2.0 SITE CHARACTERISTICS

2.3 Meteorology

To ensure that a nuclear power plant or plants can be designed, constructed, and operated on an applicant's proposed early site permit (ESP) site in compliance with the U.S. Nuclear Regulatory Commission's (NRC's) regulations, the NRC staff evaluates regional climatological and local meteorological information, including climate extremes and occurrences of severe weather phenomena that may affect the design, siting, and operation of a nuclear plant. The NRC staff also reviews information on the atmospheric dispersion (χ/Q) characteristics of a proposed nuclear power plant site to determine whether the radioactive effluents from postulated accidental releases, as well as from routine operational releases, comply with NRC regulations.

The NRC staff has prepared Sections 2.3.1 through 2.3.5 of this safety evaluation report (SER) in accordance with the review procedures described in NUREG–0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Input to these SER sections was developed based on the staff's evaluation of the information presented primarily in: (1) Section 2.3 of the Clinch River Nuclear (CRN) Site ESP site safety analysis report (SSAR) (Revision 1) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17362A298); (2) the applicant's responses to NRC staff requests for additional information (RAIs); (3) the staff's assessment of technical information and supporting analyses discussed during an audit conducted in May 2018 (ADAMS Accession No. ML18248A113); and (4) generally available reference materials identified in applicable sections of NUREG–0800.

2.3.1 Regional Climatology

2.3.1.1 Introduction

In SSAR Section 2.3.1, "Regional Climatology," the applicant provided information regarding regional climatic conditions and the occurrence of meteorological phenomena (including both averages and extremes) that could potentially influence the design and affect the operating bases of safety- and nonsafety-related structures, systems, and components (SSCs) for the proposed nuclear power plant.

2.3.1.2 Summary of Application

In SSAR Section 2.3.1, 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), general airflow patterns (wind direction and speed), temperature and humidity, precipitation (rain, snow, etc.), potential influences from regional topographic features, and relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions.

- Regional meteorological conditions relevant to the design and operating bases for the CRN Site (i.e., information summarized in Table 2.0-1, "Site Characteristics," of the SSAR).

- Frequencies and descriptions of severe weather phenomena that could reasonably be expected to impact the proposed site, including extreme wind, tornadoes, tropical cyclones, precipitation extremes, winter precipitation (snowstorms and ice storms), and thunderstorms (including hail and lightning).

- A description of design-basis dry- and wet-bulb temperatures for the proposed site.

- A discussion regarding potential climate changes in the proposed site region.

- A description of regional air quality conditions, including a discussion of projected air quality as a result of electricity generation from two or more small modular reactors (SMRs) at the CRN Site.

Based on the above information, the applicant provided in SSAR Table 2.0-1 a list of characteristics that describe climatological conditions that might reasonably be expected to occur at the CRN Site. Site characteristics are the actual physical, environmental, and demographic features of a site and are used to verify the suitability of a proposed plant design for a site. The applicant proposed the following climatic site characteristics as minimum design and/or operating bases applicable to the proposed CRN Site.

- The weight of the 100-year return period ground-level snowpack and the weight of the 48-hour probable maximum winter precipitation (PMWP) for use in determining the weight of winter precipitation events on the roofs of safety-related structures.

- The design-basis tornado parameters (including maximum wind speed, maximum rotational and translational wind speed, the radius of maximum rotational wind speed, maximum pressure drop, and maximum rate of pressure drop) to be used in establishing tornado loadings on SSCs important to safety.

- The 100-year return period (straight-line) and hurricane 3-second gust wind speeds to be used in establishing wind loading on plant structures.

- Ambient air temperature and atmospheric moisture statistics, including maximum dry-bulb (5-percent, 2-percent, 1-percent, 0.4-percent, and 0-percent annual exceedance with coincident wet-bulb temperatures; 100-year return period); minimum dry-bulb (5-percent, 2-percent, 1-percent, 0.4-percent, and 0-percent annual exceedance; 100-year return period); and maximum non-coincident wet-bulb (2-percent, 1-percent, 0.4-percent, and 0-percent annual exceedance; 100-year return period).

2.3.1.3 Regulatory Basis

The acceptance criteria for identifying regional climatological and meteorological information are based on meeting the relevant requirements of Title 10 *Code of Federal Regulations* (10 CFR) 52.17, "Contents of Applications; Technical Information," and 10 CFR Part 100, "Reactor Site Criteria." The NRC staff considered the following regulatory requirements in reviewing the applicant's identification of regional climatological and meteorological information:

- 10 CFR 52.17(a)(1)(vi), as it relates to the requirement that the application contain a description of the meteorological characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated;

- 10 CFR 100.20(c)(2), as it relates to the requirement that those meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the NRC staff's review of the acceptability of the site; and

- 10 CFR 100.21(d), as it relates to the requirement that the physical characteristics of the site, including meteorology "be evaluated and site characteristics established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site."

The climatological and meteorological information assembled by the applicant in the ESP application (in compliance with the above regulatory requirements) will be necessary to determine, in any combined license (COL) application submitted for the site, whether a proposed facility complies with the following requirements in Appendix A, "General Design Criteria for Nuclear Power Plants," of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities":

- General Design Criteria 2, "Design Bases for Protection Against Natural Phenomena," as it relates to the requirement that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

The following are the relevant SRP acceptance criteria from NUREG–0800, Section 2.3.1, "Regional Climatology":

- The description of the general climate of the region should be based on standard climatic summaries compiled by the National Oceanic and Atmospheric Administration (NOAA).

- Data on severe weather phenomena should be based on standard meteorological records from nearby representative National Weather Service (NWS), military, or other stations recognized as standard installations that have long periods of data on record.

- The tornado parameters should be consistent with Regulatory Guide (RG) 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1. Alternatively, an applicant may specify any tornado parameters that are appropriately justified, provided that a technical evaluation of site-specific data is conducted.

- The basic (straight-line) 100-year return period, 3-second gust wind speed should be based on appropriate standards, with suitable corrections for local conditions.

- To be consistent with RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants," Revision 3, the ultimate heat sink (UHS) meteorological data that would result in the maximum evaporation and, if applicable, drift loss of water and minimum water cooling should be based on long-period regional records that represent site conditions. (The guidance in this RG does not apply to passive reactor designs that utilize a passive containment cooling system as the UHS.)

- The weight of the 100-year return period snowpack should be based on data recorded at nearby representative climatic stations and/or obtained from appropriate standards with suitable corrections for local conditions. The weight of the 48-hour PMWP should be determined in accordance with hydrometeorological reports (HMRs) published by NOAA's Hydrometeorological Design Studies Center.

- Ambient temperature and atmospheric humidity statistics should be derived from data recorded at nearby representative climatic stations or obtained from appropriate standards with suitable corrections for local conditions.

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

- All other meteorological and air quality conditions identified by the applicant as design and operating bases should be documented and substantiated.

- Design Certification (DC)/COL Interim Staff Guidance (ISG) - 007, "Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures," which clarifies the NRC staff's position on identifying winter precipitation events as site characteristics and site parameters to determine normal and extreme winter precipitation loads on the roofs of seismic Category I structures.

To the extent applicable to the above-outlined acceptance criteria, the applicant applied the NRC-endorsed climatological and meteorological information selection methodologies and techniques in the following:

- RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," which provides criteria for selecting the design-basis hurricane parameters.

- NUREG/CR-7005, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane Wind Speeds for Nuclear Power Plants."

When independently assessing the information presented by the applicant in SSAR Section 2.3.1, the NRC staff applied the same above-cited methodologies and techniques.

2.3.1.4 Technical Evaluation

The NRC staff reviewed SSAR Section 2.3.1 to ensure that the ESP application represents the complete scope of information relating to the regional climatology. The staff's review confirmed the application addresses the required information relating to the preceding subject matter.

2.3.1.4.1 General Climate

The applicant described the site as being located in eastern Tennessee (TN), set alongside the southern portion of the Appalachian mountain chain. The site lies in a valley between two mountainous regions, which positions the valley in a southwest to northeast configuration. The applicant stated that prevailing winds generally flow following the orientation of the valley, and wind speeds are normally low, with a mean annual wind speed of 2.9 miles per hour (mph), based on National Climatic Data Center (NCDC, recently renamed the National Centers for Environmental Information or (NCEI)) information for Oak Ridge, TN.

The site's most dominant climate and weather influence for the region is the Azores-Bermuda high, which is a pseudo-permanent subtropical high pressure system located over the southern portion of the North Atlantic Ocean and characterized by fair, stable weather and stagnant air. This phenomenon is most pronounced in the summer and early fall, pulling warm, moist air from the Gulf of Mexico over the region. During the winter and early spring, alternating cold and warm air masses bring changes to this weather pattern.

In addition, the applicant stated that air temperatures show typical warm summers and mild winters, and precipitation averages about 51 inches (in.) annually, with January through March being the wettest period of the year and August through October being the driest. According to the applicant, snowfall is normally light and usually occurs from November through March; severe storms occur relatively infrequently, as the region is situated east of maximum tornado activity and more inland away from tropical cyclone impacts.

The NRC staff reviewed the Local Climatological Data (LCD) publications, provided by NCEI, for the cities of Oak Ridge and Knoxville, TN, for the years of 2013 (which the applicant referenced in its application) and 2016 (the most recent year available to the staff at time of review) .[1] The staff confirmed the applicant's climate description, including general temperature, precipitation, and severe weather trends for the region, and reviewed the topographic features of the area. Although not mentioned by the applicant in SSAR Subsection 2.3.1.1, the staff notes that the State of Tennessee is divided into four climate divisions. The proposed CRN Site is located in Climate Division 1 (Eastern Tennessee) which runs from Campbell County, along the northern border with Kentucky, continuing in a southwesterly direction to Hamilton County along the border with Georgia and extends eastward over the remainder of the state to its borders with Virginia and North Carolina. The CRN Site is situated in Roane County whose western boundary abuts with Climate Division 2 (Cumberland Plateau). Based on its review of the information provided by the applicant, the staff finds the information to be an appropriate account of the general climate of the site region.

2.3.1.4.2 Regional Meteorological Conditions for Design and Operating Basis

The regional climatological (meteorological) conditions that are relevant to the design and operating bases of safety-related SSCs for the CRN Site are presented in Table 2.0-1 of the SSAR. These climate-related site characteristics are reviewed by the NRC staff in the following paragraphs.

---

[1] National Centers for Environmental Information, "Local Climatological Data Publication." https://www.ncdc.noaa.gov/IPS/lcd/lcd.html | Accessed February 15, 2017.

2.3.1.4.3 Severe Weather

2.3.1.4.3.1 Thunderstorms, Hail, and Lightning

SSAR Subsection 2.3.1.3.1, "Thunderstorms, Hail, and Lightning," provides a general understanding of these severe weather phenomena in the site region. However, this subsection does not result in the generation of site characteristics for use in design or operating bases.

According to the applicant, thunderstorms in the region occur on 42 to 55 days of the year, with the greatest incidence of thunderstorms occurring during the months of May through August. Also, according to the applicant, severe hail events (0.75 in. in diameter or larger) have been reported 31 times during the period from 1950 to 2013 in Roane County, where the potential site is located. In the surrounding counties of Loudon and Knox, severe hail events were reported 43 and 81 times, respectively, since 1950, which is the beginning period of record (POR) for the NCEI Storm Events Database. However, the NRC staff understands that the POR covered by the online Storm Events database for hail events currently begins in 1955. The applicant also stated that the site area averages 13 cloud-to-ground lightning flashes per square mile (2.6 km^2) each year.

The NRC staff reviewed the LCD annual summary publications from NCEI for the cities of Knoxville, Nashville, and Oak Ridge, TN, and the tri-cities area (Bristol, Johnson City, and Kingsport, TN) for the years of 2013 and 2016. The staff reviewed the 2013 LCDs referenced in the application and the 2016 LCDs as a confirmation of the data provided by the applicant. The staff also reviewed Vaisala's National Lightning Detection Network flash density (2005-2014) for the contiguous United States (U.S.)[2] and found that this portion of the SSAR was acceptable for information purposes as information related to thunderstorms, hail, and lightning are not typically identified as site characteristics.

2.3.1.4.3.2 Extreme Winds

Estimating wind loading on plant structures involves identifying a site's "basic" (50-year recurrence interval) wind speed, which is defined by the American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) Standard 7-05, "Minimum Design Loads for Buildings and Other Structures," as the "3-second gust speed at 33 feet (ft) (10 meters (m)) above the ground in Exposure Category C." Exposure Category C relies on the surface roughness categories defined in Chapter 6, "Wind Loads," of ASCE/SEI 7-05. Exposure Category C is acceptable at the CRN Site because of scattered obstructions of various sizes in the immediate site area. Exposure Category B specifies that there must be "urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger" prevailing "in the upwind direction for a distance of at least 2,600 ft (792 m) or 20 times the height of the building, whichever is greater." Exposure Category D specifies that there must be "flat, unobstructed areas and water surfaces" prevailing "in the upwind direction for a distance greater than 5,000 ft (1,525 m) or 20 times the building height, whichever is greater." Based on the site description in SSAR Subsection 2.3.3.2, "Primary Meteorological Facility," neither Exposure Category B nor Exposure Category D accurately describes the conditions at the CRN Site meteorological tower.

---

[2] Vaisala National Lightning Detection Network, "Flash Density." http://www.vaisala.com/VaisalaImages/Lightning/avg_fd_2005-2014_CONUS_2km_grid.png | Accessed March 8, 2017.

ASCE/SEI 7-05 states that Exposure Category C shall apply for all cases for which neither Exposure Category B nor D applies.

Using a plot of basic wind speeds presented in ASCE/SEI 7-05 for the portion of the U.S. that includes the proposed CRN Site, the applicant determined a 50-year return period 3-second gust wind speed of 90 mph. The applicant also included data from the 1974 Annual LCD for Knoxville, TN, which contained a maximum estimated fastest mile wind speed of 73 mph (which corresponds to a 3-second gust wind speed of 88 mph) recorded for the site region.

In addition, the applicant noted that, according to the reference "New Distributions of Extreme Winds in the United States," the 100-year return period fastest mile of wind near the CRN Site equals approximately 90 mph.[3] The applicant also provided, for comparison purposes, hourly average wind speed measurements taken at the 33-ft (10-m) level from the CRN Site (2011-2013), Tennessee Valley Authority's (TVA's) Watts Bar Nuclear Plant (1973-2013), and TVA's Sequoyah Nuclear Plant (1971-2013). The maximum observed hourly values of 14.1 mph for the CRN Site, 30.0 mph for the Watts Bar site, and 39.6 mph for Sequoyah correspond to 3-second gust wind speeds of 17, 36, and 48 mph, respectively. The NRC staff notes that the 2-year POR for the CRN Site wind data is not climatologically representative of extreme winds due to its short duration.

The NRC staff confirmed the applicant's 3-second gust wind speed value of 90 mph based on ASCE/SEI 7-05. This value is associated with a mean recurrence interval of 50 years. Using the conversion factor of 1.07 listed in ASCE/SEI 7-05, Table C6-7, "Conversion Factors for Other Mean Recurrence Intervals," the applicant calculated a 100-year return period 3-second gust wind speed of 96.3 mph, as presented in SSAR Table 2.0-1.

Since the applicant's determination of the basic wind speed site characteristic value is in accordance with the methods described in NUREG–0800, Section 2.3.1, the NRC staff finds this value reasonable and acceptable.

[3] Thom, H. C. S., New Distributions of Extreme Winds in the United States, Journal of the Structural Division, Proceedings of the American Society of Civil Engineers, Vol. 94, No. ST 7, pp 1787-1801, 1968; Figure 5.

