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2.3 METEOROLOGY

2.3.1 Regional Climatology

Information about regional conditions was obtained from National Climatological Data Center (NCDC) Storm Events Database and Local Climatological Data (LCD) for the cities of Knoxville, Nashville, Chattanooga, and Oak Ridge and the Tri-Cities (Bristol, Kingsport, and Johnson City) airport. More specific information for the Clinch River Nuclear (CRN) Site was obtained from observations for TVA Sequoyah and Watts Bar Nuclear Plants and available National Weather Service (NWS) records for Morristown and other records for Roane Country, Tennessee and surrounding counties (Anderson, Knox, Loudon, and Morgan).

2.3.1.1 General Climate

The CRN Site is in the eastern Tennessee portion of the southern Appalachian region, which is dominated much of the year by the Azores-Bermuda anti-cyclonic circulation. This dominance is most pronounced in late summer and early fall and is accompanied by extended periods of fair weather and widespread atmospheric stagnation. In winter and early spring, eastward moving migratory high- or low-pressure systems bring alternately cold and warm air masses into the area. The resultant changes in wind, atmospheric stability, precipitation, and other meteorological elements cause the normal circulation to become more diffuse over the region. In the summer and early fall, the migratory systems are less frequent and less intense. Frequent incursions of warm, moist air from the Gulf of Mexico and occasionally from the Atlantic Ocean are experienced in the summer. The site is primarily affected by cyclones from the Southwest and Gulf Coast that translate toward the Northeast U.S. by passing along either the west side or the east side of the Appalachian chain and by cyclones from the Plains or Midwest that move up the Ohio River Valley.

At the mesoscale scale, topography influences the weather and climate of the region around the CRN Site. The site, located in the City of Oak Ridge, Tennessee, is situated in “The Great Valley” between two major mountain regions. To the northwest lie the Cumberland Mountains and to the southeast are the Great Smoky Mountains. These mountainous regions orient “The Great Valley” in a southwest-to-northeast alignment. Prevailing winds in the region reflect the channeling of air flow caused by the orientation of the valleys and ridges. Wind speeds are low, with a mean annual wind speed of 2.9 miles per hour (mph) at Oak Ridge (Reference 2.3.1-11). During winter when the jet stream moves southward, the Cumberland Mountains also serve to retard or moderate cold outbreaks by blocking dense, cold polar continental air masses. In summer, the topography in the region may enhance thunderstorm activity due to orographic lift. (References 2.3.1-5 and 2.3.1-11)

Area temperatures measured in Oak Ridge indicate warm summers and mild winters. In January, the normal daily maximum temperature is 46.6°F with a normal daily minimum temperature of 28.9°F based on 30 years of data. In July, the normal daily maximum temperature is 88.4°F, while the normal daily minimum temperature is 68.6°F based on 30 years of data (Reference 2.3.1-11). Relative humidity in the region averaged 73 percent based on a 30-year period of record from the Knoxville LCD (Reference 2.3.1-5).

Precipitation averages about 51 inches annually (Reference 2.3.1-11). Late winter (January–March) is usually the wettest season, with more than 14 inches, while late summer–early autumn (August–October) is the driest season, with less than 10 inches. Droughts are uncommon in this region of the United States.

Snowfall in the Oak Ridge area, though normally light, usually occurs from November through March. Severe storms are relatively infrequent as the region is east of maximum tornado activity,

south of the most significant snowstorms, and inland from hurricane and tropical storm tracks (Reference 2.3.1-27).

2.3.1.2 Regional Meteorological Conditions for Design and Operating Basis

The regional meteorological conditions that are relevant to the design and operating bases for the CRN Site are discussed below. The relevant CRN Site meteorological characteristics are listed in Table 2.0-1.

2.3.1.3 Severe Weather

Severe weather phenomena may require consideration in the design of safety-related structures, systems and components. Statistics on severe weather phenomena were obtained from historic data. Most data is taken from the NCDC Storm Events Database (Reference 2.3.1-1) that covers the 64-year period of 1950–2013, but even longer data periods are used for some phenomena to try to capture the occurrence of rare events.

Severe storms are relatively infrequent in east Tennessee, being east of the area of major tornadic activity, south of nearly all storms producing blizzard conditions, and too far inland to be affected by the remnants of intense tropical cyclones.

2.3.1.3.1 Thunderstorms, Hail, and Lightning

Thunderstorms are common in the region with a normal range of 42–55 days with thunderstorms (References 2.3.1-2, 2.3.1-5, 2.3.1-6, and 2.3.1-7). The greatest frequency of thunderstorms is during the summer with a range of 31–36 days during May–August. This is characteristic of a diurnal afternoon thunderstorm pattern due to solar heating.

Hail

In Roane County, severe hail (3/4 inch in diameter or larger) has been reported only 31 times during 1950–2013 (Reference 2.3.1-1). This corresponds to less than one severe hail event per year. During the same period, surrounding counties reported severe hail between 43 (Loudon) and 81 (Knox) times.

Lightning

The CRN Site averages 13 cloud-to-ground lightning flashes per square mile (2.6 km^2) annually (Reference 2.3.1-12).

2.3.1.3.2 Extreme Winds

Windstorms are relatively infrequent, but may occur several times a year, usually associated with thunderstorms. Moderate and occasionally strong winds sometimes accompany migrating cyclones and air mass fronts. The strong winds are usually associated with lines of thunderstorms along or ahead of cold fronts and are more probable in the late winter and spring than any other time of the year. Brief, strong gusts of wind due to downdraft and outflow from individual thunderstorms can occur, but are generally limited to the large, intense thunderstorms that develop in the spring and summer.

Estimated extreme winds are based on climatological data from Oak Ridge and Knoxville, Tennessee (References 2.3.1-3, 2.3.1-4, 2.3.1-5, 2.3.1-8, 2.3.1-9, 2.3.1-10, and 2.3.1-11) and hourly observations from TVA Sequoyah and Watts Bar Nuclear Plants (References 2.3.1-13 and 2.3.1-14).

Determining the maximum wind speed requires comparison of different reported wind speed measurements (fastest mile and 3-second gust) since the NWS changed measurement techniques over time. Table 2.3.1-1 converts the reported wind measurements to consistent units.

The maximum estimated wind speed is 73 mph (which corresponds to a 3-second gust of 87 mph) (Reference 2.3.1-3).

The Basic Wind Speed is based on the data from American Society of Civil Engineers (ASCE) 7-05 (Reference 2.3.1-30). From Figure 6-1 of ASCE 7-05, the 50-year return 3-second gust Basic Wind speed at 33 feet above ground for Exposure Category C for the CRN Site is 90 mph. This gives a 100-year return Basic Wind Speed of 96.3 mph, based on Table C6-7 of ASCE 7-05 which provides a conversion factor of 1.07 to convert from a 50-year recurrence interval to a 100-year recurrence interval. Because only the basic wind velocity is used in design, seasonal extreme wind speeds are not provided.

For comparison, hourly average (scalar) wind speeds at the nominal 33-foot level are available from the CRN Site during 2011–2013, the Watts Bar Nuclear Plant (30 miles southwest from the CRN Site) during 1973–2013, and the Sequoyah Nuclear Plant during 1971–2013. The maximum hourly average wind speed values of 15.1 mph for CRN Site, 30 mph for Watts Bar Nuclear Plant, and 40 mph for Sequoyah Nuclear Plant correspond to 3-second gust wind speeds of 23 mph, 45 mph, and 60 mph, respectively.

The 100-year return period fastest mile of wind in the CRN Site area is approximately 90 miles per hour (Reference 2.3.1-15).

2.3.1.3.3 Precipitation Extremes

Historical precipitation for the CRN Site meteorological vicinity obtained from several surrounding NWS and TVA sites (References 2.3.1-2, 2.3.1-5, 2.3.1-6, 2.3.1-7, 2.3.1-11, 2.3.1-13 and 2.3.1-14) is summarized in Table 2.3.1-2. Based on the similarity of the maximum recorded 24-hour and monthly totals among these stations and the areal distribution of these stations around CRN Site, the data suggest that these statistics are reasonably representative of precipitation extremes that might be expected to be observed at the site. Droughts are uncommon in the vicinity of the CRN Site. Records indicate that sixteen episodes of severe drought have occurred in the past two hundred years. The worst was the decade of the 1980s, the driest overall period in the state’s history (Reference 2.3.1-34).

The maximum estimated annual precipitation is in the range of 45–53 inches. The maximum 24-hour rainfall is less than 10 inches, and the maximum monthly rainfall is less than 20 inches (see Table 2.3.1-2 for details). The probable maximum precipitation (PMP) is based on data provided in NOAA Hydro-Meteorological Report HMR-52 (Reference 2.3.1-36). The PMP is 18.8 inches/hr and 6 inches/5 minutes (Reference 2.3.1-36).

The normal annual snowfall in the vicinity of the CRN Site is less than 12 inches. Normal and Extreme snowfall events are discussed in Subsection 2.3.1.3.6.2.

2.3.1.3.4 Tornadoes

Tornado Strike Probability

The probability of a tornado occurring at the CRN Site is low based on records from the NWS Morristown Tornado Database (Reference 2.3.1-16) and the NCDC Storm Events Database

(Reference 2.3.1-1). During the 64-year period 1950–2013, five tornadoes were reported within 10 miles of the CRN Site (Table 2.3.1-3). Only one of these had an intensity greater than F0/EF0.

Based on the tornado strike probability presented in NUREG/CR-4461, the number of tornado events from 1950 through August 2003 within a 2-degree box surrounding the CRN Site is 226. This gives an annual average of four tornado events striking somewhere within the 2-degree box.

Using the principle of geometric probability described by H. C. S. Thom (Reference 2.3.1-15), the probability of a tornado striking any point in a 1-degree latitude by 1-degree longitude square may be calculated as follows:

$$P = \frac{zt}{A}$$ Equation 2.3.1-1

where:

P = mean probability of a tornado striking a point in any year in a 1-degree square.

z = mean path area of a tornado (mi^2) = 0.544 mi^2 (based on weighted average area from Table 2-10 of Reference 2.3.1-17).

t = mean number of tornadoes per year (based on Figure 2-1 in Reference 2.3.1-17).

= 55 tornadoes/53.67 years

= 1.02 tornadoes per year.

A = area (mi^2) = approximately 3,887 mi^2 for the 1-degree square containing the CRN Site.

Tornado probability (P, from Equation 2.3.1-1) = (0.544*1.02)/3887
= 0.000143 = 1.43×10^{-4}.

$$R = \frac{1}{P}$$ Equation 2.3.1-2

where:

R= mean recurrence interval for a tornado striking a point in the 1-degree square.

Recurrence interval (R, from Equation 2.3.1-2) = 1/0.000143 = 6993 years.

Design Basis Tornado (DBT) Parameters

Site characteristic tornado parameters are based on the guidance provided in Regulatory Guide 1.76, *Design Basis Tornado and Tornado Missiles for Nuclear Power Plants*. Based on Regulatory Guide 1.76, the CRN Site is located in Region I. The characteristics applicable to structures, systems, and components important to safety at the proposed CRN Site include the tornado maximum wind speed, translational speed, maximum rotational speed, radius of maximum rotational speed, pressure drop, and rate of pressure drop (from Table 1 of Regulatory Guide 1.76). The values of these parameters for the CRN Site are given in Table 2.0-1.

2.3.1.3.5 Hurricanes

Hurricane winds are mainly a concern for coastal locations as shown by the wind speed contours presented in Regulatory Guide 1.221 and NUREG/CR-7005. Due to the rapid dissipation of

hurricane winds as the move inland away from their oceanic energy source, hurricane winds should not be a concern for the CRN Site. The wind speed contours in Regulatory Guide 1.221 and NUREG/CR-7005 actually stop well short of the CRN Site location with a wind speed contour of 130 mph.

Due to the significant inland distance from both the Atlantic Ocean and the Gulf of Mexico (more than 300 miles), tropical storm impacts are rare at the CRN Site, and are mostly from storm remnants. Impacts are generally restricted to flood effects from heavy rains (already addressed in Subsection 2.3.1.3.3). From 1905 to the present, there have been ten tropical storms within a 50-mile radius of the site. Although some of these were originally classified as hurricanes, all were classified as tropical storms when they reached the site area.

Review of the NCDC Storm Events Database for the period of January 1, 1950 through November 30, 2014 shows that there was only one tropical storm on September 16, 2004 near Roane County that caused minimal damage. This storm was associated with Hurricane Ivan.

2.3.1.3.6 Winter Storm Events

The maximum reported snow depth at Knoxville (Reference 2.3.1-5) reported during the 61-year period of record was 15 inches in February 1960. Snowfall records for stations around CRN (Table 2.3.1-2) show a maximum 24-hour snowfall of 20 inches (March 1993) at Chattanooga (Reference 2.3.1-2).

Frost penetration depth is important for protection of water lines and other buried structural features that are subject to freeze damage. The extreme depth is slightly less than 19.6 inches based on Figure 13 in Reference 2.3.1-18.

2.3.1.3.6.1 Ice Storms

Estimations of regional glaze probabilities have been made by Tattelman and Gringorten (Reference 2.3.1-19). For Region V, which contains Tennessee, storms with ice greater than or equal to 1 in of ice occurred 5 times in 50 years and storms with ice greater than or equal to 2 in of ice occurred 2 times in 50 years.

For ice storms with wind gusts greater than or equal to 44.7 mph, the estimated ice thickness is less than 1 in for 25- and 50-year return periods, and 1.4 in for a 100-year return period.

Based on the data provided in ASCE 7-05 (Reference 2.3.1-30), Figure 10-2, the 50-year mean recurrence interval of uniform ice thickness due to freezing rain for Roane County is 0.75 inch with a concurrent 3-second wind gust of 30 mph.

For glaze ice, the point probabilities for ice thicknesses are about 0.20 for greater than or equal to 0.5 in and 0.36 for greater than or equal to 0.25 in. These probabilities correspond to recurrence intervals of once in five years and once in three years, respectively. Glaze ice thicknesses less than or equal to 0.5 in generally results in little structural damage. However, storms which produce these lesser ice thicknesses can present a hazard to travel in the affected areas, and when combined with strong winds, can damage above-ground utility wires.

2.3.1.3.6.2 Normal and Extreme Winter Precipitation Events

Snowpack, as used in this section, is defined as a layer of snow and/or ice on the ground surface, and is usually reported daily, in inches, by the NWS at all first order weather stations. Historical snowpack and snowfall were developed by reviewing data from 1st order NWS stations and the cooperative network.

From Figure 7-1 of American Society of Civil Engineers (ASCE) Standard No. 7-05, the 50-year mean recurrence interval snowpack for the Oak Ridge area is determined to be 10 pounds per square foot (psf). Converting this to a 100-year return period snowpack, using the 1.22 adjustment factor presented in Table C7-3 of ASCE 7-05, the 100-year return period snowpack is determined to be 12.2 psf.

The maximum reported snow depth at Chattanooga, TN (Reference 2.3.1-2), the highest snow depth at a nearby NWS station, was used to estimate the weight of the maximum historic snow pack at the CRN Site. The greatest snow depth reported during the 77-year period of record (1938–2014) for Chattanooga, was 19 inches in March 1993. Interim Staff Guidance (ISG) on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures (ISG-7) (Reference 2.3.1-38), provides an algorithm (below) for converting historical maximum snowpack depth to a ground snow load

$$L = 0.279D^{1.36} \qquad \text{Equation 2.3.1-3}$$

Where, D is the snowpack depth in inches and L is the resulting snow load in psf.

Using the 19-inch snow depth for Chattanooga gives a snow load of 15.3 psf for the maximum historical snowpack.

The 100-year return period snowfall event is given in data provided by the National Climatic Data Center. Based on this data, the 48-hour 100-year return snowfall event for Oak Ridge is 15.3 inches and 21.1 inches for Knoxville. The historical maximum snowfall event for a 48-hour period was determined to be 28 inches recorded in Westbourne, TN from February 19, 1960 to February 21, 1960 (Reference 2.3.1-39). The equation below from ISG-7 was used to determine the snow load due to the 48-hour 100-year return period snowfall event and the historical maximum snowfall event.

$$L = 0.15 \times S \times 5.2 \qquad \text{Equation 2.3.1-4}$$

Where L is the snow load in psf and S is the Snowfall depth in inches.

Using the maximum 100-year return snowfall event of 21.1 inches results in a snow load of 16.5 psf. Using a 28 inch historical maximum snowfall event for a 48-hour period results in a snow load of 21.9 psf.

The Normal Winter Precipitation Event, defined as the maximum ground-level weight (lb/ft^2) of the 1) 100-year snowpack (snow cover), 2) historical snowpack (snow cover), 3) 100-year return 2-day snowfall event, or 4) historical maximum 2-day snowfall event, is determined to be 21.9 psf. The Extreme Frozen Winter Precipitation Event, defined as the maximum of the 1) 100-year return 2-day snowfall event or 2) historical maximum 2-day snowfall event, is also determined to be 21.9 psf.

From Hydro-Meteorological Report HMR-53, NUREG/CR-1486, (Reference 2.3.1-32) the 48-hour Probable Maximum Winter Precipitation (PMWP) (January through March) for a 10 square-mile area is estimated to be 23.5 inches by logarithmic interpolation. The March PMWP was utilized since the historically highest snowpack occurred in March 1993. The 48-hour PMWP is equivalent to the Extreme Liquid Winter Precipitation Event.

2.3.1.4 Design Basis Dry- and Wet-Bulb Temperatures

This section provides ambient temperature and humidity statistics for use in establishing heat loads for the design of normal plant heat sink systems, post-accident containment heat removal systems, and plant heating, ventilating, and air conditioning systems. The following parameters have been calculated:

- maximum dry-bulb temperatures at 0%, 0.4%, 1%, 2%, 5%, and 95% annual exceedance levels,
- maximum coincident wet-bulb temperatures at 0%, 0.4%, 1%, 2%, and 5% annual exceedance levels,
- maximum non-coincident wet-bulb temperature at 0%, 0.4%, 1%, and 2% annual exceedance levels,
- minimum dry-bulb temperature at 0%, 0.4%, 1%, and 2% annual exceedance levels,
- 100-year return maximum dry-bulb, coincident wet-bulb, non-coincident wet-bulb, and minimum dry-bulb temperatures.

Meteorological data from the Chattanooga Lovell Airport was obtained from the National Oceanic and Atmospheric Administration (NOAA) NCDC for use in determining extreme values. This data is the best available long-term data record because the data record for Oak Ridge is incomplete (data gap between 1985 and 1999). The ambient design temperatures required for the site envelope parameters are based on the criteria in the EPRI ALWR Utility Requirement Document (URD) [Reference 2.3.1-33], Table 1.2-6, and various design parameters as required by NRC Regulatory Guide 1.27 and SRP 2.3.1. While each of these documents sets forth various criteria, all evaluations are conducted on either dry-bulb or wet-bulb temperature. SRP 2.3.1 requires the following data be provided:

> *Ambient temperature and humidity statistics (e.g., 2% and 1% annual exceedance and 100-year maximum dry-bulb temperature and coincident wet bulb temperature; 2% and 1% annual exceedance and 100-year maximum wet bulb temperature (non-coincident); 98% and 99% annual exceedance and 100-year minimum dry-bulb temperature) for use in establishing heat loads for the design of normal plant heat sink systems, post-accident containment heat removal systems, and plant heating, ventilating, and air conditioning systems.*

However, additional values were determined in accordance with the EPRI URD.

Sixty-six years of raw climatological data were obtained from NOAA/NCDC for the Chattanooga Lovell Airport. This data set contains hourly measurements of dry-bulb and dewpoint temperature records, amongst several other meteorological variables. This data was used to calculate the various exceedance temperatures. Results of the ambient design temperature analysis are presented in Table 2.0-1. Similar evaluations were performed using NOAA/NCDC data for Knoxville. Because the Chattanooga data produced more conservative results, these results are used as the design basis.

