Enclosure 2

Revisions to SSAR Section 2.3 and ER Section 2.7 for Responses to RAIs 2.3.1-1 (revised), 2.3.1-2, 2.3.1-3, 2.3.1-4, 2.3.1-5, 2.3.1-6, 2.3.2-1, and 2.3.2-2

The following application revisions reflect the responses to RAIs 2.3.1-1 (revised), 2.3.1-2, 2.3.1-3, 2.3.1-4, 2.3.1-5, 2.3.1-6, 2.3.2-1, and 2.3.2-2 contained in Enclosure 1 to this letter.

SSAR Sections 2.3.1 through 2.3.2 will be revised to read as follows:

2.3.1 Regional Climatology

2.3.1.1 Data Sources

Data acquired by the National Weather Service (NWS) at its Richmond, Virginia first-order station and from its network of cooperative observer stations, as compiled and summarized by the National Climatic Data Center (NCDC) and its predecessor agencies, have been used to characterize the regional climatology pertinent to the ESP site.

Normals (i.e., 30-year averages), means and extremes of temperature, rainfall, and snowfall are based on:

- The 2003 Local Climatological Data (LCD) Annual Summary with Comparative Data for Richmond, Virginia (Reference 1),
- Climatography of the United States No. 20 (CLIM 20) summaries for the cooperative network stations of Louisa (Reference 10), Piedmont Research Station (Reference 11) and Charlottesville 2W, Virginia (Reference 8),
- Climatography of the United States No. 20-44 summary for Partlow 3WNW, Virginia (Reference 12),
- Climatography of the United States No. 81 (CLIM 81), U.S. Daily Climate Normals (1971-2000) summaries for Fredericksburg National Park and Gordonsville 3S, Virginia (Reference 39), and
- Cooperative Summaries of the Day (TD3200) for Charlottesville 2W, Fredericksburg National Park, Gordonsville 3S, Louisa, Partlow 3WNW, Piedmont Research Station, Bremo Bluff PWR and Free Union, Virginia (Reference 40).

First-order NWS stations record observations of other weather elements including winds and relative humidity (typically on an hourly basis), as well as fog and thunderstorms (when those events occur). LCD summaries for the Richmond NWS station have been used to describe these characteristics. Several databases containing hourly temperature measurements (dry- and wet-bulb) made at this station between 1961 and 2003, or summaries based on portions of that period of record, have been used to represent various frequencies of occurrence for these parameters and to evaluate characteristics associated with the ultimate heat sink (Reference 41) (Reference 42) (Reference 43) (Reference 44).

Design basis extreme wind conditions are characterized based on information in the American National Standards Institute's (ANSI) publication "Minimum Design Loads for Buildings and Other Structures" (Reference 45) and its current version by the American Society for Civil Engineers and the Structural Engineering Institute (Reference 46). In addition, since the NWS changed the averaging interval for collecting maximum wind speeds in 1990, the 1989 LCD for Richmond has been used to report observed fastest-mile-wind information on a long-term basis for the ESP site area (Reference 6). Similarly, design basis snow load conditions are characterized based on the weights of probabilistic snow pack and winter probable maximum precipitation amounts derived from (Reference 46) and (Reference 47), respectively.

Information on severe weather has been collected from a variety of sources. Severe storm, tornado and hurricane data have been obtained from the NCDC's Storm Events database for Virginia (Reference 3) (Reference 48), Thom (Reference 4), the historical tropical cyclone tracks database available through the National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center (Reference 49), and Virginia Tropical Cyclone Climatology (Reference 7).

The frequency and magnitude of hailstorms, snowstorms and ice storms have been characterized by information available in the Climate Atlas of the United States (Reference 50), measurements from NWS cooperative observation network stations in the ESP site area (Reference 40), and entries from the NCDC publication "Storm Data" (Reference 51).

Information regarding the climatology of restrictive dilution conditions has been obtained from a variety of sources dealing with the potential for stagnating conditions and atmospheric mixing heights in the United States (Reference 14) (Reference 15) (Reference 16).

2.3.1.2 General Climate

The climate in the Piedmont region of Virginia, where 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). Site-characteristic dry- and wet-bulb temperatures associated with various exceedance values and a 100-year return period, are listed in Table 2.3-18. The exceedance values were obtained directly from the NCDC's Engineering Weather Data summary for Richmond, Virginia covering the 1973 to 1996 period of record (Reference 41). The 100-year return period maximum and minimum dry-bulb temperatures and wet-bulb temperature are extrapolations of several databases for Richmond covering the 30-year period from 1973 to 2002 (Reference 42), (Reference 43), (Reference 44).

Based on the latest 30-year normal period from 1971 to 2000 at Richmond, the area around the site receives an annual average total rainfall of approximately 44 inches. Rainfall is fairly well distributed over the entire year, with the exception of July and August, when thunderstorm activity raises monthly totals to between about 4.2 and 4.7 inches (Reference 1). Tropical cyclones can also contribute significantly to precipitation (rainfall) totals.

Based on the latest 30-year normal period at Richmond, monthly snowfall is greatest during January and February averaging 4.3 and 4.8 inches, respectively, with an annual average total of 12.4 inches. The long-term period of record for this station (62 years) is similar – 4.7 and 3.8 inches in January and February with a slightly higher annual total of 13.5 inches (Reference 1). Snow generally remains on the ground for only 1 or 2 days (Reference 1) although durations of a week or more have occurred following heavy snowfall events and/or cold air outbreaks after the storm's passage (Reference 40).

2.3.1.2.1 Interaction Between Synoptic Scale Processes and Local Conditions

Synoptic scale processes are commonly examined with respect to the general circulation and general climatological characteristics of a region. Therefore, synoptic scale processes generally involve examination of gross meteorological conditions, such as prevailing wind patterns, temperature variability, precipitation patterns, and the occurrence of meteorological phenomena (e.g., fog, severe storms) in the site region. The analysis of the micrometeorology (local conditions) of a region usually encompasses the examination of the gross climatic characteristics of the region with respect to how local conditions can alter or influence a change in the general climatology of the region at a specific location. There are times when certain meteorological variables would deviate from the expected normal due to topographic effects or man-made interference.

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 contour lines of the region. Lake Anna has a moderating effect with respect to extreme temperatures in the immediate vicinity of the site region.

For the most part, the general synoptic conditions predominate in regard to climatic characteristics of the site region; however, during periods of extreme temperatures or light wind conditions, the local conditions have an influence on the micrometeorology.

2.3.1.3 Severe Weather

2.3.1.3.1 Extreme Winds

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 45). Values for other recurrence intervals are listed in Table 2.3-4 (Reference 45). 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 6). 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 46.

2.3.1.3.2 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 3). The 2-degree square is the area enclosed by two degrees of longitude and latitude lines centered on the ESP site (Reference 18). This averages 4.35 tornadoes per year within this area, which includes counties in Virginia, three counties (Charles, Prince Georges and Montgomery) in Maryland, one county in West Virginia (Hardy), and Washington, D.C. Among those 235 tornadoes, 204 occurred in Virginia, 29 in Maryland, two in Washington, D.C., and none in West Virginia.