2.3.1.4.3.3 Precipitation Extremes

Table 2.3-1
Precipitation for Stations around Clinch River Nuclear Site
(Reproduced from SSAR Table 2.3.1-2)

Station	Normal Annual Rainfall (in.)	Max 24-hour Rainfall (in.)	Max Monthly Rainfall (in.)	Normal Annual Snowfall (in.)	Max 24-hour Snowfall (in.)	Max Monthly Snowfall (in.)
Oak Ridge NWS Station	50.91 30-year POR	7.48 66-year POR, Aug 1960	19.27 66-year POR, July 1967	11.1 30-year POR	12.0 52-year POR; March 1960	21.0 52-year POR; March 1960
Knoxville NWS Station	47.86 30-year POR	5.98 72-year POR; Sept 2011	12.67 72-year POR; Jan 2013	6.5 30-year POR	18.2 69-year POR; Nov 1952	23.3 69-year POR; Feb 1960
Chattanooga NWS Station	52.48 30-year POR	9.50 74-year POR; Sept 2011	16.32 74-year POR; March 1980	3.9 30-year POR	18.5 76-year POR; March 1993	20.0 76-year POR; March 1993
Nashville NWS Station	47.25 30-year POR	9.09 74-year POR; May 2010	16.43 74-year POR; May 2010	6.3 30-year POR	10.2 66-year POR; Dec 1963	18.9 66-year POR; Feb 1979
TVA Sequoyah	45.79 30-year POR	8.04 40-year POR; Sept 2004	13.34 40-year POR; March 1980	---	---	---
TVA Watts Bar	45.70 30-year POR	8.43 41-year POR; Sept 2011	12.33 41-year POR; March 1975	---	---	---

Based on the observations from four nearby first-order NWS monitoring stations and from TVA's Sequoyah and Watts Bar nuclear plant sites, the applicant presented historical precipitation extremes for the region in SSAR Table 2.3.1-2, "Precipitation for Stations around Clinch River Nuclear Site" (reproduced as Table 2.3-1 of this report). According to the applicant, the maximum estimated annual precipitation for the area ranges from 45 to 53 in., and the maximum 24-hour rainfall is less than 10 in., with the maximum monthly rainfall measuring less than 20 in. The probable maximum precipitation (PMP) values provided by the applicant are based on NOAA's HMR No. 52, which determined the PMP values for a 1-square mile area to be 18.8 in./1-hr and 6 in./5 minutes. The applicant listed this PMP value as a "maximum rainfall rate" site characteristic in SSAR Table 2.0-1. Subsection 2.4.3.4.2, "Probable Maximum

Precipitation," of this SER discusses the applicant's derivation of the 1-hr 1-square mile PMP value for the CRN Site.

The NRC staff reviewed the 2013 LCD publications for the first-order NWS stations at Chattanooga, Knoxville, Nashville, and Oak Ridge, TN, and determined that the applicant's characterization of precipitation (rainfall) normals and extremes was reasonable. The staff also reviewed NOAA's HMR No. 52 to determine whether the applicant's PMP value listed as a site characteristic was appropriate for the CRN Site. The NRC staff finds the PMP value acceptable since the applicant followed NRC guidance provided in NUREG-0800, Section 2.4.3, "Probable Maximum Flood (PMF) on Streams and Rivers." The NRC staff notes a discrepancy between the maximum 24-hour snowfall total for the Chattanooga, TN, NWS station (i.e., 18.5 in.) listed above as well as in SSAR Table 2.3.1-2, versus the value shown in the respective LCD summaries from 1993 through 2016 for that station (i.e., 20.0 in.). The NRC staff reviewed the NCDC TD-3200 daily data summaries for March 1993, which show that 18.5 in. was the daily snowfall total for March 13, and that 1.5 in. was recorded on the preceding day. Therefore, the staff concludes the maximum 24-hour snowfall total as listed in the referenced in SSAR and SER tables to be correct and the maximum 24-hour total shown in the LCDs to be incorrect, as the LCD value instead represents the maximum snowfall total for that month over the indicated POR for that station. See SER Subsections 2.3.1.4.3.6 and 2.3.1.4.3.6.2 for additional information.

2.3.1.4.3.4 Tornadoes

Tornado Strike Probability

The applicant stated that, according to the NCEI Storm Events Database, five tornadoes were reported within 10 miles of the proposed site, with only one having greater than EF-0 intensity, and presented these statistics in SSAR Table 2.3.1-3, "Tornadoes Reported within 10 Miles of Clinch River Nuclear Site (1950-2013)". The closest tornado reported near the CRN Site was rated an F3 (158 – 206 mph) at a distance of 4 miles. The NRC staff independently confirmed this information by accessing the NCEI Storm Events Database[4] for Roane, Morgan, Anderson, Knox, and Loudon Counties in Tennessee for the 64-year period of 1950 to 2013; each county has a part of its designated area located within ten miles of the proposed site.

In addition, the applicant provided calculations of tornado strike probabilities in SSAR Subsection 2.3.1.3.4 that could potentially occur at the proposed site. The calculations are based on the tornado strike probability presented in Revision 2 of NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," which utilizes the principle of geometric probability described by H.C.S. Thom.[3] According to the reference H.C.S. Thom, the probability of a tornado striking any point in a 1-degree latitude by 1-degree longitude square can be calculated as follows:

[4] National Centers for Environmental Information, NOAA, "Storm Events Database." https://www.ncdc.noaa.gov/stormevents/ | Accessed March 20, 2017.

$$P = \frac{zt}{A}$$ (Listed as Equation 2.3.1-1 in the SSAR)

P = mean probability of a tornado striking a point in any year within a 1-degree square
z = mean path area of a tornado (mi^2)
t = mean number of tornadoes per year
A = area (mi^2)

The applicant determined the mean probability of a tornado striking a point in any year in a 1-degree box to be 1.43 x 10^{-4} per year, which equals a recurrence interval of 6993 years.

The applicant also provided additional information related to tornado strike probability that is included in NUREG/CR-4461. The SSAR mentions that the number of tornado events from 1950 to August 2003 within a 2-degree latitude/longitude box surrounding the CRN Site is 226, which presents an annual average of four tornado events striking somewhere within the 2-degree box.

The NRC staff independently reviewed the information referenced by the applicant and confirmed the applicant's tornado strike probability calculations. The staff finds the applicant's characterization of this material to be reasonable for informational purposes, as information in this subsection related to tornado strike probability does not result in the generation of site characteristics for use in design or operating bases.

Design Basis Tornado (DBT) Parameters

In SSAR Subsection 2.3.1.3.4, the applicant developed tornado site characteristics for the CRN Site based on parameters in RG 1.76, Revision 1, which provides design-basis tornado characteristics for three tornado-intensity regions throughout the contiguous U.S., each with a 10^{-7} probability of occurrence. The proposed CRN Site is located within tornado intensity Region I. The applicant proposed the following tornado site characteristics, which are listed in SSAR Table 2.0-1:

maximum wind speed	103 m/s (230 mph)
translational speed	21 m/s (46 mph)
maximum rotational speed	82 m/s (184 mph)
radius of maximum rotational speed	45.7 m (150 ft)
pressure drop	83 millibars (mb) (1.2 psi)
rate of pressure drop	37 mb/s (0.5 psi/sec)

Since the applicant's tornado site characteristics are based on parameters in Revision 1 of RG 1.76 for the appropriate tornado intensity region, the NRC staff finds these characteristics to be acceptable.

2.3.1.4.3.5 Hurricanes

The applicant viewed the NCEI Storm Events Database and noted that there was one tropical storm, associated with Hurricane Ivan, on September 16, 2004, near Roane County that caused minimal damage. The applicant stated that from 1905 to 2013, there have been ten tropical storms within a 50-mile radius of the proposed site; however, some of these storms were initially classified as hurricanes before impacting the area. Potential impacts from these events included flood effects from heavy rains.

The applicant stated that they reviewed both RG 1.221 and NUREG/CR-7005 and came to the conclusion that because the site lies at an extended distance from the coast, hurricane winds will not present a safety concern for the proposed CRN Site; the 3-second gust wind speed contours provided in RG 1.221 and NUREG/CR-7005 (below) cease at 130 mph after certain distances inland from the U.S. coasts, as can be seen in Figure 2.3-1 of this SER.

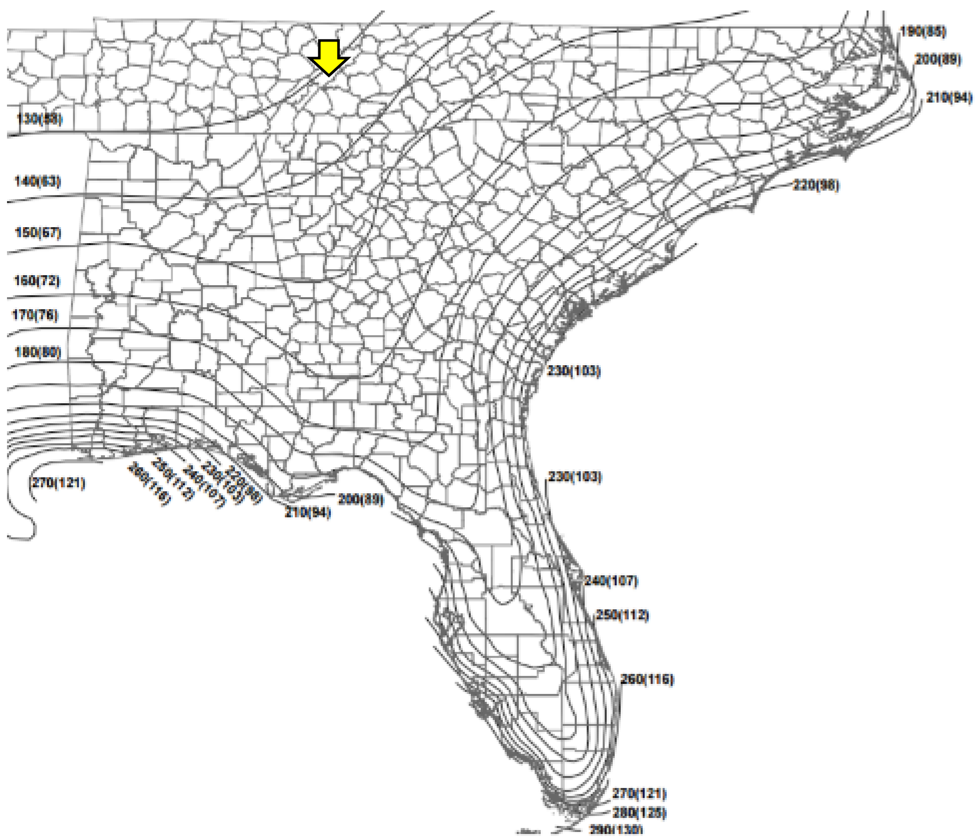

Figure 2.3-1. Design-Basis Hurricane Windspeeds for the Eastern Gulf of Mexico and Southeastern Atlantic U.S. Coastline Representing Exceedance Probabilities of 10^{-7} per Year (Reproduced from RG 1.221). Values are nominal 3-second gust windspeeds in miles per hour (meters per second) at 33 ft (10 m) above ground over open terrain. Approximate location of Clinch River site indicated by yellow arrow.

The NRC staff reviewed the Storm Events Database, provided through NCEI (formerly named NCDC), and confirmed the applicant's information regarding one tropical storm that impacted the county on September 16, 2004[4]. The applicant stated that the NCEI Storm Events Database POR for tropical storms began in 1950. However, the NRC staff understands that the POR covered by the on-line Storm Events database for tropical cyclone events (including, but not limited to, hurricanes, tropical storms) currently only begins in 1996. The NRC staff also reviewed NOAA's Office for Coastal Management "Historical Hurricane Tracks" database which contains more comprehensive records that date back to the mid-1800s, by applying a 50-nautical mile search radius to the site location.[5] The staff noted that no tropical cyclones with winds exceeding tropical storm strength have traversed the 50-nautical mile radius area around the proposed site.

The applicant provided a site characteristic hurricane wind speed of 130 mph (3-second wind gust speed) in Table 2.0-1. Based on Figure 2.3-1 of this SER, which is reproduced from RG 1.221 and confirms applicant's site hurricane wind speed, the NRC staff agrees with the applicant's conclusion and finds this information acceptable.

2.3.1.4.3.6 Winter Storm Events

In SSAR Subsection 2.3.1.3.6, "Winter Storm Events," the applicant identified a maximum reported snow depth at the Knoxville, TN, first-order NWS station of 15 in. for February 1960 based on a 61-year POR. The applicant also identified a maximum 24-hour snowfall of 18.5 in. reported for March 1993 at Chattanooga, TN.

See SER Subsection 2.3.1.4.3.3 regarding the NRC staff's evaluation of the maximum 24-hour snowfall total reported for the Chattanooga, TN, NWS station. The NRC staff confirmed the maximum reported snow depth for the Knoxville, TN, NWS station but notes that this observation is not a controlling event directly used in estimating normal or extreme winter precipitation roof loads for the CRN Site as discussed in SER Section 2.3.1.4.3.6.2, "Normal and Extreme Winter Precipitation Events."

2.3.1.4.3.6.1 Ice Storms

The applicant used the reference "Estimated Glaze Ice and Wind Loads at the Earth's Surface for the Contiguous United States," by Paul Tattleman and Irving I. Gringorton to characterize ice storms for the site area.[6] According to Tattleman and Gringorton, Region V (which includes Tennessee) experienced 5 ice storms greater than or equal to 2.5 cm (1 in.) of ice accumulation and 2 ice storms greater than or equal to 5 cm (2 in.) ice accumulation, both of which were determined for a period of 50 years. According to the same reference, ice thicknesses in Region V with wind gusts greater than or equal to 20 m/s (44.7 mph) are less than 1 in. for 25- and 50-year return periods and less than 1.4 in. for a 100-year return period.

The applicant also provided ice thickness data from Figure 10-2, "50-Year Mean Recurrence Interval Uniform Ice Thicknesses Due to Freezing Rain with Concurrent 3-Second Gust Speeds: Contiguous 48 States," of the ASCE/SEI 7-05 standard. The applicant stated that Roane County, which contains the proposed site, lies within the 0.75-in. ice thickness contour with a concurrent 3-second wind gust of 30 mph.

In addition, the applicant discussed glaze ice point probabilities for ice thicknesses. For accumulations greater than or equal to 0.5 in., the probability equals 0.20, and for accumulations greater than or equal to 0.25 in., the probability equals 0.36. According to the

[5] National Ocean Service, NOAA, "NOAA Historical Hurricane Tracks," https://oceanservice.noaa.gov/news/historical-hurricanes

[6] National Centers for Environmental Information, NOAA, "Storm Events Database." https://www.ncdc.noaa.gov/stormevents/

applicant, these probabilities correspond to recurrence intervals of once in five years and once in three years, respectively. The applicant also mentioned that glaze ice results in little structural damage when the thicknesses are less than or equal to 0.5 in.; however, these lesser ice thicknesses present concerns for travel in affected areas and can damage above-ground utility wires, when combined with strong winds.

The NRC staff reviewed the paper "A Review of the Effect of Ice Storms on the Power Industry," by William B. Bendel and Dawna Paton,[7] which contains data based on Tattleman and Gringorten (1973), as well as Figure 10-2 of the ASCE/SEI 7-05 standard. Based on this review, the NRC staff finds these references and the information provided by the applicant regarding ice storms to be reasonable for the proposed CRN Site region.

2.3.1.4.3.6.2 Normal and Extreme Winter Precipitation Events

In SSAR Subsection 2.3.1.3.6.2, "Normal and Extreme Winter Precipitation Events," the applicant discussed the climatological data and the methods used to develop site characteristic values for the normal, extreme frozen, and extreme liquid winter precipitation events. In a letter dated April 9, 2018 (ADAMS Accession No. ML18100A950), the applicant committed to updating SSAR Subsection 2.3.1.3.6.2 and SSAR Table 2.0-1 with revised snowfall estimates consistent with the approach and terminology outlined in DC/COL-ISG-007. The NRC staff's review of the proposed updates to SSAR Subsection 2.3.1.3.6.2 and SSAR Table 2.0-1 contained in the April 9, 2018, submittal confirmed that the applicant's evaluations of these climate-related design-basis events follow the guidance in DC/COL-ISG-007 which clarifies the applicable acceptance criteria in SRP Section 2.3.1.