2.3.1.5 Meteorological Data for Evaluating Ultimate Heat Sink

None of the SMR designs being evaluated relies on an external water source as its ultimate heat sink (UHS). Therefore, SRP criteria associated with evaporation and drift loss of water, minimum

water cooling, and the potential for water freezing in a UHS water storage facility are not applicable.

2.3.1.6 Climate Changes

While climatic conditions change over time, such changes are cyclical in nature on various time and spatial scales. The timing, magnitude, relative contributions to, and implications of these changes are generally more speculative, even for specific areas or locations. Further, the most extreme projected changes are for time scales much longer than any facility will be operated at CRN. Projected changes are generally small compared to natural variation. General predictions of global or U.S. climatic changes expected during the period of reactor operation are uncertain and are only applicable on a macroclimatic scale. Since the maximum data span available was used in the severe weather analysis, accurate severe weather phenomena have been provided based on best-available historic data. Projections of future severe weather conditions at the CRN Site are highly uncertain at best, based on current understanding and modeling of global climate change. Predictions provided by the USGS (Reference 2.3.1-37) vary considerably. For example, one model gives a summer maximum temperature increase from approximately 89 to 93ºF with a standard deviation of approximately 3ºF over the period of 2025 through 2075. Another model gives a summer maximum temperature increase from approximately 89 to 95ºF with a standard deviation of approximately 4ºF over the period of 2025 through 2075. TVA’s major planning processes, consistent with its Climate Change Adaptation Plan, identify opportunities as well as climate change risks with the potential to substantially impair, obstruct or prevent the success of Agency mission activities, both in the near term and particularly in the long term, using the best available science and information.

Based on the above, it is reasonable to project likely climate conditions based on climatological records of temperature and rainfall as they have varied over time (Table 2.3.1-4). The long-term records of normal temperature and precipitation presented in Table 2.3.1-4 for Knoxville and Oak Ridge demonstrate that there has not been a significant variation in regional measurements over time. Based on the consistency of these records over the period of 1921 to 2010, significant climate changes are not expected during the licensing period.

2.3.1.7 Regional Air Quality Conditions

2.3.1.7.1 Background Air Quality

The U.S. Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, and particulate matter (i.e., PM_{10} and $PM_{2.5}$ – particles with nominal aerodynamic diameters less than or equal to 10 and 2.5 microns, respectively). Areas with pollutant concentrations greater than these standards are designated as non-attainment areas. Non-attainment areas may include counties or portions of surrounding counties.

The CRN Site, which is located in Roane County, is in attainment with all criteria air pollutants (References 2.3.1-22 through 2.3.1-25). Neighboring counties (Blount, Knox and part of Anderson) were designated as attainment for ozone on June 13, 2015 (Reference 2.3.1-23). Anderson, Blount, Knox, Loudon and part of Roane County were designated non-attainment for annual $PM_{2.5}$ in 1997 and non-attainment for 24-hour $PM_{2.5}$ in 2006 (Reference 2.3.1-24). The portion of Roane County that is non-attainment for $PM_{2.5}$ is U.S. Census 2000 block 47-145-0307-2 which includes Kingston Fossil Plant. While the CRN Site is in Roane County, it is not in the census block that has been designated non-attainment for $PM_{2.5}$. Ambient air quality measurements in the vicinity of the CRN Site in 2013 are shown in Table 2.3.1-5 (Reference 2.3.1-22).

The Clean Air Act defines Class I areas as national parks greater than 6000 acres; wilderness areas greater than 5000 acres; national memorial parks greater than 5000 acres; and international parks that were in existence as of August 1977. These areas have been designated as Class I areas in order to protect their air quality under more stringent regulations as specified in Section 169A of the Clean Air Act.

The U.S. Environmental Protection Agency (EPA) promulgated the Regional Haze Rule to improve visibility in Class I areas in 1999 with the ultimate goal of restoring natural background visibility by 2064 (Reference 2.3.1-25). This rule was amended in 2005 to require certain industrial facilities to install emission controls to reduce emissions of air pollutants that reduce visibility (Reference 2.3.1-22 and Reference 2.3.1-35). These pollutants include $PM_{2.5}$ and compounds that contribute to $PM_{2.5}$ formation, such as nitrogen oxides, sulfur dioxide, certain volatile organic compounds and ammonia.

The closest Class I area to the CRN Site is the Great Smoky Mountains National Park. The nearest boundary of this park to the CRN Site is approximately 30 miles southeast. Two other Class I areas are in the vicinity of the CRN Site: Joyce-Kilmer Slickrock Wilderness Area is 36 miles south-southeast; and Cohutta Wilderness Area is 60 miles south of the site (Reference 2.3.1-26) (Figure 2.3.1-1).

2.3.1.7.2 Projected Air Quality

Generation of electricity from two or more SMRs at the CRN Site would not be a source of criteria pollutants or other air toxic pollutants. However, supporting equipment such as cooling towers, auxiliary boilers, fire pump engines, and emergency or standby diesel generators would emit criteria pollutants. These supporting sources are not expected to be a significant source of criteria pollutant emissions or to significantly impact ambient air quality. If the CRN Site facility were to emit criteria pollutants above significance thresholds, it would need to apply for a Prevention of Significant Deterioration permit prior to construction. The application for this permit would require a demonstration of compliance with applicable regulations and a demonstration that ambient air quality standards will not be threatened or exceeded as a result of the operation of this facility.

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2.3.1-32. Hydrometeorological Report HMR-53, NUREG/CR-1486, Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates, United States East of the 105th Meridian.

2.3.1-33. EPRI Advanced Light Water Reactor (ALWR) Utility Requirements Document (URD), EPRI TR-016780 - Utility Requirements Document, Volume II, Rev 8.

2.3.1-34. The Tennessee Encyclopedia of History and Culture, Version 2.0, Tennessee Historical Society.

2.3.1-35. Federal Register Vol. 70, No. 128, July 6, 2005, page 39104.

2.3.1-36. NOAA Hydrometeorological Report HMR-52, Application of Probable Maximum Precipitation Estimates – United States East of the 105th Meridian, August 1982.

2.3.1-37. U.S. Geological Survey, National Climate Change Viewer, Summary for Roane County, Tennessee, May 13, 2014.

2.3.1-38. Interim Staff Guidance (ISG) on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures (ISG-7), U.S. NRC, Issued Final.

2.3.1-39. Ludlum, David M., Weather Record Book, United States and Canada, Weatherwise, Inc., 1971, page 73.

Table 2.3.1-1
Conversion of Oak Ridge and Knoxville Wind Speeds to Consistent Units

Station	Time Period	Observed Maximum (mph)		Estimated Maximum (mph)	
		Fastest Mile	3-Second Gust	Fastest Mile	3-Second Gust
Oak Ridge	1985–1998[(a)]	NR	51 (Nov 1995)	40	51
	2000–2013[(b)]	NR	53 (Feb 2009)	42	53
Knoxville	1942–1974[(c)]	73 (Jul 1961)	NR	**73**	**87**
	1985–1995[(d)]	NR	86 (Aug 1995)	72	86
	1996–2013[(e)]	NR	76 (Apr 1996)	63	76

Station	Time Period	Maximum Hourly Average (mph)	Adjustment to 3-s gust (mph)
TVA Sequoyah[(f)] (10-m level)	1971–2013	40 (Oct 29, 1971)	60
TVA Watts Bar[(g)] (10-m level)	1973–2013	30.0 (Mar 25, 1975)	45
CRN Site (10-m level)	April 21, 2011–July 9, 2014	15.1 (Feb 19, 2013)	23

(a) Reference 2.3.1-10
(b) Reference 2.3.1-11
(c) Reference 2.3.1-3
(d) Reference 2.3.1-4
(e) Reference 2.3.1-5
(f) Reference 2.3.1-13
(g) Reference 2.3.1-14

Notes:

NR = Not Recorded

Conversions are based on TIA-222-G, “Structural Standards for Antenna Support Structures and Antennas” (Reference 2.3.1-21), Annex L.

Table 2.3.1-2
Precipitation for Stations around Clinch River Nuclear Site

Station	Period of Record (years)	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	30[a]	50.91			11.1		
	66[b]		7.48 (Aug 1960)	19.27 (Jul 1967)			
	52[b]					12.0 (Mar 1960)	21.0 (Mar 1960)
Knoxville NWS Station[b]	30	47.86			6.5		
	72		5.98 (Sep 2011)	12.67 (Jan 2013)			
	69					18.2 (Nov 1952)	23.3 (Feb 1960)
Chattanooga NWS Station[b]	30	52.48			3.9		
	74		9.50 (Sep 2011)	16.32 (Mar 1980)			
	76					20.0 (Mar 1993)	20.0 (Mar 1993)
Nashville NWS Station[b]	30	47.25			6.3		
	74		9.09 (May 2010)	16.43 (May 2010)			
	66					10.2 (Dec 1963)	18.9 (Feb 1979)
TVA Sequoyah[c]	30	45.79					
	40		8.04 (Sep 2004)	13.34 (Mar 1980)			
TVA Watts Bar[d]	30	45.70					
	41		8.43 (Sep 2011)	12.33 (Mar 1975)			

(a) Reference 2.3.1-10
(b) Reference 2.3.1-2, 2.3.1-5, 2.3.1-6, and 2.3.1-11
(c) Reference 2.3.1-13
(d) Reference 2.3.1-14

Table 2.3.1-3
Tornadoes Reported within 10 Miles of Clinch River Nuclear Site (1950–2013)

Date	Counties	Magnitude (WS range)	Length (miles)	Width (yards)	Closest Distance to CRN Site
10/1/1977	Roane	F0 (40–72 mph)	0.2	100	9 miles
2/21/1993	Roane Loudon Blount	F3 (158–206 mph)	30	100	4 miles
5/18/1995	Morgan	F0 (40–72 mph)	0.5	23	10 miles
4/27/2011	Knox	EF0 (65–85 mph)	1	50	10 miles
6/22/2011	Roane	EF0 (65–85 mph)	0.6	20	9 miles

Sources:
Reference 2.3.1-16
Reference 2.3.1-1
Notes:
CRN = Clinch River Nuclear

Table 2.3.1-4 (Sheet 1 of 2)
Normal Temperature and Precipitation

Period	Normal Daily Maximum Temperature (°F)	Normal Dry-Bulb Temperature (°F)	Normal Daily Minimum Temperature (°F)	Normal Annual Precipitation (inches)
Knoxville NWS Station[(a)]				
1921–1950	70.2	59.3	48.4	45.51
1931–1960	70.4	59.6	48.8	45.85
1941–1970	69.8	59.7	49.5	46.18
1951–1980	69.0	58.9	48.7	47.29
1961–1990	68.9	57.6	46.3	47.14
1971–2000	68.3	58.9	48.4	48.22
1981–2010	69.5	59.1	48.8	47.86

(a) 1953, 1963, 1973, 1983, 1993, 2003, and 2013 Annual Local Climatological Data (LCD) for Knoxville, TN; National Climatic Data Center. (Reference 2.3.1-28)

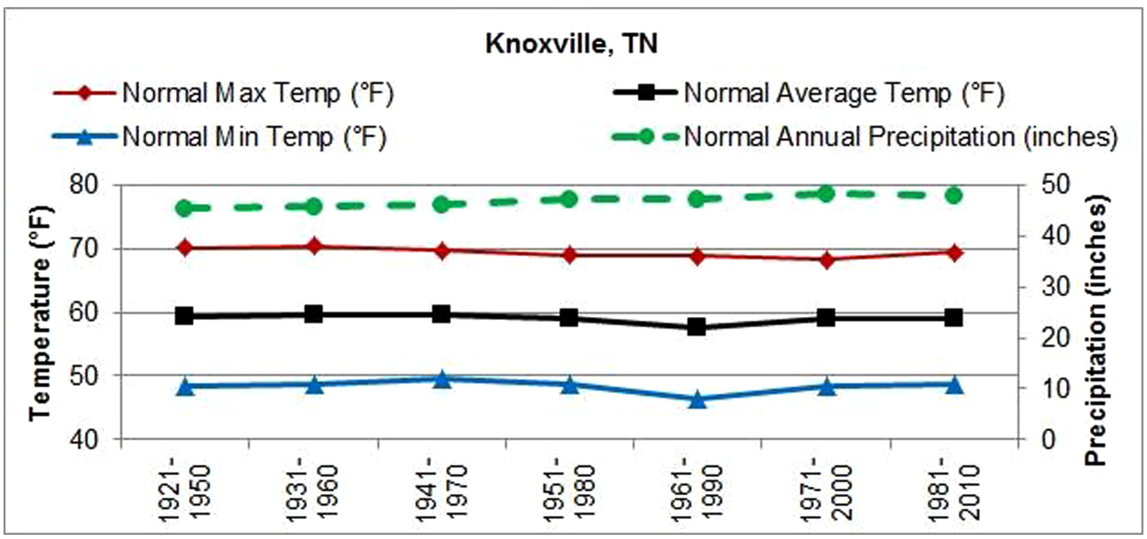


Table 2.3.1-4 (Sheet 2 of 2)
Normal Temperature and Precipitation

Period	Normal Daily Maximum Temperature (°F)	Normal Dry-Bulb Temperature (°F)	Normal Daily Minimum Temperature (°F)	Normal Annual Precipitation (inches)
Oak Ridge NWS Station(b)				
1921–1950	70.2	57.9	45.5	53.72
1931–1960	69.8	58.5	47.2	54.71
1941–1970	68.6	57.8	47.0	52.60
1951–1980	68.4	57.5	46.5	54.76
1961–1990	68.0	56.6	45.1	53.77
1971–2000	68.9	57.6	46.2	55.05
1981–2010	69.4	58.0	48.3	50.91

(b) 1953, 1963, 1973, 1983, 1993, 2003, and 2013 Annual Local Climatological Data (LCD) for Oak Ridge, TN; National Climatic Data Center. (Reference 2.3.1-29)

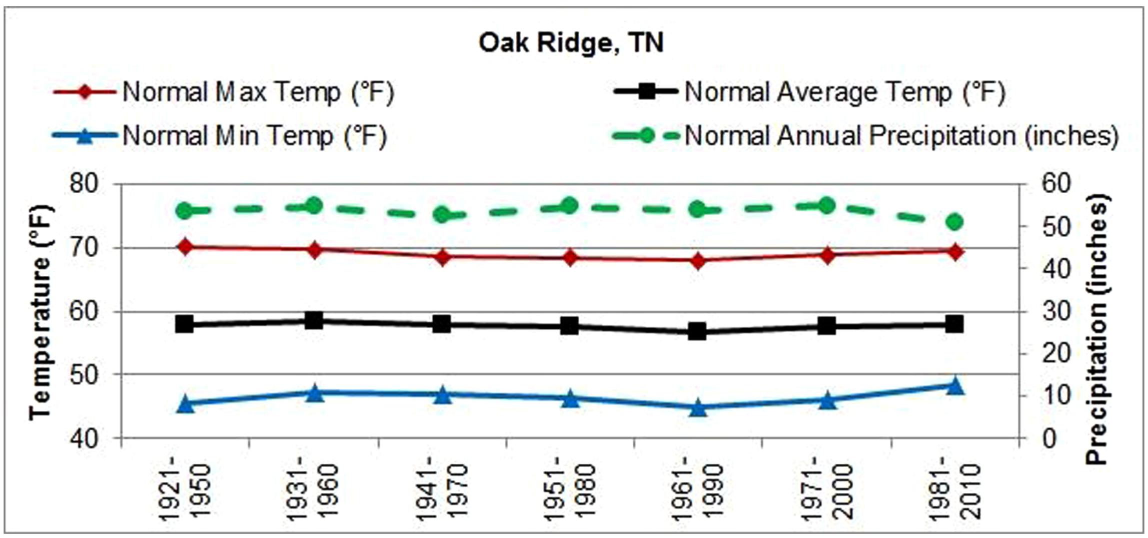


Table 2.3.1-5
Ambient Air Quality Concentrations in the Vicinity of Clinch River Nuclear Site in 2013

Pollutant	Roane County	Anderson County	Blount County	Knox County	Loudon County	NAAQS
4th Max 8-hr Ozone (ppm)	ND	0.060	0.064	0.061	0.061	0.070
2nd Max 24-hr PM_{10} (µg/m^3)	ND	ND	ND	27	ND	150
98th Percentile 24-hr $PM_{2.5}$ (µg/m^3)	18	ND	17	20	17	35
Annual Mean $PM_{2.5}$ (µg/m^3)	8.6	ND	8.6	10.2	9.1	15
99th Percentile 1-hr SO_2 (ppb)	ND	5	4	ND	ND	75

Notes:
ND indicates No Data.
ppm = parts per million
µg/m^3 = micrograms per cubic meters
ppb = parts per billion

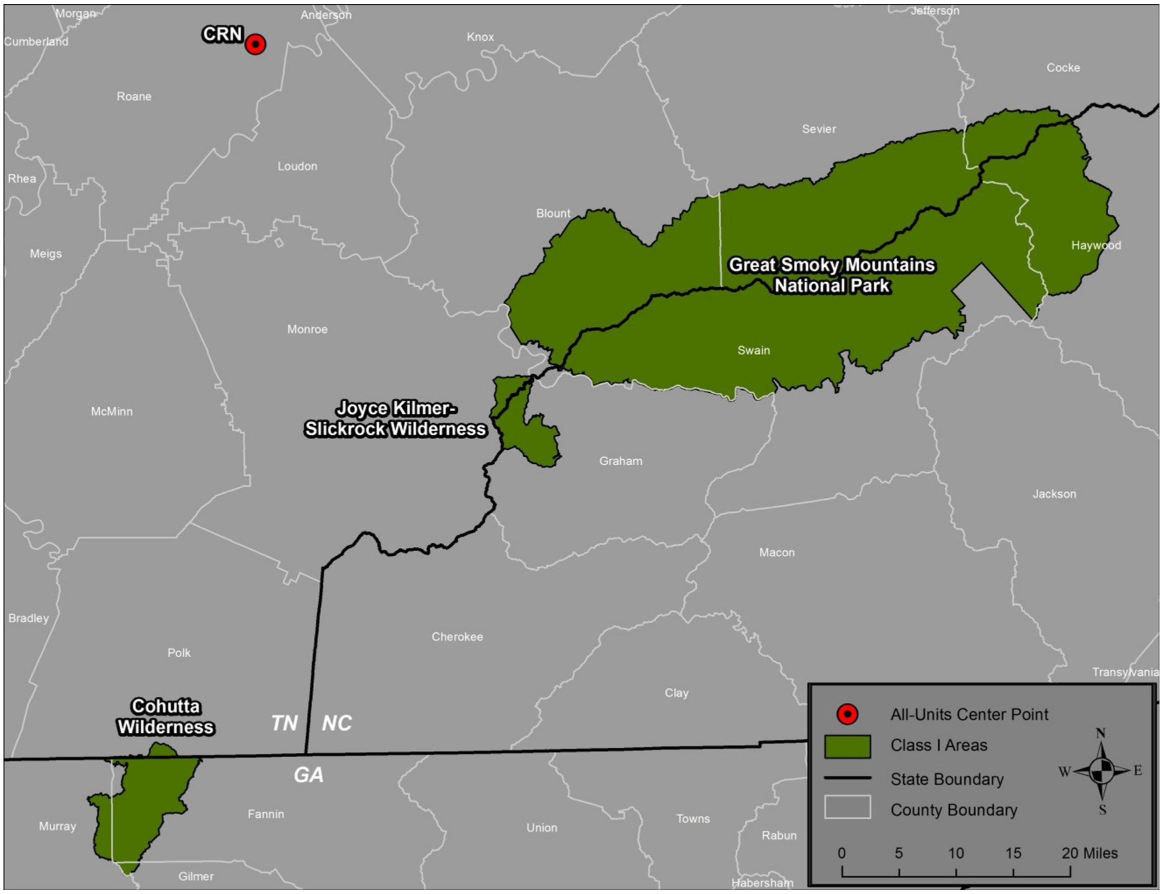


Figure 2.3.1-1. Map of Class I Areas in the Vicinity of the Clinch River Nuclear Site

2.3.2 Local Meteorology

Short-term site-specific meteorological data, collected from the TVA meteorological facility at the Clinch River Nuclear (CRN) Site during April 21, 2011–June 30, 2013, are the primary basis for dispersion meteorology analysis. In addition to onsite measurements, data representative of the site or indicative of site conditions were also obtained from previous onsite measurements, climatological records for the cities of Oak Ridge and Knoxville, and from the Watts Bar Nuclear Plant, all located in East Tennessee.