Tornado strength is classified according to the Fujita-Pearson scale, ranking from F0 (gale) to F5 (incredible). During the 54-year period, no F3 or higher tornadoes were reported in Louisa or Spotsylvania counties. The most intense tornadoes outside of these counties, and within the 2-degree square area, were three classified as F4. The wind speeds of an F3 tornado range from 158 mph to 206 mph; the wind speeds of an F4 tornado range from 207 mph to 260 mph (Reference 18).

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 4) (Reference 18):

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

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 for specific tornadoes (Reference 3). 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 strike 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. Table 2.3-1 describes the tornado with a total annual strike probability equal to 10^{-7} of striking the ESP site.

The tornado maximum wind speed consists of two components, a rotational wind speed and a translational wind speed. Using methods provided in (Reference 18), (Reference 38), and (Reference 52), and an assumed radius of maximum rotational wind speed of 150 feet, other tornado parameters have been calculated and are provided in Table 2.3-1. The radius of maximum rotational wind speed of 150 feet was suggested in (Reference 18) for intense tornadoes.

Table 2.3-1 ESP Site Tornado Parameters

Criteria	Unit Of Measure	Site Tornado (10^{-7} per year occurrence)
Maximum Wind Speed	mph	260
Maximum Rotational Speed	mph	208
Maximum Translation Speed	mph	52
Radius of Maximum Rotational Speed	ft	150
Pressure Drop	psi	1.5

Criteria	Unit Of Measure	Site Tornado (10^{-7} per year occurrence)
Rate of Pressure Drop	psi/sec	0.76

In 1988, the NRC developed an interim position (Reference 38) to replace the criteria for design basis tornadoes as specified in the 1974-issued RG 1.76 (Reference 17). Because a considerable quantity of tornado data is now available that was not available when RG 1.76 was developed, the Interim Position concluded that regional maximum wind speeds, as reported in RG 1.76, were too conservative and that the contiguous United States is better represented by four tornado regions instead of three. The ESP site is located in Region II, as designated in the Interim Position, which has a maximum wind speed of 300 mph.

2.3.1.3.3 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 7). 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 National Oceanic and Atmospheric Administration's Coastal Services Center and based on information compiled by the National Hurricane Center (Reference 49), 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 Table 2.3-5). 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 International Airport (i.e., 8.79 inches) (see also Table 2.3-5).

2.3.1.3.4 **Precipitation Extremes**

Historical precipitation extremes (rainfall and snowfall) are listed in Table 2.3-5 along with climatological extremes of temperature for the available periods of record at selected NWS and cooperative observing stations in the ESP site area.

As noted in the preceding section, the remnants of Hurricane Camille passed through the site area in August 1969 and resulted in the overall highest 24-hour (daily) rainfall total recorded at any station to date in the ESP site area - 11.18 inches at the nearby Louisa cooperative observation station (Reference 10) (Reference 49). Similarly, record 24-hour (daily) rainfall totals for other nearby stations listed in Table 2.3-5 were attributable to tropical cyclones that passed beyond 100 nautical miles of the ESP site, including:

- Piedmont Research Station (7.85 inches) in June 1972 due to Tropical Storm Agnes (Reference 40) (Reference 51),
- Richmond (8.79 inches) and Partlow 3WNW (5.45 inches) in August 1955 due to Tropical Storm Connie (Reference 1) (Reference 12) and (Reference 49).

The other 24-hour (daily) rainfall records in Table 2.3-5 are due to both synoptic-scale (e.g., stalled frontal boundaries) and regional-scale events (i.e., thunderstorms) (Reference 51). For several of these observing stations (i.e., Louisa, Gordonsville 3S and Charlottesville 2W), record monthly rainfall totals coincide with these 24-hour (daily) station records.

Table 2.3-5 also summarizes 24-hour (daily) and monthly record snowfall totals for selected stations in the ESP site area. For the available periods of record, Richmond has logged the highest 24-hour (daily) amount measuring 21.6 inches in January 1940 (Reference 1). Comparable maxima have been observed at the other stations ranging from 16.0 to 20.7 inches, many associated with the same snowstorm (e.g., March 1962).

Similarly, record monthly totals coincide with several of these 24-hour (daily) station records (e.g., at Richmond and Partlow 3WNW) or have occurred at multiple stations in the site area during the same month, including the overall highest and second-highest monthly totals of 41.0 and 32.2 inches at Partlow 3WNW and Louisa, respectively (Reference 12) (Reference 10) as well as the records at Piedmont Research Station, Gordonsville 3S and Fredericksburg National Park.

Overall, then, in terms of extreme precipitation events, these station histories indicate that rainfall and snowfall maxima over the ESP site area, when they occur, are fairly similar.

The weight of the estimated 100-year return period snow pack for the ESP site area is 30.5 pounds per square foot (lbs/ft^2), as determined in accordance with Figure 7-1 and Table C7-3 in the snow load guidance of Reference 46. The 48-hour winter Probable Maximum Precipitation (PMP) is 20.75 inches. This estimated precipitation was linearly interpolated from the 24-hour and 72-hour, 10-square-mile area, values shown in Figures 35 and 45, respectively, for December (Reference 47). The highest winter PMP values for the site area occur in December (Reference 47).

As Section 2.4.7.6 indicates, the design features that demonstrate acceptable roof structure performance for the selected reactor design would be described in the COL application.

2.3.1.3.5 Hail, Snowstorms, and Ice Storms

Frozen precipitation typically occurs in the form of hail, 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 50), published by the National Climatic Data Center in 2002, which has been developed from observations made over the 30-year period of record from 1961 to 1990.

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 data indicate 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. 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 48). 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 48) – 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 Climate Atlas (Reference 50) indicates 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.

Nevertheless, daily snowfall totals greater than these threshold values have occasionally occurred in the site area on more than one day during a given year – for example, the winters of 1962, 1966, 1987 and more recently 1996 and 2003 at Louisa and other NWS cooperative observation network stations in the ESP site area (Reference 40) (Reference 51) – some of the events during these years appear as daily or monthly total snowfall extremes in Table 2.3-5.

2.3.1.3.6 **Thunderstorms**

Based on a 67-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).

The mean frequency of lightning strikes to earth can be estimated using a method reported by the Electric Power Research Institute (EPRI) (Reference 53). 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).

$$N = 0.31T$$

As indicated previously, there are 36 thunderstorm-days per year, on average, at Richmond. 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:

$11.2/mi^2/year \times 0.068\ mi^2 = 0.76$ lightning strokes per year at the reactor area

2.3.1.3.7 Restrictive Dilution Conditions

In the ESP site region, the annual frequency of low-level inversions or isothermal layers based at or below a 500-foot elevation is approximately 30 percent according to Hosler (Reference 14). Seasonally, the greatest frequencies of inversions occur during the fall and winter (34 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 to which relatively free vertical mixing occurs in the atmosphere (Reference 15). According to Holzworth, the annual afternoon MMMD value for the ESP site is about 4900 feet (Reference 16). The seasonal afternoon MMMD values for 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.

