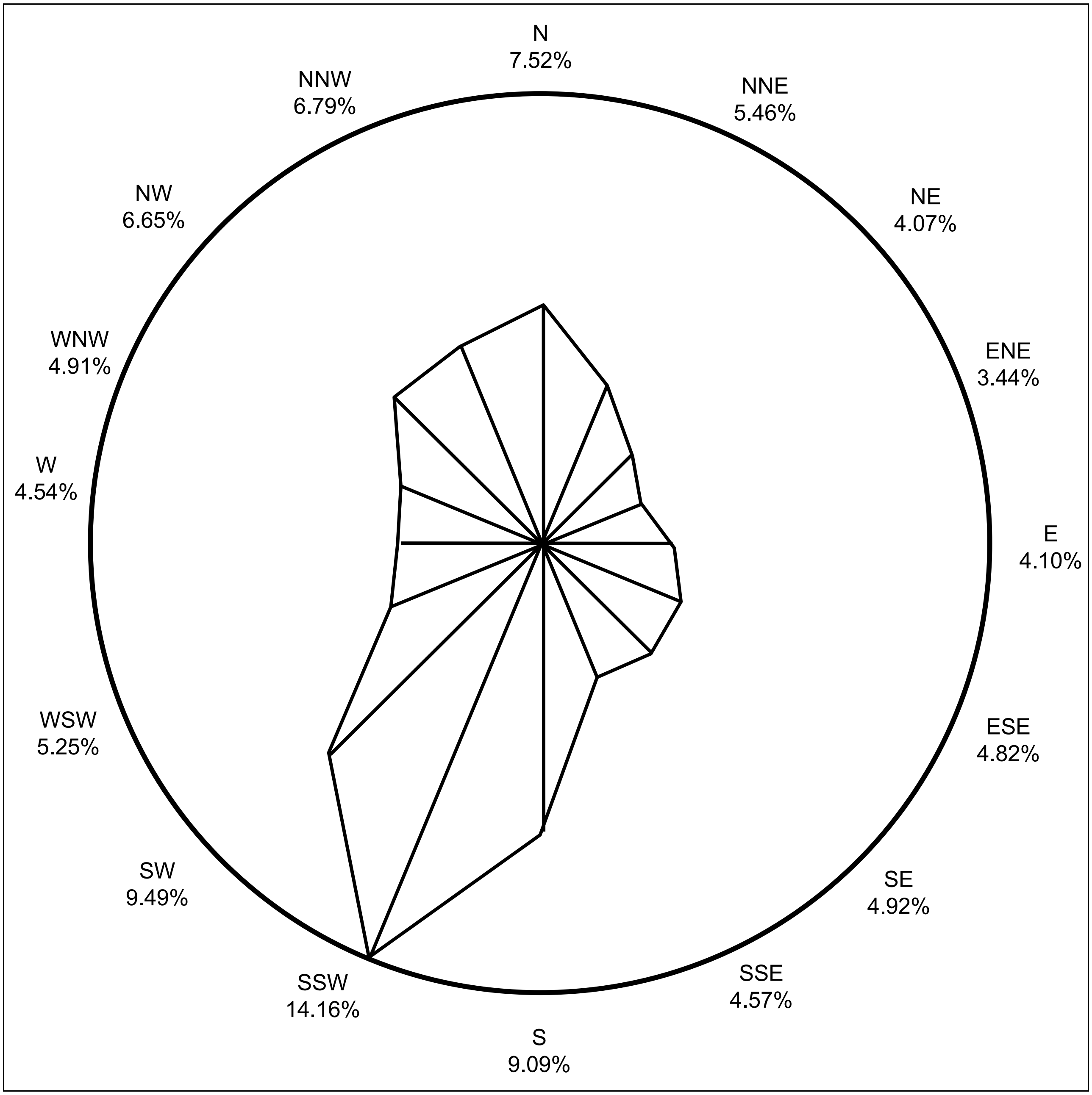


Figure 2.7-6 North Anna Seasonal Wind Direction Roses: High-Level Winds: 1974–1987: Season = Summer

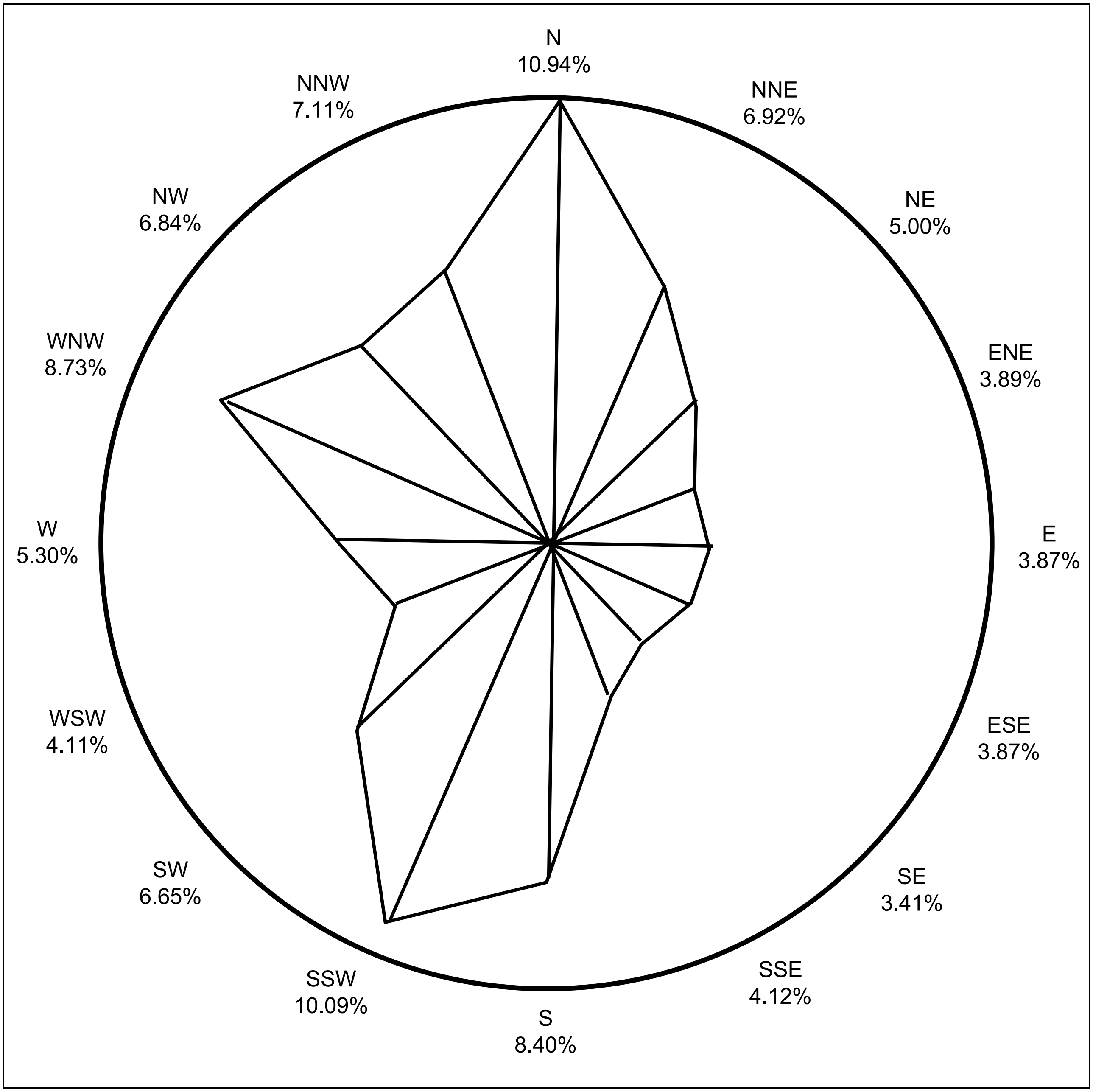


Figure 2.7-7 North Anna Seasonal Wind Direction Roses: Low-Level Winds: 1974–1987: Season = Fall

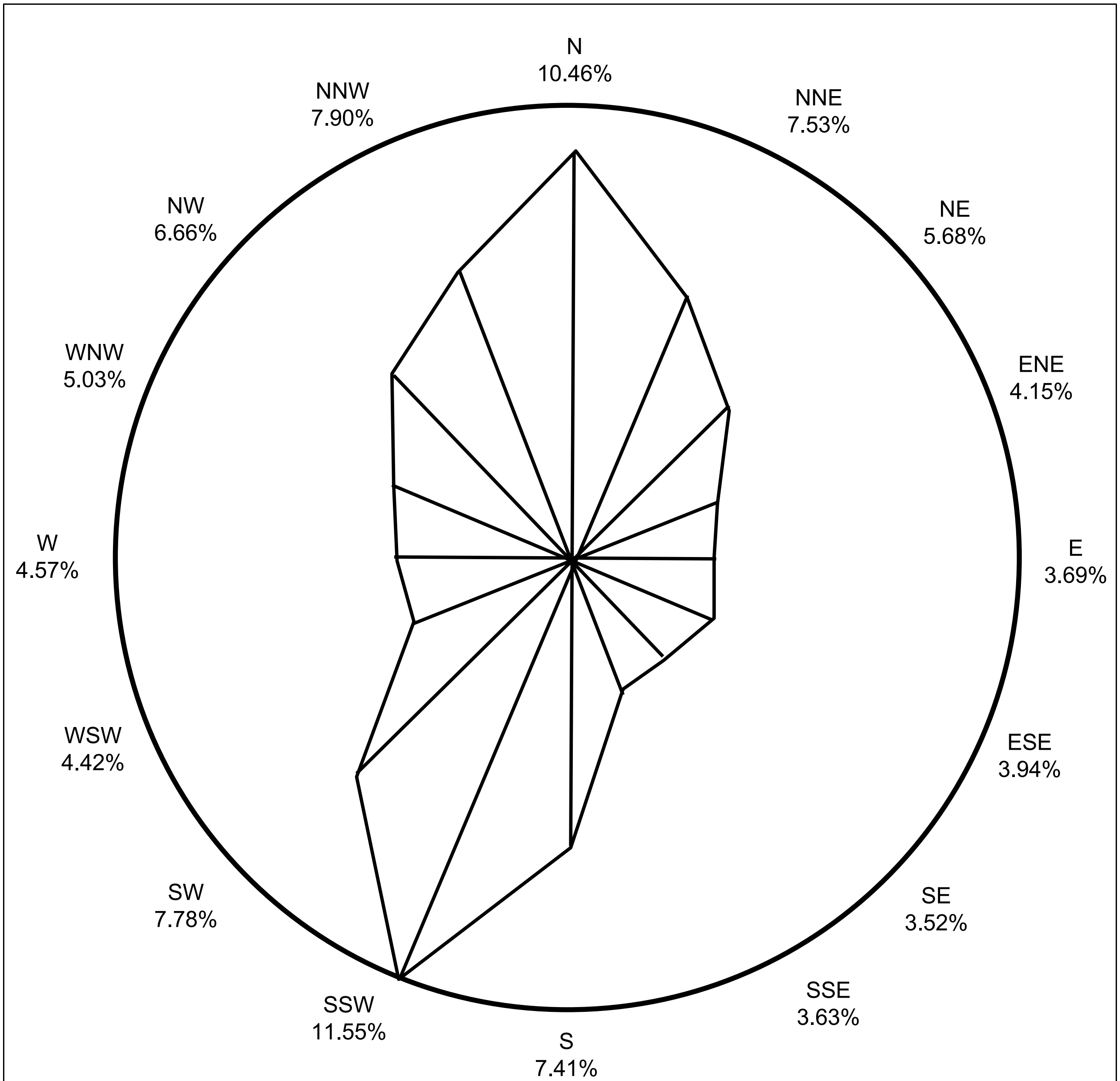


Figure 2.7-8 North Anna Seasonal Wind Direction Roses: High-Level Winds: 1974–1987: Season = Fall

