2.3 Meteorology

To ensure that a nuclear power plant(s) could be designed, constructed, and operated on an applicant's proposed ESP site in compliance with the Commission's regulations, the NRC staff evaluates regional and local climatological information, including climate extremes and severe weather occurrences that may affect the design and siting of a nuclear plant. The staff reviews information concerning atmospheric dispersion characteristics of a nuclear power plant site to determine whether the radioactive effluents from postulated accidental releases, as well as routine operational releases, are within Commission guidelines. The staff has prepared Sections 2.3.1 through 2.3.5 of this SER in accordance with the review procedures described in RS-002, using information presented in SSAR Section 2.3, responses to staff RAIs, and generally available reference materials, as described in the applicable sections of RS-002.

2.3.1 Regional Climatology

2.3.1.1 Technical Information in the Application

In this section of the SSAR, the applicant presented information concerning the averages and the extremes of climatic conditions and regional meteorological phenomena that could affect the design and siting of a nuclear power plant that falls within the applicant's PPE and that might be constructed on the proposed site. The applicant provided the following information:

- a description of the general climate of the region with respect to types of air masses, synoptic features (high- and low-pressure systems and frontal systems), general airflow patterns (wind direction and speed), temperature and humidity, precipitation (rain, snow, and sleet), and relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions

- seasonal and annual frequencies of severe weather phenomena, including tornadoes, waterspouts, thunderstorms, lightning, hail (including probable maximum size), and high air pollution potential

- meteorological conditions used as design and operating bases, including the following:

    — the maximum snow and ice load (water equivalent) on the roofs of safety-related structures

    — the ultimate heat sink meteorological conditions resulting in the maximum evaporation and drift loss of water and minimum water cooling

    — the tornado parameters, including translational speed, rotational speed, and the maximum pressure differential with the associated time interval

    — the 100-year return period straight-line winds

    — the probable maximum frequency of occurrence and time duration of freezing rain (ice storms) and, where applicable, dust (sand) storms

— other meteorological conditions used for design and operating-basis considerations

The applicant characterized the regional climatology pertinent to the North Anna ESP site using data reported by the National Weather Service (NWS) at the Richmond, Virginia, first-order weather station, as well as nearby cooperative observer stations, such as Louisa and Partlow, Virginia. The applicant obtained information on severe weather, including extreme design-basis conditions, from a variety of sources, including publications by the National Climatic Data Center (NCDC), the American Society of Civil Engineers (ASCE), the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), and the American National Standards Institute (ANSI).

The North Anna ESP site is located in the eastern Piedmont climatic division of Virginia. According to the applicant, the climate can be described as modified continental; the summers are warm and humid and the winters are generally mild. The Blue Ridge Mountains to the west act as a potential barrier to outbreaks of cold, continental air in winter. The open waters of the Chesapeake Bay and the Atlantic Ocean contribute to the humid summers and mild winters.

Temperatures in the site region rarely exceed 100 EF or fall below 0 EF. Table 2.3.1-1 presents the applicant’s dry-bulb and wet-bulb site characteristics for the North Anna ESP site, based on temperature and humidity data recorded at the Richmond weather station.

Table 2.3.1-1 Applicant's Proposed Design-Basis Ambient Air Temperature and Humidity Site Characteristics

SITE CHARACTERISTIC		VALUE	DESCRIPTION
Maximum Dry-Bulb Temperature	2% annual exceedance	90 EF with 75 EF concurrent wet bulb	Wet-bulb and dry-bulb temperatures associated with the listed exceedance values and the 100-year return period
	0.4% annual exceedance	95 EF with 77 EF concurrent wet bulb	
	0% annual exceedance	104.9 EF with 79 EF concurrent wet bulb	
	100-year return period	109 EF	
Minimum Dry-Bulb Temperature	1% annual exceedance	18 EF	
	0.4% annual exceedance	14 EF	
	100-year return period	! 19 EF	
Maximum Wet-Bulb Temperature	0.4% annual exceedance	79 EF	
	0% annual exceedance	84.9 EF	
	100-year return period	88 EF	

The applicant stated that the area around the site receives an annual average rainfall of approximately 44 in. Rainfall is fairly well distributed over the entire year, with the exception of July and August when thunderstorm activity raises the monthly totals. Extra-tropical storms can also contribute significantly to precipitation during September.

Richmond, Virginia, averages about 12.4 in. of snow a year. Snow generally remains on the ground for only 1 or 2 days, although durations of a week or more have occurred as a result of heavy snowfall events immediately followed by cold weather patterns.

According to the applicant, the general synoptic conditions typically 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 site's meteorology. Nearby Lake Anna has a moderating effect with respect to extreme temperatures in the immediate vicinity of the site. The Blue Ridge Mountains to the west also tend to channel winds along a general north-south orientation during light-wind conditions.

According to the applicant, the highest "fastest mile" wind speed recorded at Richmond during the 32-year period of record, 1958–1989, was 68 miles per hour (mi/h). As shown in Table

2.3.1-2, the applicant selected a basic wind speed site characteristic of 64 mi/h, which the applicant considers to represent a “fastest mile of wind” at 10 m (33 ft) above the ground with a 100-year return period. The applicant also stated that the 3-second gust wind speed that represents a 100-year return period is 96 mi/h at 10 m above the ground.

Table 2.3.1-2 Applicant’s Proposed Basic Wind Speed Site Characteristic

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Basic Wind Speed	64 mi/h	Operation basis wind velocity associated with a 100-year return period at 10 m (33 ft) above ground level in the site area

In RAIs 2.3.1-1 and 2.3.1-6, the staff asked the applicant to provide additional information regarding tornado data to be used as design-basis information and methodology for determining site-specific tornado design-basis characteristics. In its response, the applicant stated that a total of 235 tornadoes were reported within a 2-degree square area around the North Anna ESP site (i.e., an area enclosed by 2-degree longitudinal and latitudinal lines centered on the North Anna ESP site) during the period from 1950 to 2003. The applicant used these data to calculate the annual probability of a tornado striking a point within this 2-degree square area as 5.94×10^{-5} per year. This is equivalent to a tornado mean recurrence interval of 16,835 years. The applicant also used these data to generate the site-specific design-basis tornado site characteristics (based on 10^{-7} per year occurrence) shown in Table 2.3.1-3.

Table 2.3.1-3 Applicant’s Proposed Design-Basis Tornado Site Characteristics

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Maximum Wind Speed	260 mi/h	Sum of the maximum rotational and maximum translation wind speed components at the site resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Maximum Translational Speed	52 mi/h	Translation component of maximum wind speed at the site resulting from the movement across ground of a tornado having a probability of occurrence of 10^{-7} per year
Maximum Rotational Speed	208 mi/h	Rotation component of maximum wind speed at the site resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Radius of Maximum Rotational Speed	150 ft	Distance from the center of the tornado at which the maximum rotational wind speed occurs at the site resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Maximum Pressure Drop	1.5 lbf/in.^{2}	Decrease in ambient pressure from normal atmospheric pressure at the site resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Maximum Rate of Pressure Drop	0.76 lbf/in.^{2}/s	Maximum rate of pressure drop at the site resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year

The SSAR states that, on average, a tropical cyclone or its remnants can be expected to impact some part of Virginia each year. As stated in the SSAR, the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center hurricane database reports that 55 tropical cyclone centers or storm tracks have passed within a 100-nautical mile radius of the North Anna ESP site from 1851 through 2003. Table 2.3.1-4 presents the storm classifications and respective frequencies of these tropical cyclone occurrences over this period.

Table 2.3.1-4 Tropical Cyclones Reported within 100-Nautical Mile Radius of the North Anna ESP Site from 1851 through 2003

CLASSIFICATION	NUMBER OF OCCURRENCES	MAXIMUM SUSTAINED WIND SPEED RANGE
Category 3 Hurricane	1	111–130 mi/h
Category 2 Hurricane	1	96–110 mi/h
Category 1 Hurricane	5	74–95 mi/h
Tropical Storm	27	39–73 mi/h
Tropical Depression	13	#38 mi/h
Subtropical Depression	1	#38 mi/h
Extra-Tropical Storm	7	undefined

According to the applicant, tropical cyclones are responsible for the following record rainfall events in the North Anna ESP site area:

- In August 1969, Hurricane Camille (a tropical depression by the time it passed within 100 nautical miles of the North Anna ESP site) resulted in a record 24-hour rainfall of 11.18 in. at the Louisa cooperative weather station. The SSAR notes that this is the overall highest 24-hour rainfall total recorded at any station in the North Anna ESP site area.

- In August 1955, Hurricane Connie (a tropical storm by the time it passed within 120 nautical miles of the North Anna ESP site) resulted in a record 24-hour rainfall total of 8.79 in. at Richmond.

According to the applicant, the occurrence of snowfalls greater than or equal to 1 in. in the North Anna ESP site area ranges from about 3 to 5 days per year. Daily snowfall totals greater than or equal to thresholds of 5 in. and 10 in. occur less than 1 day per year. The applicant reported maximum 24-hour and monthly snowfall totals for the North Anna ESP site region of 21.6 in. at Richmond in January 1940 and 41.0 in. at Partlow in January 1966, respectively. The applicant reported the weight of the 100-year return period snowpack for the North Anna ESP site area as 30.5 pound-force per square foot (lbf/ft^2) and the 48-hour winter probable maximum precipitation as 20.75 in. As shown in Table 2.3.1-5, the applicant selected the 100-year return period snowpack value of 30.5 lbf/ft^2 as the snow load site characteristic for use in the design of the roofs of safety-related structures.

Table 2.3.1-5 Applicant's Proposed Design-Basis Snow Load Site Characteristic

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Snow Load	30.5 lbf/ft^2	Weight, per unit area, of the 100-year return period snowpack at the site

According to the applicant, data published by the NCDC show that Louisa and Spotsylvania counties can expect, on average, hail with diameters greater than or equal to 0.75 in. about 1 day per year. Nearby counties to the south and east of the North Anna ESP site can expect hail with diameters greater than or equal to 0.75 in. to occur from 1 to 2 days per year. Hail events with diameters up to 1.75 in. have been reported in recent years in both Louisa and Spotsylvania counties, four in Louisa County in 1998 and three in Spotsylvania County in 1993. Softball-size hail (about 4.5 in. in diameter) has been observed in recent years at two locations in the general North Anna ESP site area, once in Free Union, Virginia (approximately 42 miles west of the ESP site) on June 4, 2002, and once in Lignum, Virginia (approximately 28 miles north-northwest of the ESP site) on May 4, 1996.