Based on this regulatory guidance, there are four components to be considered in estimating the ground snow load associated with the normal winter precipitation event (i.e., the 100-year return period snowpack (snow depth), the historical maximum snowpack (snow depth), the 100-year return period two-day snowfall event, and the historical maximum two-day snowfall event in the site region). With respect to the 100-year return period snowpack (snow depth), the applicant identified a 50-year recurrence interval ground snow load for the Oak Ridge, TN, area based on Figure 7-1 in ASCE/SEI Standard 7-05, and converted it appropriately to a 100-year recurrence interval value (i.e., 12.2 pounds per square foot (psf)) as discussed elsewhere in that standard.

Regarding the historical maximum snowpack (snow depth) component of the normal winter precipitation event, the applicant identified a ground snow load for the proposed site region of 15.3 psf based on a 19-in. snow depth recorded over a 77-year POR at the first-order NWS station located in Chattanooga, TN. The applicant converted this measured snow depth to a ground snow load in accordance with DC/COL-ISG-007. A designated ground snow load of 21.9 psf, said to represent the historical maximum two-day snowfall event, was based on snowfall (precipitation) measured at the Westbourne, TN, cooperative observing station (i.e., 28 in.), again using the calculation method in DC/COL-ISG-007 and by conservatively assuming the upper limit of the range for snow densities in that guidance.

The applicant also estimated a ground snow load said to be associated with the 100-year return period two-day snowfall event measured at the Knoxville, TN, first-order NWS station. Based

---

ncdc.noaa.gov/stormevents/ | Accessed March 20, 2017.
ffect of Ice Storms on the Power Industry. Environmental Research & Technology, Incorporated.

on the referenced guidance, this 21.1-in. snowfall event is equivalent to a ground-level weight of 16.5 psf.

Consistent with the guidance in DC/COL-ISG-007, the applicant then designated the highest of these four component values (i.e., 21.9 psf, based on the historical maximum two-day snowfall (precipitation) event) as representing the controlling normal winter precipitation event.

With respect to determining the extreme winter precipitation event, the applicant provided estimates for its two components (i.e., the extreme frozen and the extreme liquid winter precipitation events). Based on the guidance in DC/COL-ISG-007, the extreme frozen winter precipitation event is considered to be the higher ground snow load associated with either the 100-year return period two-day snowfall event or the historical maximum two-day snowfall event, in this case designated by the applicant to be 21.9 psf.

The applicant developed the extreme liquid winter precipitation component, represented by the 48-hour PMWP, based on NOAA's HMR No. 53. The 48-hour PMWP value was estimated by logarithmic interpolation between the available 24- and 72-hour PMP plots for the combined months of January-February and for the month of March. The winter season was assumed to include March because historically higher snowpack (snow depths) have occurred in the site region during that month. This resulted in an estimate of 23.5 in. of rain for the 48-hour PMWP.

Finally, consistent with the guidance in DC/COL-ISG-007, the NRC staff notes that the extreme winter precipitation event live roof load is based on the sum of the roof loads associated with the controlling normal winter precipitation event plus the controlling extreme winter precipitation event and is evaluated under Chapter 3 of the COL application.

In a letter dated April 9, 2018 (ADAMS Accession No. ML18100A950), the applicant committed to updating SSAR Subsection 2.3.1.3.6.2 and SSAR Table 2.0-1 with revised snowfall estimates consistent with the approach and terminology outlined in DC/COL-ISG-007. This is **Confirmatory Item 2.3-1**.

Pending the resolution of **Confirmatory Item 2.3-1**, the NRC staff determined that the applicant has used the data resources and analytical approaches established by the guidance in DC/COL-ISG-007 and in SRP Section 2.3.1 in preparing SSAR Subsection 2.3.1.3.6.2. The NRC staff has therefore concluded that the postulated site characteristics associated with normal, extreme frozen, and extreme liquid winter precipitation events are acceptable and reasonably representative of the proposed site region.

2.3.1.4.4 Design Basis Dry- and Wet-Bulb Temperatures

In SSAR Subsection 2.3.1.4, "Design Basis Dry- and Wet-Bulb Temperatures," the applicant based its ambient (dry-bulb) air temperature and humidity site characteristics on an hourly database recorded at the first-order NWS station located at the Chattanooga Lovell Airport. The applicant presented the site characteristic temperature and humidity values in SSAR Table 2.0-1 and in SSAR Subsection 2.3.1.4. In a letter dated April 9, 2018 (ADAMS Accession No. ML18100A950), the applicant committed to updating SSAR Subsection 2.3.1.4 and in SSAR Table 2.0-1 to be more specific in its definition of the dry- and wet- bulb temperature site characteristic values.

The NRC staff used the NCDC hourly data from Chattanooga Lovell Airport (1973–2016) and climate data from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) to verify that the applicant's site-characteristic dry-bulb and wet-bulb temperatures presented in CRN Site SSAR Table 2.0-1, as modified by the April 9, 2018 submittal, are appropriate.

The NRC staff will confirm that the updates to SSAR Subsection 2.3.1.4 and in SSAR Table 2.0-1 provided in the applicant's April 9, 2018, letter are added to the next revision of the SSAR. This is **Confirmatory Item 2.3-2**.

During a public meeting on August 30, 2017, the staff requested that the applicant provide supplemental information regarding the methods used to calculate the 100-year return period coincident wet-bulb temperature for the CRN Site. In a letter dated September 7, 2017 (ADAMS Accession No. ML17257A174), TVA submitted a CD-ROM with 100-year return period wet-bulb temperature input data and spreadsheet files. The staff reviewed the applicant's submittal and the methods used to derive the site characteristic wet-bulb temperatures. Based on this review, the staff found the data and methods presented by the applicant in the aforementioned letter, as well as in the SSAR, are conservative and consistent with the staff's results, and are therefore acceptable.

2.3.1.4.5 Meteorological Data for Evaluating Ultimate Heat Sink

Revision 3 to RG 1.27 states that the UHS should be capable of providing sufficient cooling for at least 30 days. This means that a 30-day cooling water supply should be available and that the design-basis temperatures of safety-related equipment should not be exceeded. Therefore, the meteorological conditions resulting in the maximum evaporative and, if applicable, drift loss of water from the UHS, as well as the meteorological conditions resulting in minimum water cooling, should be considered to ensure that the UHS is available to perform its safety functions.

However, none of the designs in the CRN Site Plant Parameter Envelope (PPE) being evaluated rely on external water sources as the UHS. Therefore, the criteria associated with a UHS water storage facility are not applicable.

2.3.1.4.6 Climate Changes

To be compliant with NRC regulations, nuclear power plants (NPPs) must be built with consideration, in part, of the most severe natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. NPPs are designed with these stipulations on the environmental conditions that are considered at the site. Climate change is a concern because of the potential for unforeseen changes in extreme conditions in the local and regional environment. In SSAR Subsection 2.3.1.6, "Climate Changes," the applicant provided a discussion on the climatology of the Clinch River region with regards to the trends in normal daily mean, maximum, and minimum temperatures and normal maximum precipitation (rainfall).

In SSAR Subsection 2.3.1.6, the applicant analyzed trends in temperature and rainfall normals over a 90-year period for successive 30-year intervals by decade beginning in 1921 (e.g., 1921 through 1950, 1931 through 1960, etc.) for Knoxville and Oak Ridge, TN. The applicant stated that the normal (i.e., 30-year average) temperature showed no significant variation in regional measurements over the 90-year period. The applicant also showed that there has been no significant change in local precipitation (rainfall) during the 90-year period.

NUREG-0800, Section 2.3.1, states that historical data used to characterize a site should extend over a significant time interval to capture cyclical extremes. The NRC staff obtained datasets considered to be of sufficient duration to determine the adequacy of the applicant's proposed site characteristics. For example, snow load was evaluated using a 100-year return period and ambient design temperatures were based on a minimum of 30 years of hourly data and an estimated 100-year return period value. Tornado statistics were based on a 64-year POR and tornado wind speeds represented a 10^{-7} per year return interval as stated in Revision 1 to RG 1.76. Extreme winds were based on a 100-year return period.

The U.S. Global Change Research Program (USGCRP) released a report to the President and Members of Congress in November 2017 titled, "Climate Science Special Report: Fourth National Climate Assessment, Volume I."[8] This report, produced by an advisory committee chartered under the Federal Advisory Committee Act, summarizes the science of climate change and the potential impacts of climate change on the United States.

The USGCRP report found that the average annual temperature of the Southeast U.S. (which includes eastern Tennessee where the proposed Clinch River site is located) did not change significantly over the past century as a whole, but the annual average temperature has risen approximately 1.1 °C (2 °F) since 1970. Climate models predict continued warming in all seasons across the Southeast and an increase in the rate of warming through the end of the 21st century. Average temperatures in the Southeast are projected to rise by 2.2 to 5 °C (4 to 9°F) by the end of the century, depending on assumptions regarding global greenhouse-gas emissions.

The USGCRP report also states that there has been a 0- to 5-percent decrease in observed annual average precipitation from 1986 to 2015 in the region where the proposed Clinch River site is located. Future changes in total precipitation are more difficult to project than changes in temperature. Model projections of future precipitation generally indicated that southern areas of the U.S. will have less precipitation in the summer months and may remain the same the rest of the year. Except for indications that the amount of rainfall from individual hurricanes will increase, climatic models provide divergent results for future precipitation for most of the southeast.

Although not addressed in SSAR Subsection 2.3.1.6, the NRC staff notes that in the USGCRP reports, due to the challenging nature of global tropical cyclone historical data, there is low confidence in any reporting of long-term tropical cyclone activity estimates. The USGCRP report states that "within the period of highest data quality (since around 1980), the globally observed changes in the environment would not necessarily support a detectable trend in tropical cyclone intensity. That is, the trend signal has not yet had time to rise above the background variability of natural processes." The USGCRP report states that likely future changes for the U.S. and surrounding coastal waters include more intense hurricanes with related increases in wind and rain, but not necessarily an increase in the number of these storms that would make landfall and affect the CRN Site.

[8] **USGCRP**, 2017: *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp., doi: 10.7930/J0J964J6.

The USGCRP further states that there is no clear trend in the frequency or strength of tornadoes since the 1950's for the U.S. as a whole. Overall, the number of recorded tornado events has generally increased since detailed records were routinely kept beginning around 1950. However, much of this increase is attributable to a growing population, greater public awareness and interest, and technological advances in detection. The USGCRP states that a recent study suggests a projected increase in the frequency of conditions favorable for severe thunderstorms that may include tornadoes.

The USGCRP reports that the frequency of hail and severe thunderstorm wind events have changed little over the previous decades, and states that confidence in past trends for hail and severe thunderstorm winds is low. Climate models project future increases in the frequency of environmental conditions favorable to severe thunderstorms. But the inability to adequately model the small-scale conditions involved in thunderstorm development remains a limiting factor in projecting the future character of severe thunderstorms and other small-scale weather phenomena.

The NRC staff acknowledges that long-term climatic change resulting from human or natural causes may introduce changes into the most severe natural phenomena reported for the Clinch River Site. However, no conclusive evidence or consensus of opinion is available on the rapidity or nature of such changes. There is a level of uncertainty in projecting future conditions because the assumptions regarding the future level of emissions of heat trapping gases depend on projections of population, economic activity, and choice of energy technologies.

If it becomes evident that long-term climatic change is influencing the most severe natural phenomena reported in the site region, the NRC staff will follow the process described in SECY-16-0144, "Proposed Resolution of Remaining Tier 2 and 3 Recommendations Resulting from Fukushima Dai-Ichi Accident," (ADAMS Accession No. ML16286A552) to address the effects that any changes in the climatological and meteorological environment may have on the design or operating basis for any future COL holders at the CRN Site, with the understanding that the evaluation will be focused on changes in extreme, not average, conditions. The framework outlined in SECY-16-0144 provides a graded approach that allows the NRC staff to proactively, routinely, and systematically seek, evaluate, and respond to new information on natural hazards. Under this framework, the NRC staff will collect, aggregate, review, and assess information related to natural hazards on an ongoing basis. The Commission approved the framework in Staff Requirements Memorandum SRM-SECY-16-0144 (ADAMS Accession No. ML17123A453). The staff finds the applicant's characterization of climate change to be reasonable for informational purposes, as information provided in SSAR Section 2.3.1.6 is not related to, or identified as site characteristics.

2.3.1.4.7 Regional Air Quality Conditions

The applicant's discussion on regional air quality conditions in SSAR Subsection 2.3.1.7 is intended to provide a general understanding of the background and projected air quality conditions in the site region but does not result in the generation of site characteristics for use as a design basis.

2.3.1.4.7.1 Background Air Quality

In SSAR Subsection 2.3.1.7.1, "Background Air Quality," the applicant provided a general discussion of background air quality conditions in the CRN Site region. This included identifying the compliance status of criteria air pollutants for which the EPA has established National Ambient Air Quality Standards (NAAQS) (i.e., carbon monoxide, nitrogen dioxide, ozone, particulate matter less than 10 microns and less than 2.5 microns in aerodynamic diameter (or PM-10 and PM-2.5, respectively), sulfur dioxide, and lead). The applicant did not identify or discuss any differences or commonalities between the NAAQS and AAQS specific to the State of Tennessee.

The proposed CRN Site is located in Roane County, TN. Although not indicated in SSAR Subsection 2.3.1.7.1, pursuant to 40 CFR 81.57 (under Subpart B of Part 81), the site is included in the Eastern Tennessee - Southwestern Virginia Interstate Air Quality Control Region (AQCR) (formerly the Bristol (Virginia) – Johnson City (Tennessee) Interstate AQCR).

Based on the information in 40 CFR 81.343 (under Subpart C of Part 81) and the EPA's "Green Book" (Nonattainment Areas for Criteria Pollutants) current as of June 20, 2017, the NRC staff confirmed the NAAQS attainment status designations as attainment (i.e., currently meets) or unclassifiable / attainment (i.e., meeting the standard or expected to be meeting the standard despite a lack of monitoring data) for all criteria air pollutants. SSAR Table 2.3.1-5, "Ambient Air Quality Concentrations in the Vicinity of Clinch River Nuclear Site in 2013," provides a limited illustration of the compliance status based on ambient monitoring results from Roane and adjacent counties for calendar year 2013 relative to the NAAQS. A small portion of Roane County (which is near, but does not include, the CRN Site) and several adjacent counties are currently designated as non-attainment for the annual and 24-hour PM-2.5 standards.

SSAR Subsection 2.3.1.7.1 also provided a general discussion of two EPA programs designed to protect ambient air quality levels and related characteristics (i.e., in Class 1 areas under the EPA's Prevention of Significant Deterioration of Air Quality program and the Regional Haze Rule). While not associated with any site characteristics listed in SSAR Table 2.0-1, the applicant followed the NRC guidance provided in SRP 2.3.1, therefore the staff finds the information provided in that discussion to be acceptable.

2.3.1.4.7.2 Projected Air Quality

SSAR Subsection 2.3.1.7.2, "Projected Air Quality," briefly indicates that the proposed facility is not expected to be a significant source of criteria air pollutants and air toxic emissions, nor will it significantly impact ambient air quality. If necessary, any applicable air quality permits would have to be acquired in accordance with the regulations and guidance of the appropriate regulatory authorities. The staff finds the applicant's characterization of the projected air quality to be reasonable for informational purposes, as information provided in SSAR Section 2.3.1.7.2 is not related to any site characteristics.