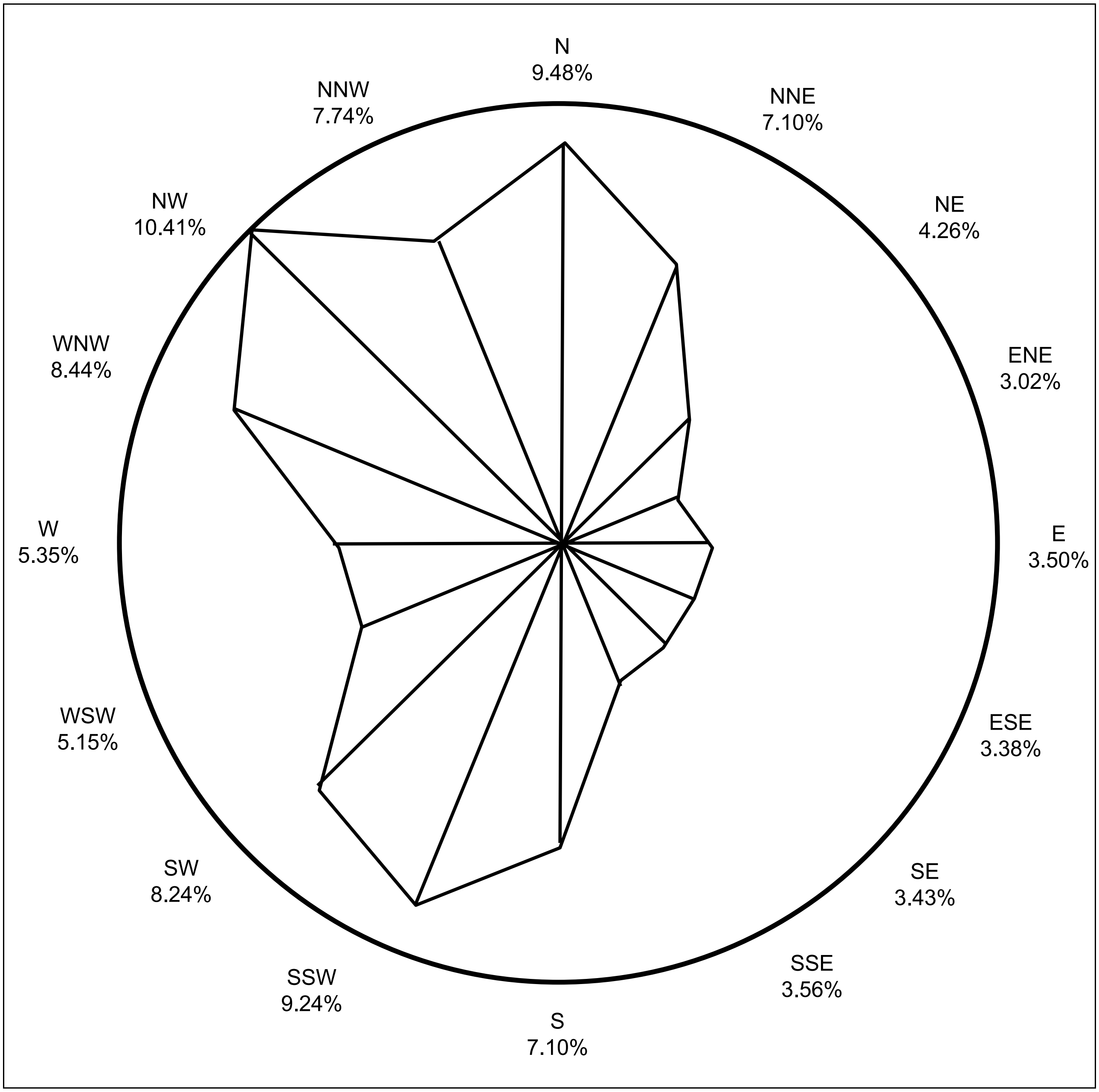


Figure 2.7-9 North Anna Seasonal Wind Direction Roses: Low-Level Winds: 1974–1987: Season = Winter

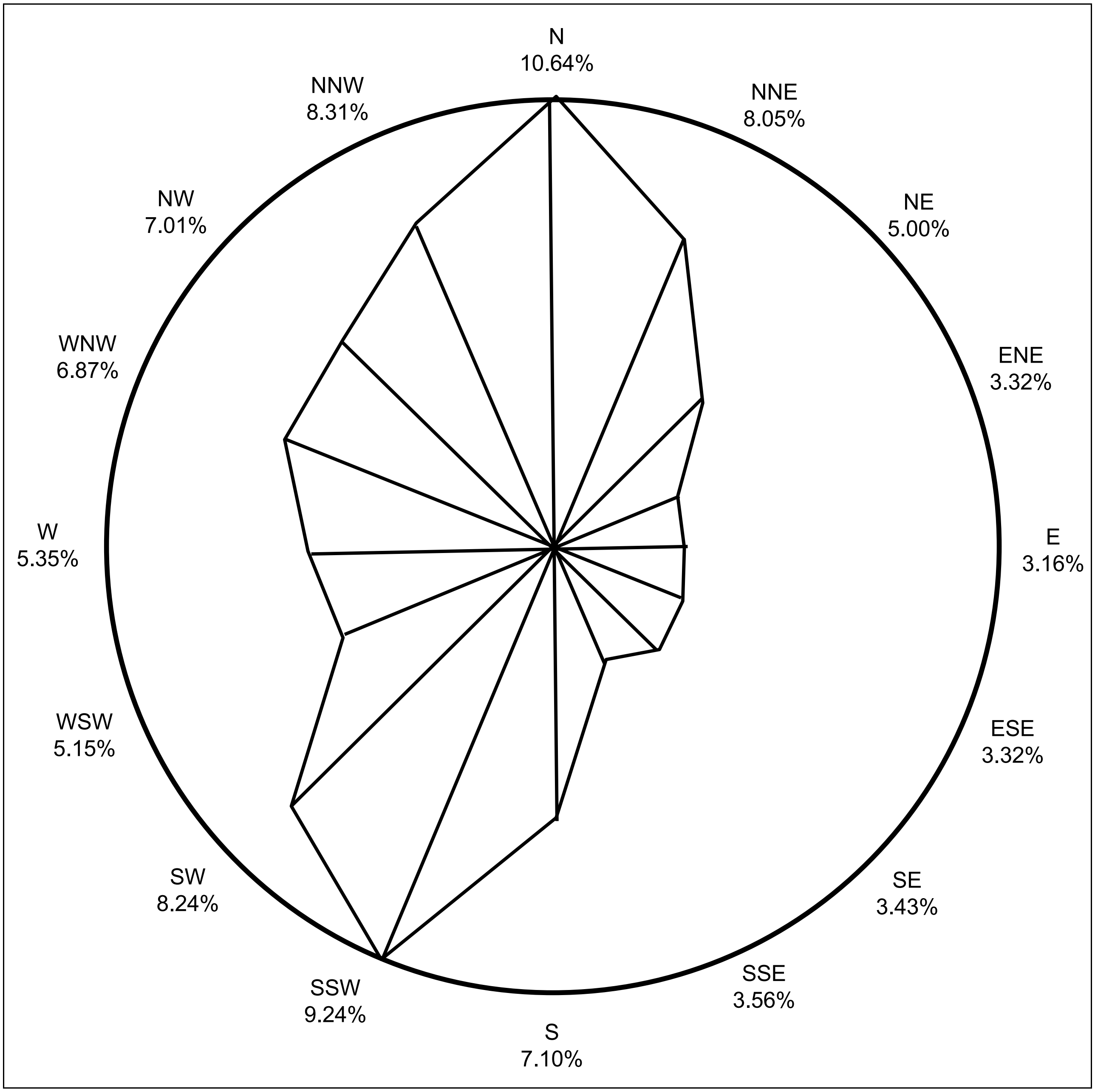


Figure 2.7-10 North Anna Seasonal Wind Direction Roses: High-Level Winds: 1974–1987: Season = Winter

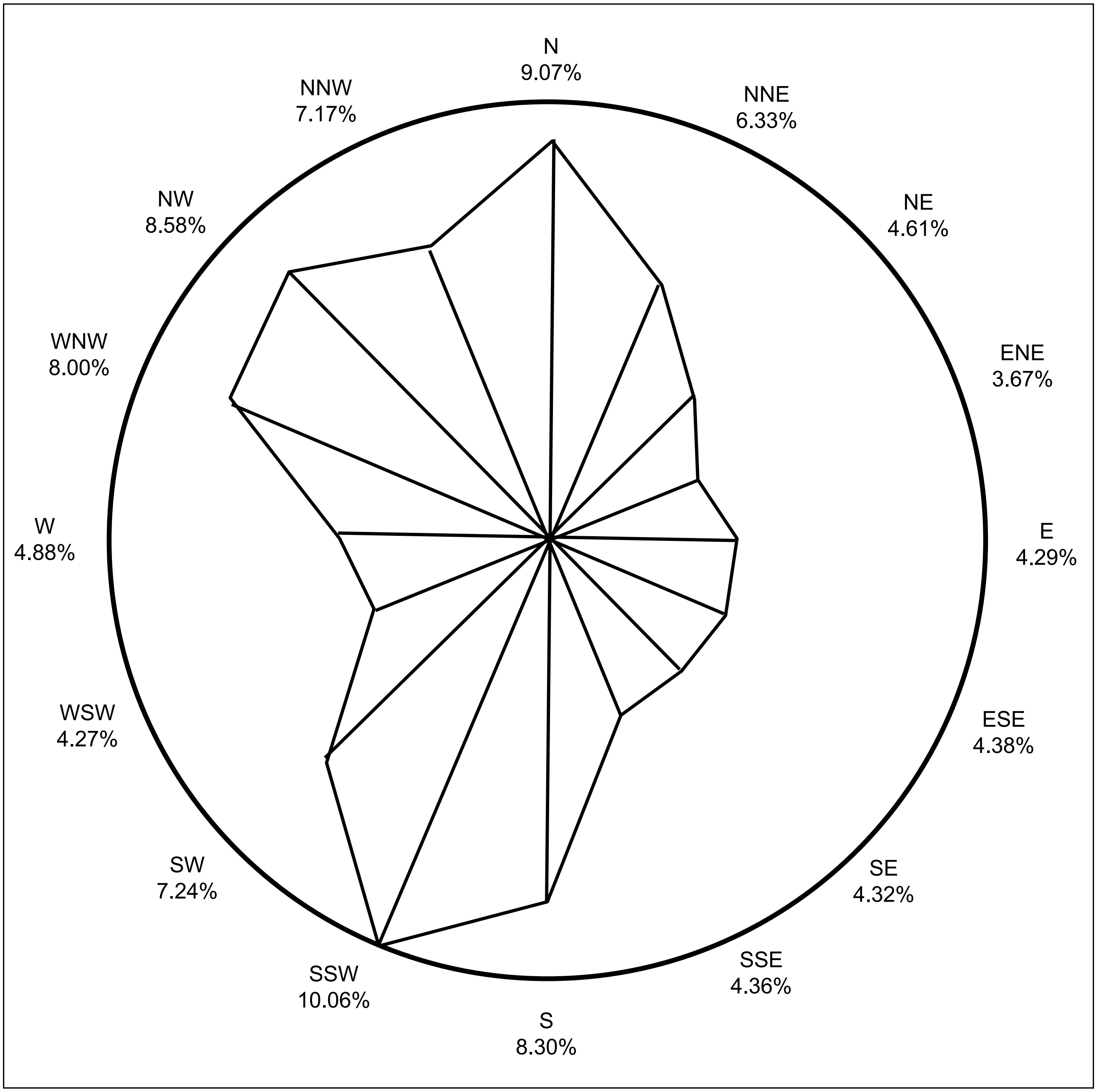


Figure 2.7-11 North Anna Seasonal Wind Direction Roses: Low-Level Winds: 1974–1987: Season = Overall