The applicant estimates that there are, on average, 36 thunderstorm-days per year in the site area, resulting in an estimated 11.2 lightning flashes to earth per square mile per year. Given the frequency of thunderstorms and the size of the North Anna ESP site PPE (site footprint within which any new reactors would be located) (0.068 mi^2), the expected frequency of lightning flashes in the site PPE is 0.76 per year.

According to the applicant, low-level inversions in the North Anna ESP site region based at or below an elevation of 500 ft occur during approximately 30 percent of the year. Most of these inversions are nocturnal in nature, generated through nighttime cooling. These inversions occur most frequently during the autumn and winter seasons and least frequently during the spring and summer seasons. Likewise, the autumn and winter seasons have the greatest frequency of occurrence of shallow mixing depths, with autumn and winter having afternoon mean maximum mixing height depths of about 4600 ft and 3300 ft, respectively.

The applicant examined temperature and humidity data from Richmond (1978–2003) to determine the meteorological design conditions for the ultimate heat sink (UHS) in accordance with RG 1.27. The applicant stated that the controlling parameters for the type of UHS selected by the applicant (i.e., a mechanical draft cooling tower over a buried water storage basin or other passive water storage facility) are the wet-bulb temperature and the coincident dry-bulb temperature. The applicant considered the worst (i.e., highest) 30-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures to represent the meteorological conditions resulting in maximum evaporation and drift loss. Likewise, the applicant considered the worst (i.e., highest) 1-day and 5-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures to conservatively represent the meteorological conditions resulting in minimum water cooling. Consequently, the applicant calculated the worst 1-day, worst 5-day, and worst 30-day daily average wet-bulb temperatures and coincident dry-bulb temperatures as UHS design-basis site characteristics values. Table 2.3.1-6 presents these results.

Table 2.3.1-6 Applicant's Proposed Design-Basis Ultimate Heat Sink Site Characteristics

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Worst 1-Day Daily Average of Wet-Bulb Temperatures and Coincident Dry-Bulb Temperatures	78.9 EF wet-bulb temperature with coincident 87.7 EF dry-bulb temperature	Meteorological conditions resulting in the minimum water cooling during any 1 day
Worst 5-Day Daily Average of Wet-Bulb Temperatures and Coincident Dry-Bulb Temperatures	77.6 EF wet-bulb temperature with coincident 80.9 EF dry-bulb temperature	Meteorological conditions resulting in the minimum water cooling during any consecutive 5 days
Worst 30-Day Daily Average of Wet-Bulb Temperatures and Coincident Dry-Bulb Temperatures	76.3 EF wet-bulb temperature with coincident 79.5 EF dry-bulb temperature	Meteorological conditions resulting in the maximum evaporation and drift loss during any consecutive 30 days

2.3.1.2 Regulatory Evaluation

In SSAR Section 1.8.1, the applicant identified the following applicable NRC regulations regarding regional climatology:

- Appendix A to 10 CFR Part 50, General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," with respect to information on severe regional weather phenomena that have historically been reported for the region and that are reflected in the design bases for SSCs important to safety

- Appendix A to 10 CFR Part 50, GDC 4, "Environmental and Dynamic Effects Design Bases," with respect to information on tornadoes that could generate missiles

- 10 CFR 100.20(c), "Reactor Site Criteria," and 10 CFR 100.21(d), "Non-Seismic Siting Criteria," with respect to the consideration that has been given to the regional meteorological characteristics of the site

In SSAR Sections 1.8.2 and 2.3.1, the applicant identified the following applicable NRC guidance regarding regional climatology:

- RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants," dated January 1976, with respect to the meteorological conditions that should be considered in the design of the ultimate heat sink

- Section 2.3.1 of RG 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants—LWR Edition," dated November 1978, with respect to the type of general climate and regional meteorological data that should be presented

- RG 1.76, “Design Basis Tornado for Nuclear Power Plants,” dated April 1974, with respect to the characteristics of the design-basis tornado

The staff finds that the applicant correctly identified the applicable regulations and guidance, with the exception that an ESP applicant need not demonstrate compliance with the GDCs with respect to regional climatology.

Sections 2.3.1 of RS-002 and RG 1.70 provide the following guidance on information appropriate for determining regional climatology:

- The description of the general climate of the region should be based on standard climatic summaries compiled by NOAA. Consideration of the relationships between regional synoptic-scale atmospheric processes and local (site) meteorological conditions should be based on appropriate meteorological data.

- Data on severe weather phenomena should be based on standard meteorological records from nearby representative NWS, military, or other stations recognized as standard installations which have long periods of data on record. The applicability of these data to represent site conditions during the expected period of reactor operation should be substantiated.

- Design-basis tornado parameters may be based on RG 1.76 or the staff’s interim position on design-basis tornado characteristics (see letter dated March 25, 1988, from NRC to the Advanced-Light Water Reactor [ALWR] Utility Steering Committee). An ESP applicant may use any design-basis tornado wind speeds that are appropriately justified, provided that a technical evaluation of site-specific data is conducted.

- Design-basis straight-line wind velocity should be based on appropriate standards, with suitable corrections for local conditions.

- The UHS meteorological data, as stated in RG 1.27, should be based on long-period regional records which represent site conditions. Suitable information may be found in climatological summaries for the evaluation of wind, temperature, humidity, and other meteorological data used for UHS design.

- Freezing rain estimates should be based on representative NWS station data.

- High air pollution potential information should be based on Environmental Protection Agency (EPA) studies.

- All other meteorological and air quality data used for safety-related plant design and operating bases should be documented and substantiated.

2.3.1.3 Technical Evaluation

The staff evaluated regional meteorological conditions using information reported by the NCDC, the National Severe Storms Laboratory (NSSL), the Southern Regional Climate Center (SRCC), ASHRAE, ASCE, and the Structural Engineering Institute (SEI). The staff reviewed statistics for the following climatic stations located in the vicinity of the North Anna ESP site:

- Partlow, Virginia, located approximately 5 mi east of the ESP site
- Louisa, Virginia, located approximately 11 mi west of the ESP site
- Richmond, Virginia, located approximately 47 mi southeast of the ESP site
- Charlottesville, Virginia, located approximately 36 mi west of the ESP site

Normal climatic data for the period 1971–2000 reported by NCDC for the eastern Piedmont climatic division of Virginia indicate that the annual mean temperature in the area is about 56.6 °F and ranges from a low monthly mean value of about 35.9 °F in January to a high monthly mean value of about 76.8 °F in July (NCDC, "Eastern Piedmont, Virginia, Divisional Normals—Temperature, Period 1971–2000, Climatography of the United States No. 85"). One of the highest temperatures recorded in the site region was 106 °F at Partlow on both August 31 and September 2, 1953 (SRCC, "Partlow, Virginia, Period of Record Monthly Climate Summary, Period of Record: 06/01/1952 to 12/31/1976"); one of the lowest temperatures recorded in the site region was −21 °F at Louisa on February 5, 1996 (SRCC, "Louisa, Virginia, Period of Record Monthly Climate Summary, Period of Record: 08/01/1948 to 03/31/2004").

The annual mean wet-bulb temperature at Richmond is 52.3 °F, ranging from a high monthly mean value of 71.5 °F in July to a low monthly mean value of 34.3 °F in January. The annual mean relative humidity is 70 percent (NCDC, "Richmond, Virginia, 2002 Local Climatological Data, Annual Summary with Comparative Data").

For the reasons set forth below, the staff concurs with the design-basis temperature and humidity site characteristics presented by the applicant. The applicant's 2 percent and 0.4 percent annual exceedance maximum dry-bulb temperatures, the 1 percent and 0.4 percent annual exceedance minimum dry-bulb temperatures, and the 0.4 percent exceedance maximum wet-bulb temperatures are based on Richmond data published by the NCDC ("Engineering Weather Data CDROM"). The applicant's 0 percent annual exceedance maximum dry-bulb and maximum wet-bulb temperatures represent the highest values recorded at Richmond during the period 1973–2002. The 100-year return period maximum dry-bulb and maximum wet-bulb temperatures provided by the applicant were extrapolated from the Richmond 1973–2002 data using a least squares regression method, as described in the applicant's response to NRC RAI 2.3.1(b). In order to verify the applicant's 100-year return period data, the staff also calculated 100-year return period maximum dry-bulb and maximum wet-bulb temperatures using NCDC data for Richmond during the period 1961–1990 (NCDC, "Solar and Meteorological Surface Observational Network (SAMSON) for Eastern U.S. CDROM") and algorithms based on the Gumbel Type 1 extreme value distribution as defined in Chapter 27 of the 2001 ASHRAE Handbook—Fundamentals. The staff found that the 100-year return period maximum dry-bulb and maximum wet-bulb temperature values calculated by the applicant bound the equivalent values calculated by the staff.

According to the 1971–2000 normal climatic data reported by NCDC for the eastern Piedmont climatic division of Virginia ("Eastern Piedmont, Virginia, Divisional Normals—Precipitation, Period 1971–2000, Climatography of the United States No. 85”), precipitation is well distributed throughout the year, with monthly climate division normals for the North Anna ESP site region ranging from a minimum of about 3.18 in. in December to a maximum of about 4.36 in. in July. In September 1987, Charlottesville experienced one of the highest monthly amounts of precipitation observed in the area—17.96 in. (SRCC, “Charlottesville, Virginia, Period of Record Monthly Climate Summary, Period of Record: 08/05/1948 to 03/31/2004”). On August 20, 1969, Louisa recorded one of the highest 24-hour precipitation totals for the site region—11.18 in. (SRCC, “Louisa, Virginia, Period of Record Monthly Climate Summary, Period of Record: 08/01/1948 to 03/31/2004”). This rainfall was associated with Hurricane Camille.