2.3.1.5 Conclusion

As discussed in the preceding subsections, the applicant presented and substantiated information to establish the regional climatological characteristics applicable to the proposed CRN Site. The NRC staff reviewed the information provided and, for the reasons given above, concludes that the applicant has provided appropriate information in their application and has established site characteristics, where applicable, that are acceptable to meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c)(2) and 10 CFR 100.21(d).

The NRC staff finds that the applicant has considered the most severe phenomena historically reported for the site and surrounding area in establishing the above site characteristics. The NRC staff, following the guidance provided in NUREG–0800, Section 2.3.1, and other applicable guidance listed in SER Subsection 2.3.1.3, has accepted the methodologies used to determine the severity of the phenomena reflected in these site characteristics. Accordingly, the staff concludes that the use of these methodologies results in site characteristics containing sufficient margin for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the NRC staff finds acceptable the site characteristics previously identified by the applicant and reviewed by the staff for use in establishing the design bases for SSCs important to safety, as may be proposed in a COL or construction permit (CP) application.

Therefore, the NRC staff concludes that the identification and consideration of the climate-related site characteristics discussed above are acceptable and meet the requirements of 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c)(2), and 10 CFR 100.21(d).

In view of the above, the NRC staff finds the applicant's climate-related site characteristics for the proposed CRN Site to be acceptable.

2.3.2 Local Meteorology

2.3.2.1 Introduction

In SSAR Section 2.3.2, "Local Meteorology," the applicant presented (1) summaries of local (site) meteorological conditions; (2) an assessment of the potential construction and operational influences of the plant and its facilities on the local meteorological conditions; (3) the impact of these modifications on plant design and operation; and (4) a topographical description of the site and its associated surroundings.

2.3.2.2 Summary of Application

In SSAR Section 2.3.2, the applicant provided the following information:

- A description of the local (site) meteorology in terms of airflow, atmospheric stability, temperature, water vapor, precipitation, fog, and potential cooling tower effects.

- An assessment of how the construction and operation of the nuclear power plant and associated facilities that are planned to be built on the proposed site will influence the local meteorology, including the effects of plant structures, terrain modification, and heat and moisture sources resulting from plant operation; and

- A topographical description of the site and its environs.

In Section 2.3.2 of this report, the NRC staff verifies that the applicant has identified and considered the meteorological and topographical characteristics of the site and the surrounding area, as well as changes to those characteristics that may be caused by the construction and operation of the proposed facility.

2.3.2.3 Regulatory Basis

The acceptance criteria, as identified in NUREG–0800, Section 2.3.2, "Local Meteorology," for identifying local meteorological parameters are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the applicant's identification of local meteorological and topographic conditions:

- 10 CFR 52.17(a)(1)(ix), as it relates to the requirement that an applicant perform an evaluation and analysis of a postulated fission product release, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences;

- 10 CFR 100.20(c)(2), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the staff's review of the acceptability of a site;

- 10 CFR 100.21(c), as it relates to the requirement that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that:

  (1) radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite; and

  (2) radiological dose consequences of postulated accidents meet the criteria set forth in 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site;

- 10 CFR 100.21(d), as it relates to the requirement that the physical characteristics of the site, including meteorology, be evaluated and site characteristics established to ensure that the potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site.

To the extent applicable to the above-outlined acceptance criteria included in NUREG-0800, Section 2.3.2, the applicant applied the following NRC-endorsed meteorological monitoring methodologies and techniques:

- RG 1.23, Revision 1, "Meteorological Monitoring Programs for Nuclear Power Plants", which provides criteria for establishing and operating an acceptable onsite meteorological measurements program for the collection of basic meteorological data needed to support plant licensing and operation.

When independently assessing the information presented by the applicant in SSAR Section 2.3.2, the NRC staff applied the same above-cited methodologies and techniques.

2.3.2.4 Technical Evaluation

The NRC staff reviewed SSAR Section 2.3.2 to ensure that the ESP application represents the complete scope of information relating to this review topic. The staff's review confirmed that the applicant addressed the required information relating to local meteorology.

2.3.2.4.1 Local Meteorology

According to the applicant, short-term site-specific meteorological data gathered from the CRN Site meteorological monitoring program during the period from April 21, 2011 to June 30, 2013, was the primary basis for the meteorological dispersion analysis. The applicant also gathered data from previous onsite measurements and climatological records from the first-order NWS stations at Oak Ridge, Knoxville, and Chattanooga, TN, and from the Watts Bar Nuclear Plant (all of which are located in East Tennessee) to provide additional data to establish the representativeness of the two-year onsite monitoring data summaries and potential site conditions.

In addition, the applicant described the topography around the site as a primary influencer on local climate. Based on discussions of the local topography in SSAR Section 2.3.2 and site visits by the NRC staff, the information regarding local climate and the topography are acceptable to the staff.

2.3.2.4.1.1 Normal and Extreme Values of Meteorological Parameters

The applicant examined long-term temperature and precipitation records to determine if data collected at the CRN Site are consistent with regional conditions, both spatially and temporally.

The applicant made comparisons of common measurements from different data periods to determine if site meteorological conditions are changing significantly over time. The comparisons are shown in SSAR Table 2.3.2-2, "Comparisons of Meteorological Tower Measurements," Section a, "Historical Primary Tower Measurements." The applicant stated that most of the common variables (such as wind speed, temperature, and dew point) can be compared directly, but wind direction is too dependent on topography for direct comparison, particularly with offsite data. The applicant stated that the data in SSAR Table 2.3.2-2, Section a, shows that there is generally good agreement between the different data periods and that the differences fall within the normally expected variations. The applicant concluded that the meteorological characteristics for these variables at the CRN Site have not changed significantly over time.

Comparing data from nearby offsite locations (Oak Ridge NWS station and the Watts Bar nuclear station) helps to determine if the CRN Site is consistent with regional conditions. Wind speed, temperature and dew point data were provided by the applicant for the period of April 21, 2011 to June 30, 2012 and are shown in SSAR Table 2.3.2-2, Section b, "Comparison of CRN Site with Offsite Locations." The applicant stated that there is good agreement between the CRN Site and the offsite locations, especially between the average values.

The applicant stated that these comparisons indicate that, for these variables, data from the CRN Site are consistent with overall meteorological conditions in the vicinity. The applicant asserted that this is characteristic of the similarity in controlling synoptic influences throughout the region and that other meteorological parameters are subject to the same synoptic controls.

The NRC staff reviewed data representing meteorological parameters for the CRN Site and surrounding area (data from Chattanooga and Knoxville, TN), and finds the applicant's data and discussion to be acceptable.

2.3.2.4.1.1.1 Winds

In SSAR Subsection 2.3.2.1.1 "Winds," the applicant stated that 10-m (33-ft) wind data were collected by the meteorological tower at the CRN Site during 2011–2013, and that the meteorological facility generally met criteria for obtaining data representative of the atmospheric conditions. However, due to concerns regarding nearby obstructions that exceeded the 1-to-10 height-to-distance criterion specified in Revision 1 to RG 1.23, the applicant stated that an evaluation of these obstructions was performed and the applicant determined these obstructions would have minimal impact on wind measurements at the CRN Site. The staff review of this evaluation is discussed in SER Subsection 2.3.3.4.1.2, "Primary Meteorological Facility."

The applicant stated that the average wind direction and wind speed conditions at the CRN Site are summarized in joint frequency distributions (JFDs) of 10-m (33-ft) wind direction and wind speed and atmospheric stability class (determined as a function of temperature change with height) from instruments at the site and are presented in SSAR Section 2.3.4, "Short-Term (Accident) Diffusion Estimates." The site data are presented as wind roses in SSAR Figures 2.3.2-3 through 2.3.2-28. Wind roses for the Chattanooga NWS station, based on ten years of data (2000–2009), are presented in SSAR Figures 2.3.2-29 through 2.3.2-41. Wind roses for the Oak Ridge NWS station, based on ten years of data (2000–2009), are presented in SSAR Figures 2.3.2-42 through 2.3.2-54.

The applicant described the wind speeds at the CRN Site during 2011–2013 (shown in SSAR Table 2.3.2-3, "Average (Scalar) Wind Speed for Clinch River Nuclear Site (2011-2013)") as generally light with an average 10-m (33-ft) speed of 1.22 m/s (2.74 mph). The highest 10-m (33-ft) hourly average observed speed was 6.75 m/s (15.1 mph). The applicant stated that the geographic orientation of the ridges and valleys generally aligns with the prevailing regional winds from the southwest, but the gaps in the ridges permit wind flow from other directions as well. The SSAR states that the combination of high pressure associated with the Azores-Bermuda anticyclonic circulation and the nearby ridges result in generally light wind speeds with average surface wind speeds for the site less than 1.8 m/s (4 mph). As stated by the applicant in SSAR Section 2.3.2.1.1, "The CRN Site is surrounded by complex terrain, with alternating ridges and valleys oriented along a southwest (SW) to northeast (NE) axis. The local wind patterns are influenced by the complex terrain, with up-valley (SW-WSW)/down-valley (NE-ENE) flow patterns common and stable conditions with light winds frequently observed, especially during the summer and fall seasons. These nonlinear flow patterns influence the dispersion around the CRN Site."

Using hourly data from the onsite meteorological measurements program and spreadsheets, the NRC staff was able to recreate the wind roses and JFDs provided by the applicant. Given the description in SSAR Subsection 2.3.3.2.4, "Data Recording and Display," wind roses and other wind-related data summaries appear to be based on vector-averaged wind directions and scalar-averaged wind speeds. However, the SSAR does not include details on whether the earlier onsite wind data summaries (SSAR Figure 2.3.2-2, “Effects of Topography on Wind Flow in the Clinch River Nuclear Site Vicinity) are based on either scalar- and/or vector-averaged wind direction and wind speed averages as discussed in a letter dated April 9, 2018 (ADAMS Accession No. ML18100A950). Similarly, the applicant’s comparison of onsite to offsite NWS wind roses for Chattanooga (SSAR Figures 2.3.2-29 through 2.3.2-41) and Oak Ridge, TN (SSAR Figures 2.3.2-42 through 2.3.2-54), which may be a composite of both scalar- and vector-averaged wind direction and/or wind speed values, make it difficult to support a determination that the onsite wind direction data are representative of long-term conditions at the site. Due to the complex nature of the terrain surrounding the CRN Site, it is unknown how much of the difference between the onsite and offsite wind roses is due to relative location of the stations, or the data collection and processing methods, or both. However, these differences do not exclude the onsite meteorological data from use in the atmospheric dispersion models since the collection of meteorological data at the site is still the most accurate way to capture the conditions directly influencing accident and routine airborne releases at the site. The Audit Report (ADAMS Accession No. ML18248A113) further discusses the staff’s review of the potential implications of the applicant’s use of vector-averaged wind directions and scalar-averaged wind speeds as input to wind-related data summaries and as input to dispersion modeling analyses.

In describing the wind direction persistence, the applicant stated that generally, the longer the winds blow in the same direction, the lower the dilution potential because effluent is not dispersing significantly to other downwind sectors. Wind direction persistence is an indicator of the duration of atmospheric transport, as summarized by the applicant, from a single 22.5-degree sector, from three adjoining sectors (67.5 degrees in total), and five adjoining sectors (112.5 degrees in total). For the CRN Site, SSAR Table 2.3.2-4, “Wind Direction Persistence for Clinch River Nuclear Site (2011-2013),” shows that the maximum persistence at 10-m (33-ft) is 19 hours from the W sector, 46 hours from the WNW clockwise through the NNW sectors (i.e., ± 1 sector centered on the NW sector), and 106 hours from the SW clockwise through the NW sectors (i.e., ±2 sectors centered on the W sector). The applicant stated that the wind data show a consistent pattern of wind directions with predominant winds from the WSW-NW, and with little seasonal variation (SSAR Figure 2.3.2-55). The applicant concluded that due to the combination of uniformly light winds speeds and surrounding terrain, there will often be little transport away from the site.

Through analysis of data from the onsite meteorological measurements program, the NRC staff independently confirmed the wind direction persistence measurements at the CRN Site, noting, as for the wind rose summaries, that wind direction data represent vector averages.

2.3.2.4.1.1.2 Air Temperature

In SSAR Subsection 2.3.2.1.2, “Air Temperature,” the applicant characterized normal and extreme temperatures for the CRN Site based on temperature data for Knoxville, TN and Oak Ridge, TN. These data are presented in SSAR Tables 2.3.2-5, “Air Temperatures for Knoxville, Tennessee,” and 2.3.2-6, “Air Temperatures for Oak Ridge, Tennessee,” respectively. The normal temperatures ranged from the upper 30s °F in the winter to the upper 70s °F in the summer at both locations. Normal daily maximum temperatures ranged from about 47 °F in mid-winter to about 88 °F in mid-summer. The normal daily minimum temperatures ranged from about 29 °F in mid-winter to about 69 °F in mid-summer. The extreme daily maxima recorded were 105 °F (June and July 2012) at the Knoxville NWS station and 105 °F (July 1952 and June 2012) at the Oak Ridge NWS station, while the extreme daily minima (during January 1985) were -24 °F and -17 °F, respectively. Through independent review of data from these NWS stations,[9] the NRC staff confirmed the temperature discussion provided by the applicant.

2.3.2.4.1.1.3 Atmospheric Moisture

In SSAR Subsection 2.3.2.1.3, "Atmospheric Moisture," the applicant provided long-term relative humidity and absolute humidity data for Knoxville and Oak Ridge. The data are presented in Table 2.3.2-7, "Humidity Values for Knoxville and Oak Ridge, Tennessee," which also lists the mean dry-bulb temperature and mean dewpoint temperature. Short-term humidity data based on measurements at the onsite meteorological facility are summarized in SSAR Table 2.3.2-8, "Humidity Values for Clinch River Nuclear Site." The table also lists the mean dry-bulb temperature and uses Tables 2.3.2-7 and 2.3.2-8 to compare the humidity data among the three sites (Knoxville, Oak Ridge, and CRN Site). The applicant stated that the CRN Site data match well with the long-term data from Knoxville and Oak Ridge.

The NRC staff independently reviewed temperatures and dewpoints from the 2013 Annual Knoxville and Oak Ridge, TN LCD.[10] The staff was able to confirm the data provided by the applicant and therefore finds the temperature and relative humidity data presented by the applicant acceptable.

2.3.2.4.1.1.4 Precipitation

The applicant stated that valid reliable onsite precipitation observations were not available from the CRN Site. Therefore, hourly data collected at the Oak Ridge NWS station (approximately 19.3 km (12 mi) northeast of the CRN Site) is being used as an alternative because it is the nearest data source to the site.

The precipitation data from Oak Ridge are presented in SSAR Table 2.3.2-9, "Historical Precipitation Data for Oak Ridge, Tennessee." The applicant stated that based on the data, precipitation falls an average of about 125 days per year, and the normal annual precipitation is nearly 130 cm (51 in.). The maximum monthly rainfall has ranged from about 17.8 cm (7 in.) to just over 48.2 cm (19 in.). The minimum monthly amount was a trace in 1963. The maximum in 24 hours was 19.0 cm (7.48 in.) in August 1960. The SSAR states that, with the exception of the drier period during late-summer/early-autumn, precipitation is fairly uniformly distributed through the year. July and March are normally the wettest months of the year.

The Oak Ridge precipitation data for the 2011–2013 CRN Site sampling period is presented in SSAR Table 2.3.2-10, "Precipitation (Inches) for Oak Ridge during 2011-2013 From Oak Ridge Monthly Local Climatological Data." The applicant stated that the data indicates wetter than normal precipitation during 2011 and 2013, and drier than normal precipitation during 2012. Overall, precipitation was slightly above normal. Maximum rainfall, estimated by statistical

---

[9] National Centers for Environmental Information, "Local Climatological Data Publication." https://www.ncdc.noaa.gov/IPS/lcd/lcd.html | Accessed June 15, 2017.