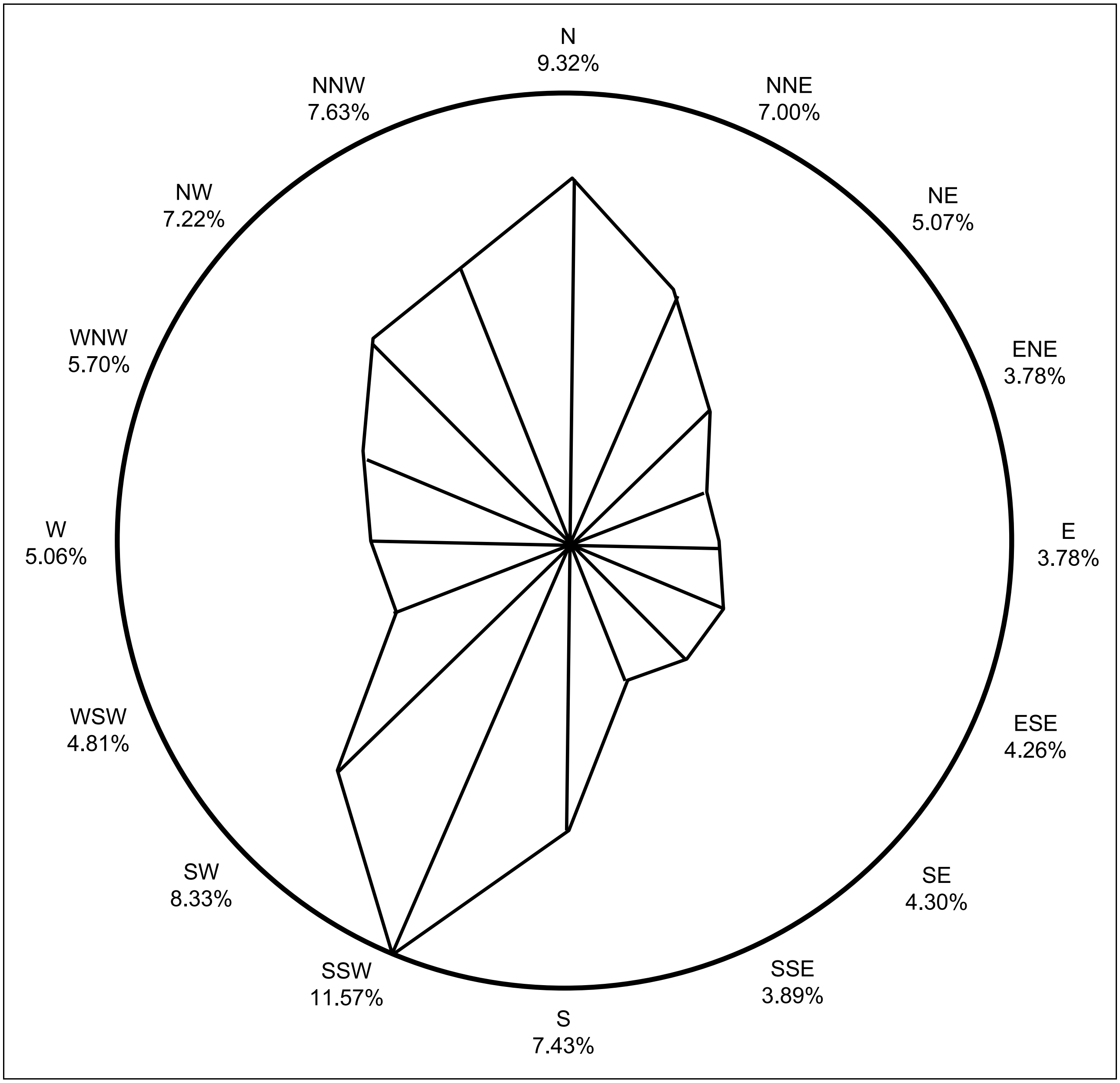


Figure 2.7-12 North Anna Seasonal Wind Direction Roses: High-Level Winds: 1974–1987: Season = Overall

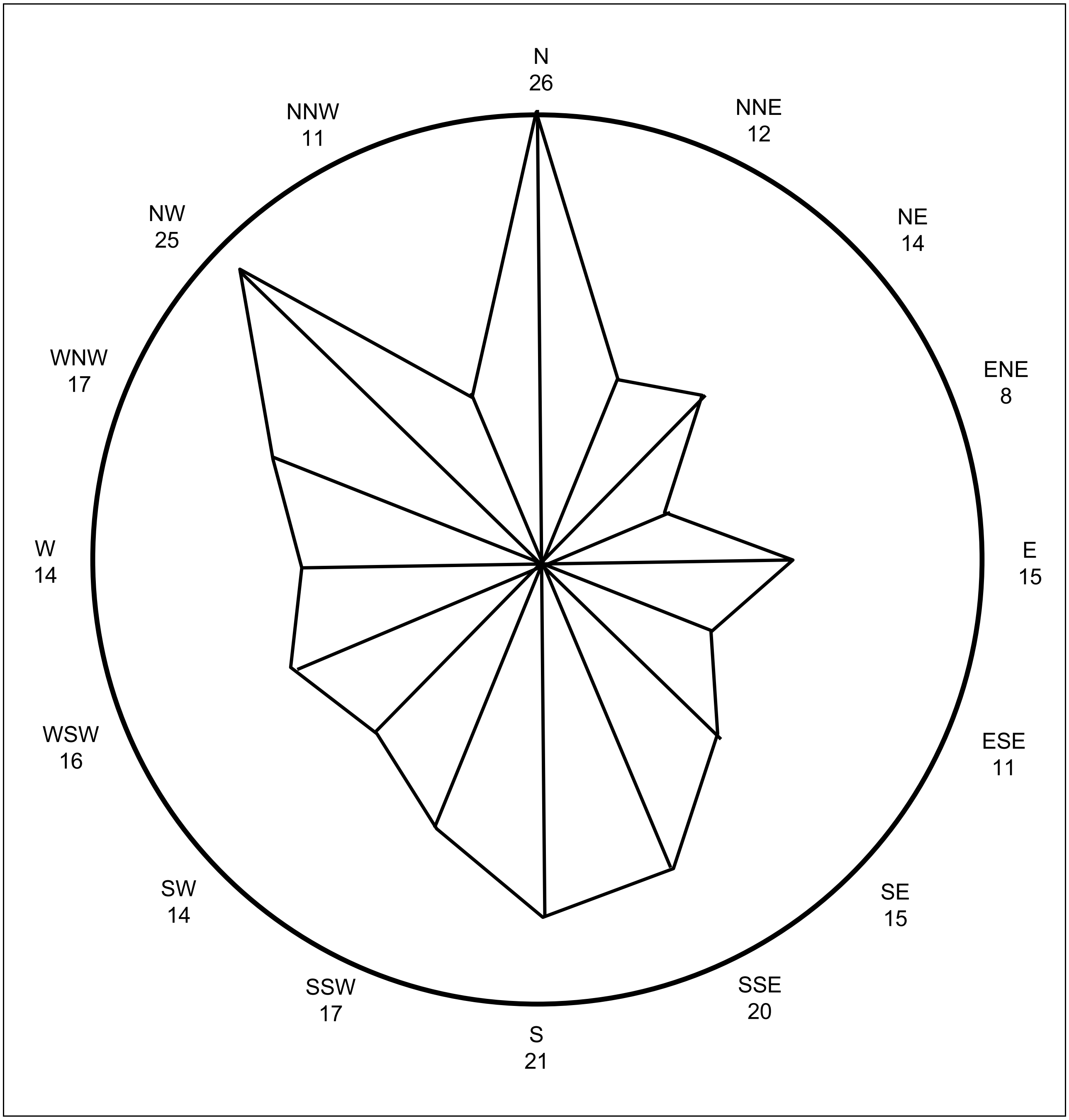


Figure 2.7-13 North Anna Seasonal Wind Persistence Roses: Low-Level Winds: 1974–1987: Season = Spring

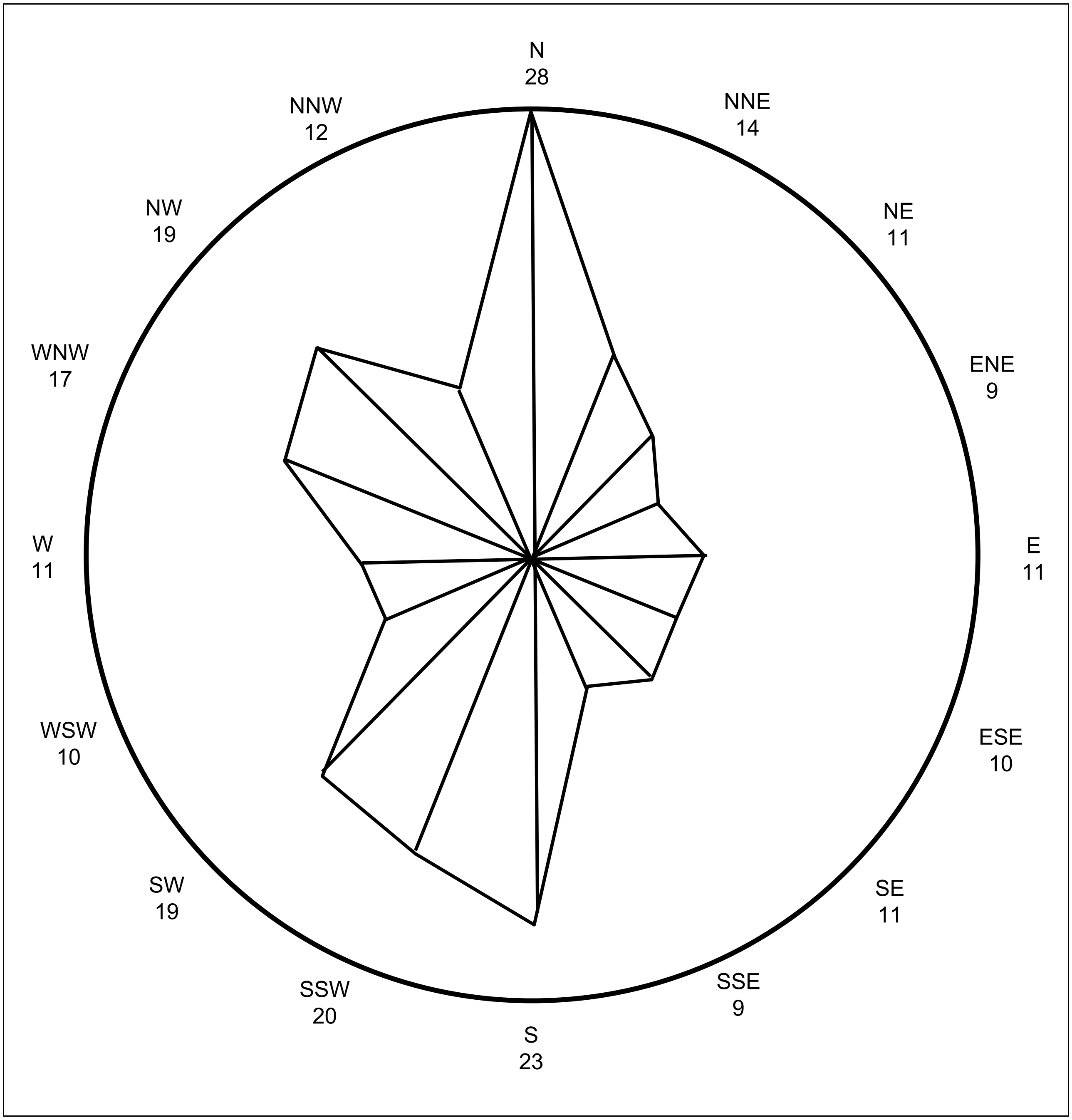


Figure 2.7-14 North Anna Seasonal Wind Persistence Roses: High-Level Winds: 1974–1987: Season = Spring