Topography around the site strongly influences the local climate. Mountain ranges located both northwest and southeast of the site are oriented generally northeast-southwest. The Appalachian Mountains to the east and southeast provide an orographic barrier that reduces the low-level atmospheric moisture from the Atlantic Ocean brought into the area by winds from the east. However, considerable low-level atmospheric moisture from the Gulf of Mexico is often brought into the area by prevailing winds from the south, southwest, or west.

The CRN Site is located at an elevation of approximately 821 feet above mean sea-level on a peninsula formed by the Clinch River arm of the Watts Bar Reservoir. Terrain in the vicinity of the site (Figure 2.3.2-1) is characterized as alternating ridges and valleys oriented along a southwest-to-northeast axis. Nearby ridges reach an elevation of 1100 feet above sea-level (approximately 300 feet above plant grade). There are significant gaps in the ridges to the east (E Clinch River Gap), south-southeast (Caney Creek Gap), and northwest (NW Clinch River Gap). Figures 2.3.2-57 through 2.3.2-64 show the elevation profiles within 50 miles of the site in each of the compass directions.

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 combination of high pressure associated with the Azores-Bermuda anti-cyclonic circulation and the nearby ridges result in generally light wind speeds. Average surface wind speeds for the site are less than 4 miles per hour (mph).

Meteorological measurements were made using three different on-site towers. These towers are designated as the Temporary, Primary, and Supplemental Towers as listed in Table 2.3.2-1 and further described in Subsection 2.3.3.1. The primary meteorological tower was used for both the Clinch River Breeder Reactor Project and the current Clinch River Small Modular Reactor Project. Data from all three towers were used to evaluate the impact of topography. The principal impact is on wind directions (Figure 2.3.2-2).

The predominant up-valley/down-valley flow is readily apparent at all three meteorological towers (Figure 2.3.2-1). For the primary and temporary towers at levels 25 meter (m) and higher and for all time periods, there are two peaks in the wind direction frequency: up-valley from the SW-WSW and down-valley from the NE-ENE. This bimodal flow also exists at the 10-m levels for all the towers (Figure 2.3.2-2, Sheet 1, Section b).

However, local effects are also apparent, due to the placement of the towers relative to surrounding terrain.

- The 10-m level on the supplemental tower (Ms) has a much greater frequency of winds from the ENE-E than the 10-m data from the other towers because it is more exposed to wind flow from the E Clinch River Gap. At the other towers, the flow through this gap tends to merge with the overall down-valley flow.

- The 10-m level on the primary tower (Mp) has a greater frequency of winds from the SSE than the other towers because of wind flow from the Caney Creek Gap.
- The temporary tower (Mt) has a noticeable sharp peak at all levels for winds from the SW due to the up-valley wind flow. This sharp peak is not as apparent at the other towers (Figure 2.3.2-2, Sheet 2, Section c).

2.3.2.1 Normal and Extreme Values of Meteorological Parameters

Long-term temperature and precipitation records were examined to determine if data collected at the CRN Site are consistent with regional conditions, both spatially and over time.

Comparisons of common measurements for the different data periods have been made to determine if site meteorological conditions are changing significantly over time (see Table 2.3.2-2, Section a). Common variables (except wind direction) can be compared directly, but wind direction is too dependent on topography for direct comparison particularly with offsite data. The data in Table 2.3.2-2, Section a shows that there is generally good agreement between the different data periods. The differences fall within the normally expected variations. Therefore, it is concluded that meteorological characteristics for the CRN Site have not changed significantly over time.

Comparing data from nearby offsite locations helps to determine if the CRN Site is consistent with regional conditions. Data were examined for April 21, 2011–June 30, 2012 (Table 2.3.2-2, Section b). There is good agreement between the CRN Site and the offsite locations, especially the average values.

These comparisons indicate that, for these variables, data from the CRN Site is consistent with overall meteorological conditions in the vicinity. This is characteristic of the similarity in controlling synoptic influences throughout the region. Other meteorological parameters are subject to the same synoptic controls.

2.3.2.1.1 Winds

During 2011–2013, 10-m wind data were collected by the meteorological tower at the CRN Site. The meteorological facility generally met criteria for obtaining data representative of the atmospheric conditions. However, concerns were expressed because of nearby obstructions that exceeded the 1-to-10 height-to-distance criteria specified in NRC Regulatory Guide 1.23. An evaluation of these obstructions determined they would have minimal impact on wind measurements at the CRN site.

Average Wind Direction and Wind Speed Conditions

Joint frequency distributions of wind direction (vector), average (scalar) wind speed, and stability class from wind instruments at 10-m at the CRN Site are presented in Subsection 2.3.4. The CRN Site data are presented as wind roses in Figures 2.3.2-3 through 2.3.2-28. Wind roses for Chattanooga, based on ten years of data (2000–2009), are presented in Figures 2.3.2-29 through 2.3.2-41. Wind roses for Oak Ridge, based on ten years of data (2000–2009), are presented in Figures 2.3.2-42 through 2.3.2-54.

Wind speeds at the CRN Site during 2011–2013 (Table 2.3.2-3) were generally light with an average 10-m speed of 2.74 mph. The maximum 10-m hourly average (scalar) wind speed was 15.1 mph. 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 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 are less than 4 mph. 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.

Wind Direction Persistence

Generally, the longer the winds blow in the same direction, the lower the dilution potential because effluent is not dispersing significantly to the sides of the plume. Wind direction persistence is an indicator of the duration of atmospheric transport from a single sector (same sector, 22.5 degrees), three adjoining sectors (± 1 sector, 67.5 degrees), and five adjoining sectors (± 2 sectors, 112.5 degrees). For the CRN Site (Table 2.3.2-4), the maximum persistence at 10-m is 19 hours from W for the same sector, 46 hours from WNW-NNW for ± 1 sector, and 106 hours from SW-NW for ± 2 sectors.

The wind data show a consistent pattern of wind directions with predominant winds from the WSW-NW. There is little seasonal variation (Figure 2.3.2-55). Due to the combination of uniformly light winds speeds and surrounding terrain, there will often be little transport away from the site.

2.3.2.1.2 Air Temperature

Temperature data for Knoxville (Reference 2.3.2-1) and Oak Ridge (Reference 2.3.2-2) are presented in Tables 2.3.2-5 and 2.3.2-6, respectively. Normal temperatures have ranged from the upper 30s in the winter to the upper 70s 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 Knoxville and 105°F (July 1952 and June 2012) at Oak Ridge, while the extreme daily minima (during January 1985) were -24°F and -17°F, respectively.

2.3.2.1.3 Atmospheric Moisture

Long-term relative humidity and absolute humidity data for Knoxville and Oak Ridge are presented in Table 2.3.2-7. Short-term humidity data based on measurements at the onsite meteorological facility are summarized in Table 2.3.2-8. The humidity data among the three sites (Knoxville, Oak Ridge, and CRN Site) are compared in Tables 2.3.2-7 and 2.3.2-8. CRN Site data match well with the long-term data.

2.3.2.1.4 Precipitation

Rain

Valid reliable onsite precipitation observations are not available from the CRN Site. Hourly data collected at the Oak Ridge National Weather Service (NWS) station (approximately 12 miles northeast of the CRN Site) is being used as an alternative because it is the nearest data source to the site.

Precipitation data from Oak Ridge (Reference 2.3.2-2) are presented in Table 2.3.2-9. Precipitation falls an average of about 125 days per year, and the normal annual precipitation is nearly 51 inches. The maximum monthly rainfall has ranged from about 7 inches to just over

19 inches. The minimum monthly amount was a trace in 1963. The maximum in 24 hours was 7.48 inches in August 1960. With the exception of late-summer/early-autumn (which are slightly drier) precipitation is fairly uniformly distributed through the year. July and March are normally the wettest months of the year.

Oak Ridge precipitation data during the 2011–2013 CRN Site sampling period (Reference 2.3.2-3, Table 2.3.2-10) indicate wetter than normal precipitation during 2011 and 2013, and drier than normal during 2012. Overall, precipitation was slightly above normal.

Maximum rainfall, estimated by statistical analysis of regional precipitation data, is given in Table 2.3.2-16 for return periods of one to 100 years and for rainfall durations of from five minutes to ten days. This data was taken from NOAA Technical Memorandum NWS Hydro-35 (Reference 2.3.2-8), NWS Technical Paper No. 40 (Reference 2.3.2-9), and NWS Technical Paper No. 49 (Reference 2.3.2-10).

Probable maximum precipitation (PMP), sometimes called maximum possible precipitation, for a given area and duration is the depth which can be reached but not exceeded under known meteorological conditions. For the site area, using a 100 year return period, the PMP for 6, 12, 24, and 48 hours is 5.0, 6.0, 6.8, and 8.0 inches, respectively (see Table 2.3.2-16).

Approximately 49 thunderstorms occur in a typical year (References 2.3.2-4). Thunderstorm activity is most predominant in the spring and summer seasons, and the maximum frequency of thunderstorm days is normally in July (Table 2.3.2-9).

Snow

Appreciable snowfall is relatively infrequent in the area. Snowfall data are summarized in Table 2.3.2-11 for Knoxville and Oak Ridge. Normal annual snowfall has ranged from about 6.5 inches at Knoxville to about 11 inches at Oak Ridge. Generally, significant snowfalls are limited to December through March. Respective 24-hour maximum snowfalls have been 18 and 12 inches at Knoxville and Oak Ridge.

Precipitation Wind Roses

Table 2.3.2-12 shows composite 2011–2013 precipitation data based on Oak Ridge hourly precipitation and CRN Site wind directions (vector). Precipitation is most associated with wind directions from SW-NW. There is a secondary maximum with wind directions from NE-ENE.

2.3.2.1.5 Fog

Fog data for Knoxville and Oak Ridge are presented in Table 2.3.2-13. 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 the autumn normally the foggiest season. The CRN Site has conditions more similar to Oak Ridge.

2.3.2.1.6 Atmospheric Stability

Atmospheric stability is based on the temperature difference between the 60-m and 10-m measurement levels. The frequency occurrence of Pasquill (classes A-G) atmospheric stability classes is presented in Table 2.3.2-14. While neutral lapse conditions (class D) occur most frequently, stable lapse conditions (i.e., inversions) typically occur over 50 percent of the time. The most stable class (class G) occurs 17 percent of the time.

Inversion Persistence

Table 2.3.2-15 presents a summary of onsite inversion persistence data, with a breakdown by stability class, for 2011–2013. Inversion persistence is defined as two or more consecutive hours of a single stable class (or combination of stable classes). The longest contiguous periods of inversion conditions were 19 hours.

Mixing Heights

Holzworth (Reference 2.3.2-5) estimated monthly mean maximum heights for Nashville, TN (the NWS upper air site closest to the CRN Site). Approximate seasonal and annual estimates of mixing heights for the CRN Site:

- Winter (December, January, February) – 563 m (1847 feet) (morning), 1123 m (afternoon).
- Spring (March, April, May) – 606 m (1988 feet) (morning), 1783 m (afternoon).
- Summer (June, July, August) – 441 m (1447 feet) (morning), 1874 m (afternoon).
- Autumn (September, October, November) – 357 m (1171 feet) (morning), 1473 m (afternoon).
- Annual – 492 m (morning), 1563 m (5128 feet) (afternoon).

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

The plant systems which may have any noticeable effects on the local meteorology are cooling towers. There will also be some minor impacts on local air quality during construction.

Evaluations of cooling tower impacts were performed assuming that linear mechanical draft cooling towers (LMDCT) will be utilized. Salt deposition rates, as a function of distance and direction from the cooling towers, were calculated for a representative model of the LMDCT using the Seasonal and Annual Cooling Tower Impact (SACTI) code (Reference 2.3.2-11). No salt deposition rates in the highest category are expected. Several deposition rates near the towers approach or slightly exceed the 1000 to 2000 kilograms per square km per month (kg/km^2/mo) value that could cause leaf damage in many species. However, this impact is insignificant because vegetation is expected to be minimal within close proximity of the towers. At 600 m and beyond, all deposition rates are below the 100 to 200 kg/km^2/mo limit set by NUREG-1555 (Reference 2.3.2-6, Section 5.3.3.2) as generally not damaging to vegetation. Therefore, offsite impact to native plant vegetation due to salt deposition from cooling tower operation will be minimal. The maximum salt deposition rate of 421.72 kg/km^2/mo (0.0422 mg/cm^2/mo) on the switchyard, which is approximately 300 m east of the cooling towers, places this in the light contamination level category per IEEE standard C57-19-100 (Reference 2.3.2-7, Table 1). Therefore, impact to the switchyard due to salt deposition is expected to be minimal. Area rainfall rates are sufficient to remove minor salt deposition. Water deposition, total dissolved solids (TDS) deposition, plume shadowing, plume length frequency, and plume height frequency were also determined for the LMDCTs. Results for these parameters are illustrated in Figures 2.3.2-65 through 2.3.2-70.

2.3.2.3 Local Meteorological Conditions for Design and Operating Bases

The local meteorological conditions for the design and operational bases are provided in Subsection 2.3.1.

2.3.2.4 References

2.3.2-1. National Climatic Data Center, “2013 Annual Local Climatological Data for Knoxville, Tennessee,” 2014.

2.3.2-2. National Climatic Data Center, “2013 Annual Local Climatological Data (LCD) for Oak Ridge,” Tennessee, 2014.

2.3.2-3. National Climatic Data Center, “2011–2013 Monthly Local Climatological Data (LCD) for Oak Ridge, Tennessee,” 2014.

2.3.2-4. National Climatic Data Center, “1998 Annual Local Climatological Data (LCD) for Oak Ridge, Tennessee,” 1999.

2.3.2-5. Holzworth, George. C., “Mixing Heights, Wind Speeds, And Potential for Urban Air Pollution Throughout the Contiguous United States,” Environmental Protection Agency, January 1972.

2.3.2-6. NUREG-1555, Rev. 0, “Standard Review Plans for Environmental Reviews for Nuclear Power Plants,” October 1999.

2.3.2-7. IEEE Standard C57.19.100-1995, “IEEE Guide for Application of Power Apparatus Bushings.”

2.3.2-8. NOAA Technical Memorandum NWS Hydro-35, “Five- to 60-minute Precipitation Frequency for the Eastern and Central United States,” June 1977.

2.3.2-9. National Weather Service Technical Paper No. 40, “Rainfall Frequency Atlas of the United States for Durations from 30 minutes to 24 Hours and Return Periods from 1 to 100 Years,” U.S. Department of Commerce, May 1961.

2.3.2-10. National Weather Service Technical Paper No. 49, “Two- to Ten-day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States, U.S. Department of Commerce, 1964.

2.3.2-11. EPRI CS-3403-CCM, “User’s Manual: Cooling-Tower-Plume Prediction Code,” September 1987.

Table 2.3.2-1
Clinch River Nuclear Site Meteorological Towers

Tower	Location	Data Collected	Data Collection Period
Clinch River Breeder Reactor Project (CRBRP)			
[Mt] Temporary	Latitude: 35° 53' 20" N Longitude: 84° 23' 10" W Elevation: 772.5 ft-msl UTM: Zone 16 Northing = 3974.58 km Easting = 735.95 km	60-, 25-m Wind 60-, 25-m Temperature	April 11, 1973– April 2, 1974
		60-, 25-, 10-m Wind 60-, 25-, 10-m Temperature 10-m Dewpoint (1975+)	April 3, 1974– March 2, 1978
[Mp] Primary	Latitude: 35° 53' 07" N Longitude: 84° 22' 33" W Elevation: 800.1 ft-msl UTM: Zone 16 Northing = 3974.21 km Easting = 736.88 km	110-, 60-, 10-m Wind 110-, 60-, 10-m Temperature 10-m Dewpoint Rainfall Atmospheric Pressure Solar Radiation	February 16, 1977– March 6, 1978
		110-, 60-, 10-m Wind 110-, 60-, 10-m Temperature 10-m Dewpoint Rainfall Solar Radiation	March 25, 1982– November 4, 1983
[Ms] Supplemental	Latitude: 35° 53' 43" N Longitude: 84° 22' 56" W Elevation: 851.9 ft-msl UTM: Zone 16 Northing = 3975.31 km Easting = 736.28 km	10-m Wind	February 16, 1977– March 6, 1978
		10-m Wind	March 25, 1982– November 4, 1983
Clinch River Small Modular Reactor Project			
[Mp] Primary	**Same as CRBRP Primary** Latitude: 35° 53' 07" N Longitude: 84° 22' 33" W Elevation: 800.1 ft-msl UTM: Zone 16 Northing = 3974.21 km Easting = 736.88 km	60-, 10-m Wind 60-, 10-m Temperature 60-, 10-m Dewpoint Rainfall Atmospheric Pressure Solar Radiation	April 21, 2011– July 9, 2013

Table 2.3.2-2
Comparisons of Meteorological Tower Measurements

a. Historical Primary Tower Measurements

Variable	2/16/77–3/6/78			3/25/82–11/4/83			4/21/11–6/30/13		
	Min	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
60-m Average (scalar) Wind Speed (mph)	0.0	**5.70**	33.0	0.1	**4.9**	32.8	0.3	**4.88**	27.1
10-m Average (scalar) Wind Speed (mph)	0.0	**3.45**	19.6	0.1	**2.8**	19.2	0.2	**2.75**	15.1
60-m Temperature (°F)	4.60	**55.64**	92.7	16.38	**60.81**	98.12	17.36	**60.03**	100.95
10-m Temperature (°F)	4.60	**54.92**	93.9	16.93	**60.06**	99.44	17.18	**59.11**	102.17
10-m Dewpoint (°F)	-13.1	**46.19**	76.9	-5.13	**52.12**	79.19	-3.43	**50.05**	78.19
Solar Radiation (langley/min)	0.00	**0.23**	1.43	0.00	**0.26**	1.48	0.00	**0.27**	1.51
Stability (from 60 m–10 m ΔT)	**% Occurrence**			**% Occurrence**			**% Occurrence**		
Unstable (Classes A-C)	7.88			13.02			13.69		
Neutral (Class D)	36.63			33.10			30.05		
Stable (Class E-G)	55.49			53.88			56.26		

b. Comparison of CRN Site with Offsite Locations

Variable	Clinch River (CRN) 10-m			Oak Ridge NWS Station 10-m			Watts Bar Nuclear 10-m		
	Min	**Avg**	**Max**	**Min**	**Avg**	**Max**	**Min**	**Avg**	**Max**
Wind Speed (mph)	0.00	**2.75**	15.1	0	**2.31**	26	0.00	**3.46**	17.30
Temperature (°F)	17.18	**59.11**	102.17	17	**60.79**	105	17.71	**60.70**	102.77
Dewpoint (°F)	-3.43	**50.05**	78.19	-10	**49.44**	77	-3.05	**50.28**	78.30

Notes:

Data Period: April 21, 2011–June 30, 2013

Table 2.3.2-3
Average (Scalar) Wind Speed for Clinch River Nuclear Site (2011–2013)

	Average (scalar) 10-m Wind Speed (miles per hour)
2011	
2nd quarter	2.74
3rd quarter	2.29
4th quarter	2.59
2012	
1st quarter	3.30
2nd quarter	2.49
3rd quarter	2.07
4th quarter	2.77
2013	
1st quarter	3.72
2nd quarter	2.79
Overall	**2.74**

Table 2.3.2-4
Wind Direction Persistence for Clinch River Nuclear Site (2011–2013)

	Maximum Hours of WD Persistence at 10 m		
WD Sector	**Same Sector**	**± 1 Sector**	**± 2 Sectors**
N	6	15	59
NNE	7	15	35
NE	10	29	39
ENE	8	26	32
E	6	17	31
ESE	6	17	26
SE	6	13	25
SSE	10	17	25
S	8	14	23
SSW	4	14	39
SW	7	33	44
WSW	15	36	55
W	**19**	36	**106**
WNW	11	43	86
NW	15	**46**	67
NNW	7	45	69

Notes:
Bold indicates the maximum values.
Grey fill indicates the sector range.
Data Period: April 21, 2011–June 30, 2013.
WD = Wind Direction

Table 2.3.2-5
Air Temperatures for Knoxville, Tennessee

	Normal Daily Maximum	Normal Dry Bulb	Normal Daily Minimum	Extreme Daily Maximum	Extreme Daily Minimum
Period of Record (yrs)	**30[a]**	**30[a]**	**30[a]**	**72**	**72**
January	47.3	38.2	29.2	77	-24[c]
February	52.3	42.4	32.4	83	-8
March	61.4	50.3	39.2	86	1
April	70.3	58.8	47.3	92	22
May	78.1	67.2	56.2	96	32
June	85.4	75.0	64.7	105[b]	43
July	88.2	78.4	68.7	105[b]	49
August	87.8	77.8	67.8	102	49
September	81.8	71.1	60.4	103	36
October	71.2	59.9	48.5	91	25
November	60.4	49.7	39.0	84	5
December	49.8	40.8	31.7	80	-6
Annual	69.5	59.1	48.8	105[b]	-24[c]

(a) 1981–2010
(b) June 2012 and July 2012
(c) January 1985

Notes:

Air Temperature (°F) from 2013 Annual Knoxville Local Climatological Data.