[10] National Centers for Environmental Information, "Local Climatological Data Publication." https://www.ncdc.noaa.gov/IPS/lcd/lcd.html | Accessed June 15, 2017.

analysis of regional precipitation data, is presented in SSAR Table 2.3.2-16, “Point Precipitation (Inches) by Recurrence Interval for Region,” for return periods of one to 100 years and for rainfall durations from five minutes to ten days.

The applicant states that for a 100-year return period the point precipitation values for the CRN Site area for 6, 12, 24, and 48 hours are 5.0, 6.0, 6.8, and 8.0 in., respectively. SSAR Subsection 2.3.2.1.4 describes this information as the PMP for the site. The NRC staff does not agree that these values represent the PMP, which is commonly defined as the greatest depth of precipitation meteorologically possible and generally has a recurrence interval much less frequent than 100 years. The PMP values for Maximum Rainfall Rates (as provided in SSAR Table 2.0-1) for the CRN site are discussed in more detail in SER Sections 2.4.2, “Floods,” and 2.4.3, “Probable Maximum Flood (PMF) on Streams and Rivers.”

The applicant stated that approximately 49 thunderstorms occur in a typical year. SSAR Table 2.3.2-9 shows that thunderstorm activity is most predominant in the spring and summer seasons, and the maximum frequency of thunderstorm days is normally in July.

The applicant stated that appreciable snowfall is relatively infrequent in the area of the CRN Site. The snowfall data are summarized in SSAR Table 2.3.2-11, “Historical Snowfall for Knoxville and Oak Ridge, Tennessee.” Normal annual snowfall has ranged from about 6.5 in. at Knoxville to about 11 in. at Oak Ridge, TN. The applicant noted that generally, significant snowfalls are limited to December through March. Respective 24-hour maximum snowfalls have been 18 in. and 12 in. at Knoxville and Oak Ridge.

SSAR Table 2.3.2-12, “Oak Ridge Precipitation by Clinch River Nuclear Site Wind Direction,” shows composite 2011–2013 precipitation data based on Oak Ridge hourly precipitation and CRN Site wind directions. Precipitation is most associated with wind directions from SW clockwise through the NW sectors. There is a secondary maximum with wind directions from NE and ENE sectors. As mentioned for other wind-related data summaries, wind directions appear to be based on vector-averaged data.

Using snowfall and rainfall data from the Knoxville and Oak Ridge NWS stations,[11] the NRC staff verified the precipitation statistics presented in SSAR Subsection 2.3.2 and finds them acceptable.

2.3.2.4.1.1.5 Fog

Fog data for Knoxville and Oak Ridge, TN are presented in SSAR Table 2.3.2-13, “Fog Occurrence for Knoxville and Oak Ridge, Tennessee.” In Subsection 2.3.2.1.5, “Fog,” the applicant stated that these data indicate that heavy fog (visibility ≤ 1/4 mile) occurs about 30 days per year at Knoxville and 52 days per year at Oak Ridge, with autumn normally the foggiest season. The applicant stated that the CRN Site has conditions more similar to those at Oak Ridge.

---

[11] National Centers for Environmental Information, “Local Climatological Data Publication.” https://www.ncdc.noaa.gov/IPS/lcd/lcd.html | Accessed June 15, 2017.

Using the 2013 LCDs for Knoxville and Oak Ridge,[12] the NRC staff confirmed the applicant's assertion that the Oak Ridge station reports approximately 52 days per year with heavy fog observations. The staff agrees that the frequency of fog conditions at Oak Ridge is expected to be similar to that at the proposed CRN Site because of the similarity of topographic features at both locations.

2.3.2.4.1.1.6 Atmospheric Stability

The applicant classified atmospheric stability in accordance with the guidance provided in RG 1.23, Revision 1. Atmospheric stability is a critical parameter for estimating dispersion characteristics as applicable for SSAR Sections 2.3.4 and 2.3.5, "Long-Term (Routine) Diffusion Estimates." Dispersion of effluents is greatest for extremely unstable conditions (i.e., Pasquill stability class A) and decreases progressively through extremely stable conditions (i.e., Pasquill stability class G) as discussed in RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants."

The applicant based its stability classification on temperature change with height (i.e., delta-temperature or $\Delta T/\Delta Z$) between the 60-m (197-ft) and 10-m (33-ft) heights, as measured by the CRN Site onsite meteorological monitoring program between June 1, 2011 and May 31, 2013. In SSAR Table 2.3.2-14, "Pasquill Atmospheric Stabilities for the Clinch River Nuclear Site," the applicant provided the percent occurrence of Pasquill atmospheric stability classes (by quarter) for the 2-year period. The table shows that there is a predominance of neutral (Pasquill stability class D) and slightly stable (Pasquill stability class E) conditions at the proposed CRN Site. Extremely unstable conditions (Pasquill stability class A) occur about 3 percent of the time. Extremely stable conditions (Pasquill stability class G) occur about 17 percent of the time. Based on the staff's past experience with stability data at various sites, a predominance of neutral (Pasquill stability class D) and slightly stable (Pasquill stability class E) conditions at the proposed CRN Site is generally consistent with expected meteorological conditions.

Through analysis of the hourly data from the onsite meteorological measurements program, collected from June 1, 2011 through May 31, 2013, the NRC staff independently confirmed the atmospheric stability measurements at the proposed CRN Site, and thus finds the applicant's data and discussion acceptable.

2.3.2.4.2 Potential Influence of the Plant and Its Facilities on Local Meteorology

The staff has found through previous COL and ESP reviews that the associated paved, concrete, or other improved surfaces resulting from the construction of the proposed nuclear facility are insufficient to generate discernible long-term effects on local-scale meteorological conditions. Wind flow may be altered immediately adjacent to and downwind of larger site structures, but these effects will likely dissipate within 10 structure heights downwind. Although temperature may increase above altered surfaces at the proposed CRN Site, the effects will be too limited in their vertical profile and horizontal extent to alter local- or regional-scale ambient temperature changes. Due to the limited and localized nature of the expected modifications associated with the proposed plant structures and the associated improved surfaces, the staff

[12] National Centers for Environmental Information, "Local Climatological Data Publication." https://www.ncdc.noaa.gov/IPS/lcd/lcd.html | Accessed June 15, 2017.

concludes that the proposed facility will not have significant impacts on local meteorological conditions.

The SSAR stated that the cooling tower evaluation for the CRN Site assumes that the site will include two Linear Mechanical Draft Cooling towers. The plume from these towers was evaluated by the applicant in the CRN Site ESP SSAR using the Electric Power Research Institute sponsored Seasonal/Annual Cooling Tower Impact (SACTI) computer model. The SSAR also stated that in addition to the plume, small water droplets associated with the circulating water and containing dissolved solids, known as drift, may be emitted from the cooling towers. These may eventually deposit on the local surroundings including land surfaces, buildings and vegetation.

The NRC staff inspected the input and output files provided by the applicant for the SACTI computer code for estimating the impacts from fogging, icing, and drift deposition from the operation of the mechanical draft cooling towers. The staff found that there is a minimal threat of fogging and icing in the vicinity immediately surrounding the cooling towers. The applicant also stated that a small amount of dissolved and suspended solids may result in solid particle deposition on the surface, primarily in close proximity to the plant. The staff has confirmed that two months of salt accumulation would result in 0.0422 milligrams per cubic ($mg/cm^2/mo$) on the switchyard, which is near the lower end of the "Light Contamination Level" range defined by the Institute of Electrical and Electronic Engineers (IEEE) standard.[13] The staff concludes that total accumulation reaching amounts that require mitigation is highly unlikely due to local precipitation removing any salt deposits before it reaches a level of concern. The highest salt deposition amounts at 300 m from the cooling towers occurred to the west and had a total salt deposition of 0.0605 $mg/cm^2/2$-mo. The staff confirmed the information presented in this SSAR section. The staff finds the applicant's conclusion acceptable.

At the COL or CP stage, if the applicant chooses a plant design that requires the use of an UHS cooling tower, the applicant will need to verify the appropriate meteorological characteristics (i.e., maximum evaporation and drift loss and minimum water cooling conditions) used to evaluate the design of the chosen UHS cooling tower. In accordance with 10 CFR 52.17(a)(1)(iii), "Contents of applications; general information," at the time of the COL or CP application, the applicant will provide information on the type of cooling system that may be associated with each facility; if the plant design uses an UHS, characteristics of the UHS will be provided. As such, the staff identified the following COL Action Item:

COL Action Item 2.3-1: An applicant for a COL or a CP referencing this ESP should verify the cooling tower plume characteristics described in the ESP. Future COL or CP applications referencing this ESP should also include an evaluation of the cooling tower plume impacts on the switchyard, as designed, and any impacts on safety-related air intakes and the adjacent cooling tower.

2.3.2.4.3 Local Meteorological Conditions for Design and Operating Bases

The local meteorological conditions for the design and operational bases were provided by the applicant in SSAR Section 2.3.1 and are reviewed by the NRC staff in SER Section 2.3.1.

---

[13] IEEE Guide for Application of Power Apparatus Bushings, IEEE Standard C.57.19.100-1995, Aug 1995.

2.3.2.5 Conclusion

As discussed above, the applicant 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 or plants, falling within the applicant's PPE, that might be constructed on the proposed CRN Site. The NRC staff reviewed the 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 52.17(a)(1)(ix), 10 CFR 100.20(c)(2), 10 CFR 100.21(c), and 10 CFR 100.21(d), and are sufficient to determine the acceptability of the site.

2.3.3 Onsite Meteorological Measurements Program

2.3.3.1 Introduction

In Section 2.3.3 of the SSAR, "Onsite Meteorological Measurements Program," the applicant presented information concerning the onsite meteorological measurements program in support of its ESP application.

2.3.3.2 Summary of Application

In SSAR Section 2.3.3, the applicant provided the following information:

- a description of meteorological instrumentation, including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the quality assurance (QA) program for sensors and recorders, and data acquisition and reduction procedures;
- hourly meteorological data, including consideration of the POR and amenability of the data for use in characterizing atmospheric dispersion conditions.

2.3.3.3 Regulatory Basis

The acceptance criteria for the development and implementation of an onsite meteorological program are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the applicant's development and implementation of an onsite meteorological program:

- 10 CFR 52.17(a)(1)(ix), as it relates to the requirement that an applicant perform an evaluation and analysis of the postulated fission product release, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences;
- 10 CFR 100.20(c)(2), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the staff's review of the acceptability of a site;

- 10 CFR 100.21(c), as it relates to the requirement that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that:

  (1) radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite, and

  (2) radiological dose consequences of postulated accidents meet the criteria set forth in 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site.

The assessment and conclusions made in this section, regarding the adequacy of onsite meteorological instrumentation (including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the QA program for sensors and recorders, and data acquisition and reduction procedures), are pertinent to the NRC staff's evaluation, in SER Chapter 13 of the applicant's proposed emergency plan, in accordance with the requirements of 10 CFR 50.47, "Emergency Plans," and 10 CFR Part 50, Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities."

The development and implementation of an onsite meteorological program is necessary for the collection of onsite meteorological information. This information is necessary for the applicant to demonstrate compliance with the numerical guides for doses contained in 10 CFR Part 50, 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."

The following RG is applicable to this section:

- RG 1.23, Revision 1, which provides criteria for establishing and operating an acceptable onsite meteorological measurements program for the collection of basic meteorological data needed to support plant licensing and operation.

The related acceptance criteria from Section 2.3.3 of NUREG–0800, Onsite Meteorological Measurements Program," are as follows:

- The preoperational and operational monitoring programs should be described, including: (1) a site map (drawn to scale) that shows tower location and true north with respect to man-made structures, topographic features, and other features that may influence site meteorological measurements; (2) distances to nearby obstructions of airflow in each downwind sector; (3) measurements made; (4) elevations of measurements; (5) exposure of instruments; (6) instrument descriptions; (7) instrument performance specifications; (8) calibration and maintenance procedures and frequencies; (9) data output and recording systems; and (10) data processing, archiving, and analysis procedures.

- Meteorological data should be presented in the form of JFDs of wind speed and wind direction by atmospheric stability class in the format described in RG 1.23, Revision 1. An hour-by-hour listing of the hourly-averaged parameters should be provided in the format described in RG 1.23, Revision 1. If possible, evidence of how well these data represent long-term conditions at the site should also be presented, possibly through comparison with offsite data.

- At least two consecutive annual cycles (and preferably three or more whole years), including the most recent 1-year period, should be provided with the ESP application. These data should be used by the applicant to calculate: (1) the short-term atmospheric dispersion estimates for accident releases discussed in SER Section 2.3.4; and (2) the long-term atmospheric dispersion estimates for routine releases discussed in SER Section 2.3.5.

The applicant should identify and justify any deviations from the guidance provided in RG 1.23, Revision 1.

2.3.3.4 Technical Evaluation

Using the approaches and methodologies described in NUREG–0800, Section 2.3.3, the NRC staff reviewed the ESP application. The applicant used the pre-application onsite meteorological measurements program at the CRN Site to collect data. At the COL stage, the applicant should update the description of the proposed operational onsite meteorological measurements program at the time of the COL application in accordance with Subsection C.I.2.3.3 of RG 1.206, “Onsite Meteorological Measurements Program.”

2.3.3.4.1 Onsite Meteorological Measurements Program

2.3.3.4.1.1 Meteorological Measurements History

To support the CRN Site ESP application, the 110 meter (m) primary meteorological tower was reactivated to collect meteorological data at the 10- and 60-m levels from June 1, 2011 through May 31, 2013. This tower was originally operated to support the construction of the Clinch River Breeder Reactor Project. The 110 m primary tower used to collect this data was removed at the end of the observation period. A new tower will be installed to collect data during the CRN Site operational phase as stated in SSAR Subsection 2.3.3.1, “Meteorological Measurements History.”

2.3.3.4.1.2 Primary Meteorological Facility

The staff requested the applicant in RAI Letter No. 9 (eRAI-8972, Question 30256, ADAMS Accession No. ML17237A195), to provide a description of the type of meteorological tower used to collect data and the location of the wind and temperature sensors on the tower. The applicant provided a response to the RAI on September 25, 2017 (ADAMS Accession No. ML17268A391), which contained the requested information, and applicant subsequently updated the SSAR with this information. The staff confirmed that the applicable information provided in applicant’s letter dated September 25, 2017, was included in Revision 1 of the SSAR and therefore, this RAI is closed.

The applicant provided a narrative of the onsite meteorological monitoring system in SSAR Subsection 2.3.3.2. According to the applicant, the primary meteorological tower is an open-lattice tower with observation equipment mounted at heights of 10 and 60 m above ground level. Measured data include wind speed and direction at 10 and 60 m, temperature at 10 and 60 m, differential temperature between 60 and 10 m, dewpoint temperature (calculated based on the coincident ambient temperature and relative humidity measurements) at 10 and 60 m, and precipitation and solar radiation at the tower base (ground level). The wind sensors were mounted on booms extending more than 2 tower widths from the tower and the temperature and dewpoint sensors were mounted in downward pointed radiation shields 1.5 tower widths from the tower. After reviewing the information provided by the applicant, the staff finds that these sensor mounts met Revision 1 to RG 1.23 criteria and precluded the tower from affecting the wind and temperature measurements.

The applicant also explained that the base of the meteorological tower is at an elevation 7 m below plant grade and is located approximately 830 m south-southeast of the expected plant site. The applicant stated that an environmental data station, located in close proximity to the meteorological tower, housed the data processing and recording instrumentation, as well as a system of lightning and surge protection circuitry and proper grounding.