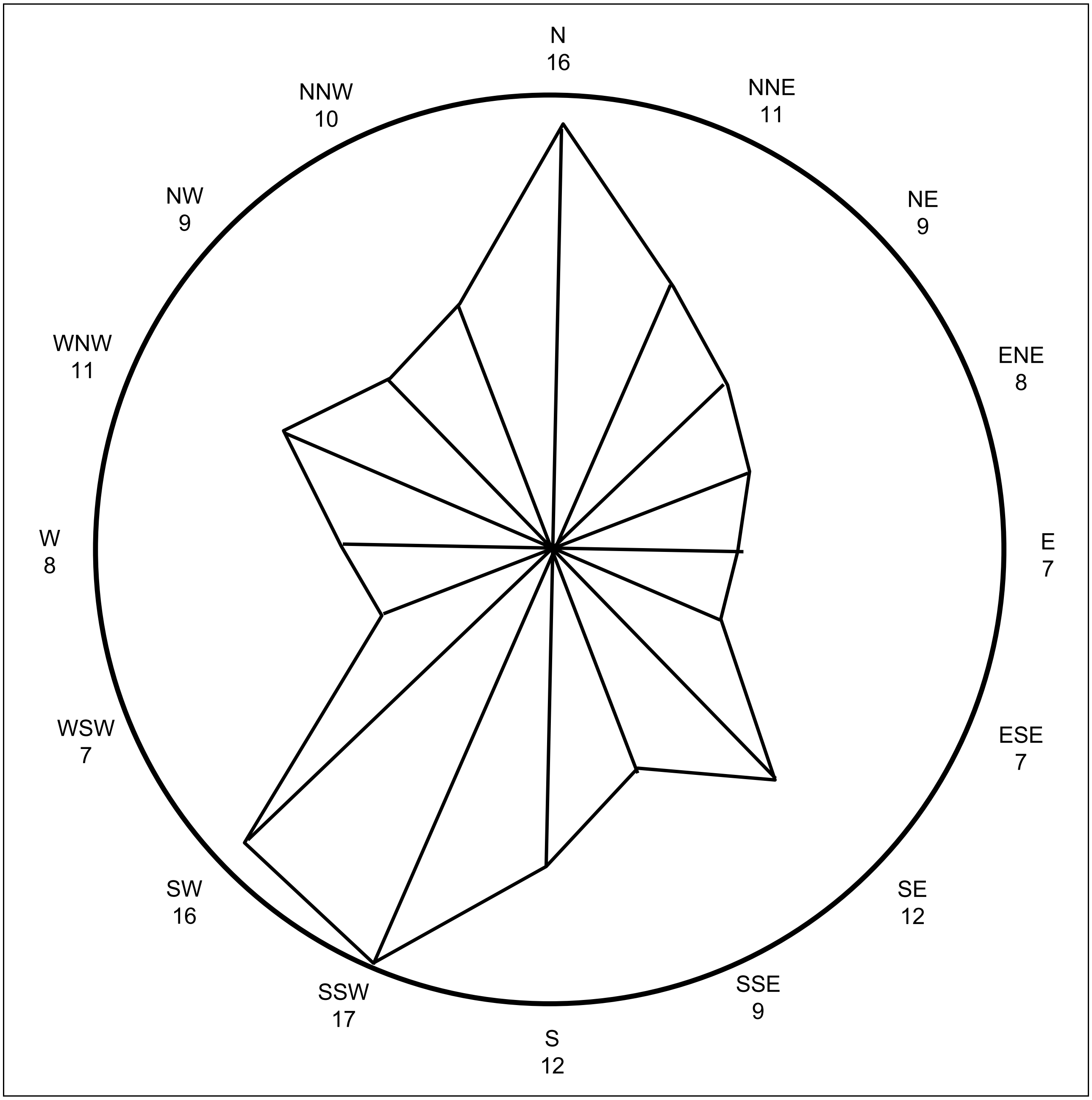


Figure 2.7-15 North Anna Seasonal Wind Persistence Roses: Low-Level Winds: 1974–1987: Season = Summer

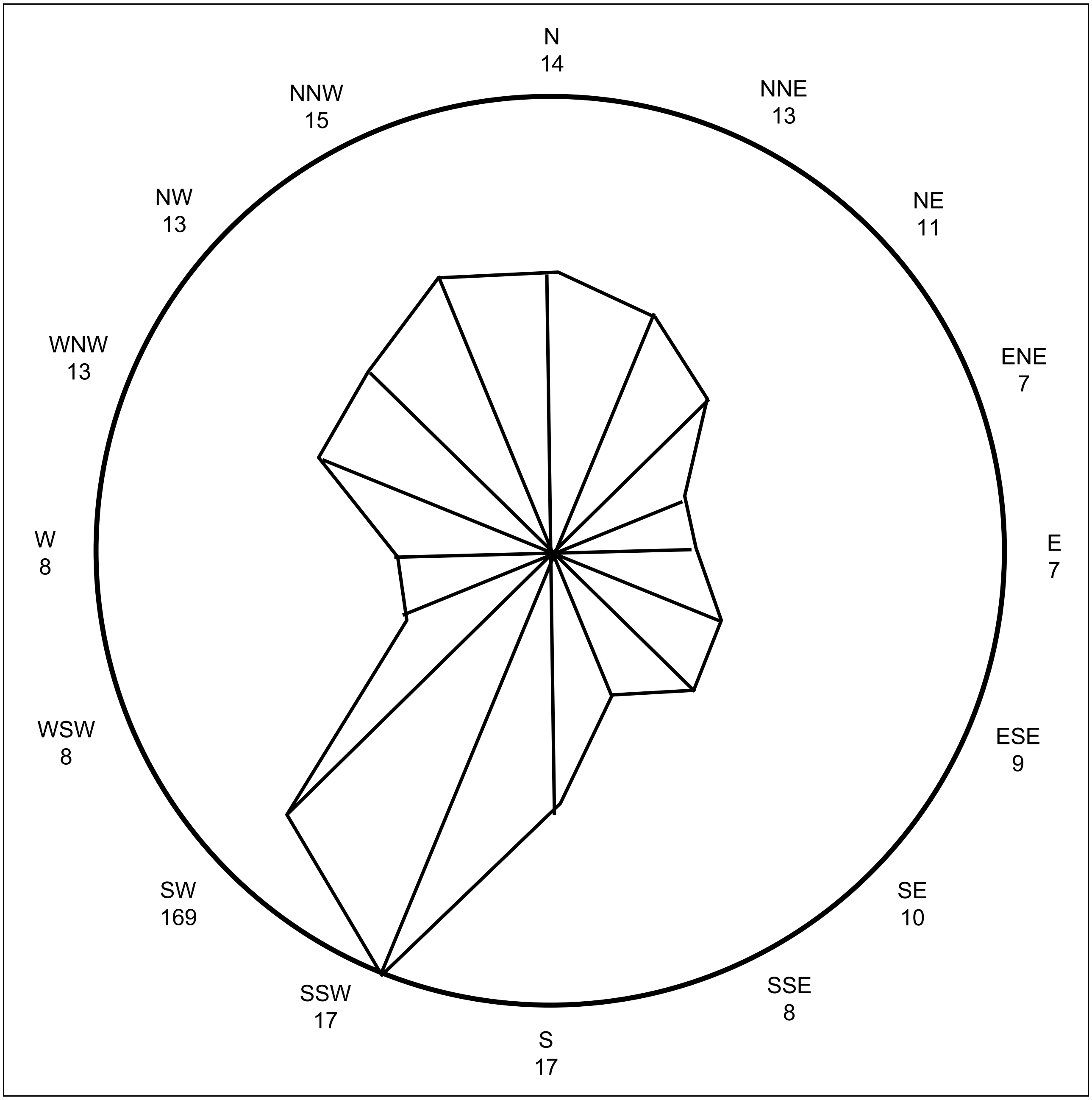


Figure 2.7-16 North Anna Seasonal Wind Persistence Roses: High-Level Winds: 1974–1987: Season = Summer

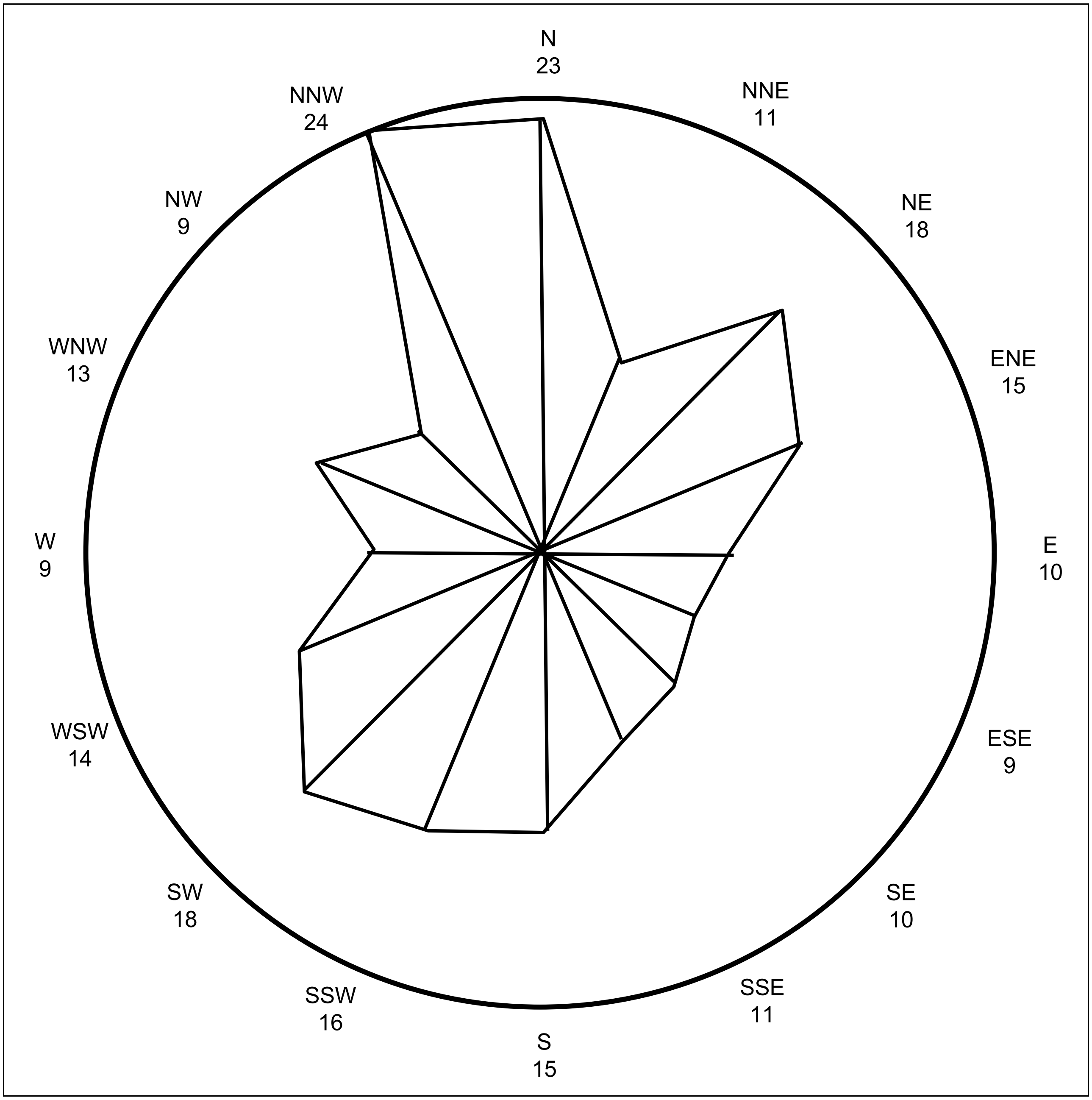


Figure 2.7-17 North Anna Seasonal Wind Persistence Roses: Low-Level Winds: 1974–1987: Season = Fall