Snowfall in the site vicinity averages approximately 16.6 in. per year, based on historical data collected during 1952–1976 at the Partlow cooperative weather station (SRCC, “Partlow, Virginia, Period of Record Monthly Climate Summary, Period of Record: 06/01/1952 to 12/31/1976”). Measurable snowfall has occurred from November through April, with the most snow typically falling in January (5.7 in. on average in Partlow).

Damaging storms occur mainly from snow and freezing rain in winter, and from hurricanes, tornadoes, and severe thunderstorms in other seasons (NCDC, “Richmond, Virginia, 2002 Local Climatological Data, Annual Summary with Comparative Data”). Damage may be caused by wind, flooding, or rain, or by any combination of these. Tornadoes are infrequent, but some occurrences have been observed within the area.

The applicant proposed a design-basis site characteristic wind speed of 64 mi/h, which the applicant stated represents a “fastest mile of wind” at 10 m (33 ft) above the ground with a 100-year return period. This value is presented in Table A-7 of ANSI A58.1-1982, “Minimum Design Loads for Buildings and Other Structures,” as the extreme fastest-mile wind speed having a 0.01 annual probability of being exceeded at Richmond. The applicant’s chosen 100-year return period fastest-mile design-basis wind speed of 64 mi/h is not conservative when compared to the minimum 50-year return period fastest-mile basic wind speed of 70 mi/h specified in Section 6.5.2 of ANSI A58.1-1982. The applicant’s chosen value is also not conservative when compared to the highest fastest-mile wind speed of 68 mi/h recorded at Richmond during the 32-year period of record, 1958–1989. The applicant needs to justify an acceptable design basis wind speed. This is **Open Item 2.3-1.**

The applicant has also defined a 3-second gust wind speed site value of 96 mi/h, based on a 100-year return period at 10 m above the ground. The applicant determined this value in accordance with the guidance provided by ASCE and SEI (“Minimum Design Loads for Buildings and Other Structures,” SEI/ASCE 7-02). Therefore, the staff concludes that a 3-second gust wind speed site characteristic of 96 mi/h is acceptable.

According to the NSSL (NCDC, “Severe Thunderstorm Climatology, Total Threat”), the mean number of days per year with the threat of tornados occurring within 25 mi of the North Anna ESP site is approximately 0.4 to 0.6 for any tornado, approximately 0.05 to 0.10 for a significant tornado (F2 or greater; wind speeds in excess of 113 mi/h), and less than 0.005 for a violent tornado (F4 or greater; wind speeds in excess of 207 mi/h).

At NRC’s direction, Pacific Northwest National Laboratories (PNNL) prepared a technical evaluation report evaluating the design-basis tornado for the North Anna ESP site (Ramsdell, Jr., V.A., “Technical Evaluation Report on Design Basis Tornadoes for the North Anna ESP Site”). This report derived a best estimate annual tornado strike probability of 1.6×10^{-4}, based on tornado data from the period January 1950 through August 2003. This probability corresponds to a mean recurrence interval of 6250 years. Using a slightly different methodology and period of record, the applicant calculated a similar but higher tornado return period of 16,835 years. The PNNL report also derived a best estimate 10^{-7} per year occurrence design-basis tornado wind speed of 245 mi/h, which is bounded by the applicant’s design-basis tornado wind speed of 260 mi/h. Assuming the radius of the maximum rotational wind speed is 150 ft and the ratio between the rotational wind speed and the translational wind speed is 4, the remaining design-basis tornado site characteristics calculated by the applicant (e.g., the pressure drop and rate of pressure drop) bound the corresponding design-basis tornado site characteristics calculated by the PNNL report methodology. Therefore, the staff concludes that the applicant’s design-basis tornado site characteristics are acceptable.

During the period from 1900 through 2002, a total of 4 hurricanes and 17 tropical storms directly hit Virginia (Landreneau, D., “Atlantic Tropical Storms and Hurricanes Affecting the United States: 1899–2002,” NOAA Technical Memorandum NWS SR-206 (updated through 2002)). These storms typically weaken as they move inland, so wind damage is usually confined to the coastal regions, while damage inland comes primarily from heavy rain and flooding. One of the most significant tropical cyclones to affect portions of east-central Virginia during the last several decades was Hurricane Isabel on September 18–19, 2003. Isabel made landfall near Drum Inlet, North Carolina, as a Category 2 hurricane (maximum sustained winds between 96 mi/h and 100 mi/h), then weakened to a tropical storm over southern Virginia as it tracked northwest into central Virginia, just west of Richmond. The highest sustained wind speed recorded at Richmond was 38 mi/h; the highest gust recorded at Richmond was 73 mi/h. The unusually large wind field resulted in the most extensive power outages ever experienced in Virginia. Inland flooding also resulted from rainfall amounts ranging from 4 to 7 in., which occurred over parts of the Piedmont regions of central and south central Virginia (Beven, J., and H. Cobb, “Tropical Cyclone Report, Hurricane Isabel, 6–19 September 2003,” National Hurricane Center and NCDC Storm Event Database, “Storm Events for Virginia, 01/01/1950 through 04/30/2004”). Although Hurricane Isabel had a significant impact on the ESP site region, it did not result in any record-breaking wind or rainfall statistics and, as such, has no impact on the climatic site characteristics of the North Anna ESP site.

The highest monthly and annual total snowfalls recorded at the Partlow station were 41 in. and 54 in., respectively. One of the highest reported 24-hour snowfall observations in the site region was 21.6 in. in January 1940 at Richmond (NCDC, “Richmond, Virginia, 2002 Local Climatological Data, Annual Summary with Comparative Data”). One of the highest snow depths recorded in the site region was 24 in. on January 26, 1987, and on January 30, 1966, in Louisa (SRCC, “Louisa, Virginia, Period of Record Monthly Climate Summary, Period of Record: 08/01/1948 to 03/31/2004”).

The applicant has identified a 100-year return period snowpack of 30.5 lbf/ft^2 for the North Anna ESP site. The applicant determined this value in accordance with the guidance of SEI/ASCE 7-02. Because the applicant performed its analysis in accordance with the appropriate guidance and the results bound the observations described above, the staff concludes that a 100-year return period snowpack site characteristic value of 30.5 lbf/ft^2 is acceptable.

The applicant has identified a 48-hour winter probable maximum precipitation (PMP) value of 20.75 in. for the North Anna ESP site. The winter PMP value is specified in RG 1.70 to assess the potential snow loads on the roofs of safety-related structures. However, the applicant has proposed an alternative approach (as discussed in the following paragraph) for defining the site characteristic snow load that does not rely on the winter PMP value. Consequently, the staff did not evaluate or accept the applicant's winter PMP value.

As noted above, the applicant has proposed a site characteristic ground snow load value of 30.5 lbf/ft^2, which is based on the 100-year return period snowpack for the North Anna ESP site. Section 2.3.1.2 of RG 1.70 states that the weight of snow and ice on the roof of each safety-related structure should be a function of the weight of the 100-year return period snowpack and the weight of the 48-hr winter PMP for the site vicinity. The combined 100-yr return snowpack and the estimated winter PMP may be an unreasonable snow/ice roof loading for a structure at the North Anna ESP site, given that snow generally remains on the ground for only 1 or 2 days. As an alternative, a combination of the 100-year return snowpack and the maximum-recorded monthly snowfall in the North Anna ESP site region may be a reasonably conservative site-characteristic ground snowload for designing the roofs of safety-related structures. The applicant needs to justify the exclusive use of snowpack weight or provide an alternative method. This is **Open Item 2.3-2**.

The following discussion on freezing rain, hail, and lightning is intended to provide a general climatic understanding of the severe weather phenomena in the site region but does not result in the generation of site characteristics for use as design or operating bases.

The NCDC reports a 50-year return period uniform radial ice thickness of 0.75 in. resulting from freezing rain, with a concurrent 3-second gust wind speed of 30 mi/h for the North Anna ESP site area (Jones, K., et al., "The Development of a U.S. Climatology of Extreme Ice Loads," Technical Report 2002-01).

Hail often accompanies severe thunderstorms. According to the NCDC's storm events database (NCDC Storm Event Database, "Storm Events for Virginia, 01/01/1950 through 07/31/2003"), 66 occurrences of hail with diameters of 0.75 in. or greater were reported in the five-county region surrounding the site between January 1, 1955, and July 31, 2003. Seventeen of these occurrences reported hail diameters of 1.5 in. or more. The largest reported size was 2.5 in. which occurred on July 9, 1977, in Caroline County, approximately 25–30 mi southeast of the site. According to the NSSL (NCDC, "Severe Thunderstorm Climatology, Total Threat"), the threat of hail occurring within 25 mi of the North Anna ESP site is approximately 2 days per year for damaging hail (i.e., 0.75 in. in diameter or greater), and 0.25 to 0.50 days per year for hail 2 in. or more in diameter.

The applicant has estimated that there are approximately 11.2 lightning flashes per year per square mile around the site area. The applicant's estimate is consistent with the mean annual ground flash density of 4 flashes per square kilometer (10.4 flashes per square mile) presented in NUREG/CR-3759, "Lightning Strike Density for the Contiguous United States from Thunderstorm Duration Records," for the North Anna ESP site region.

Large-scale episodes of atmospheric stagnation are not infrequent in the site region. Korshover ("Climatology of Stagnating Anticyclones East of the Rocky Mountains, 1936–1975") reports that, during the 40-year period between 1936 and 1975, high-pressure stagnation conditions, lasting for 4 days or more, occurred about 49 times, with an average of 4.8 stagnation days per case. Five of these stagnation cases lasted 7 days or longer.

The staff found that, according to Holzworth ("Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States"), seasonal mixing heights range from an average low of 400 m (1300 ft) during autumn mornings, to an average high of 1800 m (5900 ft) during spring and summer afternoons. According to Hosler ("Low-Level Inversion Frequency in the Contiguous United States"), low-level, mostly nocturnal inversions are expected to occur approximately 30 percent of the time, with the greatest frequency during the fall and winter (approximately 34 percent of the time and 33 percent of the time, respectively), and the least frequency during the spring and summer (approximately 28 percent of the time for each season).