RG 1.23, Revision 1 indicates that obstructions to airflow (such as buildings) should be located at least 10 obstruction heights from the meteorological tower to prevent adverse building wake effects. As described in SSAR Subsection 2.3.3.2, there are two obstructions to wind flow near the onsite meteorological tower that have been evaluated and were determined to have a minimal impact on the wind measurements. The applicant describes these obstructions as a lattice structure transmission tower approximately 120 m northeast of the primary tower and a row of trees approximately 70 m southeast of the tower. Images of these obstructions are provided in SSAR Figure 2.3.3-2, "Primary Met Tower Wind Obstructions." The locations of the obstructions with respect to the tower is shown in SSAR Figure 2.3.3-1, "Map of Obstructions Related to Primary Met Tower." The NRC staff reviewed the figures provided by the applicant and viewed the tower location during a site audit (ADAMS Accession No. ML17226A023). Due to the distance from the meteorological tower, and the relatively small cross-sections of the obstructions, the staff finds it reasonable to conclude that the obstructions had little to no impact on the meteorological observations.

2.3.3.4.1.2.1 Instrument Maintenance

In SSAR Subsection 2.3.3.2.5, "Equipment Servicing, Maintenance, and Calibration" the applicant provided a description of how often the meteorological equipment is inspected and serviced. The applicant stated that most equipment is calibrated or replaced at least every six months. The NRC staff reviewed this information and concludes that the instrument maintenance practices, as described in SSAR Subsection 2.3.3.2.5, conform to the guidance provided in RG 1.23, Revision 1. Accordingly, the staff finds these descriptions acceptable.

2.3.3.4.1.2.2 Data Collection and Analysis

In SSAR Subsection 2.3.4.2, "Calculation Methodology and Assumptions," the applicant discussed the meteorological data and its acceptable use for atmospheric dispersion analysis. For the 2011-2013 data set, the average data recovery rates were above the 90-percent criterion established in Revision 1 of RG 1.23 for all variables. The SSAR stated that the operational meteorological program will be consistent with the guidance in RG 1.23 to maintain 90-percent recoverability for all of the data collected. The NRC staff reviewed the applicant's meteorological dataset and confirms that each measured parameter exceeded the 90-percent recovery criterion. The meteorological data are scanned periodically and the data values are stored as stated in SSAR Subsection 2.3.3.2.4, "Data Recording and Display."

The staff performed a quality review of the 2011 - 2013 hourly meteorological database using the methodology described in NUREG–0917, "Nuclear Regulatory Commission Staff Computer

Programs for Use with Meteorological Data," issued July 1982. The staff's examination of the data revealed generally stable and neutral atmospheric conditions at night and unstable conditions during the day. Wind speed, wind direction, and stability class frequency distributions for each measurement channel were reasonable. As discussed in SER Section 2.3.2, the staff verified and was able to reproduce the lower- and upper-level JFDs and wind roses provided by the applicant.

Revision 1 to RG 1.23, Section B (Discussion), Paragraph 5, specifically references American National Standards Institute / American Nuclear Society (ANSI/ANS) Standard 3.11-2005, "Determining Meteorological Information at Nuclear Facilities," with respect to best practices for onsite meteorological measurements programs at commercial nuclear power plants. Section 5.3.1 of ANSI/ANS-3.11-2005 states that the transport wind direction for straight-line Gaussian models should be based on the scalar mean (or unit vector) wind direction. The PAVAN and XOQDOQ atmospheric dispersion models used in SSAR Sections 2.3.4 and 2.3.5 are straight-line Gaussian models.

The staff requested the applicant in RAI Letter No. 9 (eRAI-8972, Question 30595, ADAMS Accession No. ML17237A195) to clarify the collection and use of scalar- versus vector-averaged wind speed and wind direction values. The applicant provided a response to the RAI on September 25, 2017 (ADAMS Accession No. ML17268A391), which stated that scalar meteorological data were used to develop the wind roses in SSAR Section 2.3.2 and to prepare the JFDs used as input to the straight-line Gaussian dispersion models discussed in SER Subsections 2.3.4 and 2.3.5. However, in its response, the applicant did not provide the requested justification regarding why the chosen type of wind direction and/or wind speed data (i.e., scalar and/or vector average) were used to generate wind-related data summaries and model input data.

Because the applicant used vector-averaged wind direction data as input to these straight-line Gaussian dispersion models, the NRC staff contends that the applicant did not follow the best practice guidance described in RG 1.23 (and by extension ANSI/ANS 3.11-2005) and the SRP. The applicant voluntarily provided a submittal on April 9, 2018 (ADAMS Accession No. ML18100A950), which evaluated the effects of having used vector-averaged wind directions in lieu of scalar-averaged wind directions on the results of the accident and routine release atmospheric dispersion estimates presented in SSAR Sections 2.3.4 and 2.3.5.

With respect to the accident-related dispersion estimates, the applicant's analysis showed that the modeling results were conservatively higher based on the use of vector-averaged wind directions. Regarding the modeling of airborne routine radiological releases, the applicant acknowledged that atmospheric dispersion and deposition factors were greater in some directions and lower in others using scalar-averaged wind directions. Consequently, the applicant evaluated the associated normal radiological doses. The applicant concluded that for normal (as well as accident) gaseous release dose assessments, the existing analyses included in the ESP application, which are based on vector-averaged wind directions, is conservative and remains the basis of the CRN Site ESP application.

The NRC staff conducted an audit (ADAMS Accession No. ML18122A219) of the calculation packages that supported the applicant's April 9, 2018, voluntary submittal related to comparing the results of the offsite accident and routine release dispersion modeling analyses and the resulting radiological doses using vector- versus scalar-averaged wind directions and scalar-averaged wind speeds as meteorological input. The audit report (ADAMS Accession No.

ML18248A113) documents the staff's review and conclusion that the applicant's calculations supported its April 9, 2018, submittal and the applicant's position that the doses from airborne accident and normal releases presented in the SSAR, calculated using vector-averaged wind direction data, are bounding.

Because the applicant provided adequate justification for using vector-averaged wind direction data along with scalar-averaged wind speed data for determining the accident and routine release atmospheric dispersion and deposition factors (i.e., the resulting doses as presented in the SSAR are bounding), the NRC staff concludes that eRAI-8972, Question 30595, is closed. However, Subsection 2.3.3.5 further discusses the limitation of this conclusion to the CRN site and to the two-year POR of onsite meteorological data referenced in the SSAR.

2.3.3.4.1.3 Operational Meteorological Program

In SSAR Subsection 2.3.3.3, "Operational Meteorological Program," the applicant stated that a new tower will be installed to collect data during the CRN Site operational phase and the resulting meteorological program will be consistent with the guidance given in RG 1.23. The meteorological monitoring system used to collect onsite measurements for the ESP application was dismantled and removed after collecting the necessary data. To ensure that any future onsite meteorological measurement system used for a COL or a CP application is consistent with the system described in the ESP, the staff identified the following COL Action Items:

COL Action Item 2.3-2: An applicant for a COL or a CP referencing this ESP should verify that the onsite meteorological measurement system, including the instrument tower, expected at the site prior to operation, is as described in SSAR Section 2.3.3. Any differences in instrumentation, exposure, or siting should be identified and discussed in order to demonstrate that the meteorological measurements program continues to meet the guidance provided in RG 1.23.

COL Action Item 2.3-3: An applicant for a COL or a CP referencing this ESP should verify whether the operational phase of the onsite meteorological measurements program will include wind data averaging on the basis of scalar or vector averages.

COL Action Item 2.3-4: An applicant for a COL or a CP referencing this ESP should identify and justify the wind speed and direction averaging approach(es) (either vector or scalar) to be used in the COL or CP:

1. for modeling accident-related Control Room and Technical Support Center (TSC) atmospheric dispersion; and

2. to be used during the operational phase to support emergency planning.

2.3.3.4.2 COL Action Items Related to the On-Site Meteorological Measurements Program

The CRN Site ESP application, Part 5A, "Emergency Plan (Site Boundary EPZ)," describes the information "to ensure compatibility of the proposed emergency plans (for onsite areas) with facility design features, site layout, and site location." This Part is based on TVA's "Nuclear Power Radiological Emergency Plan (NP-REP)", which has been approved by the NRC for use at all of the TVA operating nuclear facilities. In accordance with 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," Part 5A addresses the emergency planning requirements of Appendix E to 10 CFR Part 50, Section III, the “Final Safety Analysis Report; Site Safety Analysis Report.” 10 CFR Part 50, Appendix E (III) states, “[t]he final safety analysis report or the SSAR for an early site permit that includes major features of emergency plans under 10 CFR 52.17(b)(2)(i) of this chapter shall contain the plans for coping with emergencies.”

The CRN Site Emergency Management Organization is divided into two categories; the Onsite Organization and the Offsite Emergency Organization, which are designated as Central Emergency Control Center (CECC) staff. The CECC is responsible for directing and coordinating the overall TVA response to an emergency condition. The following positions within the CECC are responsible for meteorological data and analysis:

- Radiological Assessment Coordinator (ESP Part 5A, Section 3.3.17): Coordinates dose assessment, environs, and meteorological assessment activities in the Radiological Assessment Area located in the CECC; ensures that information is provided to the TSC on dose projections, environs measurements, and meteorological conditions.

- Meteorologist (ESP Part 5A, Section 3.3.20): Coordinates the analysis of environs samples with the Western Area Radiological Laboratory (WARL); evaluates meteorological data and develops forecasts which may be used for dose assessment and other emergency preparedness activities; reviews adequacy of observed data and replaces missing or invalid observations; makes forecasts of dispersion conditions that affect radiological effluents; provides dispersion knowledge to dose assessment staff; prepares other meteorological forecasts needed for emergency preparedness activities.

These items will be addressed by the COL applicant in the COLA, and the requirements will be met by way of fulfilling COL Action Item 13.3-1. This COL Action Item is addressed in Section 13.3, “Emergency Planning,” of this report.

2.3.3.5 Conclusion

As discussed above, the applicant presented and substantiated information to establish the onsite meteorological monitoring program and the resulting database in support of the CRN Site ESP application. The NRC staff reviewed the information provided and, for the reasons given above, concludes that the onsite meteorological monitoring system provided adequate data to represent onsite meteorological conditions as required by 10 CFR 100.20 and 10 CFR 100.21. The onsite data also provide an acceptable basis for: (1) making estimates of atmospheric dispersion for design-basis accident releases and routine releases from a nuclear power plant or plants that might be constructed on the proposed site; and (2) meeting the requirements of 10 CFR Part 20, 10 CFR Part 50, Appendix I and 10 CFR Part 100.

However, the applicant’s use of vector-averaged wind directions and scalar-averaged wind speeds as input to the accident and routine release dispersion modeling analyses in SSAR Sections 2.3.4 and 2.3.5, respectively, and for developing wind-related data summaries in SSAR Section 2.3.2, introduced uncertainties as discussed in the NRC staff’s Audit Report evaluating its potential implications (see ADAMS Accession No. ML18248A113). Further, the NRC staff maintains that this approach is a departure from the guidance in RG 1.23. Therefore, the NRC staff’s acceptance of the offsite accident and routine release dispersion modeling analyses, the corresponding downstream dose estimates, and wind-related data summaries presented in the SSAR for the CRN Site is limited to this site only and to the two-year POR of onsite meteorological data referenced in the SSAR.

2.3.4 Short-Term Atmospheric Dispersion Estimates for Accident Releases

2.3.4.1 Introduction

Short-term dispersion estimates are used to determine the amount of airborne radioactive materials expected to reach a specific location during an accident situation. These dispersion estimates address the requirement for conservative atmospheric dispersion (relative concentration) factor (χ/Q value) estimates at the exclusion-area boundary (EAB) and at the outer boundary of the low-population zone (LPZ) for postulated design-basis accidental radioactive airborne releases.

2.3.4.2 Summary of Application

In SSAR Section 2.3.4, the applicant presented this specific information on atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and the outer boundary of the LPZ:

- an atmospheric transport and diffusion model to calculate dispersion estimates (atmospheric dispersion factors, relative concentrations, or χ/Q values) for postulated accidental radioactive releases,

- meteorological data summaries used as input to this dispersion model,

- diffusion parameters,

- determination of χ/Q values used for assessment of consequences of postulated radioactive atmospheric releases from design-basis accidents.

2.3.4.3 Regulatory Basis

The acceptance criteria identified in NUREG–0800, Section 2.3.4 for calculating atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the applicant’s calculations.

- 10 CFR 52.17(a)(1)(ix), as it relates to the requirement that an applicant perform an evaluation and analysis of the postulated fission product release, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences;

- 10 CFR 100.20(c)(2), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the staff’s review of the acceptability of a site;

- 10 CFR 100.21(c)(2), as it relates to the requirement that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that radiological dose consequences of postulated accidents meet the criteria set forth in 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site.

The related acceptance criteria from NUREG–0800, Section 2.3.4 are as follows:

- a description of the atmospheric dispersion models used to calculate χ/Q values for accidental releases of radioactive and hazardous materials to the atmosphere.
- 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.
- a discussion of atmospheric diffusion parameters, such as lateral and vertical plume spread (i.e., σ_y and σ_z, respectively) as a function of distance, topography, and atmospheric conditions, should be related to measured meteorological data.
- hourly cumulative frequency distributions of χ/Q values from the effluent release point(s) to the EAB and LPZ should be constructed to describe the probabilities of these χ/Q values being exceeded.

The following RGs apply to this section:

- RG 1.23, Revision 1, which provides criteria for establishing and operating an acceptable onsite meteorological measurements program for the collection of basic meteorological data needed to support plant licensing and operation.
- RG 1.145, Revision 1, as it relates to the use of dispersion models.

2.3.4.4 Technical Evaluation

The NRC staff reviewed SSAR Section 2.3.4 to ensure that the CRN Site ESP application includes the complete scope of information relating to this review topic. The staff's review confirmed that the application addresses the required information relating to the short-term dispersion estimates.

To evaluate atmospheric dispersion characteristics with respect to airborne radiological releases, detailed design information (e.g., vent heights, intake heights, and distance and direction from release vents to the control room and TSC) is necessary. Since the ESP application uses a plant parameter envelope, and therefore little detailed and specific design information is available at this stage for the nuclear power plant or plants that might be constructed on the proposed site, a COL or CP applicant citing this ESP will need to assess the dispersion of airborne radioactive materials to the control room and TSC in any future COL or CP.

2.3.4.4.1 Atmospheric Dispersion Model

In its application, the applicant used the 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 χ/Q values at the EAB and at the outer boundary of the LPZ for potential accidental releases of radioactive material. The

PAVAN model implements the methodology outlined in RG 1.145, Revision 1, as described in SSAR Subsection 2.3.4.2.

The PAVAN code estimates χ/Q values for various time-average periods ranging from 2 hours to 30 days. The meteorological input to PAVAN consists of a JFD of hourly values of wind speed and wind direction by atmospheric stability class. The χ/Q values calculated through PAVAN are based on the theoretical assumption that material released to the atmosphere will be normally distributed (Gaussian) about the plume centerline. A straight-line trajectory is assumed between the point of release and all distances for which χ/Q values are calculated.

For each of the 16 downwind direction sectors (e.g., N, NNE, NE, ENE), PAVAN calculates χ/Q values for each combination of wind speed and atmospheric stability at the appropriate downwind distance (e.g., the EAB and the outer boundary of the LPZ). The χ/Q values calculated for each sector are then ordered from greatest to smallest and an associated cumulative frequency distribution is derived based on the frequency distribution of wind speed and stabilities for each sector. The smallest χ/Q value in a distribution will have a corresponding cumulative frequency equal to the wind direction frequency for that particular sector. PAVAN determines for each sector an upper envelope curve based on the derived data (plotted as χ/Q versus probability of being exceeded) such that no plotted point is above the curve. From this upper envelope, the χ/Q value, which is equaled or exceeded 0.5 percent of the total time, is obtained. The maximum 0.5 percent χ/Q value from the 16 sectors becomes the 0-to-2-hour "maximum sector χ/Q value".

Using the same approach, PAVAN also combines all χ/Q values independent of wind direction into a cumulative frequency distribution for the entire site. An upper envelope curve is determined, and the program selects the χ/Q value which is equaled or exceeded 5.0 percent of the total time. This is known as the 0-to-2-hour "5-percent overall site χ/Q value."