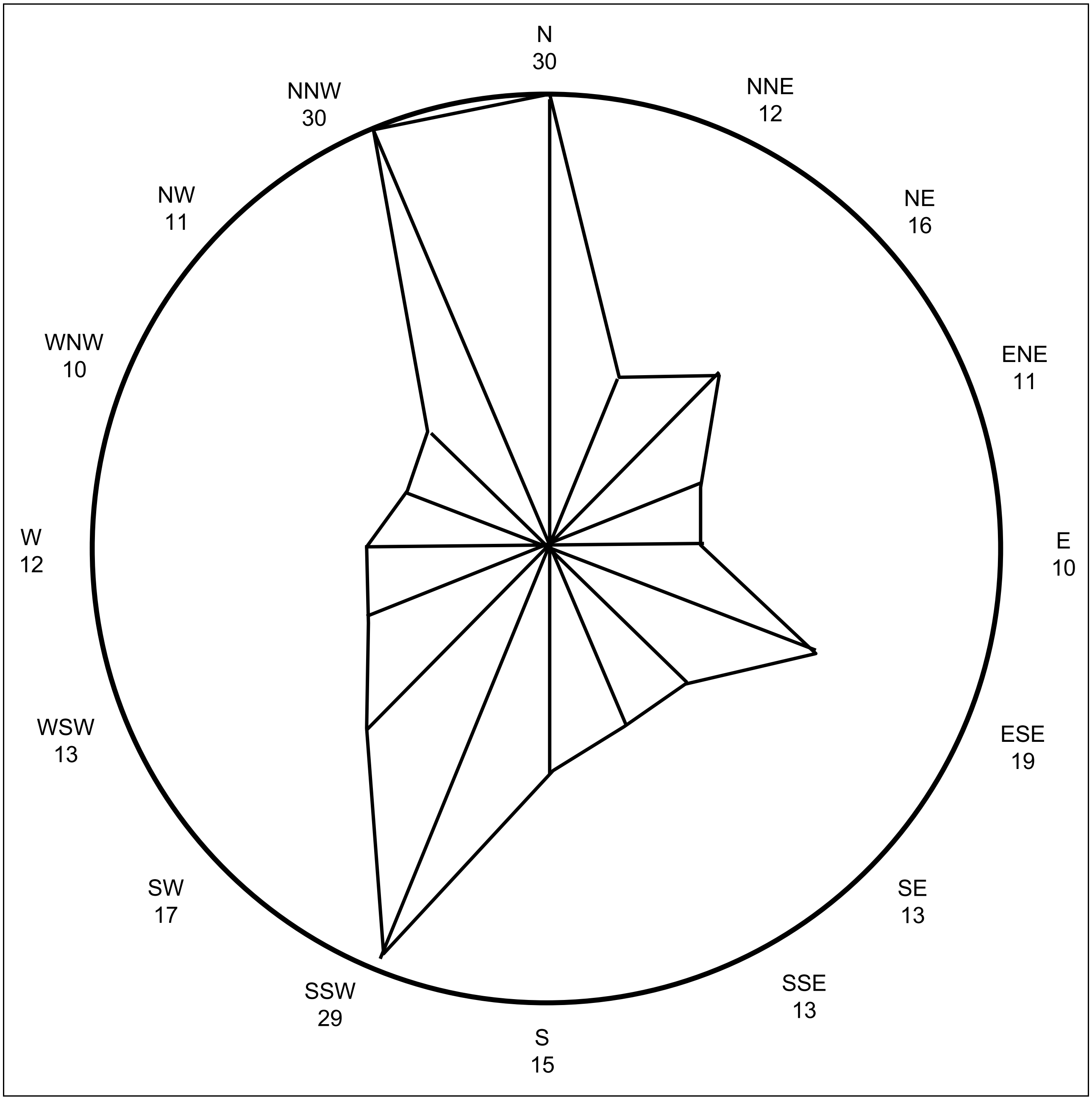


Figure 2.7-18 North Anna Seasonal Wind Persistence Roses: High-Level Winds: 1974–1987: Season = Fall

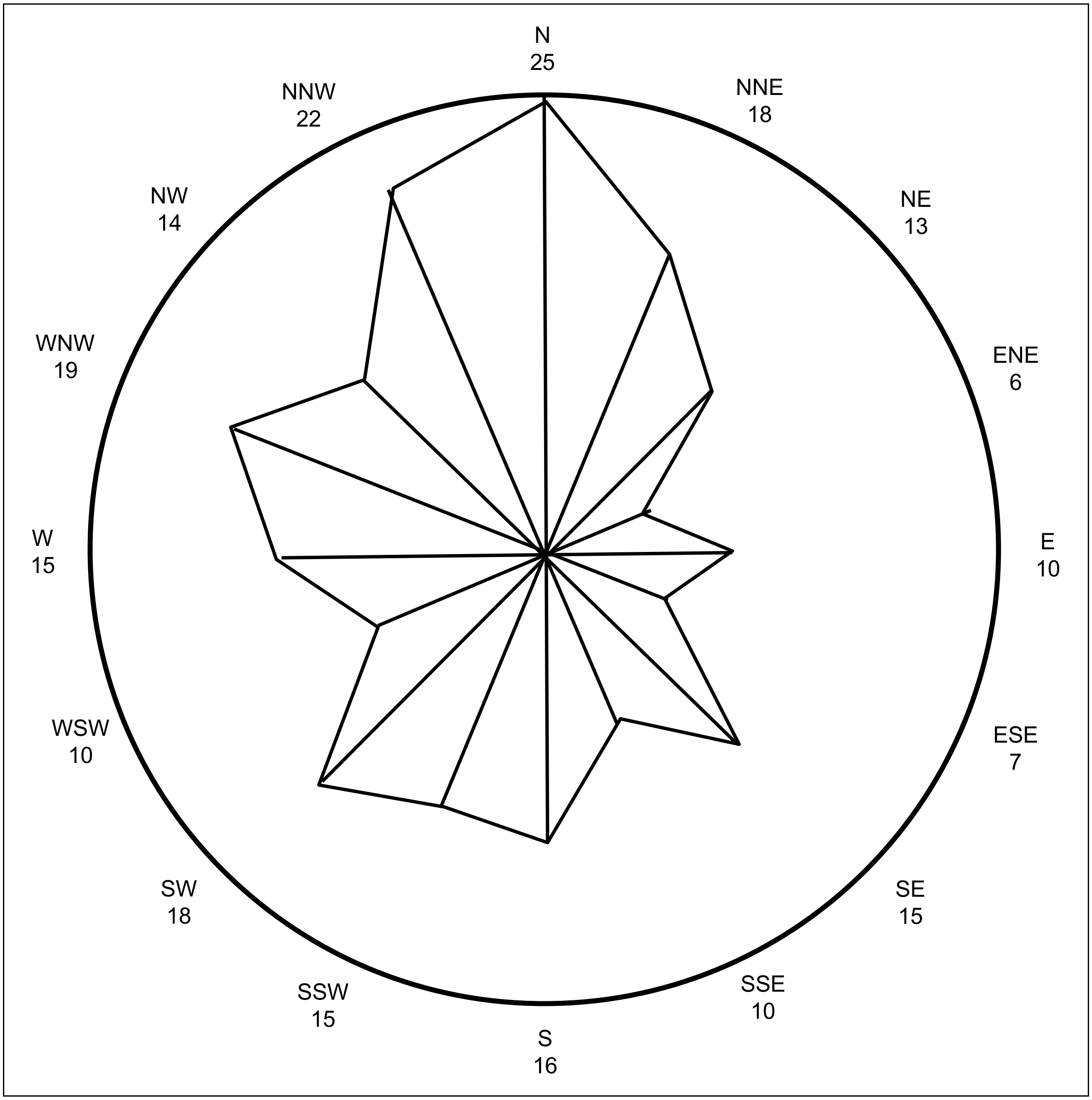


Figure 2.7-19 North Anna Seasonal Wind Persistence Roses: Low-Level Winds: 1974–1987: Season = Winter

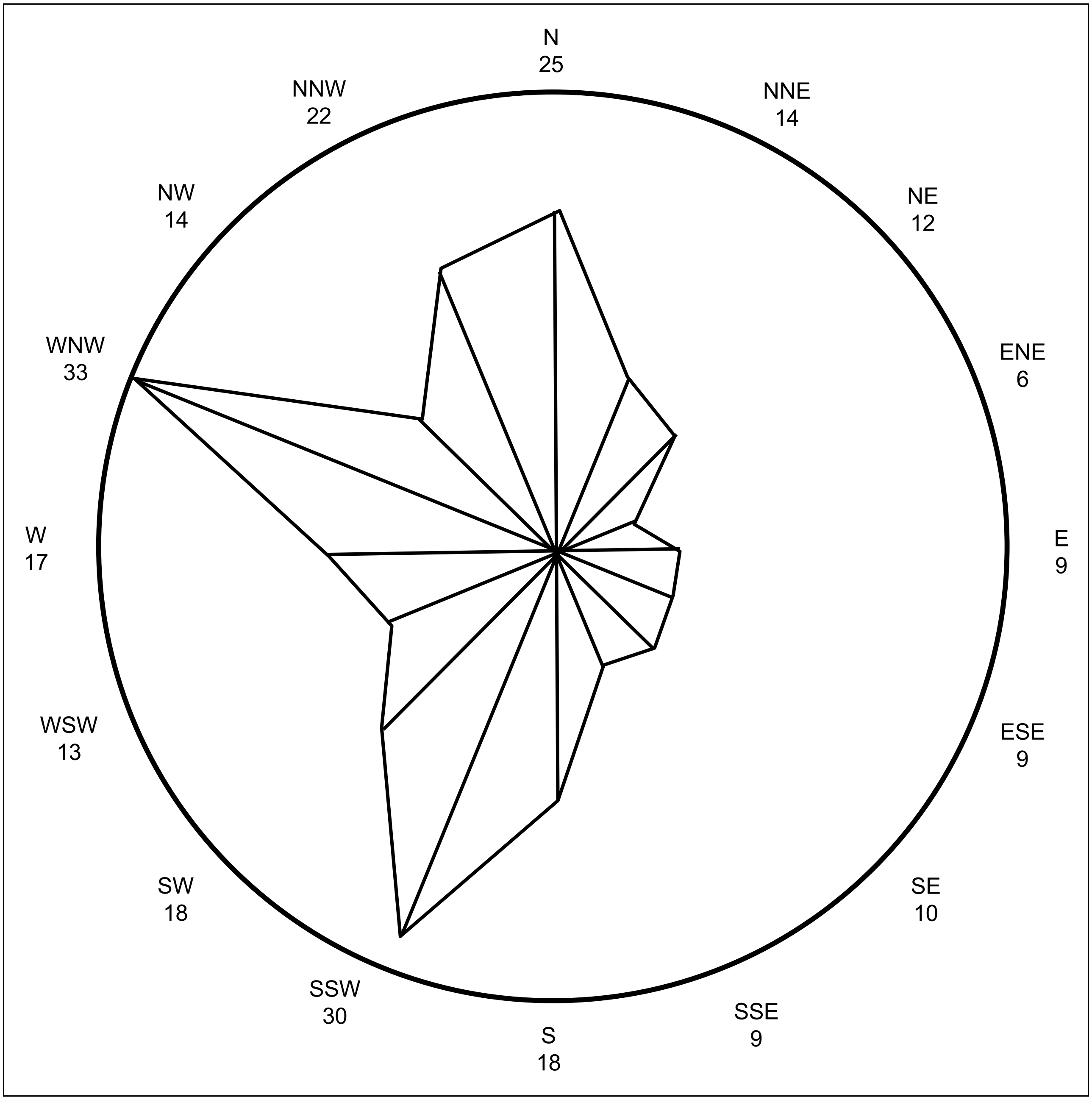


Figure 2.7-20 North Anna Seasonal Wind Persistence Roses: High-Level Winds: 1974–1987: Season = Winter