Table 2.3.2-6
Air Temperatures for Oak Ridge, Tennessee

	Normal Daily Maximum	Normal Dry Bulb	Normal Daily Minimum	Extreme Daily Maximum	Extreme Daily Minimum
Period of Record (yrs)	**30[(a)]**	**30[(a)]**	**30[(a)]**	**66**	**66**
January	46.6	37.7	28.9	76	-17[(c)]
February	51.9	41.8	31.7	79	-13
March	61.4	50.4	39.3	86	1
April	70.6	58.8	46.9	92	20
May	78.3	66.8	55.2	95	30
June	85.7	75.1	64.5	105[(b)]	39
July	88.4	78.5	68.6	105[(b)]	49
August	88.0	77.6	67.2	103	50
September	81.7	70.7	59.7	102	33
October	71.1	59.5	48.0	90	21
November	59.6	48.9	38.3	83	0
December	49.6	40.3	31.1	78	-7
Annual	69.4	58.8	48.3	105[(b)]	-17[(c)]

(a) 1981–2010
(b) July 1952 and June 2012
(c) January 1985

Notes:

Air Temperature (°F) from 2013 Annual Oak Ridge Local Climatological Data.

Table 2.3.2-7
Humidity Values for Knoxville and Oak Ridge, Tennessee

Knoxville, TN	Mean Dry Bulb Temperature	Mean Dewpoint Temperature	Mean Relative Humidity (%)	Mean Absolute Humidity (g/m^3)
January	39.2	31.1	74	4.71
February	40.7	33.6	70	4.71
March	49.8	39.6	66	6.16
April	58.5	47.6	65	8.20
May	67.4	57.8	73	12.38
June	74.1	65.3	75	15.77
July	78.1	68.7	75	17.87
August	77.1	67.9	76	17.56
September	70.8	61.5	75	14.19
October	60.1	50.9	75	9.98
November	48.3	40.9	74	6.55
December	41.1	33.9	75	5.12

Oak Ridge, TN	Mean Dry Bulb Temperature	Mean Dewpoint Temperature	Mean Relative Humidity (%)	Mean Absolute Humidity (g/m^3)
January	36.8	31.8	71	4.11
February	40.1	34.0	65	4.27
March	49.2	40.7	64	5.82
April	58.3	49.8	63	7.89
May	66.2	58.8	71	11.57
June	73.9	65.8	69	14.41
July	77.4	69.7	75	17.49
August	76.7	68.9	73	16.65
September	70.2	62.3	76	14.05
October	58.7	51.8	73	9.31
November	48.1	41.7	68	6.01
December	39.9	34.1	76	4.94

Notes:
Temperatures and Dewpoints (°F) from 2013 Annual Knoxville and Oak Ridge Local Climatological Data.

Table 2.3.2-8
Humidity Values for Clinch River Nuclear Site

CRN	Average Dry Bulb Temperature	Average Dewpoint Temperature	Mean Relative Humidity (%)	Mean Absolute Humidity (g/m^3)
January	41.0	32.2	71	4.81
February	42.6	32.3	67	4.84
March	50.9	38.5	62	6.24
April	58.2	46.2	64	8.05
May	66.0	57.3	74	11.92
June	73.1	63.7	73	14.79
July	77.7	69.7	77	17.96
August	74.3	65.0	73	15.40
September	66.6	59.6	78	12.92
October	55.4	47.2	74	8.36
November	47.1	38.5	72	6.17
December	44.0	37.4	78	5.87

Notes:
Temperatures and Dewpoints (°F) observed at the Clinch River Nuclear Site during 2011–2013.

Table 2.3.2-9
Historical Precipitation Data for Oak Ridge, Tennessee

	Normal Monthly	Maximum Monthly	Minimum Monthly	Maximum in 24 hours	Days with Precipitation (≥ 0.01 inch)	Days with Thunderstorms[a]
Period of Record (yrs)	**30[b]**	**66**	**66**	**66**	**30[b]**	**17**
January	4.54	13.27	0.93	4.25	10.9	0.7
February	4.57	12.78	0.84	5.18	10.1	1.7
March	5.06	12.24	2.13	4.74	11.2	2.5
April	4.18	14.03	0.88	6.24	10.4	4.0
May	4.29	10.70	0.80	4.41	11.9	7.0
June	4.28	11.14	0.53	3.70	10.8	7.6
July	5.27	19.27[c]	1.23	4.91	13.0	10.4
August	2.76	10.46	0.54	7.48[e]	8.9	8.7
September	3.69	10.14	0.41	6.54	8.4	3.3
October	2.92	6.95	Trace[d]	2.66	8.3	1.3
November	4.49	12.22	1.14	5.29	9.3	1.1
December	4.86	12.64	0.67	5.12	11.3	0.8
Annual	50.91	19.27[c]	Trace[d]	7.48[e]	124.5	49.1

(a) From 1998 Annual Oak Ridge Local Climatological Data
(b) 1981–2010
(c) July 1967
(d) October 1963
(e) August 1960

Notes:

Precipitation (inches) from 2013 Annual Oak Ridge Local Climatological Data

Table 2.3.2-10
Precipitation (Inches) for Oak Ridge During 2011–2013
From Oak Ridge Monthly Local Climatological Data

Year	Month	Monthly Observed	
2011	January	3.99	
	February	5.70	
	March	6.65	
	April	9.13	
	May	2.14	
	June	7.30	
	July	4.80	
	August	0.91	
	September	10.14	
	October	4.59	
	November	10.89	Annual
	December	5.02	71.26
2012	January	6.52	
	February	3.76	
	March	5.59	
	April	3.10	
	May	2.84	
	June	1.40	
	July	5.84	
	August	2.89	
	September	7.17	
	October	1.66	
	November	1.14	Annual
	December	6.58	48.49
2013	January	10.51	
	February	2.32	
	March	5.72	
	April	6.37	
	May	5.33	
	June	7.92	
	July	8.04	
	August	4.61	
	September	3.38	
	October	0.72	
	November	4.43	Annual
	December	8.04	67.39
Normal Annual Precipitation based on 30 years of data (1984–2013)			50.91

Notes:
Shading represents the 26-month period of data collection at the Clinch River Nuclear Site.

Table 2.3.2-11
Historical Snowfall for Knoxville and Oak Ridge, Tennessee

Knoxville, TN	Normal Monthly	Maximum Monthly	Maximum in 24 hours	Maximum Snow Depth (inches)	Normal Number of Days with Snowfall ≥ 1.0 inch
Period of Record (yrs)	**30[(a)]**	**69**	**69**	**62**	**30[(a)]**
January	2.7	15.1	12.0	10	1.0
February	1.6	23.3[(b)]	17.5	15[(d)]	0.6
March	0.9	20.2	14.1	15[(d)]	0.2
April	0.5	10.7	10.7	7	0.1
May–October	0.0	Trace	Trace	0	0.0
November	0.0	18.2	18.2[(c)]	10	0.0
December	0.8	12.2	8.9	6	0.3
Annual	6.5	23.3[(b)]	18.2[(c)]	15[(d)]	2.2

(a) 1981–2010
(b) February 1960
(c) November 1952
(d) February 1960 and March 1993

Oak Ridge, TN	Normal Monthly	Maximum Monthly	Maximum in 24 hours	Maximum Snow Depth (inches)	Normal Number of Days with Snowfall ≥ 1.0 inch
Period of Record (yrs)	**30[(a)]**	**51**	**51**	**62**	**30[(a)]**
January	4.0	9.6	8.3	8	1.4
February	3.8	17.2	11.3	6	1.3
March	0.8	21.0[(b)]	12.0[(b)]	3	0.2
April	0.2	5.9	5.4	3	0.1
May–October	0.0	Trace	Trace	0	0.0
November	0.1	6.5	6.5	1	0.0
December	2.2	14.8	10.8	10[(c)]	0.6
Annual	11.1	21.0[(b)]	12.0[(b)]	10[(c)]	3.6

(a) 1961–1990
(b) March 1960
(c) December 1963

Notes:

Snowfall (inches) from 2013 Annual Knoxville and 1998 Annual Oak Ridge Local Climatological Data.

Table 2.3.2-12
Oak Ridge Precipitation by Clinch River Nuclear Site Wind Direction

CRN Site Wind Direction (blowing from)	Percent Occurrence of Oak Ridge Precipitation				
	All Precipitation	Precip. > 0.10 in	Precip. > 0.25 in	Precip. > 0.50 in	Precip. > 1.00 in
N	3.81	5.03	10.17	6.45	0.00
NNE	3.81	3.66	3.39	6.45	0.00
NE	7.99	9.38	6.78	3.23	0.00
ENE	6.93	9.15	5.93	0.00	0.00
E	4.91	5.49	5.08	0.00	0.00
ESE	3.73	4.12	5.08	3.23	0.00
SE	2.80	2.75	2.54	3.23	0.00
SSE	3.04	2.97	4.24	9.68	33.33
S	4.58	3.66	5.93	0.00	0.00
SSW	3.65	4.12	6.78	12.90	0.00
SW	6.16	7.09	11.02	12.90	0.00
WSW	12.49	9.38	7.63	16.13	0.00
W	11.64	11.67	8.47	3.23	0.00
WNW	11.35	7.78	5.08	6.45	33.33
NW	8.56	8.24	3.39	3.23	33.33
NNW	4.54	5.49	8.47	12.90	0.00

Notes:
2011–2013 composite based on Oak Ridge hourly precipitation and CRN Site wind directions.
Data Period: April 21, 2011–June 30, 2013

Table 2.3.2-13
Fog Occurrence for Knoxville and Oak Ridge, Tennessee

	Number of Days with Heavy Fog (visibility ≤ 1/4 mile)	
	Knoxville, TN	**Oak Ridge, TN**
Period of Record (yrs)	**50**	**14**
January	2.6	2.2
February	1.8	1.4
March	1.6	1.7
April	1.3	2.3
May	2.2	5.4
June	1.7	4.5
July	2.0	5.5
August	3.3	5.3
September	3.7	7.5
October	4.2	7.5
November	2.9	5.0
December	2.4	3.6
Annual	29.7	51.9

Notes:
Days with heavy fog from 2013 Annual Oak Ridge and Knoxville Local Climatological Data.

Table 2.3.2-14
Pasquill Atmospheric Stabilities for the Clinch River Nuclear Site

Percent Occurrence of Pasquill Atmospheric Stability Classes (by quarter)	
Stability Class	**Percentage**
A	2.83
B	3.51
C	6.01
D	**31.06**
E	23.23
F	16.34
G	17.01
Unstable	12.35
Neutral	31.06
Stable	56.59

Notes:

Atmospheric Stability Class based on 60–10 m temperature differential for **June 1, 2011 through May 31, 2013**.

Table 2.3.2-15
Frequency Distribution of Consecutive Hours of Inversion Conditions

Number of Consecutive Hours	Cumulative Hours in each Stability Class[a]				
	E (0.0<ΔT≤1.5)	F (1.5<ΔT≤4.0)	G (ΔT>4.0)	F and G (ΔT>1.5)	All Inversions (ΔT>0)
2	552	605	467	692	847
3	270	401	397	601	763
4	157	293	339	559	713
5	106	225	281	524	672
6	79	159	233	494	653
7	53	123	194	467	630
8	35	79	166	439	601
9	20	55	138	407	573
10	12	34	107	380	548
11	8	13	88	336	518
12	6	6	59	270	481
13	3	1	42	153	392
14	2	0	25	93	268
15	0	0	12	53	170
16	0	0	2	31	97
17	0	0	0	12	51
18	0	0	0	1	20
19	0	0	0	0	4

(a) Values in each column are cumulative. For example, values in row 2 include values from row 3, row 3 includes row 4, etc.

Notes:

ΔT is the 60–10 m temperature differential

This table shows the number of cases when an inversion condition persisted for two or more hours, and the number of hours the condition lasted.

Data Period: April 21, 2011–June 30, 2013.

Table 2.3.2-16
Point Precipitation (Inches) by Recurrence Interval for Region

	Recurrence Intervals (Years)						
Duration	**1**	**2**	**5**	**10**	**25**	**50**	**100**
5 minutes	–	0.5	0.5	0.6	0.7	0.7	0.8
10 minutes	–	0.7	0.8	0.9	1.1	1.2	1.3
15 minutes	–	0.9	1.1	1.2	1.4	1.6	1.7
30 minutes	1.1	1.2	1.5	1.7	2.0	2.3	2.5
1 hour	1.3	1.6	2.0	2.3	2.7	3.0	3.3
2 hours	1.6	1.8	2.4	2.8	3.2	3.4	3.8
3 hours	1.8	2.1	2.6	3.0	3.5	3.8	4.2
6 hours	2.1	2.5	3.1	3.7	4.0	4.8	5.0
12 hours	2.5	2.9	3.8	4.3	4.9	5.5	6.0
24 hours	2.9	3.5	4.3	4.9	5.8	6.5	6.8
2 days	–	4.0	5.0	5.8	6.6	7.5	8.0
4 days	–	4.6	6.0	6.7	8.0	9.0	9.5
7 days	–	5.5	7.0	7.8	9.2	10.2	11.4
10 days	–	6.2	7.5	8.9	10.2	11.5	12.8

Notes:

5 minute to 60 minute data based on spatial interpolation of isopluvials given in NOAA Technical Memorandum NWS Hydro-35, “Five- to 60-minute Precipitation Frequency for the Eastern and Central United States”, June 1977. (Reference 2.3.2-8)

2 hour through 24 hour data based on spatial interpolation of isopluvials given in National Weather Service Technical Paper No. 40, “Rainfall Frequency Atlas of the United States for Durations from 30 minutes to 24 Hours and Return Periods from 1 to 100 Years”, U.S. Department of Commerce, May 1961. (Reference 2.3.2-9)

2 day through 10 day data based on interpolation of isopluvials given in National Weather Service Technical Paper No. 49, “Two- to Ten-day Precipitation for Return Periods of 2 to 100 Years in the Contiguous Unites States, U.S. Department of Commerce, 1964. (Reference 2.3.2-10)

Dashes (–) = No Value

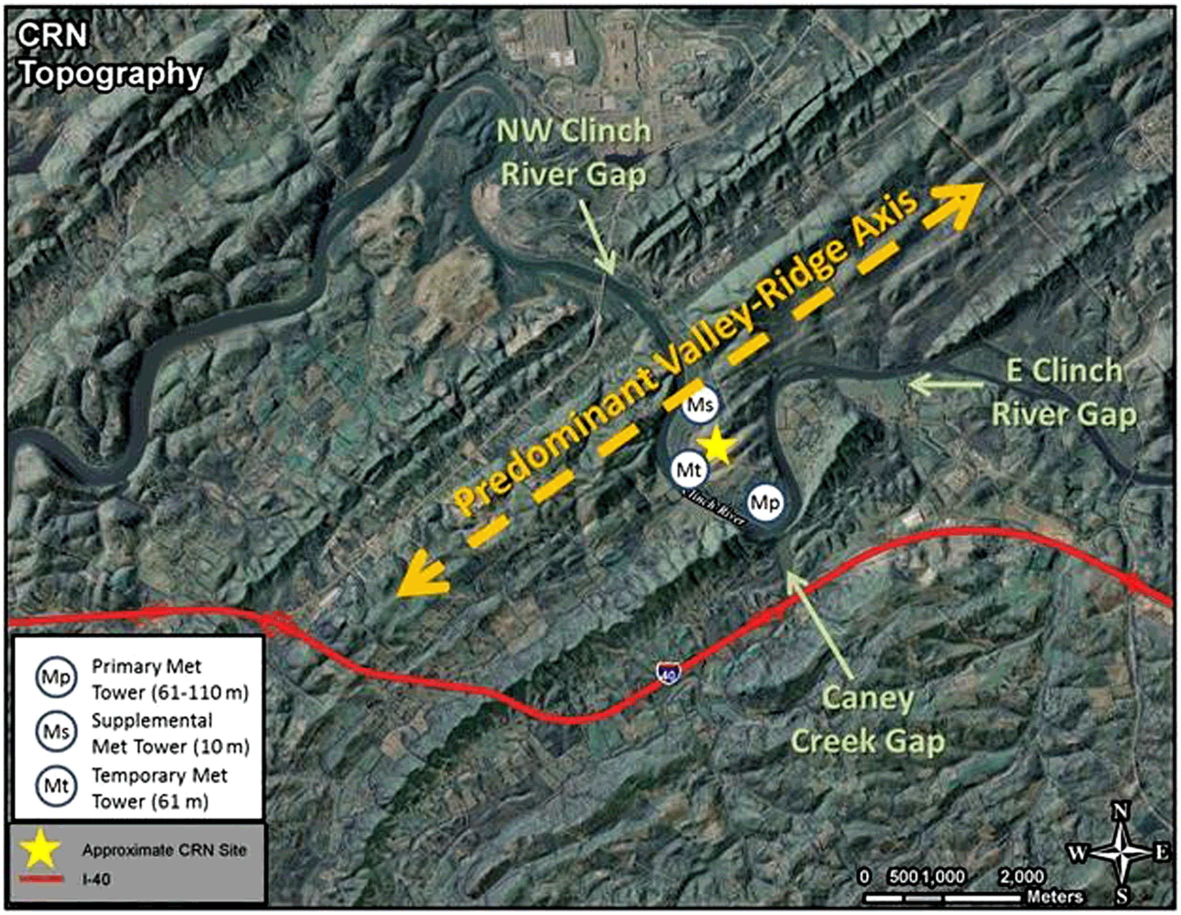
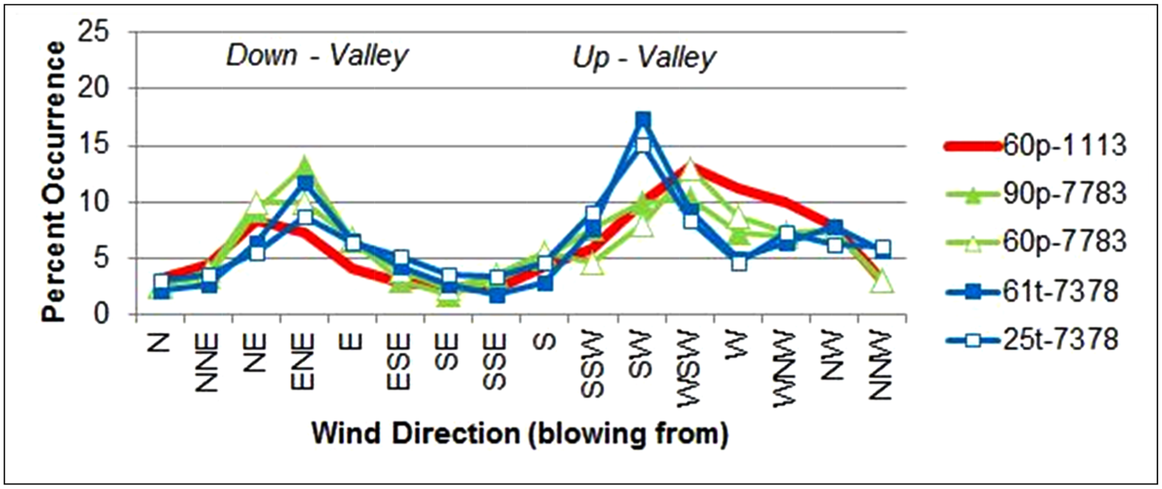