The above discussion on atmospheric stagnation, mixing heights, and inversions is intended to provide a general climatic understanding of the air pollution potential in the region. The ESP air quality conditions considered for design and operating bases are discussed in Section 2.3.2 of this SER. The atmospheric dispersion site characteristics used to evaluate short-term post-accident airborne releases and long-term routine airborne releases are presented in Sections 2.3.4 and 2.3.5, respectively, of this SER.

In order to verify the applicant's site characteristic design conditions for the UHS, the staff examined 30 years (1961–1990) of hourly temperature and humidity data from Richmond ("Solar and Meteorological Surface Observational Network [SAMSON] for Eastern U.S. CDROM"). The staff calculated 1-day, 5-day, and 30-day average wet-bulb temperatures from the hourly data and selected the periods with the highest average wet-bulb temperatures as the worst periods. The resulting maximum 1-day, 5-day, and 30-day average wet-bulb temperature values were similar to the values presented by the applicant. Based on the results of this analysis, the staff concludes that the design-basis UHS meteorological site characteristics proposed by the applicant are acceptable.

The staff believes that the applicant needs to identify an additional UHS design-basis site characteristic for use in evaluating the potential for water freezing in the UHS water storage facility, a phenomenon which would reduce the amount of water available for use by the UHS. The lowest 7-day average air temperature recorded in the site region may be a reasonably conservative site-characteristic for evaluating the potential for water freezing in the UHS water storage facility. This item is unresolved and is **Open Item 2.3-3.**

The staff intends to include the regional climatology site characteristics listed in Table 2.3.1-7 in any ESP permit that might be issued for the North Anna ESP site.

Table 2.3.1-7 Staff's Proposed Regional Climatology Site Characteristics

SITE CHARACTERISTIC		VALUE	DESCRIPTION
Ambient Air Temperature and Humidity			
Maximum Dry-Bulb Temperature	2% annual exceedance	90 EF with 75 EF concurrent wet-bulb	The ambient dry-bulb temperature (and coincident wet-bulb temperature) that will be exceeded 2% of the time annually
	0.4% annual exceedance	95 EF with 77 EF concurrent wet-bulb	The ambient dry-bulb temperature (and coincident wet-bulb temperature) that will be exceeded 0.4% of the time annually
	100-year return period	109 EF	The ambient dry-bulb temperature that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Minimum Dry-Bulb Temperature	99% annual exceedance	18 EF	The ambient dry-bulb temperature below which dry-bulb temperatures will fall 1% of the time annually
	99.6% annual exceedance	14 EF	The ambient dry-bulb temperature below which dry-bulb temperature will fall 0.4% of the time annually
	100-year return period	! 19 EF	The ambient dry-bulb temperature for which there is a 1% annual probability of a lower dry-bulb temperature (100-year mean recurrence interval)
Maximum Wet-Bulb Temperature	0.4% annual exceedance	79 EF	The ambient wet-bulb temperature that will be exceeded 0.4% of the time annually
	100-year return period	88 EF	The ambient wet-bulb temperature that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Wind Speed			
Basic Wind Speed (fastest mile)		**(Open Item 2.3-1)**	The fastest-mile wind speed at 33 ft (10 m) above the ground to be used in determining wind loads. Defined as the fastest-mile wind speed that has a 1% annual probability of being exceeded (100-year mean recurrence interval).
Basic Wind Speed (3-second gust)		96 mi/h	The highest 3-second gust wind speed at 33 ft (10 m) above the ground to be used in determining wind loads. Defined as the 3-second gust wind speed that has a 1% annual probability of being exceeded (100-year mean recurrence interval).
Design-Basis Tornado			
Maximum Wind Speed		260 mi/h	Maximum wind speed for the design-basis tornado resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Translational Speed		52 mi/h	Translation component of the maximum design-basis tornado wind speed
Rotational Speed		208 mi/h	Rotation component of the maximum design-basis tornado wind speed

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Radius of Maximum Rotational Speed	150 ft	Distance from the center of the design-basis tornado at which the maximum rotational wind speed occurs
Maximum Pressure Drop	1.5 lbf/in.^{2}	Decrease in ambient pressure from normal atmospheric pressure resulting from passage of the design-basis tornado
Maximum Rate of Pressure Drop	0.76 lbf/in.^{2}/s	Rate of pressure drop resulting from the passage of the design-basis tornado
Precipitation		
Ground Snow Load	**(Open Item 2.3-2)**	The ground snow load to be used in determining snow loads for roofs
Ultimate Heat Sink Ambient Air Temperature and Humidity		
Meteorological Conditions Resulting in the Minimum Water Cooling During Any 1 Day	78.9 EF wet-bulb temperature with coincident 87.7 EF dry-bulb temperature	Worst 1-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures resulting in minimum water cooling
Meteorological Conditions Resulting in the Minimum Water Cooling During Any Consecutive 5 Days	77.6 EF wet-bulb temperature with coincident 80.9 EF dry-bulb temperature	Worst 5-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures resulting in minimum water cooling
Meteorological Conditions Resulting in the Maximum Evaporation and Drift Loss During Any Consecutive 30 Days	76.3 EF wet-bulb temperature with coincident 79.5 EF dry-bulb temperature	Worst 30-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures resulting in maximum evaporation and drift loss
Meteorological Conditions Resulting in Maximum Water Freezing in the UHS Water Storage Facility	**(Open Item 2.3-3)**	Worst 7-day average ambient dry-bulb temperature resulting in maximum water freezing in the UHS

2.3.1.4 Conclusions

As set forth above, the applicant has presented and substantiated information relative to the regional meteorological conditions important to the safe design and siting of a nuclear power plant(s) falling within the applicant's PPE that might be constructed on the proposed site. The staff has reviewed the available information provided and, for reasons given above, concludes that the identification and consideration of the regional and site meteorological characteristics set forth above meet the requirements of 10 CFR 100.20(c) and 10 CFR 100.21(d), with the exception of the open items identified.

The staff finds that the applicant has considered the most severe regional weather phenomena in establishing the site characteristics identified above. The methodologies used to determine the severity of the weather phenomena reflected in these site characteristics have generally been accepted by the staff as documented in safety evaluation reports for previous licensing actions. Accordingly, it is the staff’s engineering judgment that the use of these methodologies results in site characteristics that contain margin sufficient for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the site characteristics identified above are acceptable for use as part of the design bases for structures, systems, and components important to safety, as may be proposed in a COL or CP application.

With regard to tornado wind speed, the applicant conducted a technical assessment of site-specific tornado data. The staff finds that assessment sufficient to justify the applicant's proposed site tornado characteristics, which deviate from the staff's interim position design-basis tornado characteristics In addition, the staff finds that these tornado site characteristics are acceptable for the design-basis tornado used for the generation of missiles.

The staff has reviewed the applicant's proposed site characteristics related to climatology for inclusion in an ESP for the applicant's site, should one be issued, and (with the exception of the open items identified above) finds these characteristics to be acceptable. The staff has also reviewed the applicant's proposed design parameters (PPE values) for inclusion in such an ESP (SSAR Section 1.3) and finds them to be reasonable. The staff did not perform a detailed review of these parameters.

2.3.2 Local Meteorology

2.3.2.1 Technical Information in the Application

In this section of the SSAR, the applicant presented local (site) meteorological information. This SSAR section also addressed the potential influence of construction and operation of a nuclear power plant(s) falling within the applicant’s PPE on local meteorological conditions that might in turn adversely impact such plant(s) or the associated facilities. Finally, the applicant provided a topographical description of the site and its environs. The applicant presented the following information:

- a description of the local (site) meteorology in terms of airflow, temperature, atmospheric water vapor, precipitation, fog, atmospheric stability, and air quality

- an assessment of the influence on the local meteorology of construction and operation of a nuclear power plant(s) falling within the applicant’s PPE that might be constructed on the proposed site and its facilities, including the effects of plant structures, terrain modification, and heat and moisture sources resulting from plant operation

- a topographical description of the site and its environs, as modified by the structures of a nuclear power plant(s) falling within the applicant’s PPE that might be constructed on the proposed site

The applicant used data from the NWS first-order weather station at Richmond, Virginia, as well as data provided by NCDC from six nearby cooperative observer weather stations, to characterize temperature, rainfall, and snowfall for the North Anna ESP site area. The applicant also provided wind, humidity, and fog data collected at Richmond.

In general, the applicant considers the more extensive meteorological data available for Richmond to be fairly representative of conditions in the ESP site area. However, the applicant noted slight differences in the Richmond data with respect to minimum temperature extremes, diurnal temperature ranges, and average annual snowfall, as compared to corresponding data observed at nearby cooperative weather stations. The applicant attributed these differences to the consequences of urban heating for the more urban Richmond location.

The applicant also characterized local meteorological conditions using data collected from the meteorological monitoring program at the existing NAPS. According to the applicant, the meteorological variables collected by the NAPS monitoring program are appropriate for use in describing local meteorological conditions because of the proximity of the NAPS meteorological tower to the ESP site.

The applicant presented historical normals (e.g., 30-year averages) and extremes of temperature, rainfall, and snowfall for the seven nearby NWS and cooperative weather stations in the North Anna ESP site area. Daily mean temperatures among the observing stations are fairly similar, ranging from 54.2 EF to 57.6 EF. Extreme maximum temperatures have ranged from 100 EF to 107 EF, whereas extreme minimum temperatures have ranged from !10 EF to !21 EF. Normal annual precipitation totals are also fairly comparable among these observing stations, ranging from 42.24 in. to 48.87 in. Normal annual snowfall totals range from 12.4 in. to 18.8 in.

According to the applicant, an average of 27.2 days per year of heavy fog has been reported for Richmond, which is the location closest to the North Anna ESP site for which a fog data set exists. Low regions at the site and in the vicinity of Lake Anna would be expected to have a higher frequency of fog occurrences because of the accumulation of relatively cool surface air from flows draining from higher elevations, as compared to the relatively flat region of the Richmond weather station.