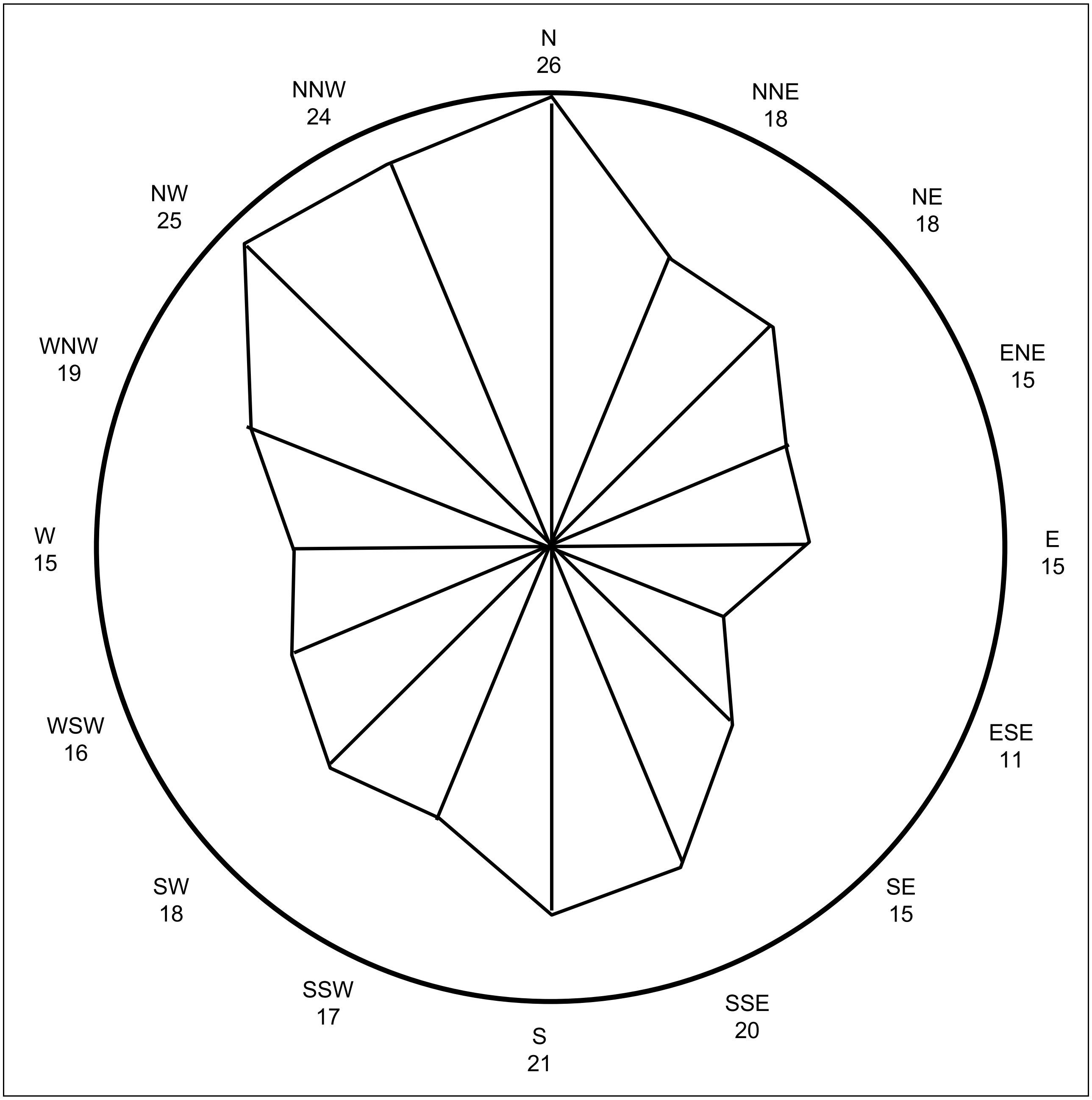


Figure 2.7-21 North Anna Seasonal Wind Persistence Roses: Low-Level Winds: 1974–1987: Season = Overall

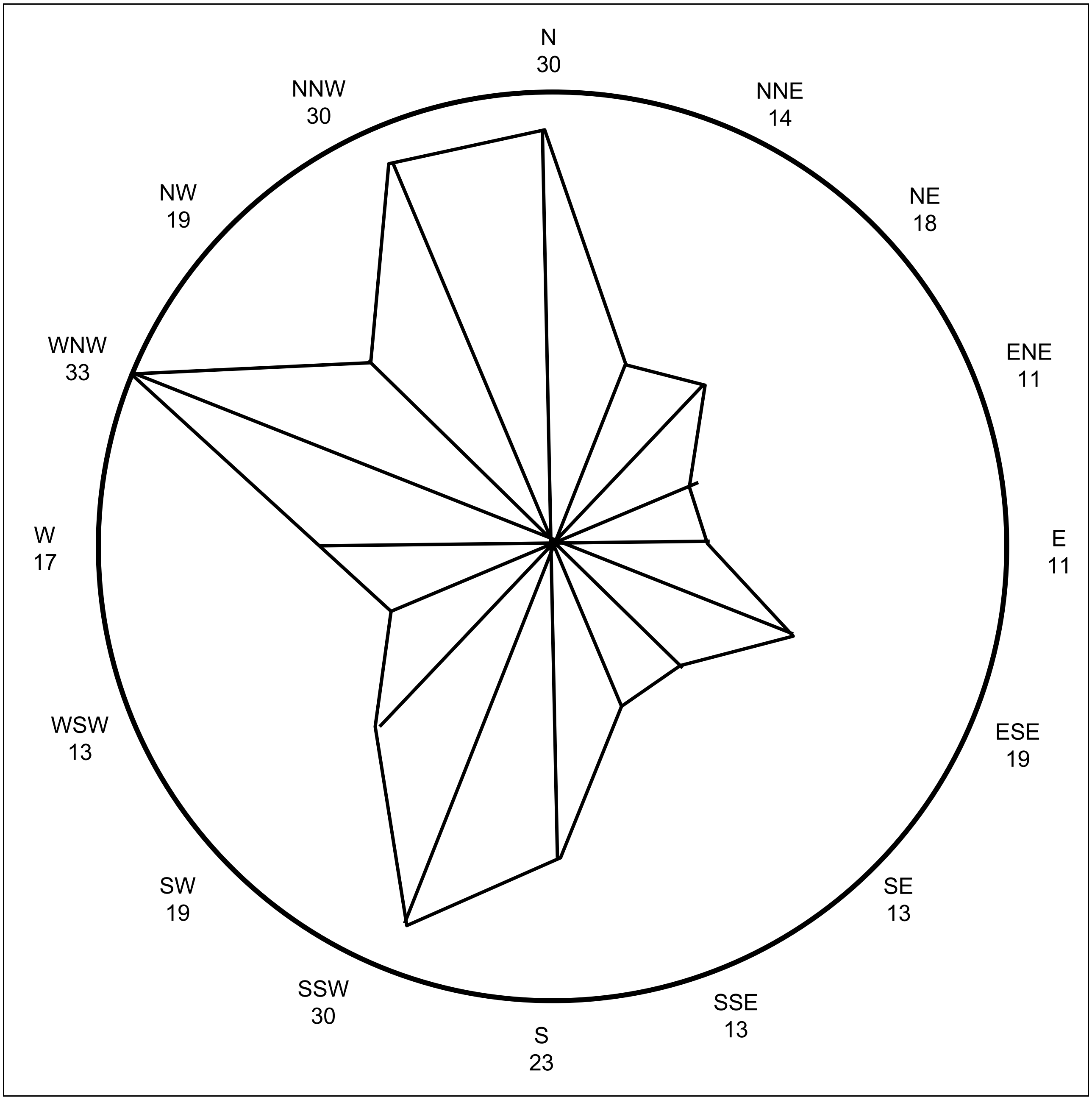


Figure 2.7-22 North Anna Seasonal Wind Persistence Roses: High-Level Winds: 1974–1987: Season = Overall