Figure 2.3.2-1. Local Topography in the Clinch River Nuclear Site Vicinity

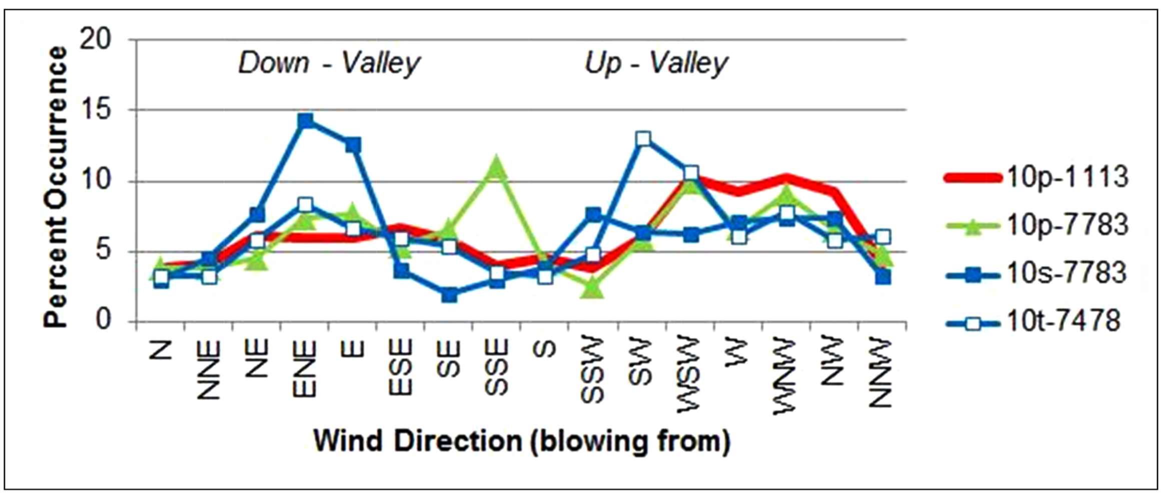
a. Frequency of Elevated Wind Directions



Primary Tower (Mp):
60p-1113 = 60 m (4/21/2011-6/30/2013)
90p-7783 = 90 m (2/16/1977-11/4/1983)
60p-7783 = 60 m (2/16/1977-11/4/1983)

Temporary Tower (Mt):
61t-7378 = 61 m (4/11/1973-3/2/1978)
25t-7378 = 25 m (4/11/1973-3/2/1978)

b. Frequency of 10-m Wind Directions

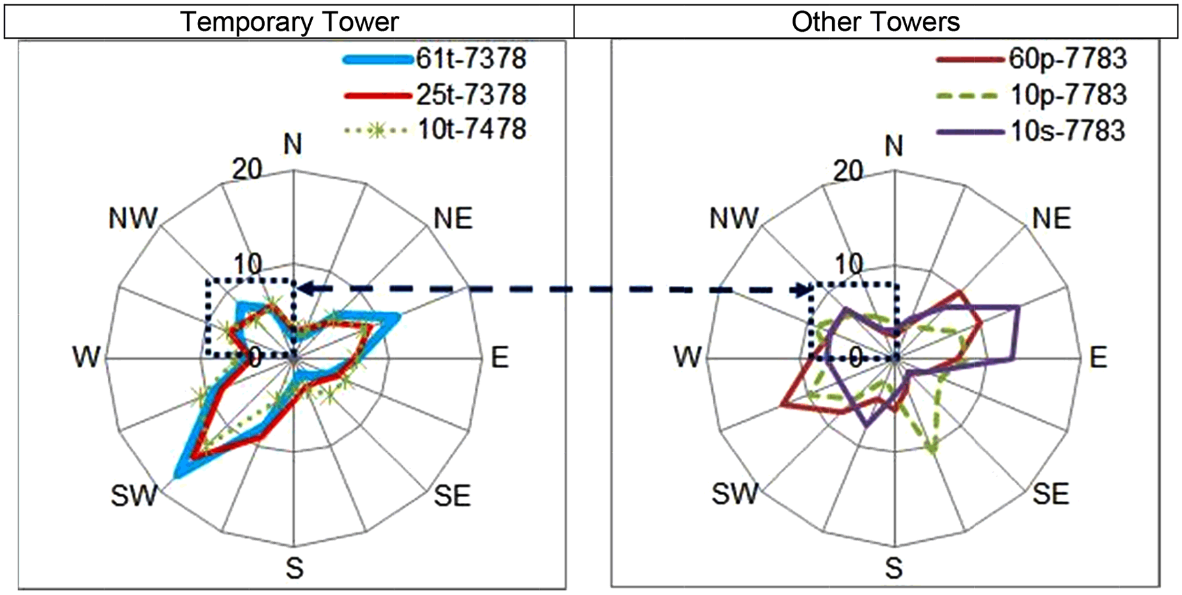


Primary Tower (Mp):
10p-1113 = 10 m (4/21/2011-6/30/2013)
10p-7783 = 10 m (2/16/1977-11/4/1983)

Supplemental Tower (Ms):
10s-7783 = 10 m (4/11/1973-3/2/1978)
Temporary Tower (Mt):
10t-7478 = 10 m (4/3/1974-3/2/1978)

Figure 2.3.2-2. (Sheet 1 of 2) Effects of Topography on Wind Flow in the Clinch River Nuclear Site Vicinity

c. Comparison of Wind Direction Peaks



Radials are percent occurrence (blowing from the indicated direction).

61t-7378 = [temporary] 61 m (1973-1978)
25t-7378 = [temporary] 25 m (1973-1978)
10t-7478 = [temporary] 10 m (1974-1978)
60p-7783 = [primary] 61 m (1977-1983)
10p-7783 = [primary] 10 m (1977-1983)
10s-7783 = [supplemental] 10 m (1977-1983)

Figure 2.3.2-2. (Sheet 2 of 2) Effects of Topography on Wind Flow in the Clinch River Nuclear Site Vicinity