According to information provided by the applicant, onsite winds occur along a north-south orientation on an annual basis, with seasonal variations. Wind data taken from the 10-m (33-ft) level of the onsite meteorological tower for the 14-year period between 1974 and 1987 indicate that the predominant wind directions are from the south-southwest (about 10 percent of the time), north (about 9 percent of the time), northwest (about 9 percent of the time), and west-northwest (about 8 percent of the time). Winds from the northeast clockwise through south-southeast and from the west-southwest and the west occur least frequently (each about 4 percent of the time). Wind direction distributions based on data from the 48-m (159-ft) level are similar to those based on the lower-level data. The onsite annual average wind speeds are 6.3 mi/h at the 10-m (33-ft) level, and 8.6 mi/h at the 48-m (159-ft) level.

The SSAR presents atmospheric stability data based on delta-temperature measurements between the 48-m (159-ft) and 10-m (33-ft) levels on the onsite meteorological tower. Neutral (Pasquill type “D”) and slightly stable (Pasquill type “E”) conditions predominate, occurring about 31 percent and 26 percent of the time, respectively. Moderately stable (Pasquill type “F”) and extremely stable (Pasquill type “G”) conditions occur about 8 percent and 5 percent of the time, respectively.

The applicant stated that the dimensions of the new plant structures and associated paved, concrete, and other improved surfaces would be insufficient to generate discernable impacts on local and regional meteorological conditions beyond the areas immediately adjacent to the site structures and improved surfaces. The applicant concluded that the small and localized surface water temperature increases on Lake Anna resulting from the operation of an open-cycle cooling system for the applicant’s proposed unit 3 would not be expected to significantly impact the ongoing moderation of temperature extremes and alterations of local wind patterns by the lake. Induced fogging conditions under extreme humidity conditions during cooler seasons would most likely coincide with naturally occurring fogging conditions, and the applicant does not expect the proposed unit 3 to significantly increase the occurrence of local fog. Similarly, the applicant expects that any increases in ambient temperatures resulting from the operation of a closed-loop dry tower system proposed for unit 4 would be very localized to the ESP site and would not affect the ambient ground and atmospheric temperatures beyond the site boundary.

According to the applicant, the North Anna ESP site region is characterized by gently rolling terrain that rises to an average height of 50 to 150 ft above Lake Anna. The primary topographic influences on local meteorological conditions at the North Anna ESP site are Lake Anna and the North Anna River Valley. Because of the complex configuration of the lake, over-water trajectories would generally be less than 2.5 mi. As a result 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. The Blue Ridge Mountains, which are located 40 to 50 mi northwest of the site, also tend to channel the prevailing winds from the south and south-southwest during the summer months.

The applicant stated that, should additional units be constructed, 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 the 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 applicant expects that terrain modifications associated with development of the ESP facility would be limited to the existing NAPS site and would not impact terrain features around the lake and valley nor significantly alter the site's existing gently undulating surface that is characteristic of its location in the Piedmont region of Virginia.

The applicant stated that air quality characteristics are not expected to be a significant factor in the design and operating bases for any new facilities that might be constructed on the ESP site. The North Anna ESP site is located within the Northeastern Virginia Intrastate Air Quality Control Region, which has been designated as being in attainment or unclassified for all EPA-designated national ambient air quality standards. The nuclear steam supply system and related radiological systems associated with any new facilities that might be constructed on the ESP site would not be sources of criteria pollutants or other air toxics. Further, the applicant does not expect the addition of supporting auxiliary boilers, emergency diesel generators, station blackout generators, and other sources of nonradiological emissions to be significant sources of criteria pollutant emissions because these units will operate on an intermittent test and/or emergency basis.

2.3.2.2 Regulatory Evaluation

In SSAR Section 1.8.1, the applicant identified the following applicable NRC regulations regarding local meteorology:

- Appendix A to 10 CFR Part 50, GDC 2, with respect to information on severe regional weather phenomena that has historically been reported for the region and that is reflected in the design bases for SSCs important to safety

- 10 CFR 100.20(c) and 10 CFR 100.21(d), with respect to the consideration that has been given to the regional meteorological characteristics of the site

In SSAR Section 1.8.2, the applicant identified the following applicable NRC guidance regarding local meteorology:

- RG 1.23, Revision 0, "Onsite Meteorological Programs," dated February 1972 and proposed Revision 1 dated September 1980, with respect to the criteria for an acceptable onsite meteorological measurements program

- Section 2.3.2 of RG 1.70, with respect to the type of local meteorological information that should be presented, including the potential impact of the plant on local meteorology and the local meteorological and air quality conditions used for design and operating basis considerations

The staff finds that the applicant correctly identified the applicable regulations and guidance, with the exception that an ESP applicant need not demonstrate compliance with the GDCs with respect to local meteorology.

Sections 2.3.2 of RS-002 and RG 1.70 provide the following guidance on information appropriate for presentation on local meteorology:

- Local meteorological data based on onsite measurements and data from nearby NWS stations or other standard installations should be presented in the format specified in Section 2.3.2 of RG 1.70. RG 1.23 provides guidance related to onsite meteorological measurements.

- A topographical description of the site and environs should be provided. Section 2.3.2.2 of RG 1.70 provides guidance on the topographical description.

- A discussion and evaluation of the influence of a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site and its facilities on local meteorological and air quality conditions should be provided. Potential changes in the normal and extreme values resulting from plant construction and operation should be discussed.

2.3.2.3 Technical Evaluation

The staff evaluated local meteorological conditions using data from the NAPS onsite meteorological monitoring system, as well as climatic data reported by NCDC. Section 2.3.3 of this SER provides a discussion of the representativeness of the NAPS onsite data.

Normal climatic data for the period 1971–2000 reported by NCDC for the eastern Piedmont climatic division of Virginia indicate that the annual mean temperature in the area is about 56.6 EF (NCDC, "Eastern Piedmont, Virginia, Divisional Normals—Temperature, Period 1971-2000, Climatography of the United States No. 85"). This value compares well with the range of daily mean temperatures reported by the applicant for nearby weather stations. Monthly mean temperatures for the eastern Piedmont climatic division range from a low monthly mean value of about 35.9 EF in January to a high monthly mean value of about 76.8 EF in July (NCDC, “Eastern Piedmont, Virginia, Divisional Normals—Temperature, Period 1971-2000, Climatography of the United States No. 85”).

Precipitation for the Piedmont climatic division averages 45.00 in. per year (NCDC, “Eastern Piedmont, Virginia, Divisional Normals—Precipitation, Period 1971–2000, Climatography of the United States No. 85”). This value compares well with the range of normal annual precipitation totals reported by the applicant for nearby weather stations. Precipitation is well distributed throughout the year, with monthly climate division normals for the North Anna ESP site region ranging from a minimum of about 3.18 in. in December to a maximum of about 4.36 in. in July.

The staff reviewed the applicant’s description of the local meteorology and determined that the information is representative of conditions at and near the site. The wind and atmospheric stability data are based on onsite data recorded by the NAPS meteorological monitoring system. Section 2.3.3 of this SER provides a discussion of the representativeness of the NAPS onsite data. The other meteorological summaries are based on data from nearby stations with long periods of record. The applicant demonstrated that synoptic-scale conditions are generally responsible for periods of excessive heat and cold outbreaks that resulted in compatible extreme temperatures being recorded throughout the ESP site area. A review of these recorded extreme values shows that they are reflected in the design-basis site characteristics presented in SSAR Section 2.3.1.

The staff reviewed topographic maps and topographic cross sections to ensure that the information needed is well labeled and can be readily extracted.

Because of the limited and localized nature of the expected terrain modifications associated with the development of the ESP facility, the staff finds that these terrain modifications, along with the resulting plant structures and associated improved surfaces, will not have enough of an effect on local meteorological conditions to affect plant design and operation. Similarly, because the operation of an open-cycle cooling system for the applicant's proposed unit 3 is not expected to significantly impact either atmospheric temperature extremes or increase the occurrence of local fog, the staff finds that the atmospheric impact of the operation of an open-cycle cooling system for proposed unit 3 will not affect plant design and operation. However, the applicant has not described how potential increases in atmospheric temperature resulting from the operation of closed-cycle dry cooling towers associated with proposed unit 4 would impact plant design and operation. This item is unresolved and is **Open Item 2.3-4.**

Since the North Anna ESP site is located in an air quality control region that has been designated as being either in attainment or unclassifiable for all EPA-designated national ambient air quality standards, the staff agrees with the applicant that the ESP site air quality conditions should not be a significant factor in the design and operating bases for the ESP facility.

2.3.2.4 Conclusions

As set forth above, the applicant has presented and substantiated information on local meteorological, air quality, and topographic characteristics of importance to the safe design and operation of a nuclear power plant(s) falling within the applicant’s PPE that might be constructed on the proposed site. The staff has reviewed the available information provided, and, for the reasons given, concludes that the applicant's identification and consideration of the meteorological, air quality, and topographical characteristics of the site and the surrounding area meet the requirements of 10 CFR Part 100, "Reactor Site Criteria," 10 CFR 100.20(c), and 10 CFR 100.21(d), and are sufficient to determine the acceptability of the site.

The staff has also reviewed available information relative to severe local weather phenomena at the site and in the surrounding area. As set forth above, the staff concludes that the applicant has identified the most severe local weather phenomena at the site and surrounding area.

2.3.3 Onsite Meteorological Measurements Program

2.3.3.1 Technical Information in the Application

In this section of the SSAR, the applicant presented information concerning its Onsite Meteorological Measurements Program, including instrumentation and measured data. Specifically, the applicant provided the following information:

- description of meteorological instrumentation, including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the quality assurance program for sensors and recorders, and data acquisition and reduction procedures

- meteorological data, including consideration of the period of record and amenability of the data for use in characterizing atmospheric dispersion conditions

The applicant used the existing Onsite Meteorological Measurements Program for the NAPS facility to collect data for the North Anna ESP site and intends to use it for the proposed ESP facility.