2.3.1.3.8 Meteorological Data for Evaluating the Ultimate Heat Sink

The evaluation for determining the meteorological conditions resulting in the maximum evaporation and drift loss of water from and the minimum cooling by the ultimate heat sink (UHS) is in accordance with the guidance of RG 1.27 (Reference 54) and uses data from (Reference 42), (Reference 43), and (Reference 44). The controlling parameters for the type of UHS selected for the ESP application (i.e., mechanical draft cooling tower over a buried water storage basin or other passive water storage facility, as required by the reactor design) are the wet-bulb temperature and coincident dry-bulb temperature.

The meteorological conditions resulting in the maximum evaporation and drift loss of water from the UHS are the worst 30-day average combination of the controlling atmospheric parameters. Calculating "running, 30-day," daily averages and selecting the 30-day period with the highest daily average wet-bulb temperature, determined the worst 30-day period. The worst 30-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures is 76.3 °F and 79.5 °F, respectively, based on the referenced data encompassing a 25-year period of record from 1978 to 2003.

The meteorological conditions resulting in minimum water cooling are the worst combination of controlling atmospheric parameters, including diurnal variations where appropriate, for the critical time periods unique to the UHS design. The worst 1-day and the worst 5-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures are considered to conservatively represent these conditions.

The worst 1-day is the day having the highest daily average wet-bulb temperature. Calculating "running, 5-day," daily averages and selecting the 5-day period with the highest daily average wet-bulb temperature determined the worst 5-day period. Both the worst 1-day and the worst 5-day temperatures were determined using the same reference data over the same period of record as the worst 30-day temperatures.

The worst 1-day wet-bulb temperature and coincident dry-bulb temperature is 78.9 °F and 87.7 °F, respectively. The worst 5-day daily average of the wet-bulb temperatures and coincident dry-bulb temperatures is 77.6 °F and 80.9 °F, respectively.

2.3.2 Local Meteorology

2.3.2.1 Data Sources

Data acquired by the NWS at its Richmond, Virginia first-order station and from six nearby locations in its network of cooperative observer stations, as compiled and summarized by the NCDC, have been used to characterize normals (i.e., 30-year averages), means and extremes of temperature, rainfall and snowfall in the

ESP site area. Section 2.3.1.1 lists the sources of these climatological summaries and data resources. The approximate distance and direction of these climatological observing stations relative to the ESP site are listed in Table 2.3-2.

First-order NWS stations also record observations of other weather elements including winds and relative humidity (typically on an hourly basis), as well as fog when those conditions occur, among others. The 2003 Local Climatological Data summary for the Richmond NWS station has been used to describe the characteristics of these parameters (Reference 1).

Table 2.3-2 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
Gordonsville 3S	22	West
Fredericksburg Nat'l Park	26	Northeast
Charlottesville 2W	40	West
Richmond	46	Southeast

The closest station to the ESP site, Partlow 3WNW, was decommissioned on December 31, 1976 (Reference 20). Nevertheless, a climatological summary of means and extremes of temperature and precipitation covering a 20-year period of record from 1952 through 1971 was prepared by the NCDC (Reference 12). With the exception of temperature measurements from Gordonsville 3S, longer-term periods of record for the other stations listed in Table 2.3-2, as well as summaries of the latest 30-year station normals (averages) from 1971 through 2000, are available from NCDC and have been taken into consideration.

Besides using data from these nearby climatological observing stations, data collected from the meteorological monitoring system at the existing units was also used to characterize local meteorological conditions. The onsite primary meteorological tower is located about 1750 feet east-northeast of the Unit 1 containment building (see Figure 2.3-23 and Figure 2.3-24). Based on proximity, the meteorological parameters (i.e., wind speed and wind direction) collected by this tower are representative of the ESP site. Consequently, they are appropriate for use in describing local meteorological conditions.

2.3.2.2 Normal and Extreme Values of Meteorological Parameters

2.3.2.2.1 Local Climatological Data

Historical extremes of temperature, rainfall and snowfall are presented in Table 2.3-5 for the seven nearby NWS and cooperative observing stations in the ESP site area that are listed in Table 2.3-2. The normals, means, and extremes of the more extensive set of measurements and observations made at the Richmond, Virginia first-order NWS station is provided in Table 2.3-6 (Reference 1). Table 2.3-7 compares the annual normal (i.e., 30-year average) daily maximum, daily minimum and daily mean temperatures, as well as the normal annual rainfall and snowfall totals for these stations. The precipitation extremes have been discussed previously in Section 2.3.1.3.4.

Extreme maximum temperatures have ranged from 100 °F to 107 °F with the highest reading observed at Charlottesville 2W in September 1954 (Reference 8). As seen for the extreme rainfall and snowfall events, the synoptic-scale conditions responsible for periods of excessive heat affect the overall ESP site area. For example, the record high temperature at Charlottesville 2W was coincident with the station maxima at Louisa and Piedmont Research Station. Similarly, the 106 °F record maxima at Partlow 3WNW at the end of August and the beginning of September 1953 occurred at the same time that the station records were tied at Louisa and set at Fredericksburg National Park.

Extreme minimum temperatures have ranged from –10 °F to –21 °F with the lowest reading observed at Louisa (about 12 miles west of the ESP site) in February 1996 (Reference 10). Like the extreme maximum temperatures discussed above, excessive cold air outbreaks affect the overall ESP site area considering that comparable low temperature records were also set at the same time at Gordonsville 3 S and Bremo Bluff PWR (i.e., -18 °F) (Reference 40) and Piedmont Research Station. The slightly higher record minimum temperatures for Richmond and to some extent Fredericksburg National Park (i.e., -12 °F) (Reference 1) (Reference 40) are probably moderated somewhat by urban heat-island effects.

Daily mean temperatures for the NWS and cooperative observing stations in Table 2.3-7 are fairly similar ranging from a low of 54.2 °F at Louisa (Reference 10) to a high of 57.6 °F at Richmond (Reference 1). In general, the diurnal (day-to-night) temperature ranges, as indicated by the differences between the daily maximum and minimum temperatures, are slightly greater at the more rural stations closest to the ESP site (i.e., Louisa and Partlow 3WNW) than at those stations within or adjacent to urban areas (i.e., Richmond, Fredericksburg National Park and Charlottesville 2W). These rural settings typically allow for greater radiational cooling at night.

Normal annual precipitation totals are fairly comparable for these stations ranging from 42.24 to 48.87 inches of rainfall, and from 12.4 to 18.8 inches of snowfall. Notwithstanding the record 24-hour (daily) snowfall total for the site area, the lowest of the range of annual average snowfall totals (i.e., at Richmond) is considered to be another consequence of urban heating.

On balance then, the more extensive meteorological data available for the Richmond NWS station are fairly representative of conditions in the ESP site area although slight differences are noted with respect to minimum temperature extremes, diurnal temperature ranges, and annual average total snowfall.