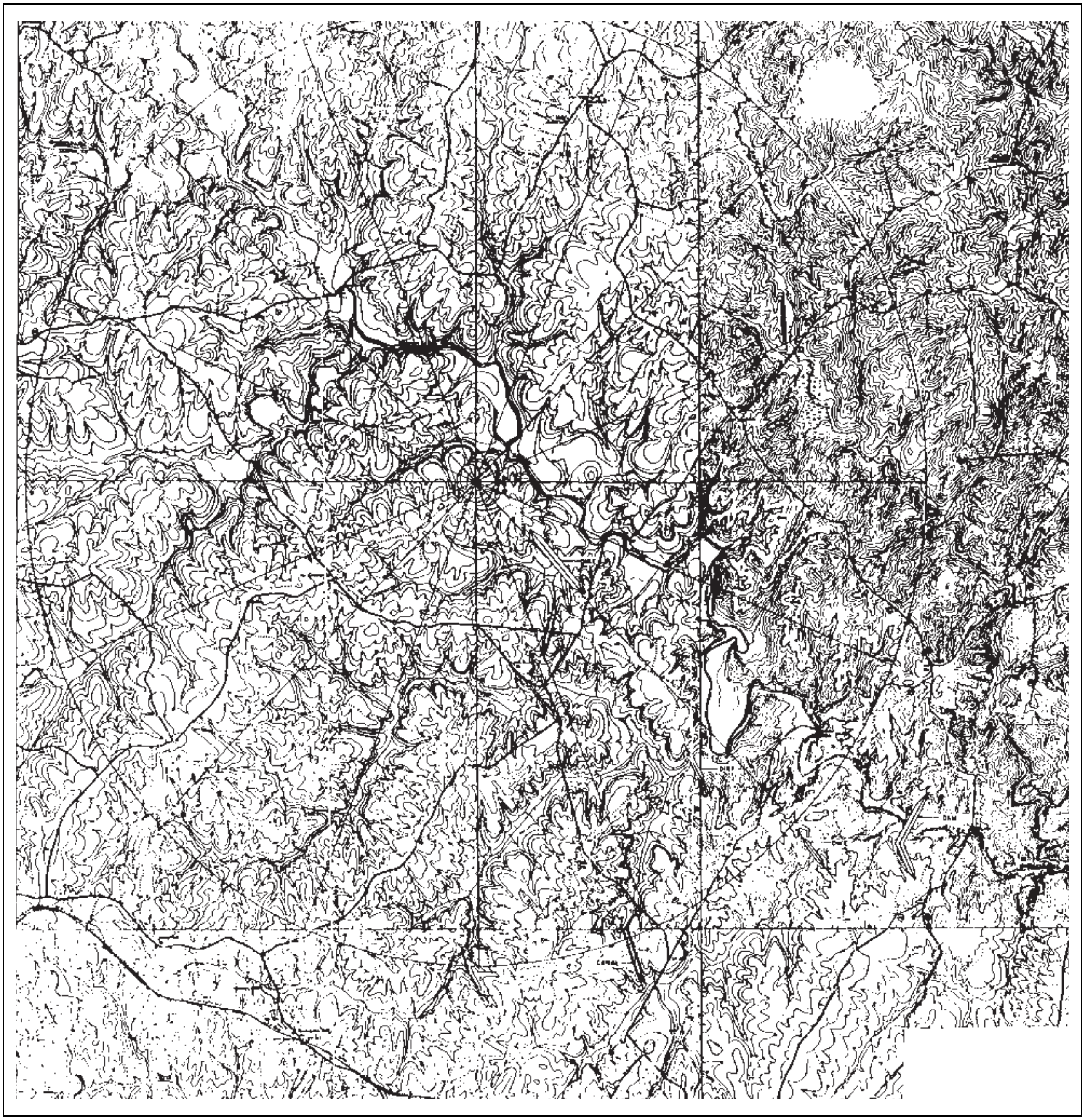
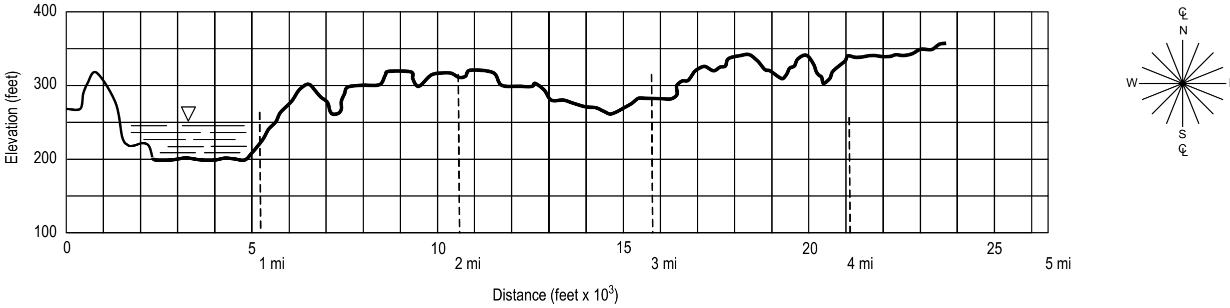
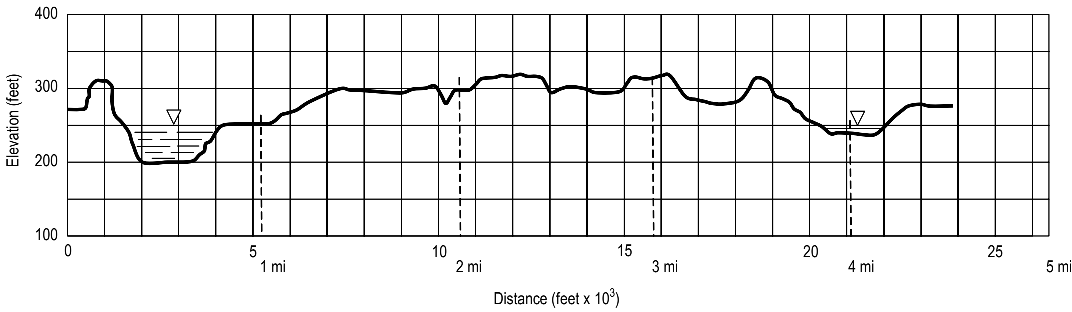


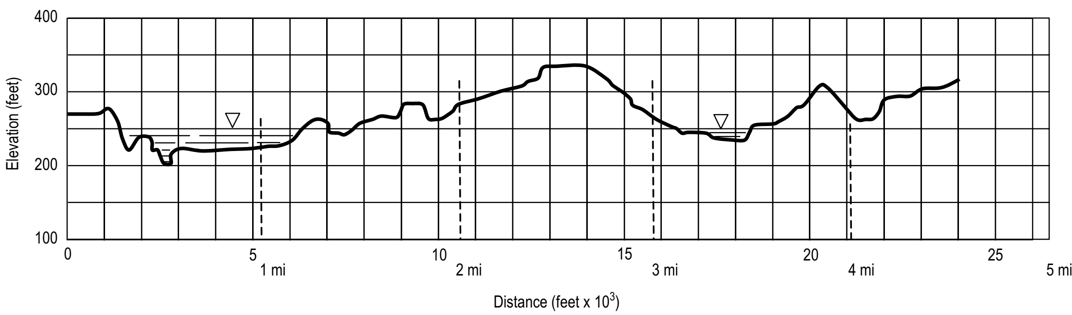
Figure 2.7-23 Topographic Map
Source: Reference 2



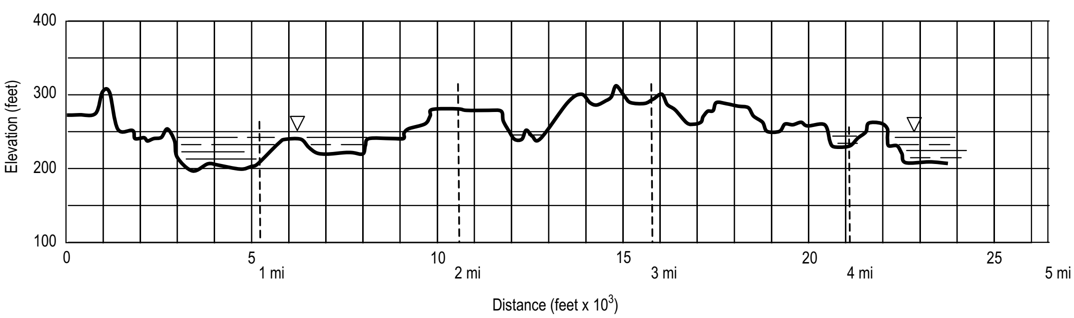
From Reactor 3 to Reference Point (Lat. 38°-07′12″, Long. 77°-04′20″)



From Reactor 3 to Reference Point (Lat. 38°-04′20″, Long. 77°-43′57″)



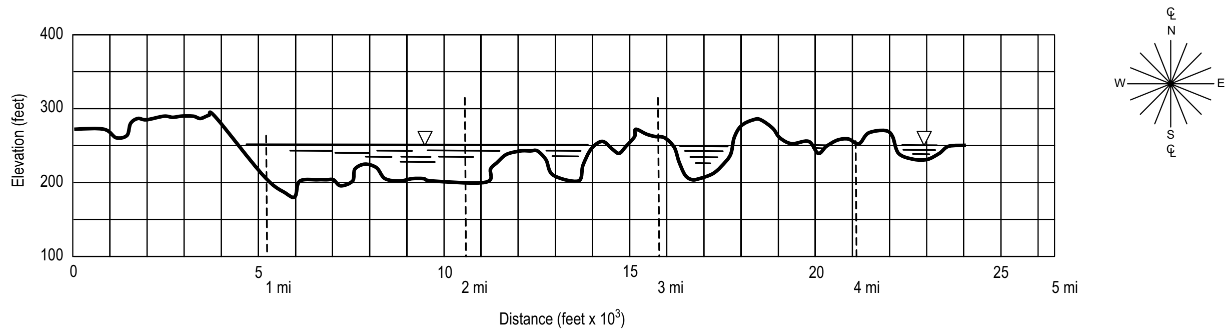
From Reactor 3 to Reference Point (Lat. 38°-03′02″, Long. 77°-42′51″)



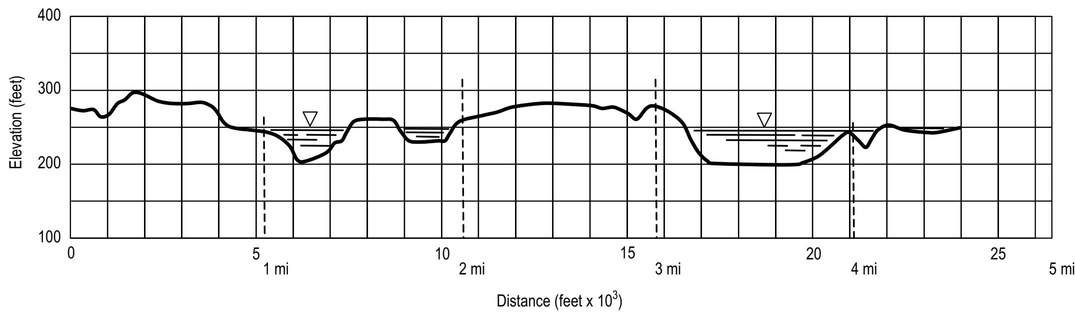
From Reactor 3 to Reference Point (Lat. 38°-03′03″, Long. 77°-42′30″)

Figure 2.7-24 Vertical Profiles (Sheet 1 of 4)

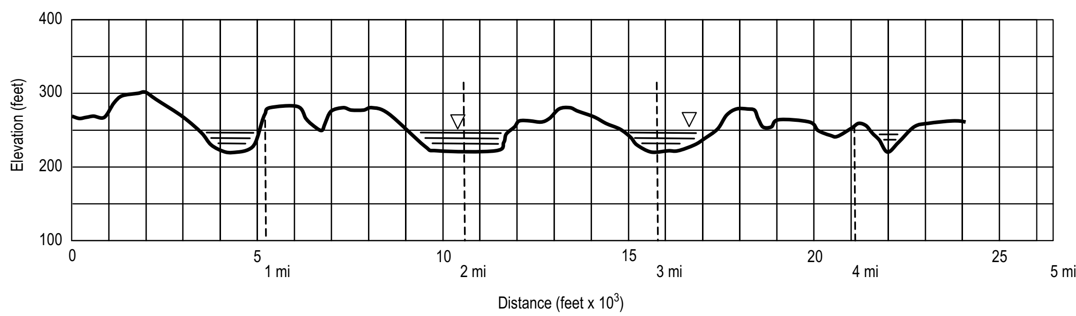
Source: Reference 2



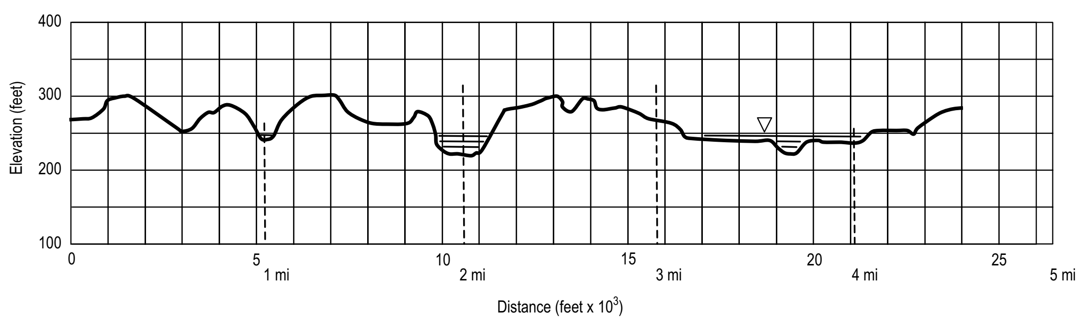
From Reactor 3 to Reference Point (Lat. 38°-01′-37″, Long. 77°-42′-51″)