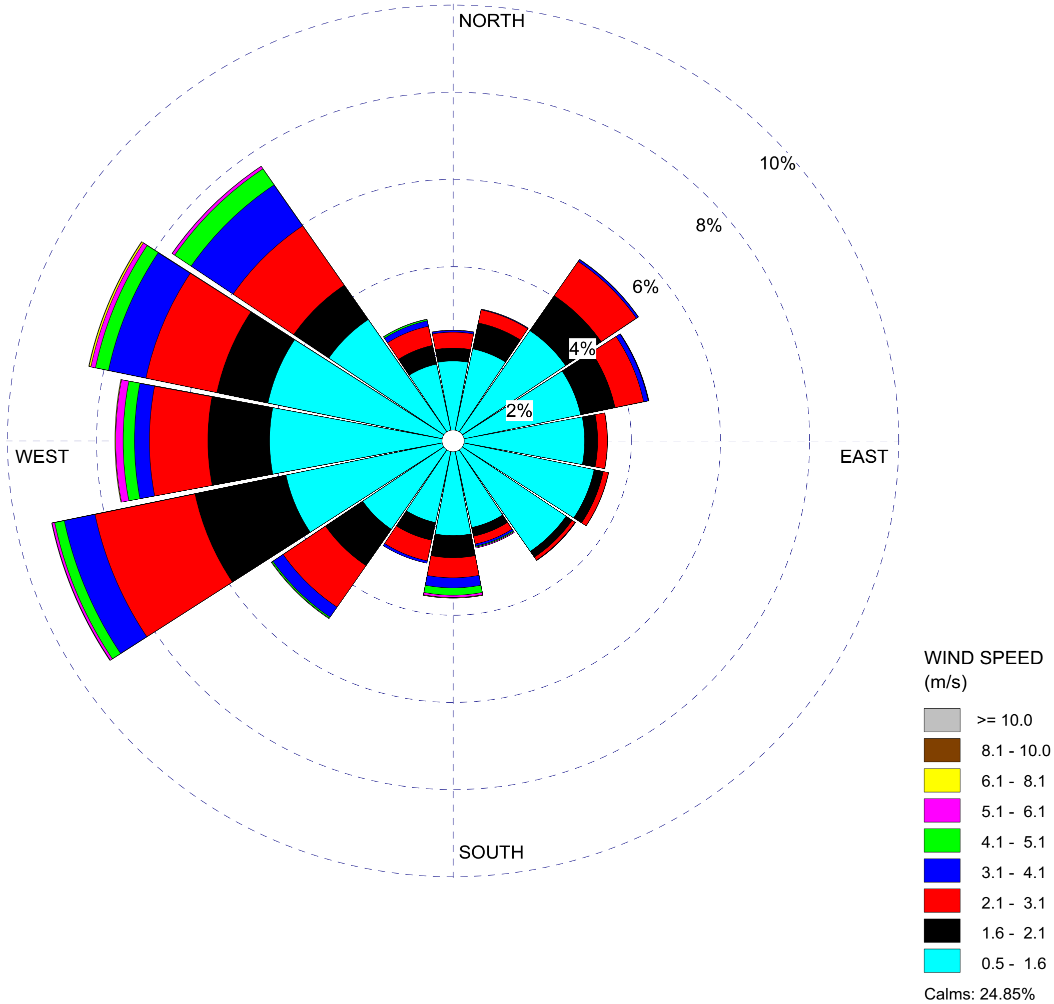


Figure 2.3.2-3. Wind Rose Clinch River Nuclear Site 10 m All Data

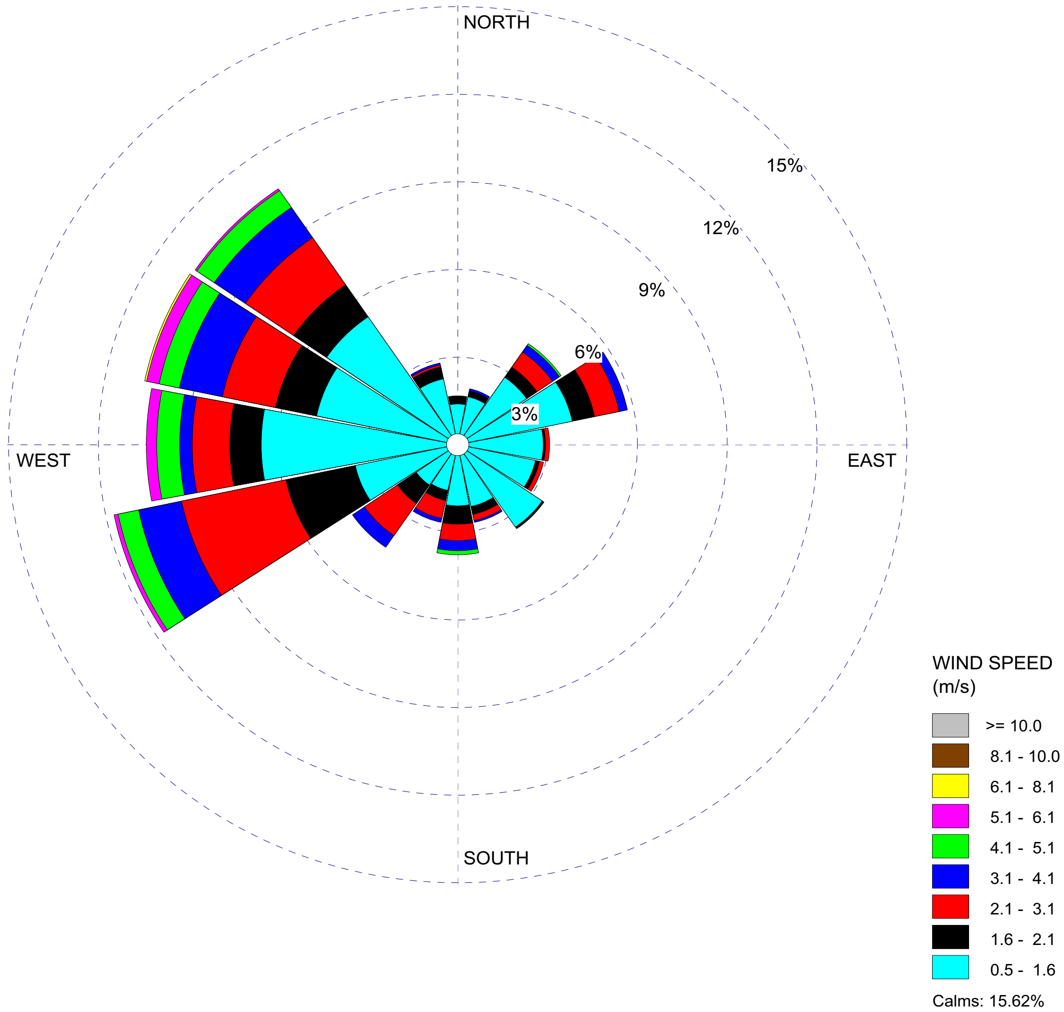


Figure 2.3.2-4. Wind Rose Clinch River Nuclear Site 10 m January

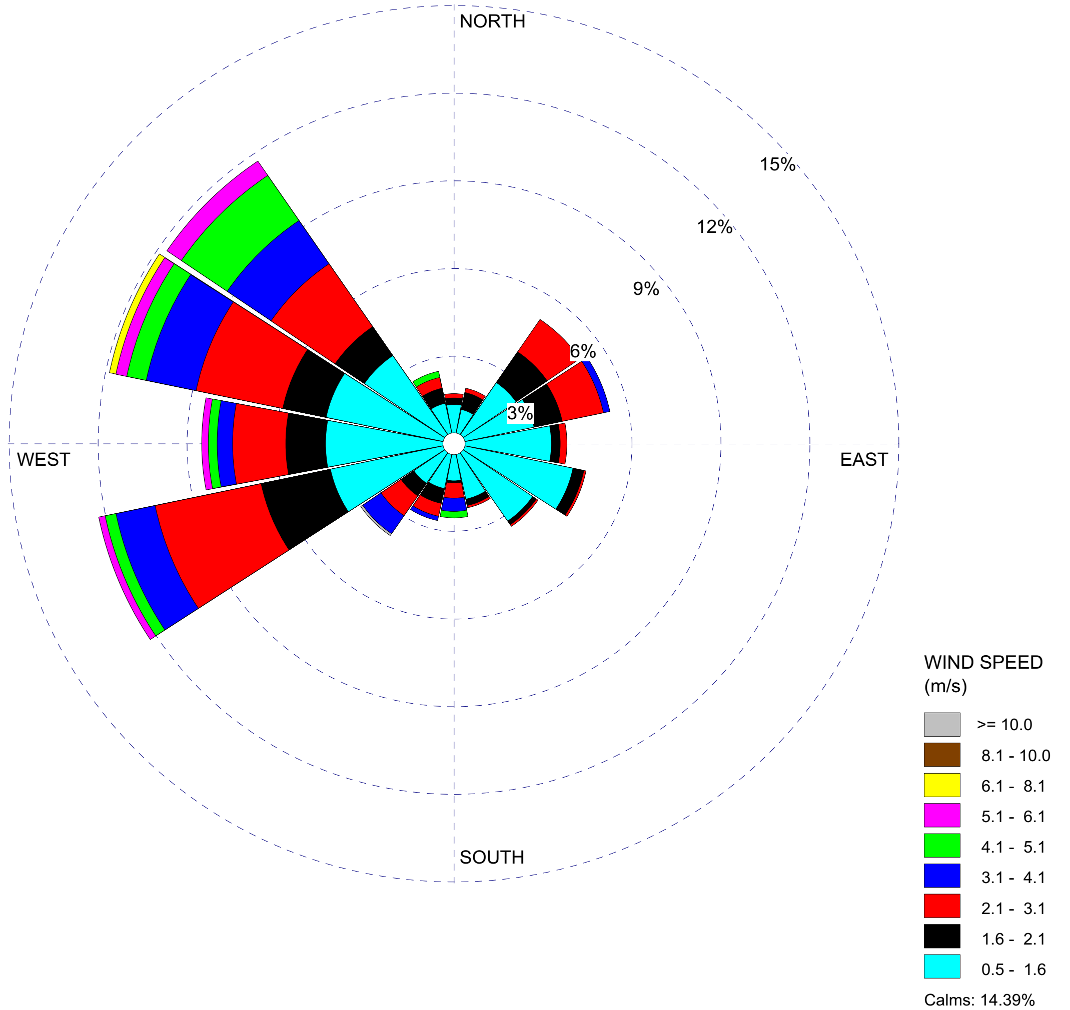


Figure 2.3.2-5. Wind Rose Clinch River Nuclear Site 10 m February

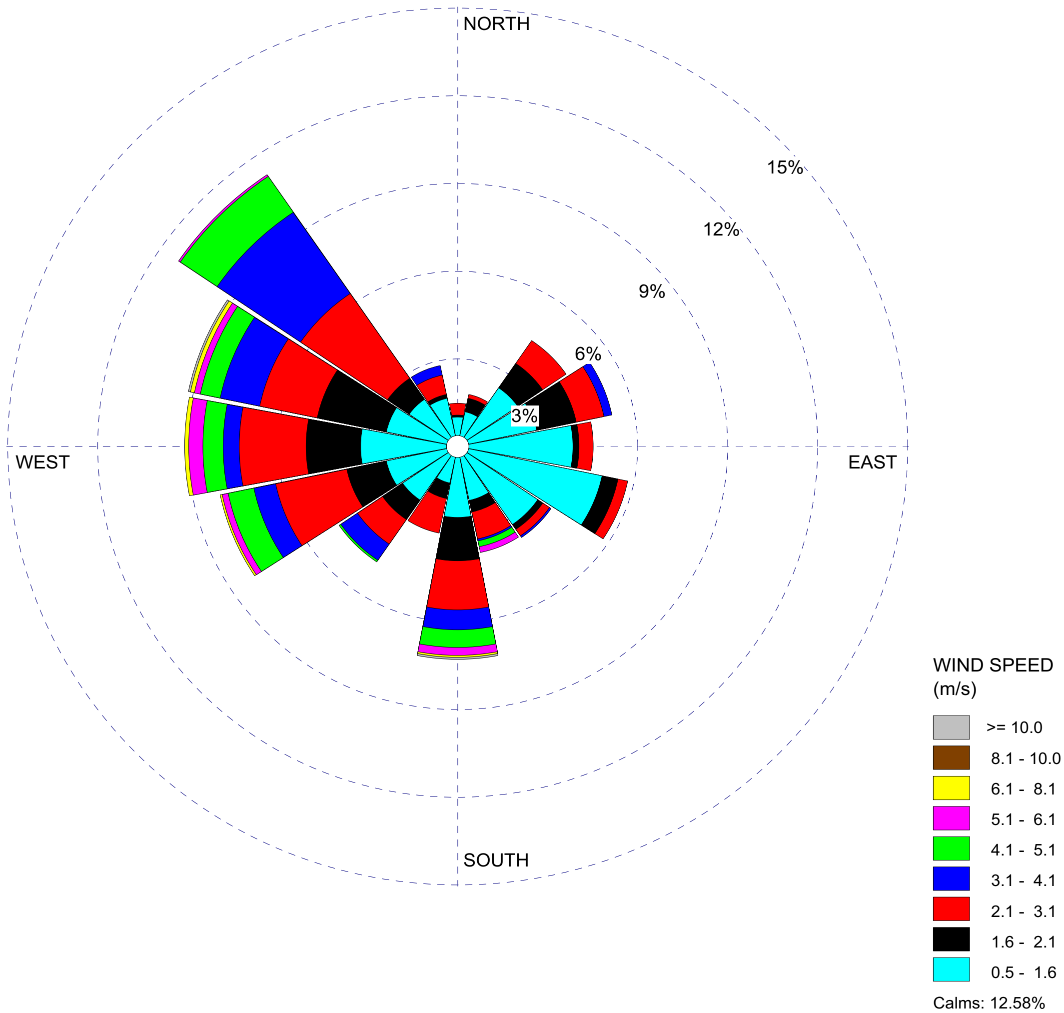


Figure 2.3.2-6. Wind Rose Clinch River Nuclear Site 10 m March

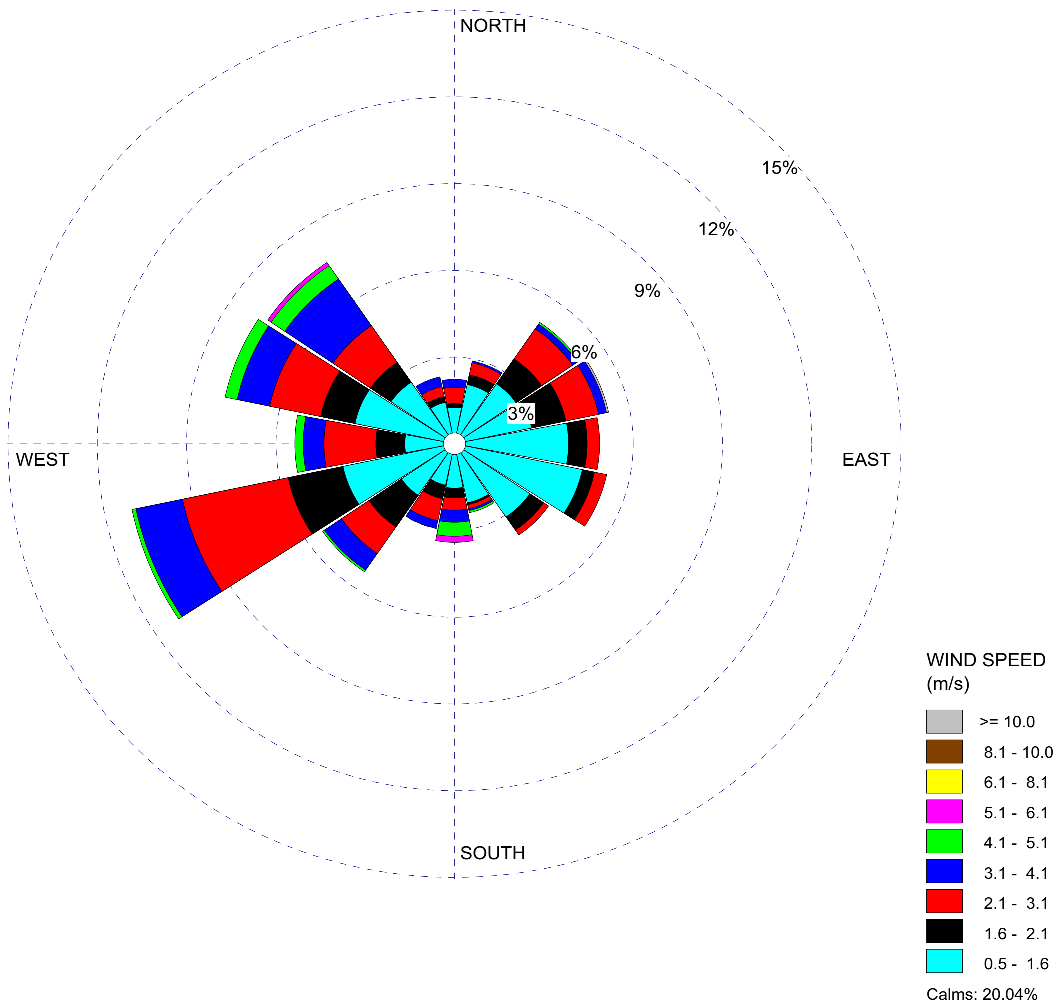


Figure 2.3.2-7. Wind Rose Clinch River Nuclear Site 10 m April

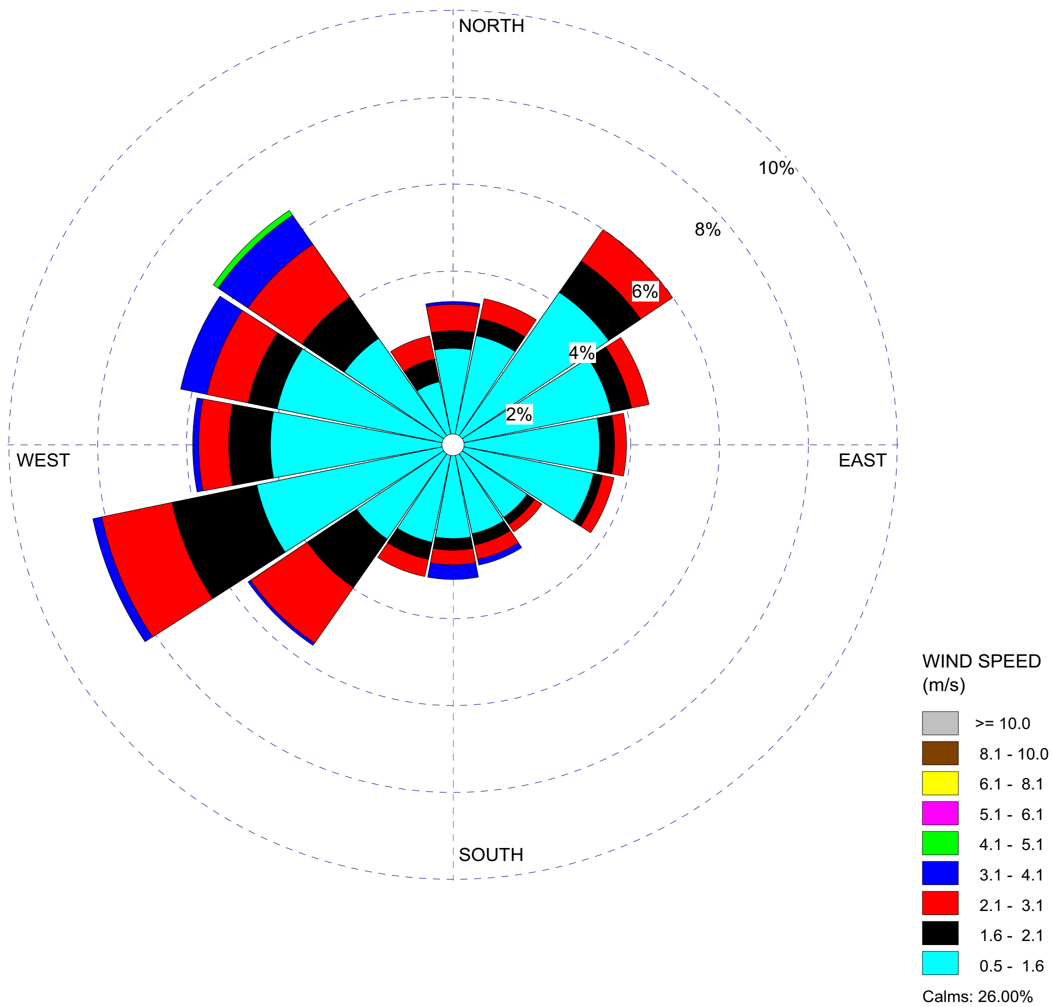


Figure 2.3.2-8. Wind Rose Clinch River Nuclear Site 10 m May

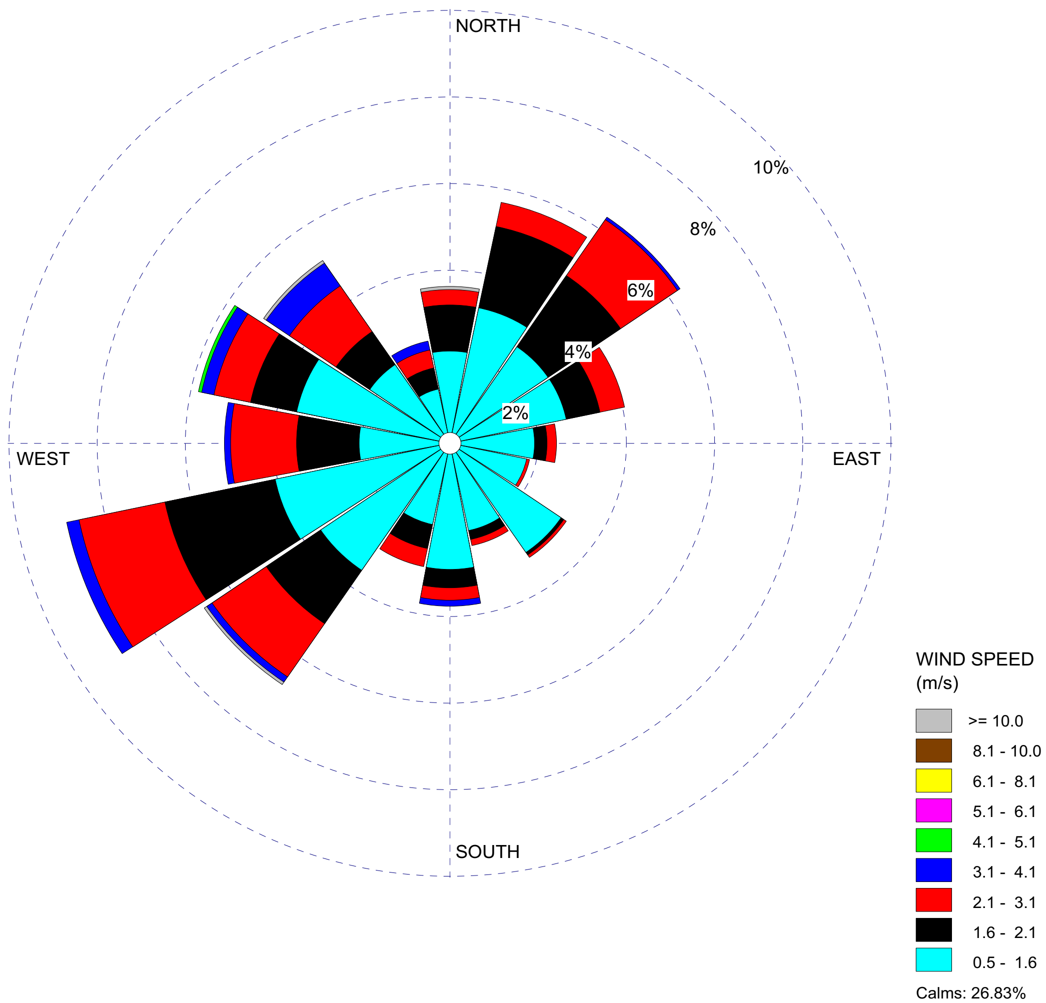


Figure 2.3.2-9. Wind Rose Clinch River Nuclear Site 10 m June