The applicant upgraded the existing NAPS monitoring program in June 1977 and, according to the applicant, it meets the system accuracy criteria presented in proposed Revision 1 to RG 1.23. Measurements are available from both a primary and backup system. The backup system is intended to function when the primary system is out of service, providing assurance that basic meteorological information will be available during and immediately following an accidental airborne radioactivity release.

The primary NAPS meteorological monitoring program consists of a guyed, triaxial, open lattice 48.8-m (160-ft) tower located approximately 1900 ft east of the NAPS Unit 1 reactor containment building. Wind speed, wind direction, and horizontal wind direction fluctuation (sigma theta) are measured at the 10-m (33-ft) and 48.4-m (159-ft) elevations. Ambient temperature and dew point temperature are measured at the 10-m (33-ft) elevation, and vertical temperature difference (delta-temperature) is measured between the 48.4-m (160-ft) and 10-m (33-ft) elevations. Precipitation is monitored at the ground level.

The backup NAPS meteorological monitoring program consists of a freestanding 10-m (33-ft) tower located approximately 1300 ft northeast of the NAPS Unit 1 reactor containment building. Wind speed, wind direction, and horizontal wind direction fluctuation (sigma theta) are measured at the top of the tower. The bases of both towers are at similar elevation to plant grade, and the ground cover at the base of the primary tower (which measures delta-temperature) is primarily native grasses.

Signal cables from both the primary and backup towers are routed through conduit into an instrument shelter at the base of each tower. Inside each shelter, the signals are provided as input to the appropriate signal-conditioning equipment, with output going to digital data recorders. These data are transmitted daily via modem to the applicant's corporate headquarters where they are reviewed to identify anomalous data and then archived. Output from the signal-conditioning equipment is also sent to strip chart recorders in the control room and the emergency response facility data system for use in emergency response.

The primary tower wind sensors are mounted on booms approximately twice the tower face width and are positioned so that the tower would not influence the prevailing south-southwest wind flow. The ambient temperature, dew point temperature, and delta-temperature sensors are housed in motor-aspirated shields to insulate them from the effects of precipitation and thermal radiation.

The meteorological monitoring system is calibrated at least semiannually. Data recovery for the 1996–1998 period of record used to evaluate atmospheric dispersion exceeded 90 percent.

2.3.3.2 Regulatory Evaluation

In SSAR Section 1.8.1, the applicant identified the following applicable NRC regulations regarding the Onsite Meteorological Measurements Program:

- 10 CFR 50.47, "Emergency Plans," and Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," to 10 CFR Part 50, as they relate to additional meteorological measurements taken for emergency preparedness planning

- Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, as it relates to meteorological data used to determine compliance with the numerical guides for doses in meeting the criterion of "as low as is reasonably achievable" (ALARA)

- 10 CFR 100.20(c) and 10 CFR 100.21(d), as they relate to meteorological data collected for use in characterizing the meteorological conditions of the site

In SSAR Sections 1.8.2 and 2.3.3, the applicant identified the following applicable NRC guidance regarding onsite meteorological measurements programs:

- RG 1.23, Revision 0, and proposed Revision 1, with respect to the criteria for an acceptable onsite meteorological measurements program

- Section 2.3.3 of RG 1.70, with respect to describing the meteorological measurements at the site and providing joint frequency distributions of wind speed and direction by atmospheric stability class

- Section 2.3 of RG 4.2, “Preparation of Environmental Reports for Nuclear Power Stations,” dated July 1976, with respect to providing at least one annual cycle of onsite meteorological data

- Appendix 2 to NUREG-0654, Revision 1, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” dated November 1980; NUREG-0696, “Functional Criteria for Emergency Response Facilities,” dated February 1981; and NUREG-0737, “Clarification of TMI Action Plan Requirements,” dated October 1980, with respect to meteorological measurements taken for emergency preparedness planning

The staff finds that the applicant correctly identified the applicable regulations and guidance. However, this section of the application did not address the requirements of 10 CFR 50.47 and Appendix E to 10 CFR Part 50. Consequently, the staff did not review this section for compliance with these requirements.

Both RG 1.23 and Section 2.3.3 of RS-002 document the criteria for an acceptable onsite meteorological measurements program. The onsite meteorological measurements program should produce data that describe the meteorological characteristics of the site and its vicinity for the purpose of making atmospheric dispersion estimates for both postulated accidental and expected routine airborne releases of effluents, and for comparison with offsite sources to determine the appropriateness of climatological data used for design considerations.

Sections 2.3.3 of RS-002 and RG 1.70 provide guidance on information appropriate for presentation on an onsite meteorological measurements program. As set forth in this guidance, at least one annual cycle of onsite meteorological data should be provided. These data should be presented in the form of joint frequency distributions of wind speed and wind direction by atmospheric stability class in the format described in RG 1.23. If a site has a high occurrence of low wind speeds, a finer category breakdown should be used for the lower speeds so data are not clustered in a few categories. A listing of each hour of the hourly-averaged data should also be provided on electronic media in the format described in Appendix A to Section 2.3.3 of RS-002. Evidence of how well these data represent long-term conditions at the site should be discussed.

2.3.3.3 Technical Evaluation

The staff evaluated the Onsite Meteorological Measurements Program by reviewing the program description presented in the SSAR, as well as conducting a site visit. The site visit consisted of reviewing the meteorological monitoring system location and exposure, sensor type and performance specifications, data transmission and recording, data acquisition and reduction, and instrumentation maintenance and calibration procedures. In addition, the staff reviewed an hourly listing of the 1996–1998 meteorological database provided by the applicant in its response to RAI 2.3.3-1.

The staff considers the meteorological data collected by the existing NAPS monitoring program to be representative of the dispersion conditions at the North Anna ESP site. The North Anna ESP site is within the existing NAPS site, and the proposed facility is intended to be in close proximity to the existing facility. The NAPS primary meteorological tower is located far enough away from existing plant structures to preclude any adverse impact on measurements. The base of the tower is at an elevation similar to plant grade to both NAPS and the proposed ESP facility. The ground cover at the base of the meteorological tower is primarily native grasses.

The staff reviewed the location of the primary and backup towers with respect to nearby ground features and potential obstructions to flow (e.g., trees, buildings), including existing plant structure layouts, and concluded that there are minimal adverse effects on the measurements taken at the towers. The nearby instrument shelters for both towers are less than 10 ft in height. Pine trees, previously 30–35 ft in height and located approximately 135 ft northwest and south of the primary tower, were cut in 2002 to 23–27 ft in height. Dominion Energy has put these trees on a 3-year pruning schedule to ensure they remain below 30 ft in height (i.e., below the lower measuring height on the primary tower), as recommended in proposed Revision 1 to RG 1.23.

The staff evaluated the types and heights of the meteorological variables being measured and found them to be compatible with the criteria of RG 1.23. During the site visit, the staff also reviewed the applicant's sensor types and performance specifications, data transmission and recording methods, and the inspection, maintenance, and calibration procedures and frequencies. The staff found them to be consistent with RG 1.23.

The staff performed a quality review of the NAPS 1996–1998 hourly meteorological database provided by the applicant in response to RAI 2.3.3-1 using the methodology described in NUREG-0917, "Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data." The staff performed further review using computer spreadsheets. Examination of the data revealed generally stable and neutral atmospheric conditions at night and unstable and neutral conditions during the day, as expected. Wind speed, wind direction, and stability class frequency distributions for each measurement channel were similar from year to year, and the 1996–1998 wind direction and stability class frequency distributions were reasonably consistent with the 1974–1987 data presented in Section 2.3.2 of the NAPS UFSAR. A comparison between the joint frequency distribution used by the licensee as input to PAVAN and XOQDOQ and a staff-generated joint frequency distribution from the hourly database showed good agreement.

2.3.3.4 Conclusions

As set forth above, the applicant has provided and substantiated information on the Onsite Meteorological Measurements Program. The staff has reviewed the available information relative to the meteorological measurements program and the data collected by the program. On the basis of this review and as set forth above, the staff concludes that the system provides data adequate to represent onsite meteorological conditions, as required by 10 CFR 100.20. The onsite data also provide an acceptable basis for (1) making estimates of atmospheric dispersion for design-basis accident and routine releases from a nuclear power plant(s) falling within the applicant's PPE that might be constructed on the proposed site and (2) meeting the requirements of 10 CFR Part 100 and Appendix I to 10 CFR Part 50.

2.3.4 Short-Term (Accident) Diffusion Estimates

2.3.4.1 Technical Information in the Application

In this section of the SSAR, the applicant presented atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and LPZ. The applicant provided the following information:

- atmospheric transport and diffusion models to calculate relative concentrations for postulated accidental radioactive releases
- meteorological data summaries used as input to diffusion models
- specification of diffusion parameters
- probability distributions of relative concentrations
- determination of relative concentrations used for assessment of consequences of postulated radioactive atmospheric releases from design-basis and other accidents

Section 2.2 of this SER addresses potential nonradiological accidents on or in the vicinity of the site that could affect control room habitability (such as toxic chemical releases). However, in order to evaluate atmospheric dispersion characteristics with respect to radiological releases to the control room, detailed design information (e.g., vent heights, intake heights, distance and direction from release vents to the room) is necessary. Because little detailed design information is available for the nuclear power plant(s) that might be constructed on the proposed site, the staff will evaluate the dispersion of airborne radioactive materials to the control room at the COL or CP stage. This is **COL Action Item 2.3-1**.

The applicant used the NRC-sponsored computer code PAVAN (NUREG/CR-2858, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations") to estimate relative concentration (χ/Q) values at the EAB and LPZ for potential accidental releases of radioactive material. The PAVAN model implements the methodology outlined in RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants."