The closest station to the ESP site at which observations of fog are made and routinely recorded is the NWS station at Richmond Byrd International Airport. The 2003 LCD summary for Richmond (Reference 1) indicates an average of 27.2 days per year of heavy fog conditions based on a 75-year period of record. The NWS defines heavy fog 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 than for 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.

a. **Average Wind Direction and Speed**

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 located 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 southeast or easterly wind.

Topographic features also influence the wind direction distribution during 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 would typically follow 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 13, Section 2.3.2.2.1.1).

The seasonal and annual average distributions of wind direction based on site data are presented in Figure 2.3-1 through Figure 2.3-10 for the lower (33 ft) and upper (159 ft) tower levels (Reference 13). 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. Richmond wind data show a south-southwest/north orientation (Reference 1) that is similar to the general wind flow at the ESP site.

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 median wind speeds at the ESP site are presented in Table 2.3-8. 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 13, Section 2.3.2.2.1.1).

b. **Wind Direction Persistence**

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 2.3-11 through Figure 2.3-20. 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 13, Section 2.3.2.2.1.2).

c. **Atmospheric Stability**

Atmospheric stability, as applied in this report, is determined by the ΔT method as defined by the NRC (Reference 13, 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 2.3-9. The vertical stability data, based on ΔT site measurements, indicate the predominance of neutral and slightly stable conditions (Reference 13, 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 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 atmospheric stability. This instrumentation is discussed in Section 2.3.3.1.5. From the temperature recorder discussed in Section 2.3.3.1.3, a ΔT can be ascertained. The existing units Emergency Plan Implementing Procedures identify station-specific instructions and appropriate temperature values for determining RG 1.23, Table 2 (Reference 21) 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.

2.3.2.3 Potential Influence of the Plant and the Facilities on Local Meteorology

Lake Anna, comprising the North Anna Reservoir and the WHTF, has some effects on diffusion climatology, with those effects mainly confined to the immediate area of the lake. Slade (Reference 22) has documented that on average, a 50 percent reduction of horizontal wind direction fluctuation values and a 25 percent increase in wind speeds occurs after over-water trajectories of 7 miles. Because of the complex configuration of the lake, over-water trajectories would generally be less than 2.5 miles. Since the average water temperature in the reservoir is higher at the outfall and immediate surroundings within the WHTF than the average air temperature is, enhanced low-level atmospheric turbulent vertical mixing would occur. Although it is difficult to extrapolate Slade's results to other distances, the reduction of horizontal wind direction fluctuation values and the increase in wind speeds would be smaller than those reported by Slade due to the shorter over-water trajectories near the ESP site. Therefore, the offsite impact due to the effect of the lake on local diffusion climatology would be minimal.

The dimensions of the new nuclear plant structures and the associated paved, concrete, or other improved surfaces are insufficient to generate discernable impacts to local and regional meteorological conditions. While wind conditions may be altered in areas immediately adjacent to the larger site structures, these impacts will likely dissipate within ten-structure heights downwind of the intervening structure. Likewise, the daytime ambient atmospheric temperatures immediately above any newly improved surfaces could increase. However, these localized temperature influences are too limited in their vertical profile and coverage area to alter local ambient or regional temperature patterns.

As discussed in ER Section 5.3.2.1.2, maximum daily surface water temperature on the Lake resulting from operation of the Unit 3 cooling system would increase over the existing 2-unit operating temperature by 4.6 °F at the discharge, 3.6 °F near the dam and 2.8 °F near the cooling water intake. These small and localized temperature increases are not expected to significantly impact the ongoing moderation of temperature extremes and alterations of wind patterns by the lake. Under extreme humidity conditions during cooler seasons, cooling lake induced-fog formation could occur. However, these induced fogging conditions would most likely coincide with naturally occurring foggy conditions. Therefore, these effects are not expected to significantly increase the occurrence of local fog.

Similarly, the convective and conductive heat losses to the atmosphere resulting from operation of the Unit 4 closed-loop dry tower system would dissipate rapidly through continuous mixing and entrainment with the surrounding moving air mass. Therefore, any increases in overall ambient temperature would be very localized to the NAPS site and would not affect the ambient atmospheric and ground temperatures beyond the NAPS site boundary, or otherwise significantly alter local temperature patterns.

2.3.2.4 Topographic Description

The ESP site and exclusion area (approximately 1803 acres) is located 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 divided 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 2.3-21 and Figure 2.3-22 present the topographic features of the site. Section 2.3.2.2.1 discusses 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. The lake comprises the North Anna Reservoir and WHTF, which together cover a surface area of about 13,000 acres and contain approximately 100 x 10^9 gallons of water (Reference 13, Section 2.1.1.2).

Because of the gently rolling terrain, cold air drains 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 & 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 order to accommodate the new units since a large portion of the area to be developed is already relatively level. 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 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.

2.3.2.5 Current and Projected Site Air Quality Conditions

The ESP site is located within the Northeastern Virginia Intrastate Air Quality Control Region (AQCR). The region is designated as being in attainment or unclassified for all criteria pollutants (40 CFR 81.347) (Reference 55). Attainment areas are areas where the ambient air quality levels are better than the EPA-designated (national) ambient air quality standards. Criteria pollutants are those for which National Ambient Air Quality Standards (NAAQS) have been established (i.e., sulfur dioxide (SO_2), fine particulate matter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), Ozone (O_3), and Lead (Pb)) (Reference 56).

The Commonwealth of Virginia is also subject to the revised 8-hour O_3 standard and the new standard for $PM_{2.5}$ (fine particulate matter with an aerodynamic diameter of less than or equal to 2.5 microns), both promulgated by the EPA in July 1997 (Reference 56). Currently, Louisa County is designated as attainment for the ozone 8-hour standard (Reference 55). The attainment status for $PM_{2.5}$ standards has not been determined for the Northeastern Virginia Intrastate AQCR or resident ESP site. However, both the Virginia Department of Environmental Quality (VDEQ) recommendations and the EPA response as provided in a "Comparison of state and EPA recommendations" conclude that the entire Northeastern Virginia Intrastate AQCR should be designated attainment for the fine particulate matter ($PM_{2.5}$) standards (Reference 58). Attainment status designations for this pollutant are expected to be finalized in December 2004.

The ESP site development could be influenced by its relative proximity to two pristine regions referred to as Class I areas (the James River Face Wilderness and the Shenandoah National Park). Maintenance and restoration of visibility is the primary focus in these sensitive areas.

These air quality characteristics are not expected to be a significant factor in the design and operating bases of the new nuclear plant(s). The new nuclear steam supply system and other related radiological systems are not sources of criteria pollutants or other air toxics. The addition of supporting auxiliary boilers, emergency diesel generators, station blackout generators (and other non-radiological emission sources) are not expected to be significant sources of criteria pollutant emissions because these units operate on an intermittent test and/or emergency basis. Thus, these emissions are not expected to significantly impact ambient air quality or visibility in Class I areas, and they are likely to be regulated by the Virginia Department of Environmental Quality (VDEQ) via an Exclusionary General Permit – the permit that currently regulates all non-radiological emission sources on the NAPS site.