The larger of the two χ/Q values, either the 0.5-percent maximum sector-dependent value or the 5-percent overall site value, is selected to represent the χ/Q value for the 0-to-2-hour time interval (note that this resulting χ/Q value is based on 1-hour averaged data but is conservatively assumed to apply for 2 hours).

To determine χ/Q values for longer time periods during an accident scenario (i.e., 0 to 8 hours, 8 to 24 hours, 1 to 4 days, and 4 to 30 days), PAVAN performs a logarithmic interpolation between the 0-to-2-hour χ/Q values and the annual average χ/Q values for each of the 16 sectors and the overall site. For each time period, the highest χ/Q value from among the 16 sectors and the overall site is identified and becomes the short-term site characteristic χ/Q value for that time period.

2.3.4.4.2 Meteorological Data Input

The meteorological input to PAVAN used by the applicant consisted of a JFD of wind speed, wind direction, and atmospheric stability based on hourly onsite data from June 1, 2011, through May 31, 2013, as described in SSAR Subsection 2.3.4.4.1. The wind data were obtained from the 9.78-m (32.1-ft) (nominal 10 m) level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken at the 59.22-m (194.3-ft) (nominal 60 m) and 9.78-m (32.1-ft) levels of the onsite meteorological tower.

The NRC staff independently developed an annual wind rose for each level of the meteorological tower from the hourly meteorological database provided by the applicant. The onsite wind roses developed by the staff and the onsite and offsite wind roses provided by the applicant in SSAR Figures 2.3.2-3 through 2.3.2-54 show high frequencies of winds from the west-southwest through the northwest (clockwise). As stated in Section 2.3.2 of this report, this is generally consistent with the wind patterns recorded in the site region.

The wind rose presented in SSAR Figure 2.3.2-3, "Wind Rose Clinch River Nuclear Site 10 m All Data," depicts the wind patterns and wind speeds for all 16 wind direction sectors. The figure also states that the wind was calm 24.85 percent of all hours recorded. The NRC staff compared the number of calms in the wind rose to the JFDs included in SSAR Tables 2.3.4-2 through 2.3.4-8. The NRC staff determined that the wind rose in the SSAR followed the guidance provided in Table 3 of Revision 1 to RG 1.23, and defined any wind speed below the 0.5 m/s (1.1 mph) threshold as "calm." The JFD tables in SSAR Section 2.3.4 provide a summary of the wind speed distribution by stability class. The wind speeds rendered as "CALM" in SSAR Figure 2.3.2-3 are accounted for by the first three winds speed classes in the referenced JFD tables (i.e., CALM (0.0 mph), greater than 0.0 mph and less than or equal to 0.50 mph, and greater than 0.50 mph to less than or equal to 1.10 mph). The staff noted and accounted for the different units of measure between the wind roses and the JFD tables in the SSAR.

As discussed in Sections 2.3.2 and 2.3.3 of this report, the staff considers the 2011-2013 onsite meteorological database suitable for input to the PAVAN model. During an audit of documents added to the CRN Site electronic reading room (ERR) conducted during May 2018 (ADAMS Accession No. ML18248A113), the staff reviewed JFDs derived using scalar-averaged wind speed and direction. The staff determined that the scalar-averaged wind speed and wind direction frequencies used in the PAVAN dispersion model as provided in the ERR show some differences when compared against the scalar-averaged wind speed and vector-averaged wind direction data provided in the CRN Site ESP SSAR. However, because the controlling accident-related χ/Q value and the resulting dose calculations based on vector-averaged wind directions remain the bounding value, the staff finds the meteorological data provided in the SSAR, confirmed during the audit, and as documented in the audit report, to be acceptable. Further details are discussed in SER Subsections 2.3.3.4.1.2.2 and 2.3.4.4.4.

2.3.4.4.3 Diffusion Parameters

The applicant chose to implement the diffusion parameter assumptions outlined in RG 1.145 as a function of atmospheric stability for its PAVAN model runs, as described in SSAR Subsection 2.3.4.2. The NRC staff evaluated the applicability of the PAVAN diffusion parameters and concluded that no unique topographic features (such as rough terrain, restricted flow conditions, or coastal or desert areas) preclude the use of the PAVAN model for the CRN Site at the EAB and outer boundary of the LPZ. Therefore, the staff finds the applicant's use of diffusion parameter assumptions, as outlined in RG 1.145, acceptable.

2.3.4.4.4 Conservative Short-Term Atmospheric Dispersion Estimates for EAB and LPZ

The applicant modeled one ground-level release point and did not take credit for building wake effects, as described in SSAR Subsection 2.3.4.2. SSAR Table 2.0-2 lists the ground-level release point elevation as a design parameter for any future uses of this ESP. Not accounting for building wake effects for a ground-level release decreases the amount of atmospheric turbulence assumed to be in the vicinity of the release point, resulting in higher (more conservative) χ/Q values. A ground-level release assumption is, therefore, acceptable to the NRC staff.

The applicant described the EAB to be an ellipse fixed completely within the CRN property boundary that encompasses the nuclear island and the analytical EABs, as described in SSAR Subsection 2.3.4.2. The CRN Site SSAR describes the EAB as follows:

> RG 1.145 requires that, for each of the 16 compass sectors, the distance to the EAB should be the minimum distance between the release point and the EAB within a 45-degree sector centered on the compass direction of interest. For conservatism and simplicity, the effluent release point is evaluated as a circular effluent release boundary (ERB) that encloses potential release points from the nuclear island as shown in Figure 2.3.4-1 [reproduced below as Figure 2.3-2]. A circular analytical EAB is established 1100 ft (335 m) from the ERB. For χ/Q modelling (SSAR Table 2.3.4-11), the analytical EAB is used as a bounding representative distance to the EAB. To account for multiple units on site, nuclear islands are positioned at multiple locations within the power block area with associated ERBs and EABs as shown in SSAR Figure 2.3.4-1. The analytical EABs can be encompassed by an ellipse fixed completely within the CRN Property boundary, i.e. the actual EAB (SSAR Figure 2.3.4-1), which demonstrates that dispersion factor computations are conservative.

As described in SSAR Section 2.3.4.2, “Calculation Methodology and Assumptions, “the nuclear island ERB is used to conservatively enclose all possible release points for the selected reactor technologies. The distance from the outer edge of the power block area to the EAB is 335 m (1100 ft), as shown in SSAR Table 2.3.4-11, “Distances and Elevations for the EAB and LPZ in the 16 Wind Direction Sectors,” and SSAR Figure 2.3.4-1 (reproduced below as Figure 2.3-2). To account for the potential of multiple units on the site, nuclear islands are positioned at multiple locations within the power block with associated ERBs and EABs, as shown in Figure 2.3-2 below. A circular analytical EAB is established 335 m (1100 ft) from the ERB. All of the potential nuclear island sites are bounded by the ellipse shown below that encompasses all of the analytical EAB and is completely contained within the CRN Site. Since the distance from the outer edge of the power block to the EAB is less than the actual distance from the nuclear island to the EAB, and will result in higher (more conservative) χ/Q values, the NRC staff considers the assumptions in the dispersion analysis to be reasonable.

The outer boundary of the LPZ for the CRN Site is a circle surrounding the power block area with a radius of 1609 m (1 mi). The distance from the power block area to the LPZ is shown in SSAR Table 2.3.4-11 and SSAR Figure 2.3.4-2, “Site Center Point and Distance to the LPZ.”

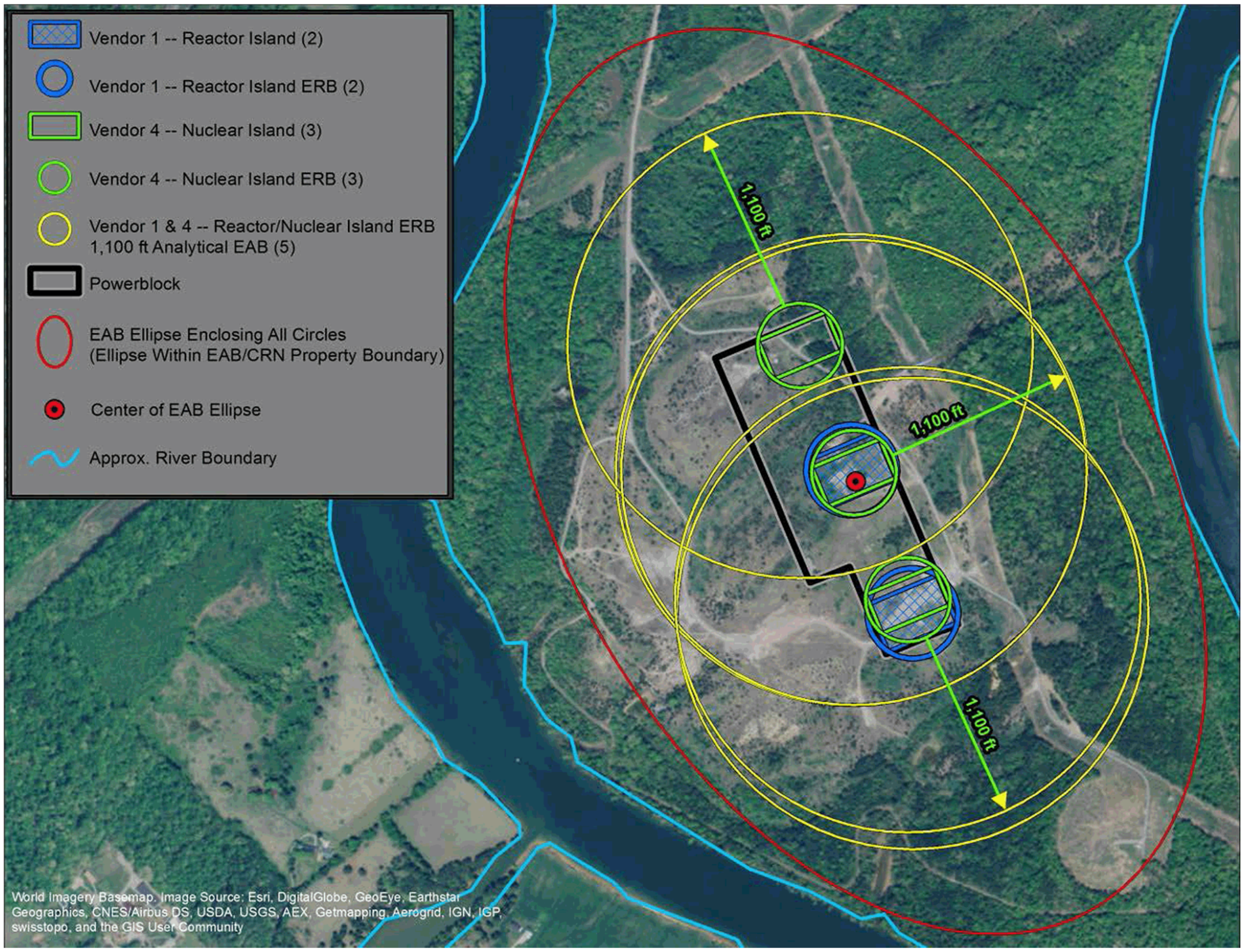

Figure 2.3-2 Effluent Release Zones with Analytical EABs

SSAR Tables 2.3.4-12, 2.3.4-13, and 2.3.4-14 list the short-term atmospheric dispersion estimates for the EAB and the outer boundary of the LPZ that the applicant derived from its PAVAN modeling run results. The applicant identified these χ/Q values as site characteristics in SSAR Table 2.0-1. The NRC staff finds these χ/Q values acceptable for use as site characteristics because the applicant followed an acceptable method provided by RG 1.145 to determine the atmospheric dispersion factors at the proposed CRN Site. These atmospheric dispersion site characteristics are used by the applicant to demonstrate compliance with the requirements of 10 CFR 100.21(c)(2) for the radiological dose consequences of postulated accidents.

The Audit Report (ADAMS Accession No. ML18248A113) describes, among other things, the NRC staff's review of the applicant's comparison of accident-related atmospheric dispersion results using vector- versus scalar-averaged wind directions and scalar-averaged wind speeds as input to the PAVAN model. The controlling accident χ/Q value (i.e., in this case, the highest 0.5 percent, sector-dependent χ/Q for the 0-2 hour period at the analytical EAB distance of 335 m downwind) based on vector-averaged wind directions remains the bounding value relative to the corresponding accident-related χ/Q values based on scalar-averaged wind directions. As stated in the Audit Report, the dominant sector (i.e., WNW) was unchanged using either wind direction data averaging approach.

The applicant provided tabular summaries of JFDs of wind speed and wind direction by atmospheric stability class used as meteorological input to the PAVAN dispersion model in SSAR Tables 2.3.4-2 through 2.3.4-8. The NRC staff notes that the applicant proposed to correct the column labels in these tables in letter CNL-18-045, dated April 9, 2018 (ADAMS Accession No. ML18100A950), to represent the actual ranges of the wind speed classes rather than the current labels in the SSAR, which imply that the JFDs represent cumulative frequency distributions. These proposed changes are being tracked as **Confirmatory Item 2.3-3.**

Using the information presented by the applicant in SSAR Table 2.3-10, "List of Inputs used in the PAVAN Modeling," including the JFDs of wind speed and wind direction measured at the 10-m (33-ft) level, and atmospheric stability, the NRC staff confirmed the applicant's χ/Q values by creating an independent JFD from the applicant's onsite hourly meteorological database, running the PAVAN computer code, and obtaining consistent results (within about 1 percent). The staff accepts the short-term accident χ/Q values presented by the applicant.

2.3.4.5 Conclusion

As discussed above, the applicant presented and substantiated information to establish short-term (post-accident) atmospheric dispersion site characteristics. The NRC staff reviewed the information provided and, for the reasons given above, concludes that the applicant has established site characteristics and design parameters acceptable to meet the requirements of 10 CFR 52.17(a)(1)(ix), 10 CFR 100.20(c)(2), and 10 CFR 100.21(c)(2). Subsection 2.3.3.5 of this report further discusses the limitation of this conclusion to the CRN site and to the staff's acceptance of these accident χ/Q values.

2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

2.3.5.1 Introduction

Long-term dispersion estimates are used to determine the amount of airborne radioactive materials expected to reach a specific location during normal operations. These dispersion estimates address the requirement concerning atmospheric dispersion and dry deposition estimates for routine releases of radiological effluents to the atmosphere.

2.3.5.2 Summary of Application

In SSAR Section 2.3.5, the applicant provided details on the following specific areas:

- atmospheric dispersion and deposition 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.

- meteorological data and other assumptions used as input to the atmospheric dispersion models.

- derivation of diffusion parameters (e.g., σ_z).

- atmospheric-dispersion (relative concentration) factors (χ/Q values) and deposition factors (D/Q values) used for assessment of consequences of routine airborne radioactive releases.

- the characteristics of each release mode.

- the location of potential receptors for offsite dose computations.

- any additional information requirements prescribed in the “Contents of Application” section of 10 CFR Part 52, Subpart A, “Early Site Permits”.

2.3.5.3 *Regulatory Basis*

The acceptance criteria identified in NUREG-0800, Section 2.3.5 for calculating atmospheric dispersion estimates for routine releases of radiological effluents are based on meeting the relevant requirements of 10 CFR Part 50 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the applicant’s calculation of atmospheric dispersion estimates for routine releases of radiological effluents:

- 10 CFR 100.20(c)(2), as it relates to the requirement that the meteorological characteristics of the site that are necessary for safety analysis or that might have an impact on plant design be identified and characterized as part of the staff’s review of the acceptability of a site;

- 10 CFR 100.21(c)(1), as it relates to the requirement that site atmospheric-dispersion characteristics be evaluated and dispersion parameters established to ensure that radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite.