The PAVAN code estimates χ/Q values for various time-averaging periods ranging from 2 hours to 30 days. The meteorological input to PAVAN consists of a joint frequency distribution of wind speed, wind direction, and atmospheric stability data. The PAVAN code computes χ/Q values at the EAB and LPZ for each combination of wind speed and atmospheric stability for each of the 16 downwind direction sectors. The code then ranks χ/Q values for each sector in descending order, and it derives an associated cumulative frequency distribution based on the frequency distribution of wind speed and stabilities for that sector. The χ/Q value that is equaled or exceeded 0.5 percent of the total time is determined for each sector, and the highest 0.5 percentile χ/Q value among the 16 sectors becomes the maximum sector-dependent χ/Q value. The code also ranks χ/Q values independent of wind direction into a cumulative frequency distribution for the entire site. The PAVAN program then selects the χ/Q value that is equaled or exceeded 5 percent of the total time. The code uses the larger of the two values, the maximum sector-dependent 0.5 percent χ/Q value and the overall site 5-percent χ/Q value, to represent the χ/Q value for a 0–2 hour time period.

To determine χ/Q values for longer time periods, PAVAN calculates an annual average χ/Q value. Logarithmic interpolation is then used between the 0–2 hour χ/Q values and the annual average χ/Q values to calculate the values for intermediate time periods (i.e., 8 hours, 16 hours, 72 hours, and 624 hours).

The applicant utilized the following input data and assumptions in applying the PAVAN model for the North Anna site:

- The meteorological input to PAVAN consisted of a joint frequency distribution of wind speed, wind direction, and atmospheric stability data based on 3 years (1996–1998) of onsite meteorological data. The applicant used wind data from the 10-m (33-ft) level of the onsite meteorological tower, and it derived the stability data from the vertical temperature difference (delta-temperature) measurements taken between the 48.4-m (159-ft) and 10-m (33-ft) levels of the onsite meteorological tower.

- The applicant modeled one conservative ground-level release point and took no credit for building wake effects.

- The EAB is the perimeter of a 1524-m (5000-ft) radius circle from the center of the abandoned Unit 3 containment. In order to calculate the χ/Q values for the EAB, the applicant used the shortest distances from the ESP plant envelope area boundary to the EAB. The LPZ is a 15.7-km (6-mile) radius circle centered at the Unit 1 containment building. Similarly, in order to calculate the χ/Q values for the LPZ, the applicant used the shortest distances from the ESP plant envelope area boundary to the LPZ.

Based on the PAVAN modeling results, the applicant proposed short-term (accident release) atmospheric dispersion site characteristics for inclusion in an ESP, as presented in Table 2.3.4-1, should one be issued for the applicant's proposed ESP site.

Table 2.3.4-1 Applicant's Proposed Short-Term (Accident Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2 hr χ/Q Value @ EAB	2.26×10^{-4} s/m^3	The atmospheric dispersion factor used in the safety analysis to estimate dose consequences of accidental airborne releases
0–8 hr χ/Q Value @ LPZ	2.05×10^{-5} s/m^3	The atmospheric dispersion factor used in the safety analysis to estimate dose consequences of accidental airborne releases
8–24 hr χ/Q Value @ LPZ	1.36×10^{-5} s/m^3	The atmospheric dispersion factor used in the safety analysis to estimate dose consequences of accidental airborne releases
1–4 day χ/Q Value @ LPZ	5.58×10^{-6} s/m^3	The atmospheric dispersion factor used in the safety analysis to estimate dose consequences of accidental airborne releases
4–30 day χ/Q Value @ LPZ	1.55×10^{-6} s/m^3	The atmospheric dispersion factor used in the safety analysis to estimate dose consequences of accidental airborne releases

2.3.4.2 Regulatory Evaluation

In SSAR Section 1.8.1, the applicant identified the applicable NRC regulation regarding short-term (accident release) diffusion estimates as 10 CFR 100.21, with respect to the meteorological considerations used in the evaluation to determine an acceptable exclusion area and LPZ.

In SSAR Sections 1.8.2 and 2.3.4, the applicant identified the following applicable NRC guidance regarding accident release diffusion estimates:

- RG 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors," dated March 1971; RG 1.24, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Radioactive Gas Storage Tank Failure," dated March 1972; RG 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors," dated March 1972; RG 1.77, "Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors," dated May 1974; and RG 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," dated December 2001, with respect to an acceptable basis for implementing the requirements of 10 CFR Part 100

- RG 1.23, Revision 0, "Onsite Meteorological Programs," dated February 1972 and proposed Revision 1 dated September 1980, with respect to the criteria for an acceptable onsite meteorological measurements program

- Section 2.3.4 of RG 1.70, with respect to providing conservative and realistic estimates of atmospheric diffusion at the EAB and LPZ, based on the most representative meteorological data and impacts caused by local topography

- RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," dated July 1977, with respect to criteria for characterizing atmospheric transport and diffusion conditions for evaluating the consequences of routine releases

- RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," dated November 1982, with respect to acceptable methods for choosing atmospheric dispersion factors (χ/Q values) for evaluating the consequences of potential accidents

- RG 4.7, "General Site Suitability Criteria for Nuclear Power Stations," dated April 1998, with respect to discussing the major site characteristics related to public health and safety that the staff considers in determining the suitability of the site

The staff finds that the applicant correctly identified the applicable regulations and guidance.

Sections 2.3.4 of RS-002 and RG 1.70 provide the following guidance on information appropriate for presentation on short-term (accident release) diffusion estimates. The application should present or describe:

- conservative estimates of atmospheric transport and diffusion conditions at appropriate distances from the source for postulated accidental releases of radioactive materials to the atmosphere

- a description of the atmospheric dispersion models used to calculate relative concentrations (χ/Q values) in air resulting from accidental releases of radioactive material to the atmosphere, with models documented in detail and substantiated within the limits of the model so that the staff can evaluate their appropriateness to site characteristics, plant characteristics (to the extent known), and release characteristics

- the meteorological data used for the evaluation (as input to the dispersion models) which represent annual cycles of hourly values of wind direction, wind speed, and atmospheric stability for each mode of accidental release

- an explanation of the variation of atmospheric diffusion parameters used to characterize lateral and vertical plume spread (σ_y and σ_z) as a function of distance, topography, and atmospheric conditions, as related to measured meteorological parameters, and description of a methodology for establishing these relationships that is appropriate for estimating the consequences of accidents within the range of distances that are of interest with respect to site characteristics and established regulatory criteria

- cumulative probability distributions of relative concentrations (χ/Q values) and the probabilities of these χ/Q values being exceeded, presented for appropriate distances (e.g., the EAB and LPZ) and time periods as specified in Section 2.3.4.2 of RG 1.70, as well as an adequate description of the methods used for generating these distributions

- the relative concentrations used for assessing the consequences of atmospheric radioactive releases from design-basis and other accidents

2.3.4.3 Technical Evaluation

The applicant generated its atmospheric diffusion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and LPZ utilizing the staff-endorsed computer code PAVAN. The staff evaluated the applicability of the PAVAN model and concluded that there are no unique topographic features that preclude use of the PAVAN model for the North Anna ESP site. The staff also reviewed the applicant's input to the PAVAN computer code, including the assumptions used concerning plant configuration and release characteristics, and the appropriateness of the meteorological data input. The staff found that the applicant made conservative assumptions by ignoring building wake effects and treating all releases as ground-level releases. The staff made an independent evaluation of the resulting atmospheric diffusion estimates by running the PAVAN computer model and obtained similar results.

From this review, the staff concludes that the applicant has used an adequately conservative atmospheric dispersion model and appropriate meteorological data to calculate relative concentrations for appropriate distances and directions from postulated release points for accidental airborne releases of radioactive materials.

The staff intends to include the short-term (accident release) atmospheric dispersion factors listed in Table 2.3.4-2 as site characteristics in any ESP permit that might be issued for the North Anna ESP site.

Table 2.3.4-2 Staff's Proposed Short-Term (Accident Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2 hr χ/Q Value @ EAB	2.26×10^{-4} s/m^3	The 0–2 hour atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the EAB
0–8 hr χ/Q Value @ LPZ	2.05×10^{-5} s/m^3	The 0–8 hour atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ
8–24 hr χ/Q Value @ LPZ	1.36×10^{-5} s/m^3	The 8–24 hour atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ
1–4 day χ/Q Value @ LPZ	5.58×10^{-6} s/m^3	The 1–4 day atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ
4–30 day χ/Q Value @ LPZ	1.55×10^{-6} s/m^3	The 4–30 day atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ

2.3.4.4 Conclusions

As set forth above, the applicant has made conservative assessments of postaccident atmospheric dispersion conditions using its meteorological data and appropriate diffusion models. The applicant has calculated representative atmospheric transport and diffusion conditions for the EAB and the LPZ. The staff has reviewed the applicant's proposed short-term atmospheric dispersion site characteristics for inclusion in an ESP for the applicant's site, should one be issued, and, as discussed above, finds these characteristics to be acceptable. Therefore, the staff concludes that the applicant's atmospheric dispersion estimates are appropriate for the assessment of consequences from radioactive releases for design-basis accidents, in accordance with 10 CFR 100.21.

Based on these considerations, the staff concludes that the applicant's short-term atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR Part 100. The staff will address atmospheric dispersion estimates used to evaluate radiological doses for the control room in its review of the COL or CP application that references this information.

2.3.5 Long-Term (Routine) Diffusion Estimates

2.3.5.1 Technical Information in the Application

In this section of the SSAR, the applicant presented its atmospheric diffusion estimates for routine releases of effluents to the atmosphere. Specifically, the applicant provided the following information:

- the atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material to the atmosphere

- the meteorological data used as input to diffusion models

- diffusion parameters

- relative concentration (χ/Q) and relative deposition (D/Q) values used to assess the consequences of routine airborne radioactive releases

- points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations

The applicant used the NRC-sponsored computer code XOQDOQ (NUREG/CR-2919, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations") to estimate χ/Q and D/Q values resulting from routine releases. The XOQDOQ model implements the methodology outlined in RG 1.111. The applicant utilized the following input data and assumptions in applying the XOQDOQ model for the North Anna ESP site:

- The meteorological input to XOQDOQ consisted of a joint frequency distribution of wind speed, wind direction, and atmospheric stability data based on 3 years (1996–1998) of onsite meteorological data. The wind data were from the 10-m (33-ft) level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 48.4-m (159-ft) and 10-m (33-ft) levels of the onsite meteorological tower.