SSAR Section 2.3 References will be revised to read as follows:

Section 2.3 References

1. *Richmond, Virginia, 2003 Local Climatological Data, Annual Summary with Comparative Data*, National Climatic Data Center, National Environmental Satellite, Data and Information Service (NESDIS), National Oceanic and Atmospheric Administration (NOAA).

2. Deleted.

3. *Storm Events for Virginia, 01/01/1950 Through 12/31/2003*, National Climatic Data Center, NOAA, Website, www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, accessed June 2004.

4. Thom, H. C. S. *Tornado Probabilities*, Monthly Weather Review, 1963, Vol. 91, Nos. 10-12, 730–736.

5. Deleted.

6. *Richmond, Virginia, 1989 Local Climatological Data, Annual Summary with Comparative Data*, National Climatic Data Center, NESDIS, NOAA.

7. Virginia Tropical Cyclone Climatology, Website, www.hpc.ncep.noaa.gov/research/roth/vaclimohur.htm, accessed December 12, 2002.

8. *Charlottesville 2W, Virginia, Climatography of the United States No. 20 (1971-2000)*, National Climatic Data Center, NESDIS, NOAA.

9. Deleted.

10. *Louisa, Virginia, Climatography of the United States No. 20 (1971-2000)*, National Climatic Data Center, NESDIS, NOAA.

11. *Piedmont Research Station, Virginia, Climatography of the United States No. 20 (1971-2000)*, National Climatic Data Center, NESDIS, NOAA.

12. *Partlow 3WNW, Virginia, Climatological Summary, Means and Extremes for Period 1952–1971, Climatography of the United States, No. 20-44*, NOAA, in cooperation with the Water Resources Research Center and the Research Division of Virginia Polytechnic Institute and State University.

13. North Anna Updated Final Safety Analysis Report, Rev. 38, Dominion Virginia Power

14. Hosler, C. R. *Low-Level Inversion Frequency in the Contiguous United States*, Monthly Weather Review, 1961, Vol. 89, No. 9, 319-332.

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16. Holzworth, G. C. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, U.S. Environmental Protection Agency, 1971.

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18. *Technical Basis for Interim Regional Tornado Criteria*, WASH-1300, U.S. Atomic Energy Commission, May 1974.

19. Deleted.

20. *Virginia Climate Advisory 12/00*, Virginia State Climatology Office, Website, climate.virginia.edu/advisory/2000/ad00-12.htm, accessed March 24, 2003.

21. Regulatory Guide 1.23, Onsite Meteorological Program, U.S. Nuclear Regulatory Commission, 1972.

22. Slade, D. H. *Estimates of Dispersion from Pollutant Releases of a Few Seconds to 8 Hours in Duration*, Technical Note 39-ARL-3, Report No. 3, Environmental Science Services Administration, U.S. Department of Commerce, April 1966.

23. 10 CFR 50.47, *Emergency Plans*, January 19, 2001.

24. NUREG-0696, *Functional Criteria for Emergency Response Facilities*, Final Report, U.S. Nuclear Regulatory Commission, 1981.

25. NUREG-0737, *Clarification of TMI Plan Requirements*, U.S. Nuclear Regulatory Commission, 1980.

26. NUREG-0654, FEMA-REP-1, Rev. 1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, U.S. Nuclear Regulatory Commission, 1996.

27. Regulatory Guide 1.23, *Meteorological Programs in Support of Nuclear Power Plants*, Second Proposed Revision 1, U.S. Nuclear Regulatory Commission, 1986.

28. 10 CFR 50, Appendix E, Emergency Planning and Preparedness for Production and Utilization Facilities (Integrated), June 14, 1996.

29. NUREG/CR-2858, PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations, PNL-4413, U.S. Nuclear Regulatory Commission, 1982.

30. NUREG-1437, Supplement 7, Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding North Anna Power Station, Units 1 and 2, Final Report, U.S. Nuclear Regulatory Commission, November 2002.

31. Regulatory Guide 4.7, *General Site Suitability Criteria for Nuclear Power Stations*, Rev. 2, U.S. Nuclear Regulatory Commission, April 1998.

32. 10 CFR 100, *Reactor Site Criteria*, Code of Federal Regulations, December 4, 2002.

33. Regulatory Guide 1.145, Rev. 1, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, U.S. Nuclear Regulatory Commission, 1982.

34. Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases for Light-Water-Cooled Reactors, Rev. 1, U.S. Nuclear Regulatory Commission, 1977.

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39. Climatography *of* the *United States No. 81, U.S. Daily Climate Normals (1971-2000), Version 2.0 (December)*, summaries for Fredericksburg

National Park and Gordonsville 3S, Virginia, National Climatic Data Center, NOAA.

40. *Cooperative* Summary *of the Day, TD3200, Period of Record through 2001 includes daily weather data from the Eastern United States, Puerto Rico, and the Virgin Islands, data released November 2002, Version 1.0 (CD-ROM),* data listings for Charlottesville 2W, Fredericksburg National Park, Gordonsville 3S, Louisa, Partlow 3WNW, Piedmont Research Station, Bremo Bluff PWR and Free Union, Virginia, National Climatic Data Center, NOAA.

41. *Engineering* Weather *Data, 2000 Interactive Edition, Version 1.0 (CD-ROM),* developed by the Air Force Combat Climatology Center, Asheville, NC, published by the National Climatic Data Center, summary for Richmond, Virginia.

42. *Solar and Meteorological Surface Observation Network, 1961-1990, Volume 1, Eastern U.S., Version 1.0 (September 1993),* data for Richmond, Virginia, National Climatic Data Center and National Renewable Energy Laboratory.

43. *Hourly United States Weather Observations, data for Richmond, Virginia, 1990-1995,* National Climatic Data Center, NOAA.

44. *Hourly United States Weather Observations for Richmond, Virginia, 1996-2003,* National Climatic Data Center, NOAA.

45. *Minimum Design Loads for Buildings and Other Structures, ANSI A58.1-1982,* American National Standards Institute, Revision of ANSI A58.1-1972.

46. *Minimum Design Loads for Buildings and* Other *Structures,* SEI/ASCE 7-02, Revision of ASCE 7-98, American Society of Civil Engineers (ASCE), and Structural Engineering Institute (SEI), January 2002.

47. NUREG/CR-1486, *Seasonal Variation of 10-Square Mile Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, Hydrometeorological* Report *No. 53,* U.S. Department of Commerce, National Oceanic and Atmospheric Administration, U.S. Nuclear Regulatory Commission, April 1980.

48. *Storm Events for Virginia (Hail), 1955 through February 2004,* National Climatic Data Center, NOAA, Website, http:// www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, accessed June 25, 2004.

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50. *The Climate Atlas of the United States, Version 2.0 (CD-ROM)*, National Climatic Data Center, Climate Services Division, NOAA, September 2002.

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55. 40 CFR 81, Subpart C – Section 107, "Attainment Status Designations".

56. 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards".

57. Not Used

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SSAR Tables 2.3-4 through 2.3-7 will be revised and new SSAR Table 2.3-18 will be added as shown on the following pages.