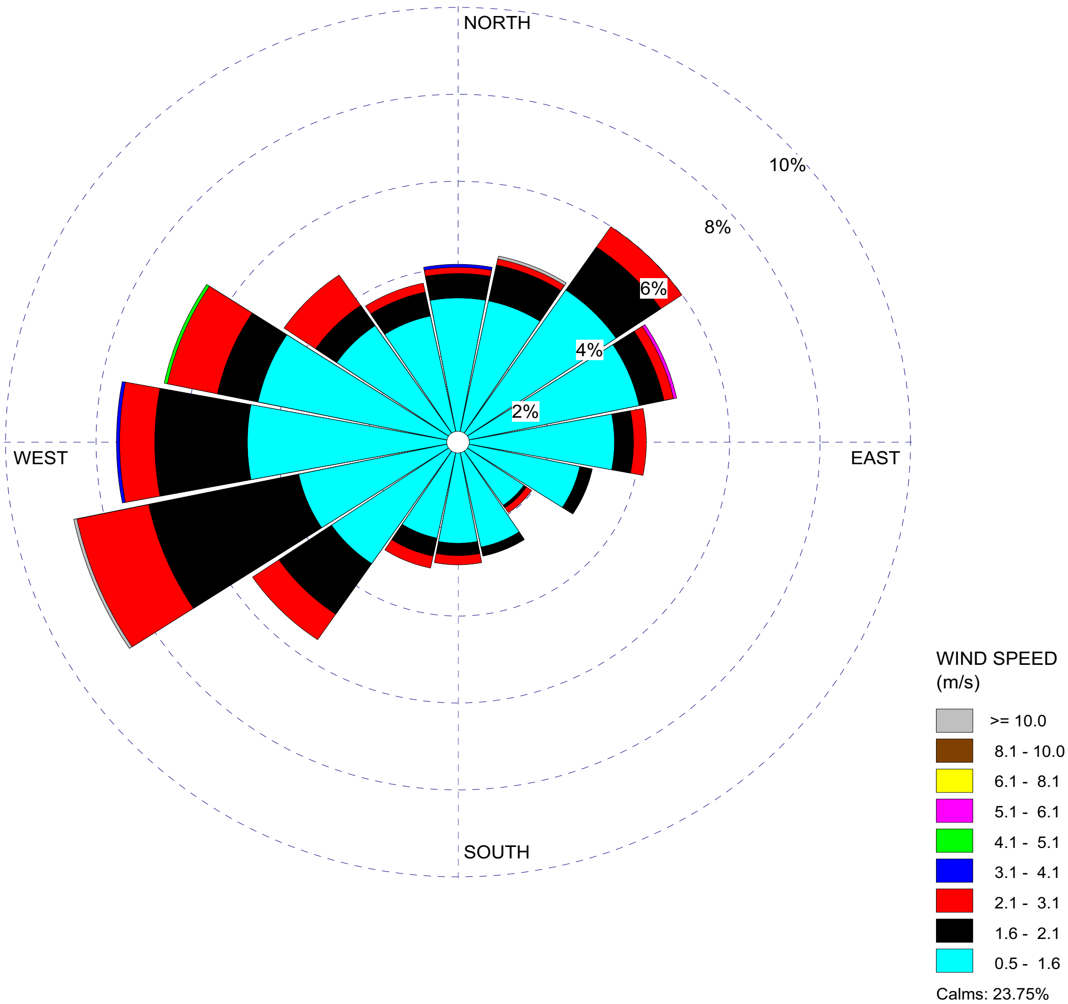


Figure 2.3.2-10. Wind Rose Clinch River Nuclear Site 10 m July

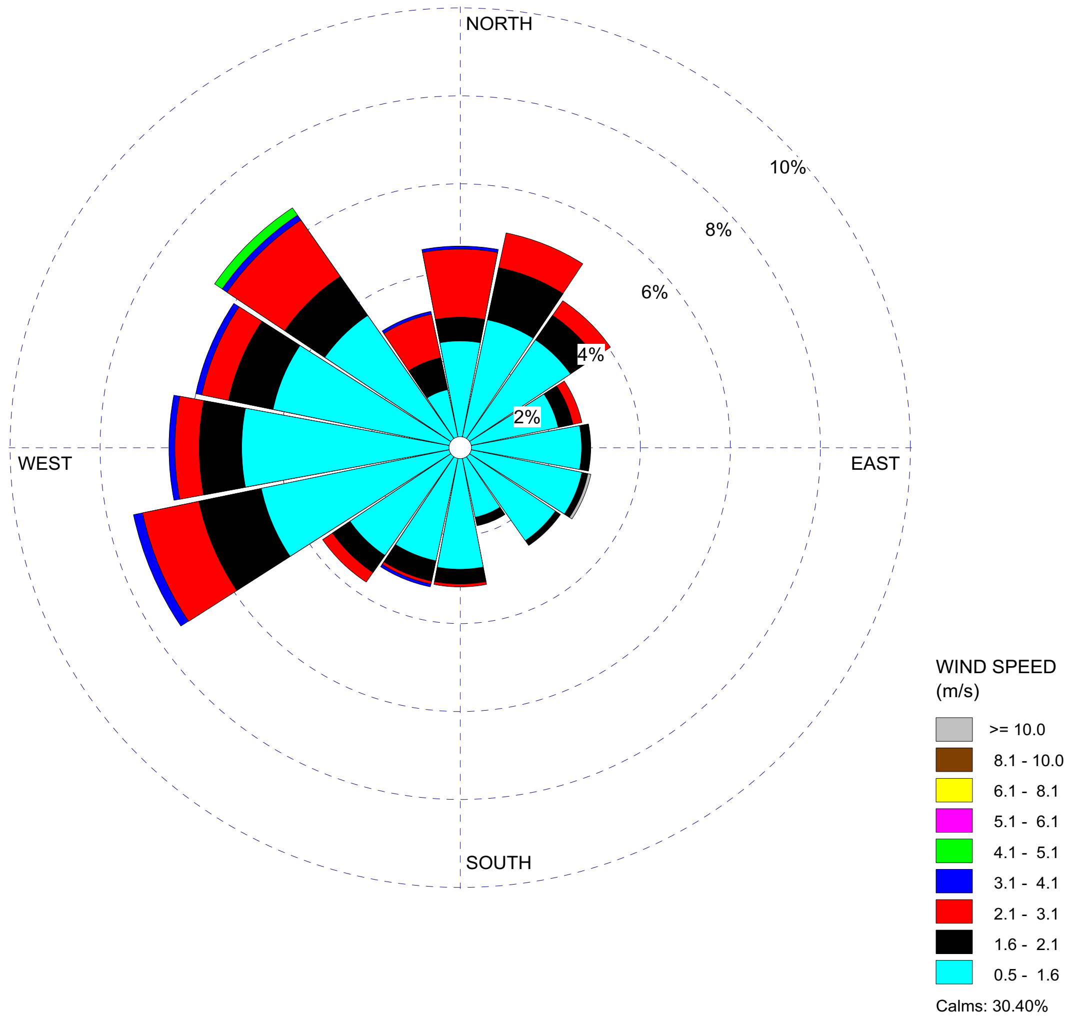


Figure 2.3.2-11. Wind Rose Clinch River Nuclear Site 10 m August

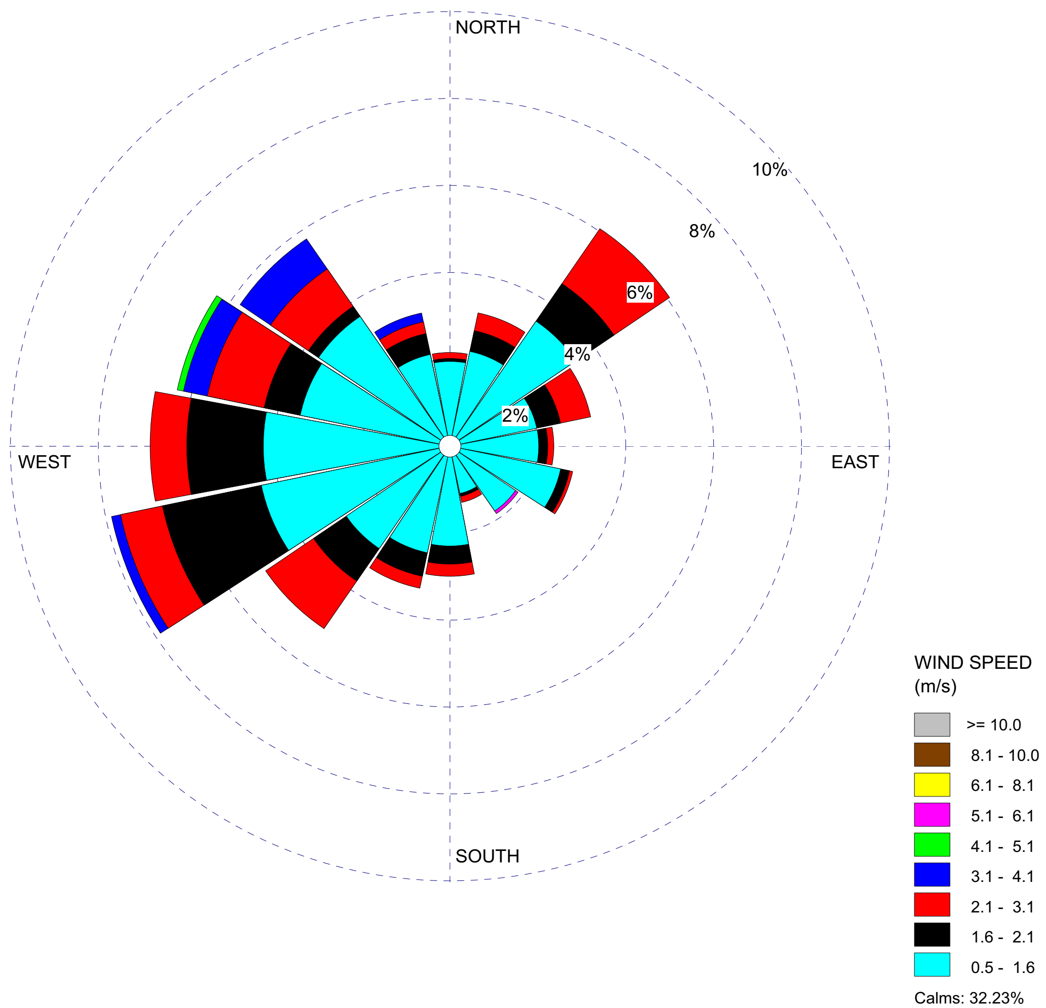


Figure 2.3.2-12. Wind Rose Clinch River Nuclear Site 10 m September

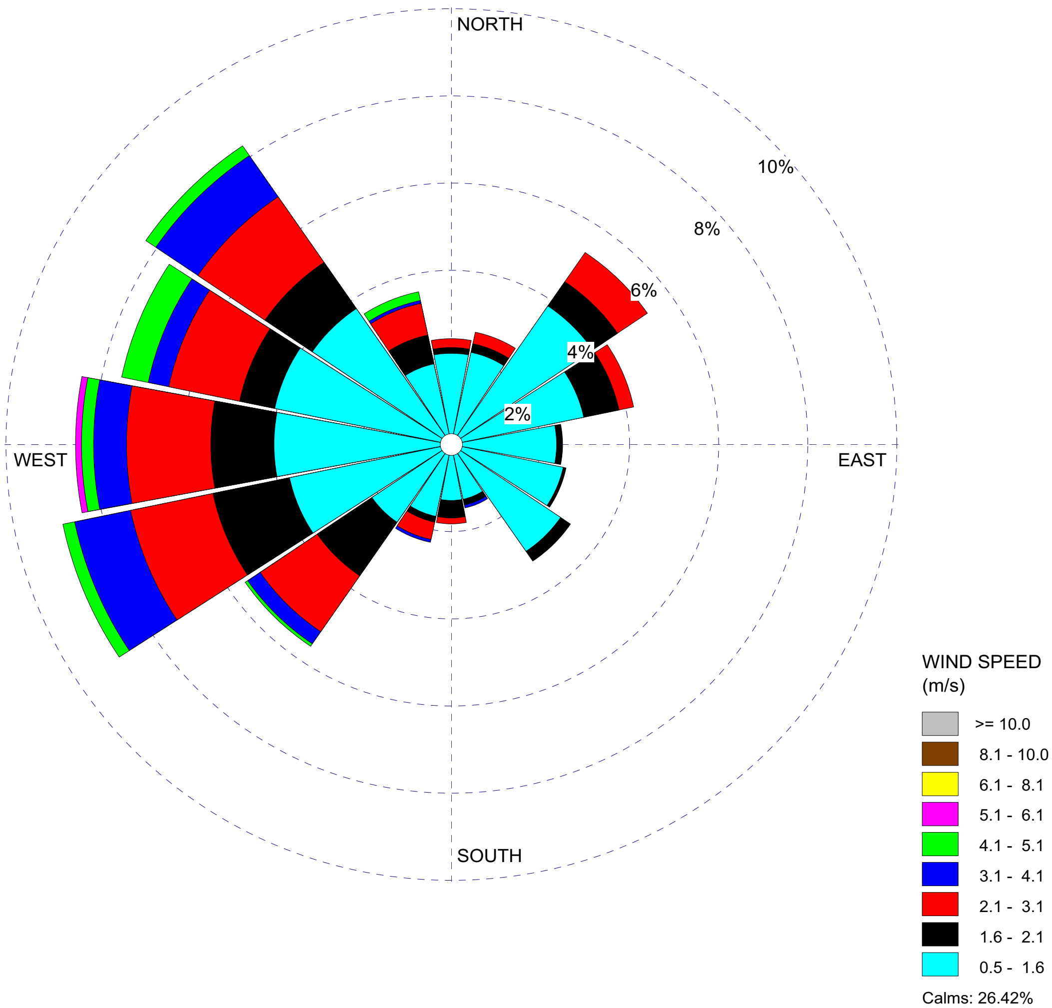


Figure 2.3.2-13. Wind Rose Clinch River Nuclear Site 10 m October

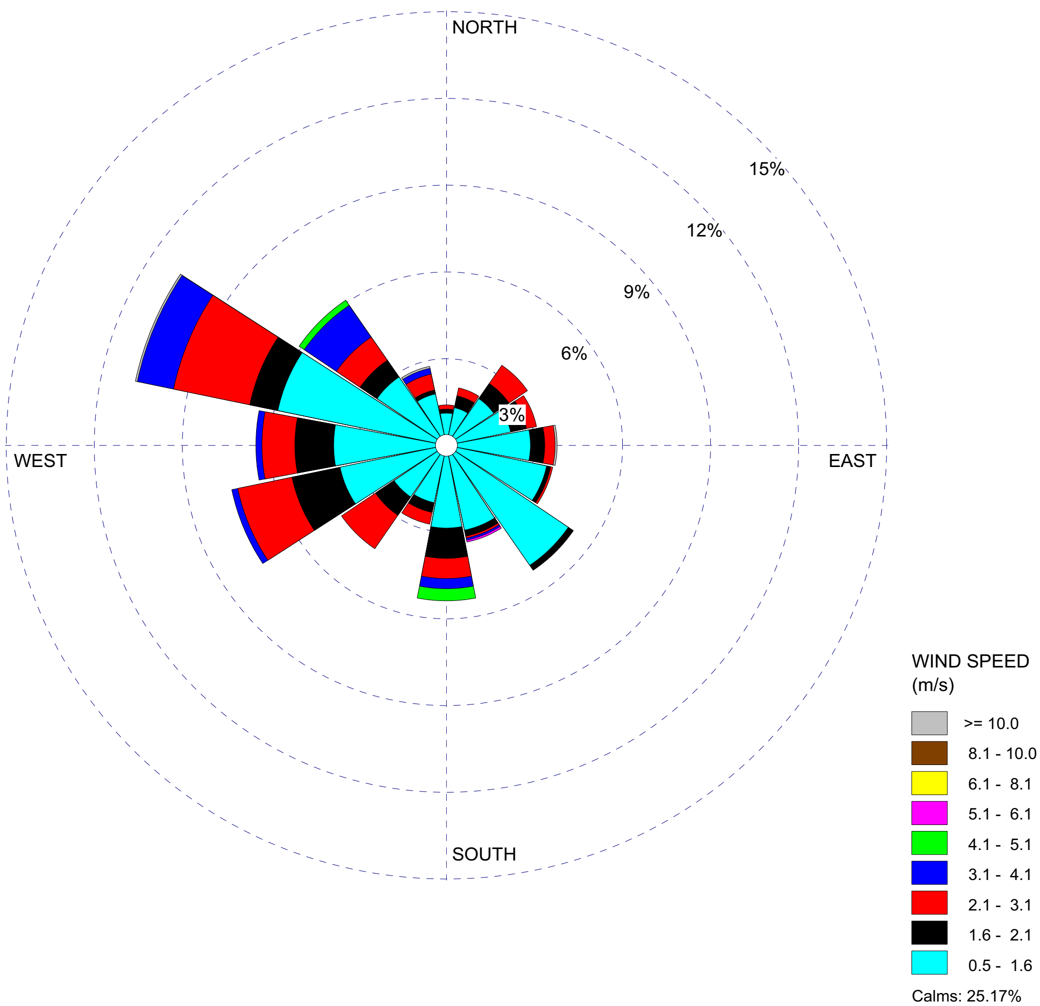


Figure 2.3.2-14. Wind Rose Clinch River Nuclear Site 10 m November

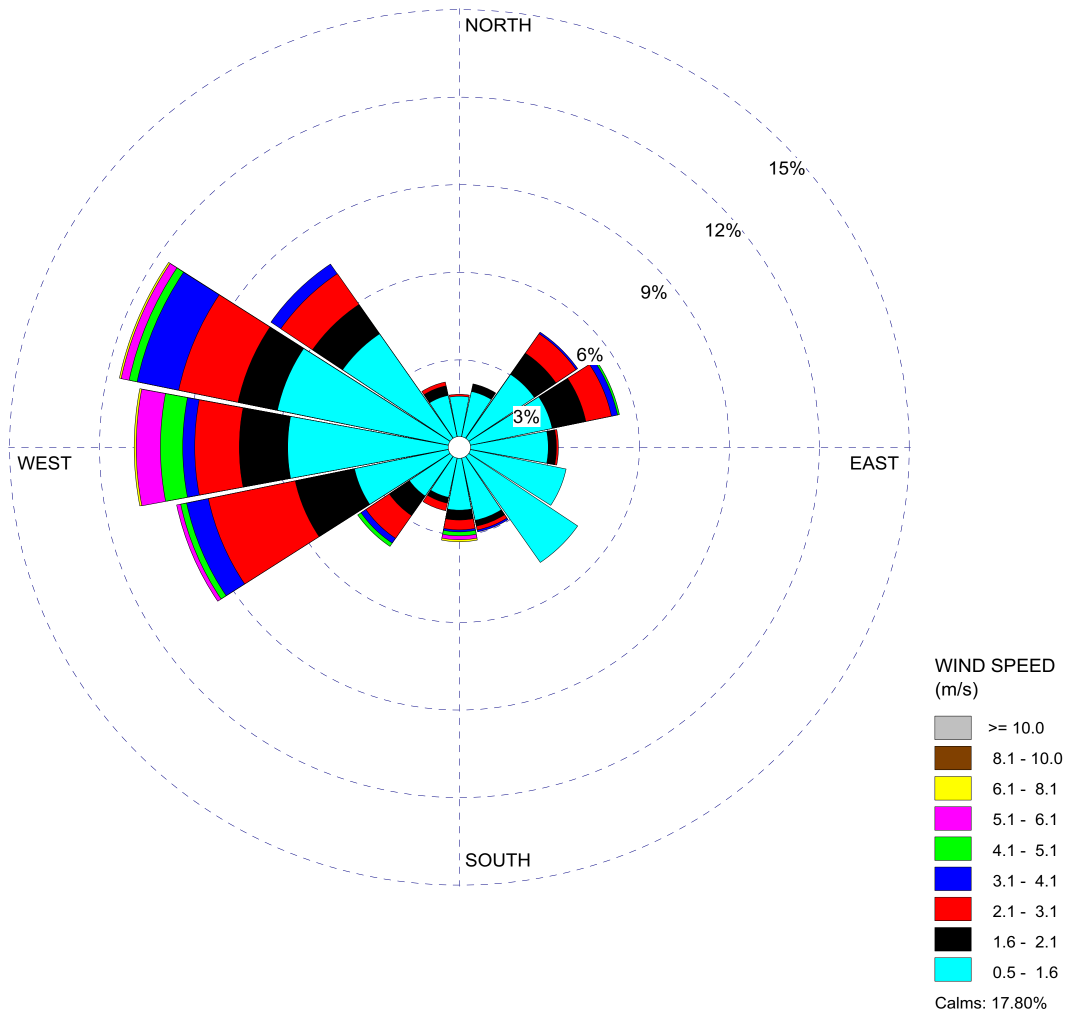


Figure 2.3.2-15. Wind Rose Clinch River Nuclear Site 10 m December

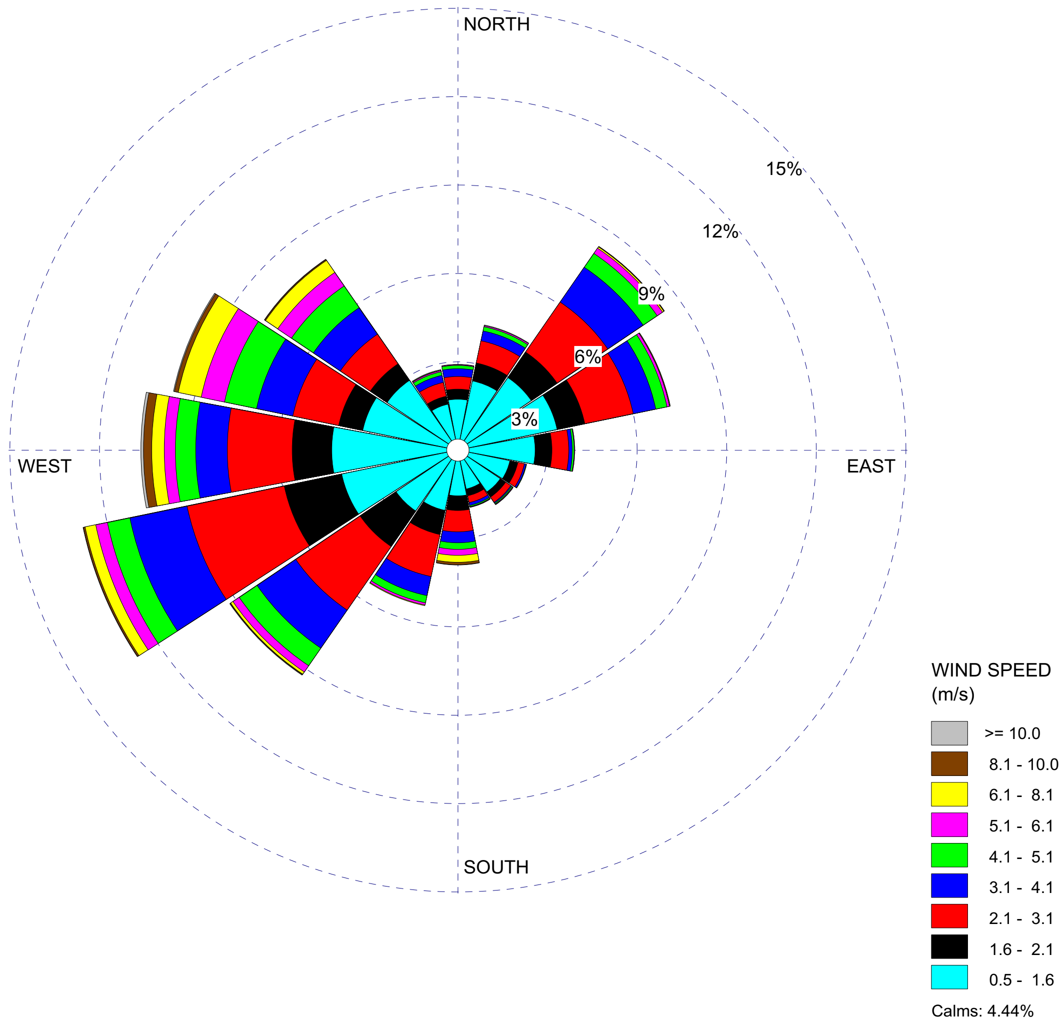


Figure 2.3.2-16. Wind Rose Clinch River Nuclear Site 60 m All Data