- The applicant modeled one conservative ground-level release point, assuming a minimum building cross-sectional area of 2250 m^2 (24,220 ft^2).

- Because the PPE area proposed for the North Anna ESP site is an area, not a point, the applicant used the shortest distances from any point on the plant envelope to the receptors of interest as input to the XOQDOQ model.

The applicant calculated annual average undepleted/no decay, undepleted/2.26 day decay, and depleted/8.00 day decay χ/Q values and D/Q values for the site boundary and special receptors of interest (nearest resident, meat animal, and vegetable garden within 5 mi in each downwind sector), as identified in the "North Anna Power Station 2001 Radiological Environmental Monitoring Program Annual Report."

Table 2.3.5-1 lists the long-term atmospheric dispersion estimates the applicant derived based on the XOQDOQ modeling results.

Table 2.3.5-1 Applicant's Long-Term (Routine Release) Diffusion Estimates

TYPE OF LOCATION	X/Q VALUE (s/m^3)			D/Q VALUE ($1/m^2$)
	UNDEPLETED NO DECAY	UNDEPLETED 2.26 DAY DECAY	DEPLETED 8.00 DAY DECAY	
EAB	3.7×10^{-6} (0.88 mi ESE)	3.7×10^{-6} (0.88 mi ESE)	3.3×10^{-6} (0.88 mi ESE)	1.2×10^{-8} (0.62 mi S)
Residence	2.4×10^{-6} (0.96 mi NNE)	2.4×10^{-6} (0.96 mi NNE)	2.1×10^{-6} (0.96 mi NNE)	7.2×10^{-9} (0.96 mi NNE)
Meat Animal	1.4×10^{-6} (1.37 mi SE)	1.4×10^{-6} (1.37 mi SE)	1.2×10^{-6} (1.37 mi SE)	3.1×10^{-9} (1.56 mi NNE)
Veg. Garden	2.0×10^{-6} (0.94 mi NE)	2.0×10^{-6} (0.94 mi NE)	1.8×10^{-6} (0.94 mi NE)	6.0×10^{-9} (0.94 mi NE)

2.3.5.2 Regulatory Evaluation

In SSAR Section 1.8.1, the applicant identified the applicable NRC regulations regarding long-term (routine release) diffusion estimates as Appendix I to 10 CFR Part 50, with respect to demonstrating compliance with the numerical guides for doses contained in this appendix by characterizing atmospheric transport and diffusion conditions in order to estimate the radiological consequences of routine releases of materials to the atmosphere.

The staff finds that the applicant should have also identified 10 CFR 100.21(c)(1), which requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located offsite. Nonetheless, for the reasons set forth below, the staff finds that the applicant has met these regulatory requirements.

In SSAR Sections 1.8.2 and 2.3.5, the applicant identified the following applicable NRC guidance regarding routine release diffusion estimates:

- Section 2.3.5 of RG 1.70, with respect to providing realistic estimates of annual average atmospheric transport and diffusion characteristics to a distance of 50 miles from the plant, including a detailed description of the model used and a calculation of the maximum annual average atmospheric dispersion factor (χ/Q value) at or beyond the site boundary for each venting location

- RG 1.111, with respect to criteria for characterizing atmospheric transport and diffusion conditions for evaluating the consequences of routine releases

The staff finds that the applicant should have also identified the following RGs as applicable NRC guidance regarding routine release diffusion estimates:

- RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," dated October 1977, with respect to the criteria to be used for specific receptors of interest (applicable to the extent the applicant provides receptors of interest at the ESP stage)

- RG 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," dated May 1977, with respect to the criteria to be used to identify release points and release characteristics (applicable to the extent the applicant provides release points and release characteristics at the ESP stage)

Nonetheless, the staff finds that the applicant has met the criteria in all applicable regulatory guides for performing routine release diffusion estimates.

Sections 2.3.5 of RS-002 and RG 1.70 provide the following guidance on information appropriate for presentation on long-term (routine release) diffusion estimates.

- The applicant should provide a description of the atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material to the atmosphere. The models should be sufficiently documented and substantiated to allow a review of their appropriateness for site characteristics, plant characteristics (to the extent known), and release characteristics.

- The applicant should discuss the relationship between atmospheric diffusion parameters, such as vertical plume spread (σ_z), and measured meteorological parameters. The applicant should substantiate the use of these parameters in terms of the appropriateness of their use in estimating the consequences of routine releases from the site boundary to a radius of 50 mi from the plant site.

- The applicant should provide the meteorological data used as input to the dispersion models. Data used for this evaluation should represent hourly average values of wind speed, wind direction, and atmospheric stability, which are appropriate for each mode of release. The data should reflect atmospheric transport and diffusion conditions in the vicinity of the site throughout the course of a year.

- The applicant should provide the relative concentration (χ/Q) and relative deposition (D/Q) values used for assessing the consequences of routine radioactive gas releases, as described in Section 2.3.5.2 of RG 1.70.

- The applicant should identify points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations (if available at the ESP stage). Bounding values for these parameters may be provided at the ESP stage. In such a case, the applicant will need to confirm, at the COL or CP stage, that the parameters provided at the ESP stage bound the actual values provided at the COL or CP stage, and that the calculational methodology used for the confirmation is consistent with that employed at the ESP stage.

2.3.5.3 Technical Evaluation

The applicant generated its atmospheric diffusion estimates for routine airborne releases of radioactive effluents to the site boundary and special receptors of interest utilizing the staff-endorsed computer code XOQDOQ. The staff evaluated the applicability of the XOQDOQ model and concluded that there are no unique topographic features that preclude use of the XOQDOQ model for the North Anna ESP site. The staff also reviewed the applicant's input to the XOQDOQ computer code, including the assumptions it used concerning plant configuration and release characteristics and the appropriateness of the meteorological data input. The staff found that the applicant made conservative assumptions by treating all releases as ground-level releases. The staff made an independent evaluation of the resulting atmospheric diffusion estimates by running the XOQDOQ computer model and obtaining similar results.

From this review, the staff is able to conclude that the applicant used an appropriate atmospheric dispersion model and adequate meteorological data to calculate relative concentration and relative deposition at appropriate distances from postulated release points for evaluation of routine airborne releases of radioactive material. Any COL or CP applicant referencing this information will need to confirm that the specific release point characteristics (e.g., release height, building wake dimensions) and specific locations of receptors of interest (e.g., nearest resident, garden) used to generate the ESP long-term (routine release) atmospheric dispersion site characteristics bound the actual values provided at the COL or CP stage. This is **COL Action Item 2.3-2**.

The staff intends to include the long-term (routine release) atmospheric dispersion factors listed in Table 2.3.5-2 as site characteristics in any ESP permit that the NRC might issue for the North Anna ESP site.

Table 2.3.5-2 Staff's Proposed Long-Term (Routine Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
Annual Average Undepleted/No Decay χ/Q Value @ EAB	3.7×10^{-6} s/m^3	The maximum annual average EAB undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26 Day Decay χ/Q Value @ EAB	3.7×10^{-6} s/m^3	The maximum annual average EAB undepleted/2.26 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00 Day Decay χ/Q Value @ EAB	3.3×10^{-6} s/m^3	The maximum annual average EAB depleted/8.00 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ EAB	1.2×10^{-8} 1/m^2	The maximum annual average EAB D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Resident	2.4×10^{-6} s/m^3	The maximum annual average resident undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26 Day Decay χ/Q Value @ Nearest Resident	2.4×10^{-6} s/m^3	The maximum annual average resident undepleted/2.26 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00 Day Decay χ/Q Value @ Nearest Resident	2.1×10^{-6} s/m^3	The maximum annual average resident depleted/8.00 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Resident	7.2×10^{-9} 1/m^2	The maximum annual average resident D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Meat Animal	1.4×10^{-6} s/m^3	The maximum annual average meat animal undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26 Day Decay χ/Q Value @ Nearest Meat Animal	1.4×10^{-6} s/m^3	The maximum annual average meat animal undepleted/2.26 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00 Day Decay χ/Q Value @ Nearest Meat Animal	1.2×10^{-6} s/m^3	The maximum annual average meat animal depleted/8.00 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual

SITE CHARACTERISTIC	VALUE	DEFINITION
Annual Average D/Q Value @ Nearest Meat Animal	3.1×10^{-9} 1/m^2	The maximum annual average meat animal D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Veg. Garden	2.0×10^{-6} s/m^3	The maximum annual average vegetable garden undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26 Day Decay χ/Q Value @ Nearest Veg. Garden	2.0×10^{-6} s/m^3	The maximum annual average vegetable garden undepleted/2.26 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00 Day Decay χ/Q Value @ Nearest Veg. Garden	1.8×10^{-6} s/m^3	The maximum annual average vegetable garden depleted/8.00 day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Veg. Garden	6.0×10^{-9} 1/m^2	The maximum annual average vegetable garden D/Q value for use in determining gaseous pathway doses to the maximally exposed individual

2.3.5.4 Conclusions

As set forth above, the applicant has provided meteorological data and an atmospheric dispersion model that are appropriate for the characteristics of the site and release points. The applicant has calculated representative atmospheric transport and diffusion conditions for 16 radial sectors from the site boundary to a distance of 50 mi, as well as for specific receptor locations. The staff has reviewed the long-term atmospheric dispersion estimates the applicant proposes for inclusion as site characteristics in an ESP for the applicant's site (should one be issued) and, for the reasons set forth above, finds these estimates to be acceptable. Therefore, the staff concludes that the applicant has provided the information required to address the requirements of 10 CFR 100.21(c)(1).

Based on these considerations, the staff concludes that the applicant's characterization of long-term atmospheric transport and diffusion conditions is appropriate for use in demonstrating compliance with the numerical guides for doses contained in Appendix I to 10 CFR Part 50.

The applicant provided bounding values for points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations. Any COL or CP applicant will need to confirm that the parameters provided at the ESP stage bound the actual values provided at the COL or CP stage, and that the calculational methodology used for the confirmation is consistent with that employed at the ESP stage.

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