Table 2.3-4 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: *Minimum Design Loads for Buildings and Other Structures, ANSI A58.1-1982*, American National Standards Institute, Revision of ANSI A58.1-1972. (Reference 45).

Table 2.3-5 Climatological Extremes at Selected NWS and Cooperative Observing Stations in the ESP Site Area (Date of Occurrence)

Parameter	Partlow 3WNW	Louisa	Piedmont Research Station	Gordonsville 3S	Fredericksburg Nat'l Park	Charlottesville 2W	Richmond
Maximum Temperature	106 °F [a] (8/53, 9/53)	104 °F [c] (d)	106 °F [e] (9/54, 7/59)	100 °F [b] (07/23/98)	106 °F [b] (09/01/53)	107 °F [f] (09/07/54)	105 °F [g] (07/77)
Minimum Temperature	-16 °F [a] (1/53, 1/70)	-21 °F [c] (02/05/96)	-11 °F [e] (02/05/96)	-18 °F [b] (02/05/96)	-12 °F [b] (01/28/35)	-10 °F [f] (01/19/94)	-12 °F [g] (1/40)
Maximum Monthly Rainfall	16.20 in. [b] (9/75)	16.33 in. [b] (8/69)	13.32 in. [b] (8/55)	14.69 in. [b] (6/95)	16.20 in. [b] (7/45)	17.96 in. [f] (9/87)	18.87 in. [g] (7/45)
Maximum Monthly Snowfall	41.0 in. [a] (1/66)	32.2 in. [b] (1/66)	32.0 in. [e] (1/87)	27.8 in. [b] (1/87)	30.5 in. [b] (1/87)	29.8 in. [b] (3/60)	28.5 in. [g] (1/40)
Maximum 24-hr Rainfall	5.45 in. [a] (08/12/55)	11.18 in. [c] (08/20/69)	7.85 in. [e] (06/22/72)	9.30 in. [b] (06/28/95)	6.17 in. [b] (10/16/42)	9.20 in. [f] (09/08/87)	8.79 in. [g] (08/55)
Maximum 24-hr Snowfall	20.0 in. [a,b] (1/66, 3/62)	16.0 in. [c] (01/07/96)	18.0 in. [b] (03/06/62)	17.0 in. [b] (03/06/62)	17.0 in. [b] (01/24/40)	20.7 in. [b] (03/06/62)	21.6 in. [g] (1/40)
Fastest Mile Wind Speed	N/A	N/A	N/A	N/A	N/A	N/A	68 mph [h] (10/54)
Fastest Mile Wind Direction	N/A	N/A	N/A	N/A	N/A	N/A	SE [h] (10/54)

Sources of information in Table 2.3-5 and other related notes:

a - Partlow 3WNW, Virginia, Climatological Summary, Means and Extremes for Period 1952-1971, Climatography of the United States No. 20-44, NOAA, in cooperation with the Water Resources Research Center and the Research Division of Virginia Polytechnic Institute and State University. (Reference 12)

b - *Cooperative Summary of the Day*, TD3200, *Period of Record through 2001* includes daily weather data from the Eastern United States, Puerto Rico, and the Virgin Islands, data released November 2002, Version 1.0 (CD-ROM), data listings for Charlottesville 2W, Fredericksburg National Park, Gordonsville 3S, Louisa, Partlow 3WNW, Piedmont Research Station, Bremo Bluff PWR and Free Union, Virginia, National Climatic Data Center, NOAA. (Reference 40).

c - Louisa, Virginia, Climatography of the United States No. 20 (1971-2000), National Climatic Data Center, NESDIS, NOAA. (Reference 10)

d - Extreme maximum temperature occurred on more than two occasions at Louisa – 7/30/53, 8/31/53 and 9/7/54.

e - Piedmont Research Station, Virginia, Climatography of the United States No. 20 (1971-2000), National Climatic Data Center, NESDIS, NOAA. (Reference 11)

f - Charlottesville 2W, Virginia, Climatography of the United States No. 20 (1971-2000), National Climatic Data Center, NESDIS, NOAA. (Reference 8)

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h - Richmond, Virginia, 1989 Local Climatological Data, Annual Summary with Comparative Data, National Climatic Data Center, NESDIS, NOAA. (Reference 6)

NA = Measurements not made.

Table 2.3-6 Richmond Climatological Data

NORMALS, MEANS, AND EXTREMES

RICHMOND, VA (RIC)