From Reactor 3 to Reference Point (Lat. 38°-00′-40″, Long. 77°-43′-57″)



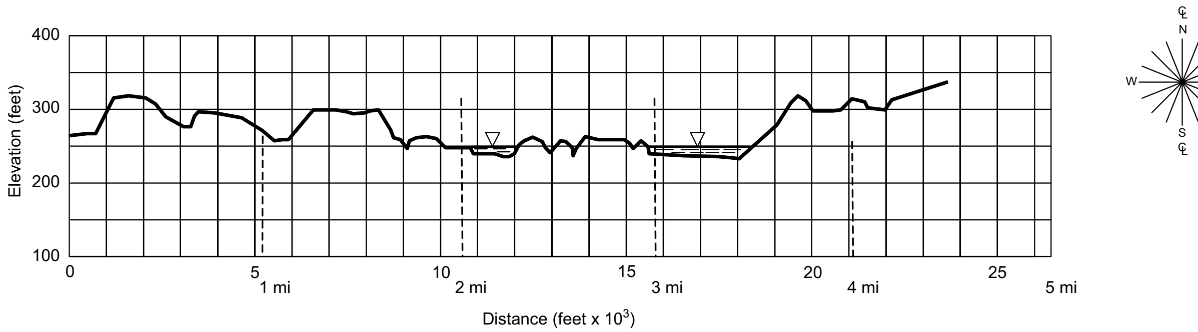
From Reactor 3 to Reference Point (Lat. 38°-00′-00″, Long. 77°-45′-30″)



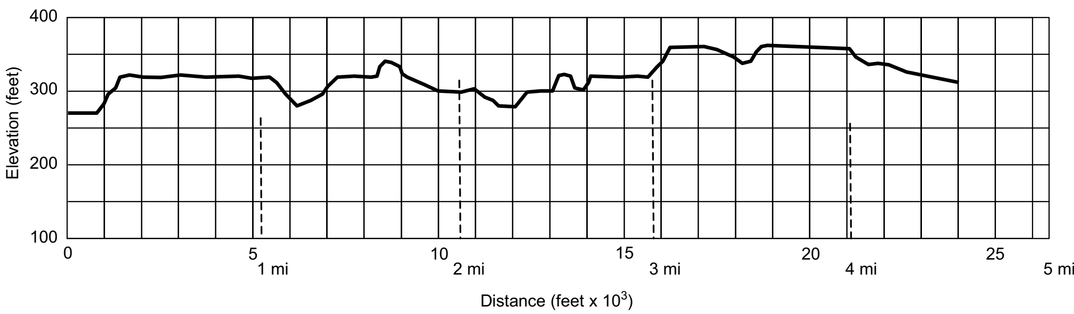
From Reactor 3 to Reference Point (Lat. 37°-59′-59″, Long. 77°-47′-28″)

Figure 2.7-24 Vertical Profiles (Sheet 2 of 4)

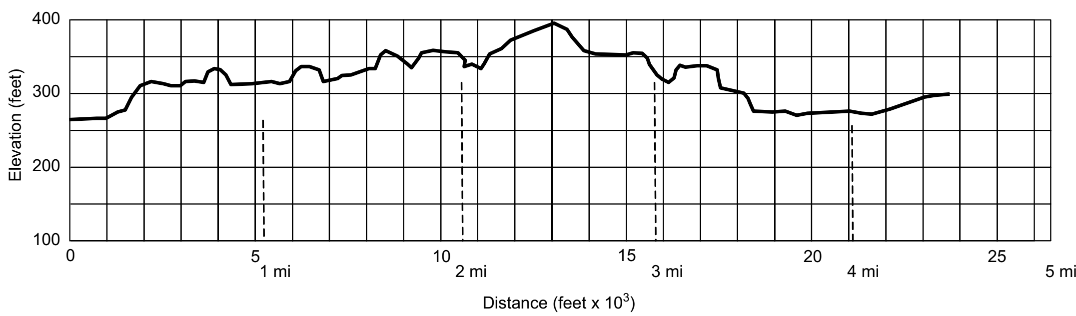
Source: Reference 2



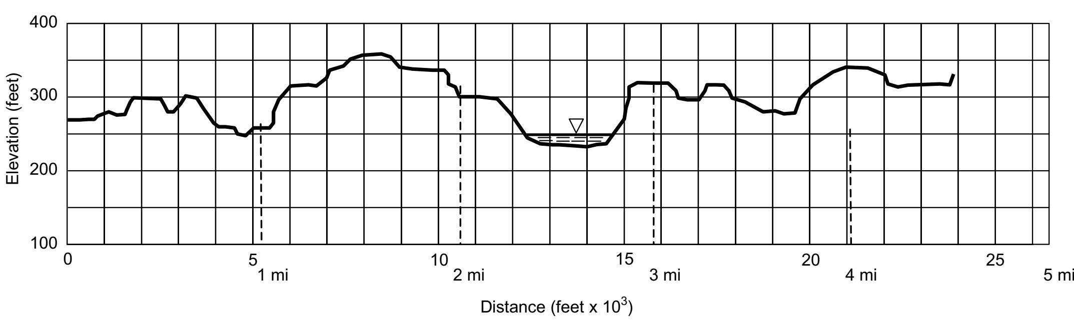
From Reactor 3 to Reference Point (Lat. 38°-00′00″, Long. 77°-49′28″)



From Reactor 3 to Reference Point (Lat. 38°-00′00″, Long. 77°-30′39″)



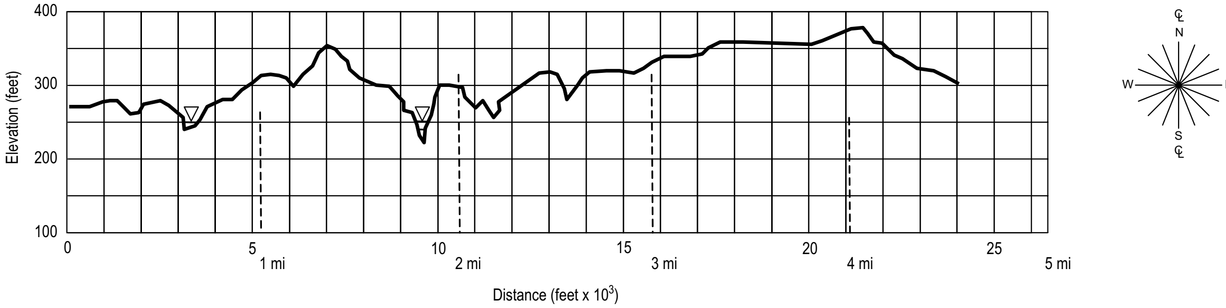
From Reactor 3 to Reference Point (Lat. 38°-01′37″, Long. 77°-32′03″)



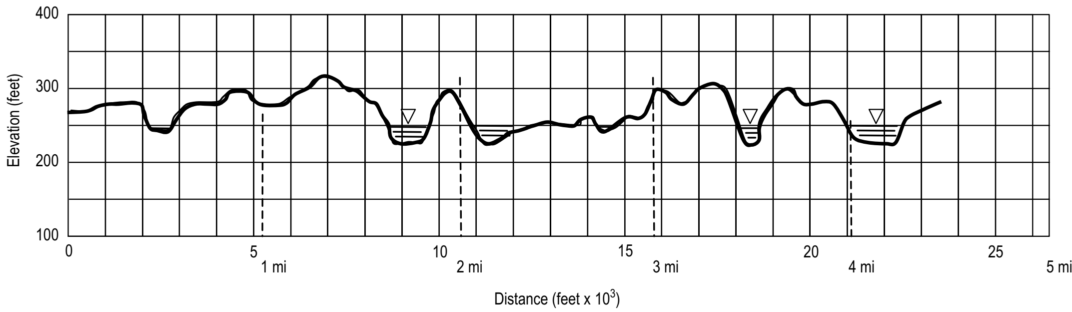
From Reactor 3 to Reference Point (Lat. 38°-03′30″, Long. 77°-52′28″)

Figure 2.7-24 Vertical Profiles (Sheet 3 of 4)

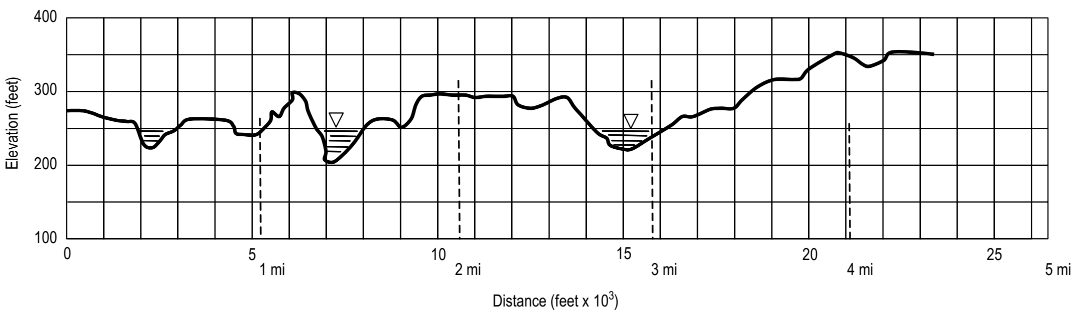
Source: Reference 2



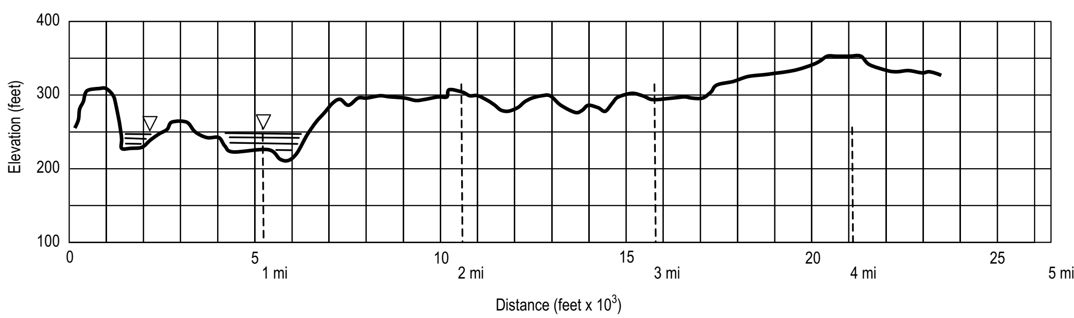
From Reactor 3 to Reference Point (Lat. 38°-05′02″, Long. 77°-52′05″)



From Reactor 3 to Reference Point (Lat. 38°-06′20″, Long. 77°-50′59″)



From Reactor 3 to Reference Point (Lat. 38°-07′12″, Long. 77°-47′23″)



From Reactor 3 to Reference Point (Lat. 38°-07′30″, Long. 77°-47′23″)

Figure 2.7-24 Vertical Profiles (Sheet 4 of 4)

Source: Reference 2

2.8 Related Federal Project Activities

The purpose of this section is to identify any federal activities related to this ESP application and to highlight the possible need for federal agencies to participate in the preparation of the environmental impact statement as cooperating agencies.

In summary, there are no known federal activities or projects associated with early site permitting at the ESP site.

Specifically:

- No known federal projects (e.g., water supply pipelines) are planned that would provide additional cooling water for the new units.
- No known federal actions are planned regarding the acquisition and/or use of the ESP site.
- No known federal projects are planned that must be completed as a condition of construction or operation of the new units.
- No known federal projects are contingent on construction or operation of the new units at the ESP site.

Section 2.8 References

None