Characterization of atmospheric transport and diffusion conditions is necessary for estimating the radiological consequences of routine releases of radioactive materials to the atmosphere in order to demonstrate compliance, in the COLA, with the numerical guides for doses contained in 10 CFR Part 50, Appendix I.

These RGs apply to this section:

- RG 1.23, Revision 1, which provides criteria for establishing and operating an acceptable onsite meteorological measurements program for the collection of basic meteorological data needed to support plant licensing and operation.

- 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,” Revision 1, as it relates to calculating offsite doses.

- RG 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” Revision 1, as it relates to calculating offsite doses.

The related acceptance criteria from NUREG–0800, Section 2.3.5 are as follows:

- a detailed description of the atmospheric dispersion and deposition models used by the applicant to calculate annual average concentrations in the air and the amount of material deposited as a result of routine releases of radioactive materials to the atmosphere

- a discussion of atmospheric diffusion parameters, such as vertical plume spread (σ_z) as a function of distance, topography, and atmospheric conditions

- meteorological data summaries (onsite and regional) used as input to the dispersion and deposition models

- points of routine release of radioactive material to the atmosphere, including the characteristics (e.g., location and release mode) of each release point

- the specific location of potential receptors of interest (e.g., the nearest vegetable garden, nearest resident, nearest milk animal, and nearest meat cow in each 22½-degree direction sector within a 5-mi (8-km) radius of the site)

- the χ/Q and D/Q values to be used for assessment of the consequences of routine airborne radiological releases as described in RG 1.206, Subsection 2.3.5.2: (1) Maximum annual average χ/Q values and D/Q values at or beyond the site boundary and at specified locations of potential receptors of interest using appropriate meteorological data for each routine venting location, and (2) estimates of annual average χ/Q values and D/Q values for 16 radial sectors to a distance of 50 mi (80 km) from the plant using appropriate meteorological data

2.3.5.4 Technical Evaluation

The NRC staff reviewed SSAR Section 2.3.5 to ensure that the ESP application includes the complete scope of information relating to this review topic. The staff's review confirmed that the application addresses the required information relating to long-term atmospheric dispersion estimates.

2.3.5.4.1 Atmospheric Dispersion Model

The applicant used the NRC-sponsored computer code XOQDOQ (described in NUREG/CR-2919, "XOQDOQ Computer Program for the Meteorological Evaluation of Routine Releases at Nuclear Power Stations,") to estimate χ/Q and D/Q values resulting from routine releases, as described in SSAR Subsection 2.3.5.2, "Calculation Methodology and Assumptions." The XOQDOQ model implements the constant mean wind direction methodology outlined in RG 1.111, Revision 1.

The XOQDOQ model is a straight-line Gaussian plume model based on the theoretical assumption that material released to the atmosphere will be normally distributed (Gaussian) about the plume centerline. In predictions of χ/Q and D/Q values for long time periods (e.g., annual averages), the plume's horizontal distribution is assumed to be evenly distributed within the downwind direction sector (i.e., "sector averaging"). A straight-line trajectory is assumed between the release point and all receptors.

To account for the complex terrain surrounding the CRN Site, the applicant performed a comparison between the NRC-endorsed XOQDOQ model and the CALPUFF modeling system developed by the U.S. EPA. The EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM)[14] Web site describes CALPUFF as "a non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain."

2.3.5.4.2 Release Characteristics and Receptors

As described in the SSAR, the applicant modeled one ground-level release point, setting the minimum building cross-sectional area and building height to zero. SSAR Table 2.0-2lists the ground level release point elevation as a design parameter for any future uses of this ESP. A ground-level release is a conservative assumption since it results in higher χ/Q and D/Q values when compared to a mixed-mode (e.g., part-time ground, part-time elevated) release or a 100-percent elevated release, as discussed in RG 1.111, Revision 1. A ground-level release assumption is, therefore, acceptable to the NRC staff.

The distance to the receptors of interest (i.e., the nearest meat animal (cow), residence, and vegetable garden) were presented in CRN ESP SSAR Table 2.3.5-5, "CRN Site Offsite Receptor Locations." Directional sectors without a receptor within 8 km (5 mi) were not modeled. The applicant calculated the distances to each of the receptors from a location defined as the center point of the site.

The CALPUFF model also used a single ground-level source located at the center point of the site with no building wake credit given. The applicant provided a summary of the CALPUFF input assumptions in SSAR Subsection 2.3.5.3, "Complex Terrain Modeling Analysis," and in SSAR Table 2.3.5-2, "CALPUFF Model Input Configuration for Complex Terrain Analysis." The NRC staff reviewed the CALPUFF input and determined that the inputs accurately reflected the conditions and topography near the CRN Site and are therefore acceptable.

2.3.5.4.3 Meteorological Data Input

As discussed in SSAR Subsection 2.3.5.3, the meteorological data used to create the JFD input to XOQDOQ included wind speed, wind direction, and atmospheric stability based on hourly onsite data from a 2-year period from June 1, 2011 through May 31, 2013. The applicant used this same hourly onsite data as input to CALPUFF. The wind data were obtained 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 59.2-m (194.3-ft) and 8.44-m (27.7-ft) levels on the onsite meteorological tower. For conservatism in comparing airborne concentrations between the XOQDOQ and CALPUFF models, SSAR Subsection 2.3.5.3 states that CALPUFF options for wet and dry deposition of I-131 was not considered during the analysis. The NRC staff confirmed that the CALPUFF modeling did not include any plume washout and that deposition and depletion was ignored for this comparison.

The wind rose presented in SSAR Figure 2.3.2-3 depicts the wind patterns and wind speeds for all 16 directions. The figure also states that the wind was calm 24.85 percent of all hours recorded. The NRC staff compared the number of calms in the wind rose to the JFDs included in SSAR Tables 2.3.4-2 through 2.3.4-8. The NRC staff determined that the applicant followed the guidance provided in Table 3 of Revision 1 to RG 1.23, and defined any wind speed below

[14] https://www3.epa.gov/scram001/dispersion_prefrec.htm Accessed 02/23/2017.

the 0.5 m/s (1.1 mph) threshold as “calm.” The JFD tables in SSAR Section 2.3.4 provide a summary of the wind speed distribution by stability class. The wind speeds rendered as “CALM” in SSAR Figure 2.3.2-3 are accounted for by the first three winds speed classes in the referenced JFD tables (i.e., CALM (0.0 mph), greater than 0.0 mph and less than or equal to 0.50 mph, and greater than 0.50 mph to less than or equal to 1.10 mph). The staff noted and accounted for the different units of measure between the wind roses and the JFD tables in the SSAR.

Following the discussions provided in SER Section 2.3.2, Subsection 2.3.3.4.1.2.2, and Section 2.3.4, the staff considers the 2011-2013 onsite meteorological database suitable for input to the XOQDOQ model. However, the NRC staff notes that SSAR Subsection 2.3.5.4 asserts that the “representativeness of observed meteorology at the site was assessed, and no long-term trends were observed which would bias the χ/Q and D/Q estimates. Therefore, the long-term, routine-release χ/Q and D/Q values correspond to conditions that would be estimated using climatological (30-year) data.” Due to the complex nature of the terrain surrounding the CRN Site, it is unknown how much of the difference between the onsite and offsite wind roses is due to the relative location of the stations, or the data collection and processing methods, or both. Given the differences in the onsite and offsite wind roses and other wind-related data summaries in Section 2.3.2, the changes in the JFD tables in Section 2.3.4 as a result of vector versus scalar wind direction averaging, and the changes in the χ/Q and D/Q values observed due to the different wind direction averaging approaches, it appears to the NRC staff that long-term data representativeness (including resulting χ/Qs and D/Qs for routine releases) is not well established at the CRN Site. Nevertheless, these differences do not exclude the 2011-2013 onsite meteorological data from use in the atmospheric dispersion models since the collection of meteorological data at the site is still the most accurate way to capture the conditions directly influencing routine airborne releases at the site.

2.3.5.4.4 Diffusion Parameters

The applicant chose to implement the diffusion parameter assumptions outlined in RG 1.111, Revision 1, as a function of atmospheric stability, for its XOQDOQ model runs. The NRC staff evaluated the applicability of the XOQDOQ diffusion parameters and concluded that no unique topographic features preclude the use of the XOQDOQ model for the CRN Site. Therefore, the staff finds that the applicant’s use of the diffusion parameter assumptions, as outlined in RG 1.111, Revision 1 is acceptable.

2.3.5.4.5 Complex Terrain Modeling

As discussed in SER Section 2.3.2, the CRN Site is located in a region of complex terrain, with alternating ridges and valleys. The applicant described the local wind patterns as being influenced by the complex terrain in SSAR Subsection 2.3.5.3. The region is prone to up-valley and down-valley flow, along with light winds, especially in the summer and fall seasons, which may lead to short-term increases in pollutant concentration due to pockets of stagnation at the base of nearby hills or near the CRN Site.

Complex terrain sites may need to make adjustments to a linear trajectory model to represent non-straight line trajectories; specifically, adjustment factors for terrain confinement and recirculation effects on annual average dispersion concentrations. These adjustments can be accomplished in two ways, as presented in NUREG/CR-2919, using the XOQDOQ code. First, a standard default correction factor that is a function of distance can be applied to the χ/Q and

D/Q values for each of the directional sectors. Second, adjustments can be made by a comparison of results with a variable trajectory model. If the variable trajectory model produced higher concentrations than the straight-line model, the concentration ratio, or adjustment factor, would be used in the straight-line model to correct for nonlinear dispersion effects. The CRN applicant chose to perform a comparison using a variable trajectory model and the NRC endorsed XOQDOQ model. These results are described in the following subsection.

2.3.5.4.6 Resulting Relative Concentration and Relative Deposition Factors

SSAR Table 2.3.5-10, "χ/Q and D/Q Values for No Decay, Decay, and Undepleted, at Each Receptor Location," lists the maximum long-term atmospheric dispersion and deposition site characteristic values for the receptors of interest that the applicant derived from their XOQDOQ modeling results. SSAR Tables 2.3.5-6 through 2.3.5-9 also contain the applicant's long-term atmospheric dispersion and deposition estimates for 16 radial sectors at standard distances and distance segments from the site out to 80 km (50 mi) from the proposed facility.

The χ/Q values presented in SSAR Tables 2.3.5-6 through 2.3.5-9 reflect several plume radioactive decay and deposition scenarios. Section C.3 of RG 1.111, Revision 1 states that radioactive decay and dry deposition should be considered in radiological impact evaluations of potential annual radiation doses to the public, resulting from routine releases of radioactive materials in gaseous effluents. Section C.3.a of RG 1.111, Revision 1 states that an overall half-life of 2.26 days is acceptable for evaluating the radioactive decay of short-lived noble gases and an overall half-life of 8 days is acceptable for evaluating the radioactive decay for all iodines released to the atmosphere. Definitions for the χ/Q categories are as follows:

- Undepleted/No Decay χ/Q values are used to evaluate ground-level concentrations of long-lived noble gases, tritium, and carbon-14. The plume is assumed to travel downwind, without undergoing dry deposition or radioactive decay

- Undepleted/2.26-Day Decay χ/Q values are used to evaluate ground-level concentrations of short-lived noble gases. The plume is assumed to travel downwind, without undergoing dry deposition, but is decayed, assuming a half-life of 2.26 days, based on the half-life of xenon-133.

- Depleted/8.00-Day Decay χ/Q values are used to evaluate ground-level concentrations of radioiodine and particulates. The plume is assumed to travel downwind, with depletion caused by dry deposition, and is decayed assuming a half-life of 8.00 days, based on the half-life of iodine-131.

Using the information provided by the applicant, including the JFDs of lower-level wind speed (scalar-averaged) and wind direction (vector-averaged), and atmospheric stability presented in SSAR Tables 2.3.4-2 through 2.3.4-8, the NRC staff confirmed the applicant's χ/Q and D/Q values by running the XOQDOQ computer code and obtaining similar results (i.e., values on average within about 1-percent).

SSAR Tables 2.3.5-3, "Long-Term Average X/Q Values at the Exclusion Area Boundary," and 2.3.5-4, "Long-Term Average X/Q Values at the Low Population Zone," present the long-term average χ/Q values at the EAB and LPZ, respectively. These tables provide the resulting χ/Q values for each sector from both XOQDOQ and CALPUFF, as well as the ratio between the two models results. This comparison shows that the χ/Q values derived using the XOQDOQ model range from approximately two times up to two orders of magnitude greater than the values derived using CALPUFF. Based on these results, the NRC staff agrees with the applicant that the XOQDOQ model did not underestimate the annual average χ/Q values at the CRN Site.

In its voluntary submittal of April 9, 2018 (ADAMS Accession No. ML18100A950), the applicant summarized its comparison of XOQDOQ modeling results using JFDs based on vector-averaged wind directions and scalar-averaged wind speeds (as presented in the SSAR) and JFDs created using scalar averaging of both wind speed and wind direction measurements. The applicant acknowledged that the routine release modeling results using scalar-averaged wind directions "are greater in some directions and lower in others". Consequently, the applicant also analyzed doses to the Maximally Exposed Individual and to the population. The applicant stated that "the doses computed using the vector wind direction are greater than those computed using the scalar wind direction input." Therefore, the applicant concluded that "for the Clinch River Site normal dose evaluations…the use of vector wind direction is conservative compared to the use of scalar wind direction." As with the accident-related dispersion modeling, the applicant concluded "that the existing analysis included in the ESPA, which is based on vector wind direction, is conservative and remains the basis of the ESPA."

As mentioned previously, the NRC staff conducted an audit (ADAMS Accession No. ML18122A219) of the calculation packages that supported the applicant's April 9, 2018, voluntary submittal. The audit report (ADAMS Accession No. ML18248A113) documents the staff's review and conclusion that the applicant's calculations supported its April 9, 2018, submittal and the applicant's position that the doses from airborne accident and normal releases presented in the SSAR, calculated using vector-averaged wind direction data, are bounding.

The audit also showed that sector-specific D/Q values for receptors of interest occur, in many cases, in different sectors as a result of the different wind direction data averaging approaches. Further, in most cases, the sectors with the maximum D/Q values differ from those implied by the sectors identified in SSAR Table 11.3-2, "Maximum Atmospheric Dispersion and Ground Deposition Factors by Location." In addition, for two of the receptors of interest (i.e., the nearest Beef (Meat) Animal and Vegetable Garden), the maximum D/Q value was slightly higher using scalar-averaged wind direction data compared to vector-averaged wind direction data. The significance of these differences from a dose standpoint is evaluated in SER Section 11.3, which concludes that the doses for the normal gaseous release using vector wind direction averaging are greater than those computed based on scalar-averaged wind directions. Therefore, the NRC staff agrees with the conclusions summarized by the applicant in its April 9, 2018, voluntary submittal and considers the XOQDOQ values in the SSAR to be conservative and appropriate for this complex terrain site. In light of the foregoing, the staff accepts the long-term χ/Q and D/Q values presented by the applicant.

2.3.5.5 Conclusion

As set forth above, the applicant has provided meteorological data, atmospheric dispersion modeling analyses appropriate for the characteristics of the CRN Site, and an evaluation of the potential effects of having used an alternate wind direction data averaging approach. The NRC staff concludes that representative atmospheric dispersion and deposition conditions have been calculated for specific locations of potential receptors of interest due to routine operational releases to the air. The characterization of atmospheric dispersion and deposition conditions satisfies the criteria described in RG 1.111 and are appropriate for demonstrating compliance with the numerical guides for doses for any individual located offsite as contained in 10 CFR Part 50, Appendix I. The NRC staff reviewed the information provided and, for the reasons given above, concludes that the applicant has established the site characteristics and design parameters acceptable to meet the requirements of 10 CFR 100.20(c)(2) and 10 CFR 100.21(c)(1). Subsection 2.3.3.5 of this report further discusses the limitation of this conclusion to the CRN site and to the staff's acceptance of these routine release χ/Q values.