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	45.3	49.3	58.4	68.9	76.2	83.6	87.5	85.7	79.7	69.3	59.7	49.7	67.8
	MEAN DAILY MAXIMUM	83	47.4	50.3	58.9	69.3	77.5	85.1	88.3	86.5	80.8	70.6	60.5	50.0	68.8
	HIGHEST DAILY MAXIMUM	74	81	83	93	96	100	104	105	102	103	99	86	81	105
	YEAR OF OCCURRENCE		2002	1932	1938	1990	1941	1952	1977	1983	1954	1941	1993	1998	JUL 1977
	MEAN OF EXTREME MAXS.	83	69.5	71.2	80.2	87.9	91.0	96.0	97.5	96.0	93.1	85.4	77.9	70.0	84.6
	NORMAL DAILY MINIMUM	30	27.6	29.7	37.0	45.3	54.6	63.3	68.3	66.8	59.9	47.2	38.4	31.1	47.4
	MEAN DAILY MINIMUM	83	28.4	30.0	36.6	45.4	54.7	63.5	68.0	66.6	60.1	47.9	38.5	30.9	47.5
	LOWEST DAILY MINIMUM	74	-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.	83	10.3	14.4	21.5	30.9	41.0	51.1	57.8	55.7	45.5	32.4	22.8	14.7	33.2
	NORMAL DRY BULB	30	36.4	39.5	47.7	57.1	65.4	73.5	77.9	76.3	69.8	58.3	49.0	40.4	57.6
	MEAN DRY BULB	83	38.0	40.1	47.8	57.4	66.2	74.3	78.2	76.6	70.5	59.2	49.6	40.4	58.2
	MEAN WET BULB	19	34.1	36.6	42.1	50.8	59.4	67.3	71.6	66.6	63.9	53.8	45.1	36.7	52.3
	MEAN DEW POINT	19	27.0	28.9	34.3	43.5	54.4	63.2	68.1	63.7	60.3	49.0	39.0	29.9	46.8
	NORMAL NO. DAYS WITH:														
	MAXIMUM ≥ 90°	30	0.0	0.0	*	0.8	1.9	8.2	15.0	10.9	3.6	0.3	0.0	0.0	40.7
	MAXIMUM ≤ 32°	30	3.5	1.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	7.2
	MINIMUM ≤ 32°	30	21.6	18.3	10.3	1.9	*	0.0	0.0	0.0	0.0	1.3	9.2	18.3	80.9
	MINIMUM ≤ 0°	30	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
H/C	NORMAL HEATING DEG. DAYS	30	873	705	528	254	80	8	0	1	27	225	470	748	3919
	NORMAL COOLING DEG. DAYS	30	0	1	8	33	107	277	415	367	187	33	6	1	1435
RH	NORMAL (PERCENT)	30	69	66	63	62	70	72	74	76	76	74	70	69	70
	HOUR 01 LST	30	75	73	72	73	83	86	88	90	89	87	80	76	81
	HOUR 07 LST	30	80	79	78	76	81	83	85	89	90	89	84	81	83
	HOUR 13 LST	30	57	53	50	46	53	54	56	57	57	53	52	56	54
	HOUR 19 LST	30	66	62	57	54	63	66	68	72	75	76	69	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)	75	2.7	2.1	1.7	1.6	1.9	1.5	2.0	2.4	2.9	3.3	2.3	2.8	27.2
	THUNDERSTORMS	67	0.2	0.4	1.6	2.5	5.3	6.5	8.1	6.3	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)	30	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)	19	30.12	30.11	30.05	29.99	30.00	29.99	30.01	30.04	30.08	30.12	30.13	30.14	30.06
WINDS	MEAN SPEED (MPH)	45	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)	28	01	01	36	19	19	20	19	19	36	36	19	36	19
	MAXIMUM 2-MINUTE:														
	SPEED (MPH)	8	38	39	37	46	41	45	33	44	46	37	36	40	46
	DIR. (TENS OF DEGS)		31	22	36	33	30	26	29	36	09	10	30	15	09
	YEAR OF OCCURRENCE		2000	2002	2003	1999	1997	2000	1999	1996	2003	1996	2003	1996	SEP 2003
	MAXIMUM 5-SECOND:														
	SPEED (MPH)	8	48	49	49	56	60	55	48	59	72	46	46	48	72
	DIR. (TENS OF DEGS)		31	26	22	25	28	27	19	32	10	10	27	16	10
	YEAR OF OCCURRENCE		2000	1997	1996	1998	1996	2000	2003	2000	2003	1996	2003	1996	SEP 2003
PRECIPITATION	NORMAL (IN)	30	3.55	2.98	4.09	3.18	3.96	3.54	4.67	4.18	3.98	3.60	3.06	3.12	43.91
	MAXIMUM MONTHLY (IN)	66	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)	66	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)	66	3.31	2.67	3.43	2.97	3.40	4.61	5.73	8.79	6.52	6.50	4.07	3.16	8.79
	YEAR OF OCCURRENCE		1962	1979	1992	1987	2003	1963	1969	1955	1999	1961	1956	1958	AUG 1955
	NORMAL NO. DAYS WITH:														
	PRECIPITATION ≥ 0.01	30	10.7	9.5	10.5	9.2	11.0	9.6	11.1	9.0	8.7	7.5	8.1	9.7	114.6
	PRECIPITATION ≥ 1.00	30	1.0	0.7	1.0	0.8	1.0	0.8	1.3	1.2	1.2	1.2	0.8	0.5	11.5
SNOWFALL	NORMAL (IN)	30	4.3	4.8	1.4	0.*	0.0	0.0	0.0	0.0	0.0	0.*	0.3	1.6	12.4
	MAXIMUM MONTHLY (IN)	64	28.5	21.4	19.7	2.0	T	0.0	T	0.0	0.0	T	7.3	12.5	28.5
	YEAR OF OCCURRENCE		1940	1983	1960	1940	1994		2003			1979	1953	1958	JAN 1940
	MAXIMUM IN 24 HOURS (IN)	64	21.6	16.8	12.1	2.0	T	0.0	T	0.0	0.0	T	7.3	7.5	21.6
	YEAR OF OCCURRENCE		1940	1983	1962	1940	1994		2003			1979	1953	1966	JAN 1940
	MAXIMUM SNOW DEPTH (IN)	79	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	1.1	1.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	3.5

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Source: *Richmond, Virginia, 2003 Local Climatological Data, Annual Summary with Comparative Data,* National Climatic Data Center, NESDIS, NOAA. (Reference 1)

Table 2.3-7 Climatological Normals (Means) at Selected NWS and Cooperative Observing Stations in the ESP Site Area

Station	Normal Annual Temperatures (°F)			Normal Annual Rainfall (inches)	Normal Annual Snowfall (inches)
	Daily Max	Daily Min	Daily Mean		
Partlow 3WNW [a]	68.9	41.5	55.2	42.24	18.6
Louisa [b]	67.1	41.2	54.2	44.02	16.8
Piedmont Research Station [c]	65.3	44.8	55.1	44.64	18.8
Gordonsville 3S [d]	----	----	----	45.42	----
Fredericksburg Nat'l Park [d]	68.4	43.5	55.9	42.72	----
Charlottesville 2W [e]	67.7	46.3	57.0	48.87	17.8
Richmond [f]	67.8	47.4	57.6	43.91	12.4

Sources of information in Table 2.3-7 and other related notes:

a - (Reference 12).
b - (Reference 10).
c - (Reference 11).
d - Climatography of the United States No. 81, U.S. Daily Climate Normals (1971-2000), Version 2.0 (December), summaries for Fredericksburg National Park and Gordonsville 3S, Virginia (Reference 39).
e - (Reference 8).
f - (Reference 1).

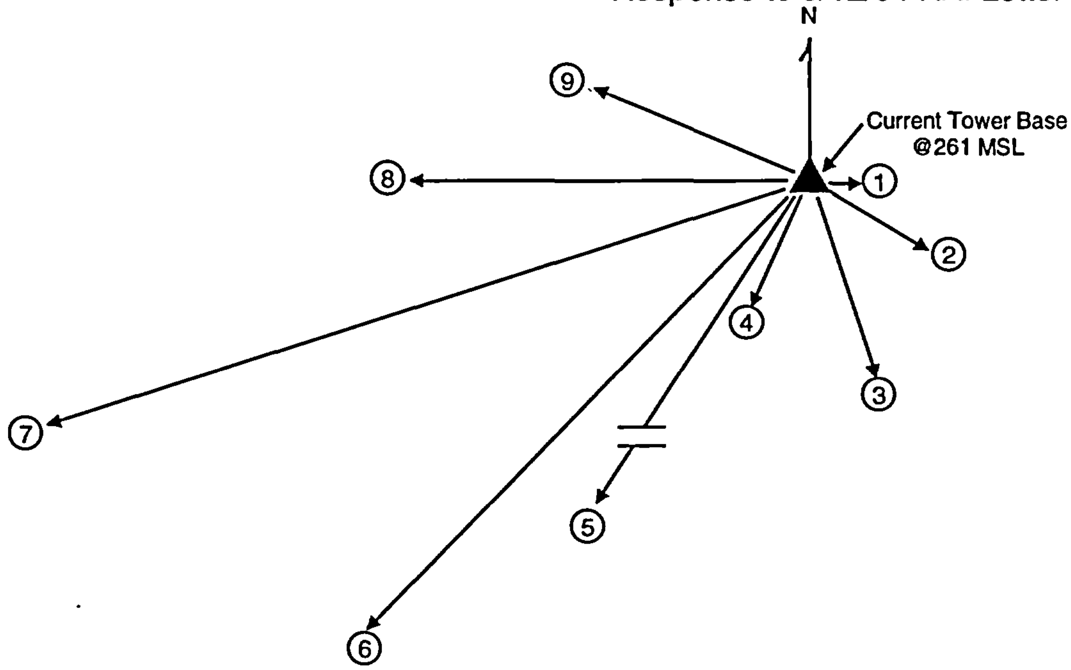
Table 2.3-18 Selected Site Characteristic Ambient Dry-Bulb and Wet-Bulb Temperatures

Parameter		Temperature (°F)
Maximum Dry-Bulb	2% annual exceedance	90 (75 concurrent wet-bulb)
	0.4% annual exceedance	95 (77 concurrent wet-bulb)
	0% exceedance	104.9 (79 concurrent wet-bulb)
	100-year return period	109
Minimum Dry-bulb	1% annual exceedance	18
	0.4% annual exceedance	14
	100-year return period	-19
Maximum Wet-bulb	0.4% annual exceedance	79
	0% exceedance	84.9
	100-year return period	88

Sources: Exceedance temperatures from Reference 41; 100-year return period temperatures calculated using data from Reference 42, Reference 43, Reference 44.

SSAR Figure 2.3-24 will be revised (revised figure is on the next page) to add the following heading above the list of values:

Approximated Directions and Distances



	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 2.3-24 Location of Meteorological Tower Relative to Local Ground Features

ER Sections 2.7.1 through 2.7.4 will be revised to read as follows:

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 National Weather Service (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 at the NAPS site 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 75.0°F 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 27.1 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. 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 discussed 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 located in Louisa County, Virginia, which is within the Northeastern Virginia Intrastate Air Quality Control Region (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 in attainment or unclassified for all criteria pollutants (40 CFR 81.347). Criteria pollutants are those for which National Ambient Air Quality Standards 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 National Climatic Data Center 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 the Electric Power Research Institute (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. 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 x 0.068 mi^2 = 0.76 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 (i.e., 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 strike 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 National Oceanic and Atmospheric Administration'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 National Climatic Data Center (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 National Weather Service (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 located 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 located 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 percents 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 (discussed 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 atmospheric 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 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 located 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 27.1 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 located 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 discusses 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 & 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 current 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 order to accommodate the new units since a large portion of the area to be developed is already relatively level. 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 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.

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ER Tables 2.7-2 and 2.7-3 will be revised as shown below:

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

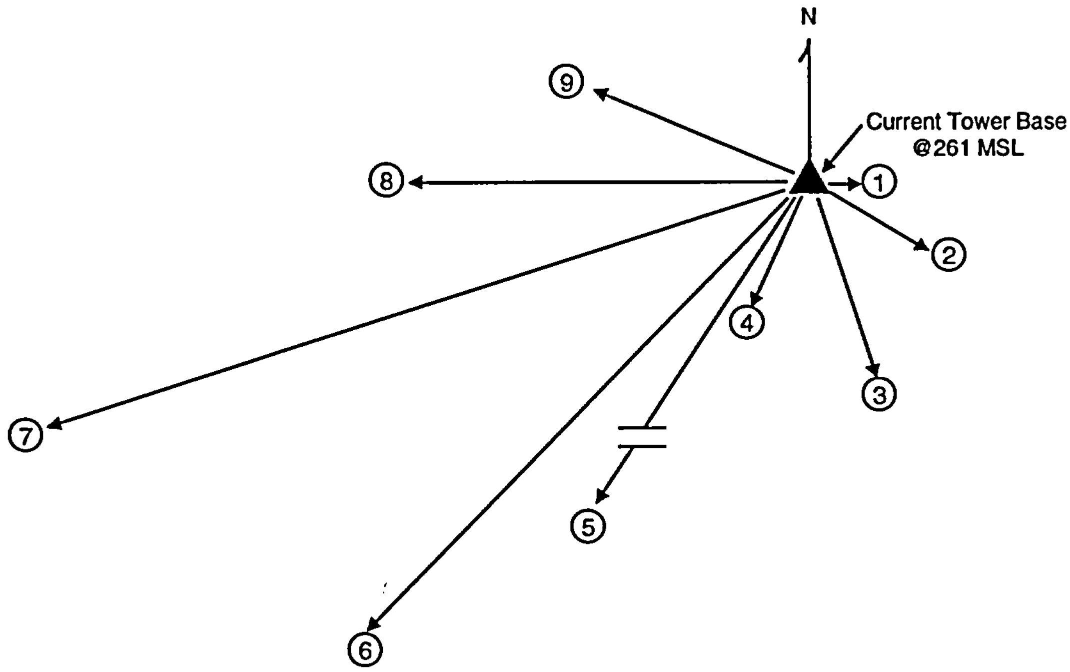
Source: ANSI A58.1, American National Standard: Minimum Design Loads for Building and Other Structures, American National Standards Institute, 1982. (Reference 38).

ER Figure 2.7-2 will be revised (revised figure is on the next page) to add the following heading above the list of values:

Approximated Direction and Distances

The 5th paragraph of ER Section 6.4.1 will be revised to read as follows:

> Descriptions of the onsite meteorological monitoring program are from the NAPS UFSAR, unless otherwise indicated. The primary meteorological monitoring site at the NAPS site consists of a Rohn Model 80, guyed, 160-ft (48.8-m) tower approximately 1750 ft (580 m) east of the Unit 1 containment building. Sensors are located at the 32.8-ft (10-m) level, the 158.9-ft (48.4-m) level, and ground level. Wind speed, wind direction, horizontal wind direction fluctuation, ambient temperature, one-half of differential temperature, and dew point temperature are measured at the 10-m elevation. Wind speed, wind direction, horizontal wind direction fluctuation, and one-half of the differential temperature are measured at the 48.4-m elevation. Precipitation is monitored at the ground level. Signal cables are routed through conduit from each location into the instrument shelter at the base of the tower. Inside the shelter, the signals are routed to the appropriate signal-conditioning equipment. The equipment outputs are directed to digital data recorders and to an interface with the intelligent remote multiplex system.



		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

Enclosure 3

Letter Referenced in Response to RAI 2.2.2-2 Regarding Annual Flight Frequency Information

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO

5720
Ser N09B10C/4U669596
March 30, 2004

Mr. Marvin L. Smith
Dominion Resources Services, Inc.
5000 Dominion Boulevard
Glen Allen, VA 23050

Dear Mr. Smith:

This refers to your request of March 17, 2004, to the Navy Representative Eastern/New England Regions - FAA, in which you seek "actual 2003 flight data and projection of 2004 flight data confirm that the previous estimate of 6,000 aircraft per year is conservative." Your request was referred to this Department for action as a Freedom of Information Act request. Your request was received by this Department on March 25, 2004, and assigned file number 200400538.

In an effort to assist you, I have referred your request to the Director, Warfare Requirements and Programs (N78), 2000 Navy Pentagon, Washington, DC 20350-2000, for action and direct response to you.

Should you require further assistance, please contact Ms. Sarah English of my staff at (202) 685-6546.

Sincerely,

DORIS M. LAMA
Head, DON PA/FOIA Policy Branch
By direction of the
Chief of Naval Operations
(202) 685-6545