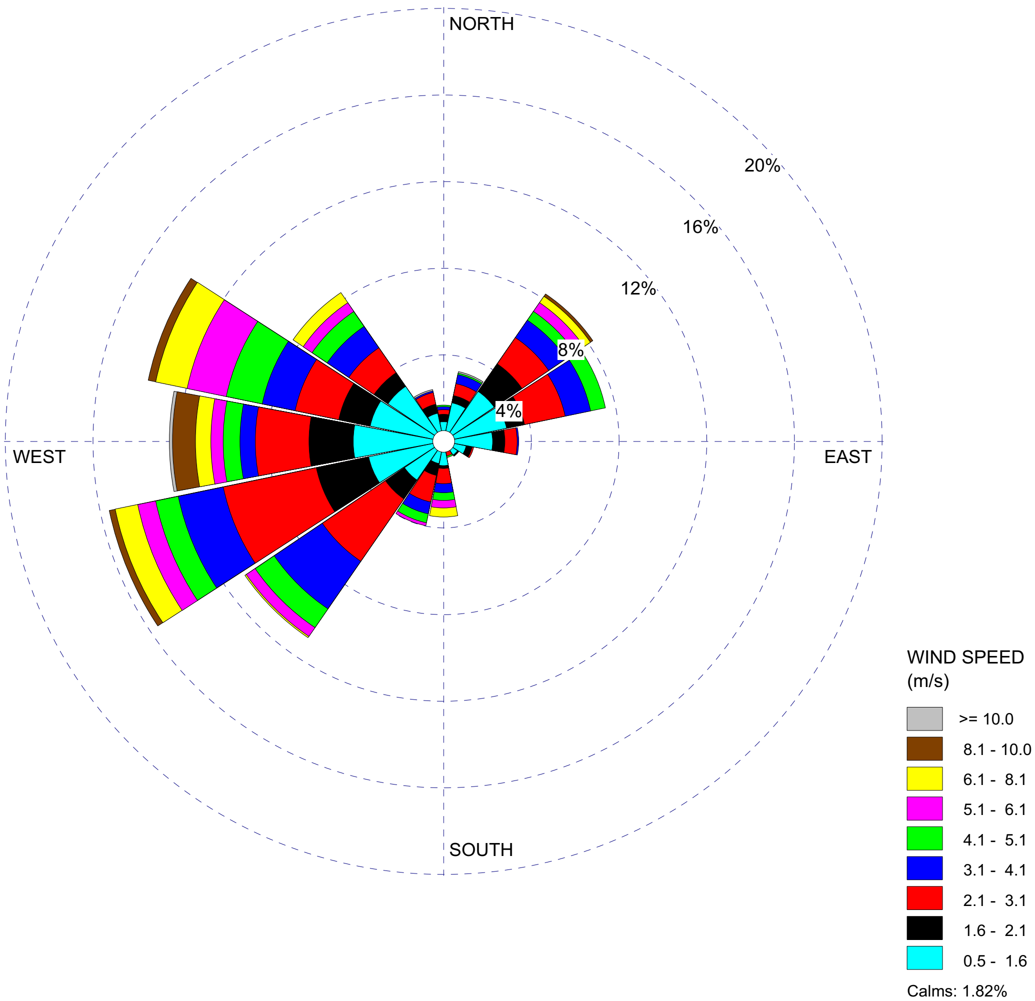


Figure 2.3.2-17. Wind Rose Clinch River Nuclear Site 60 m January

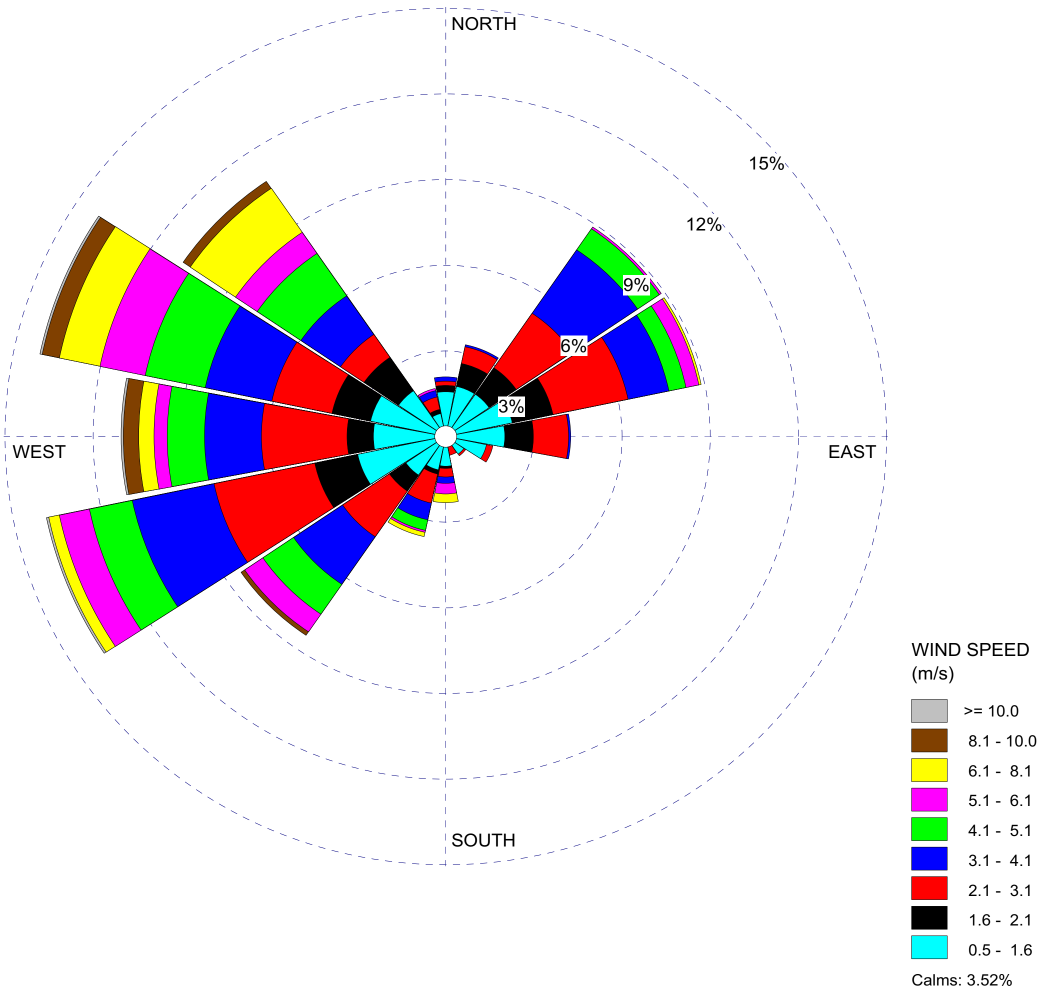


Figure 2.3.2-18. Wind Rose Clinch River Nuclear Site 60 m February

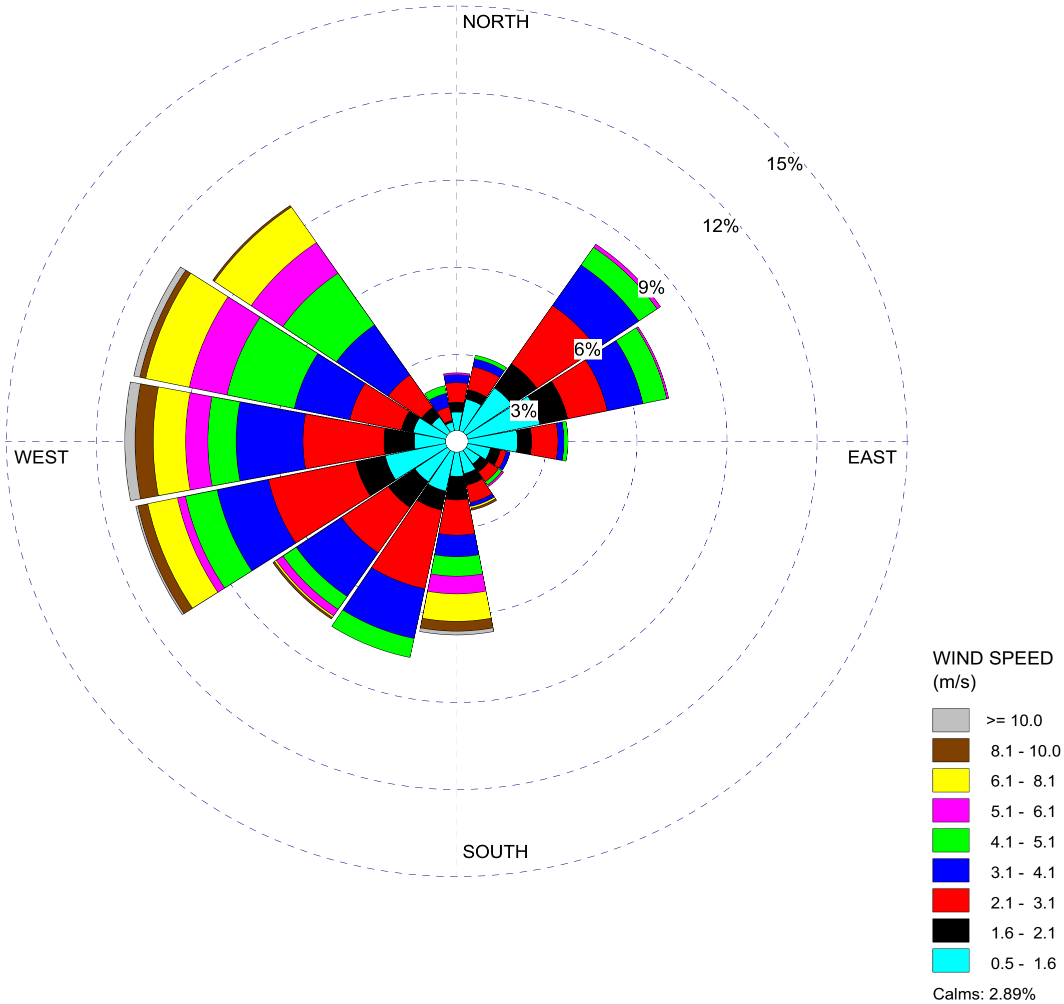


Figure 2.3.2-19. Wind Rose Clinch River Nuclear Site 60 m March

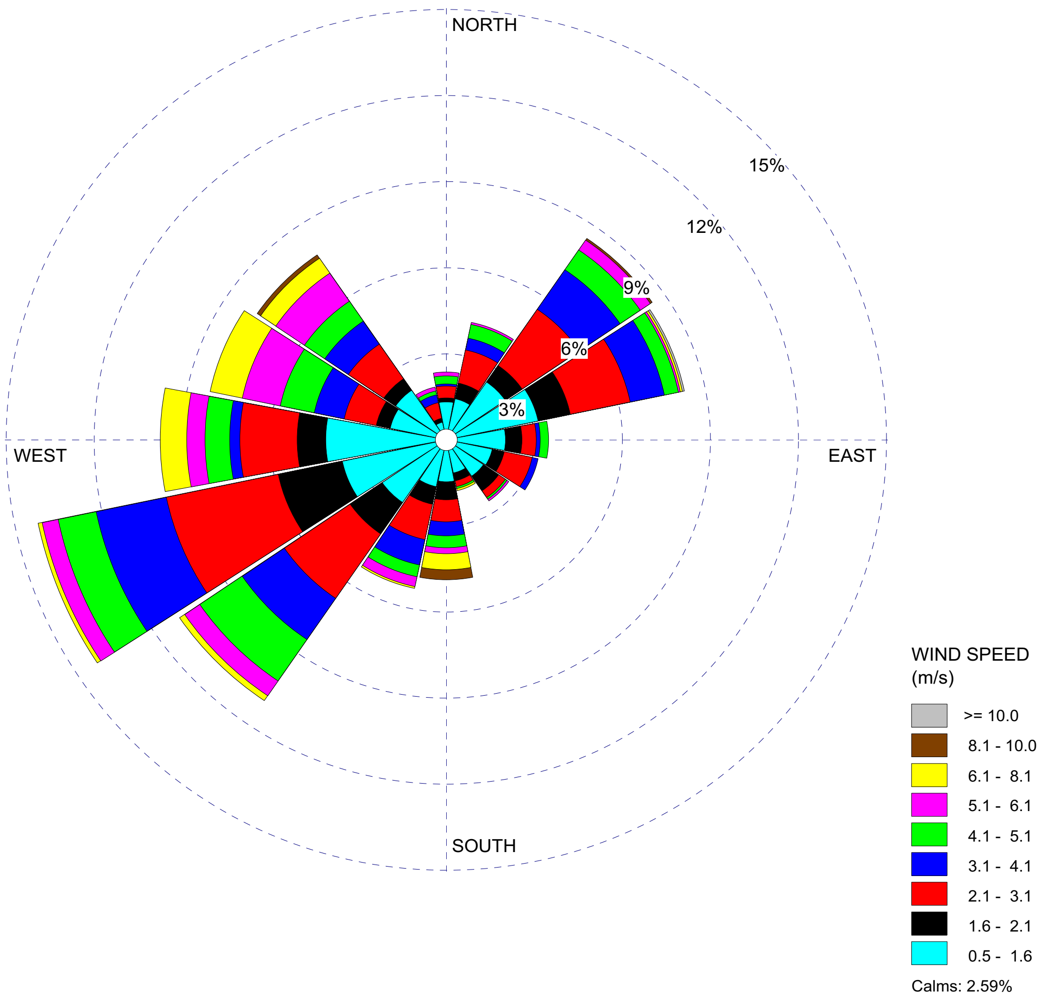


Figure 2.3.2-20. Wind Rose Clinch River Nuclear Site 60 m April

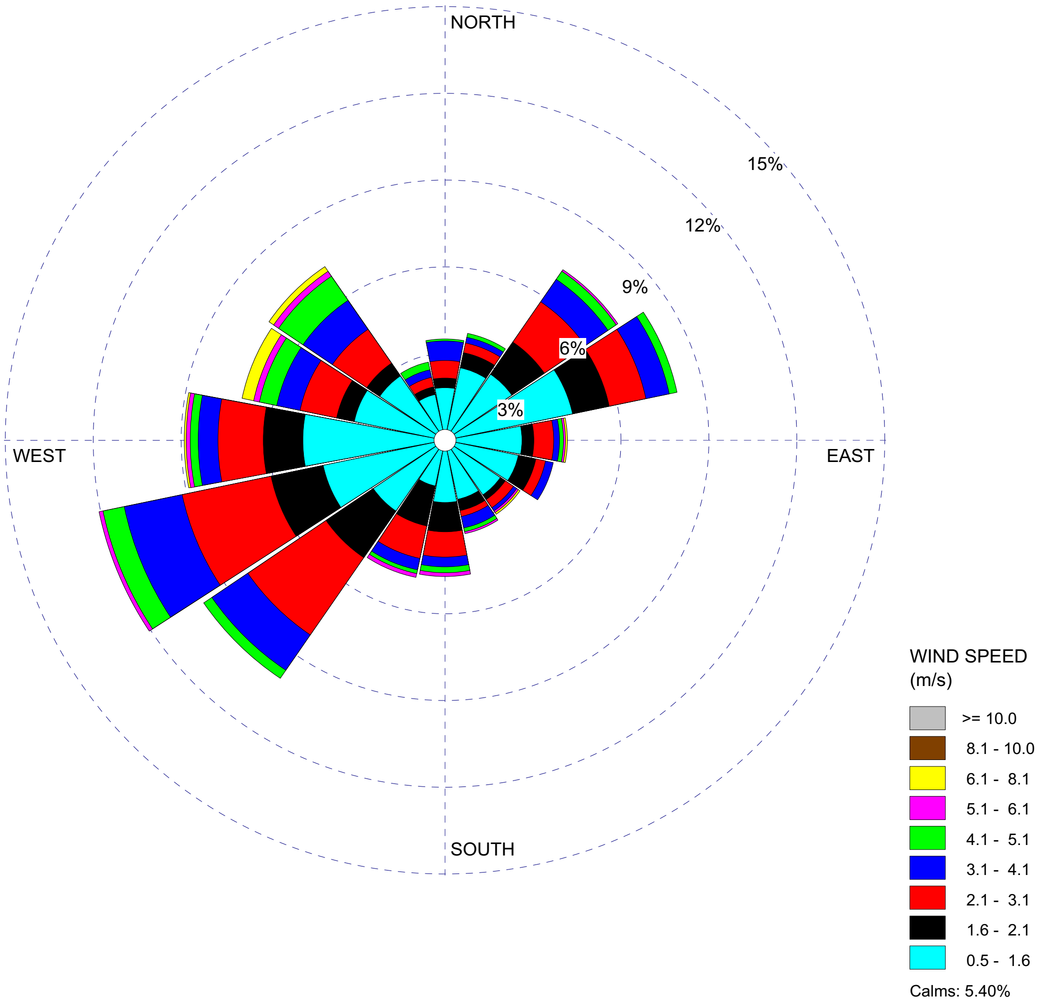


Figure 2.3.2-21. Wind Rose Clinch River Nuclear Site 60 m May

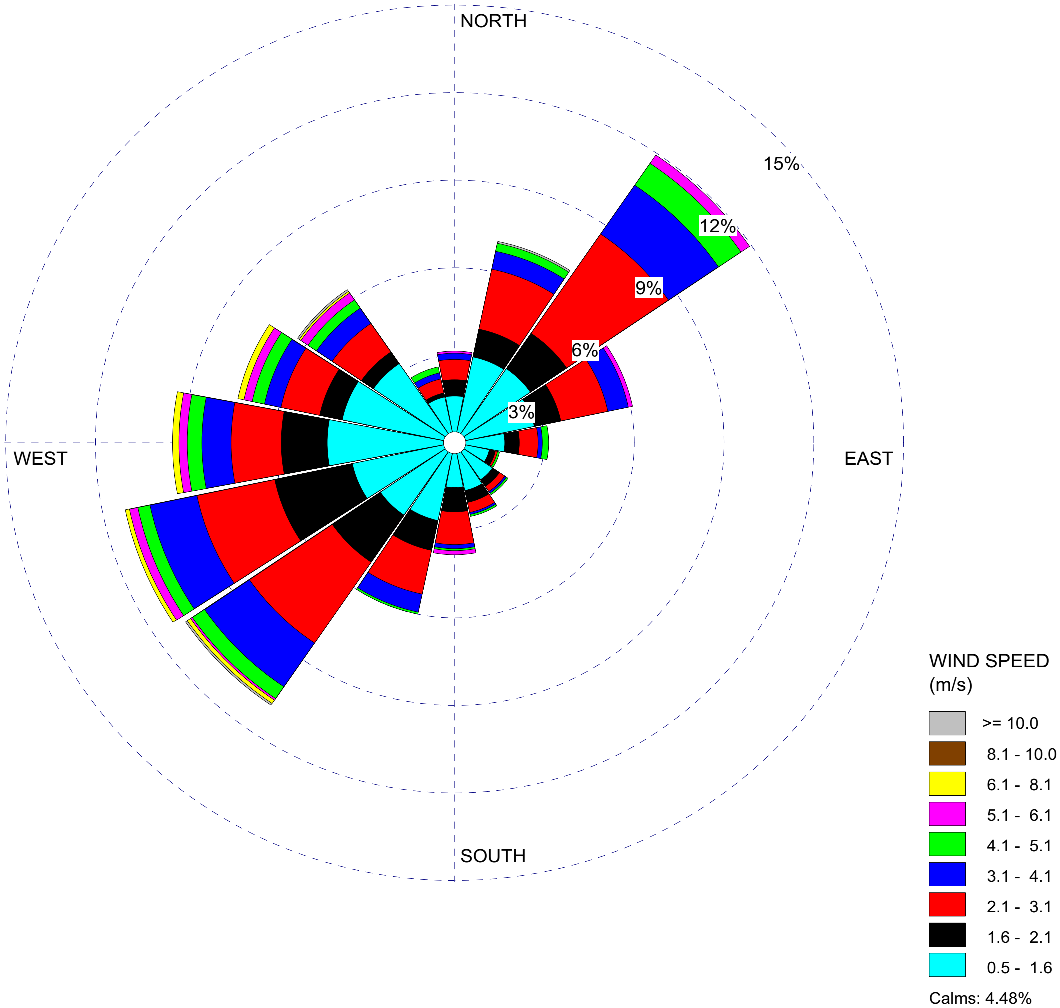


Figure 2.3.2-22. Wind Rose Clinch River Nuclear Site 60 m June

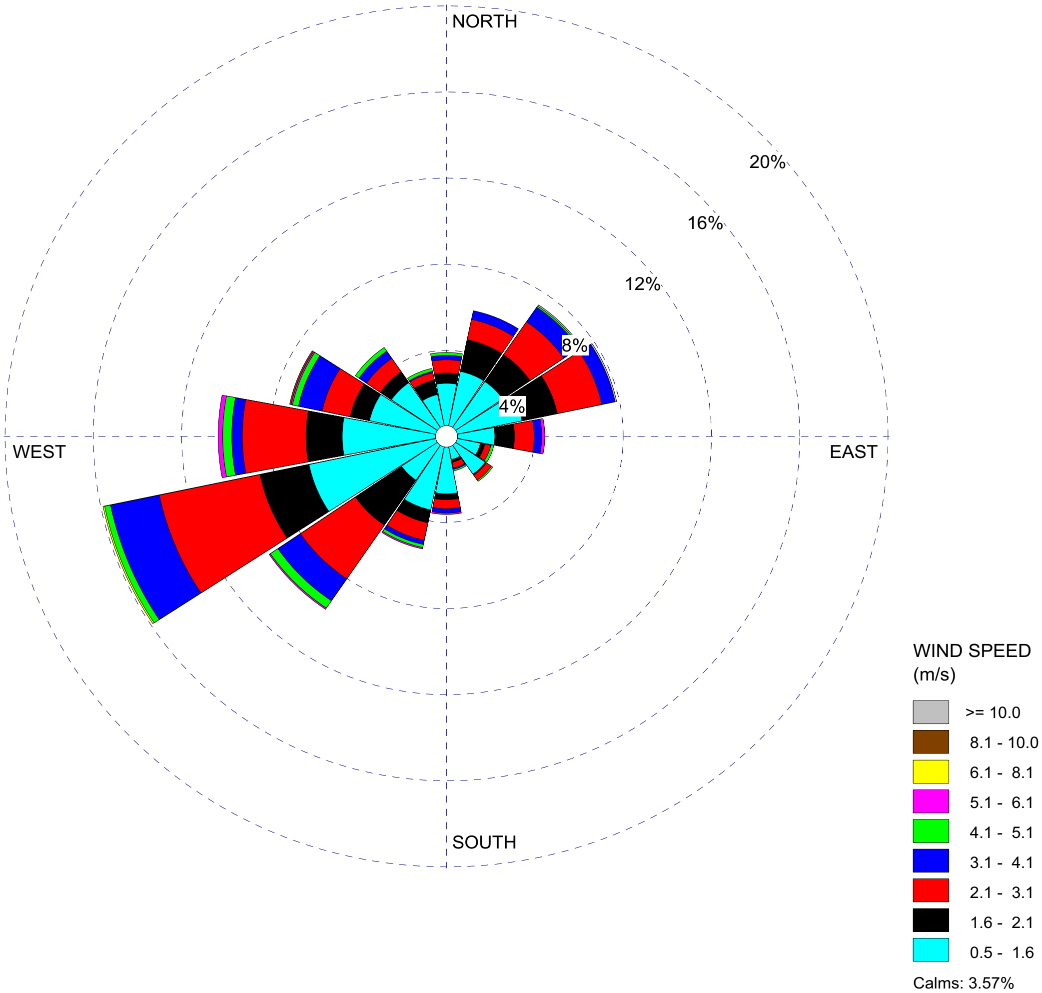


Figure 2.3.2-23. Wind Rose Clinch River Nuclear Site 60 m July

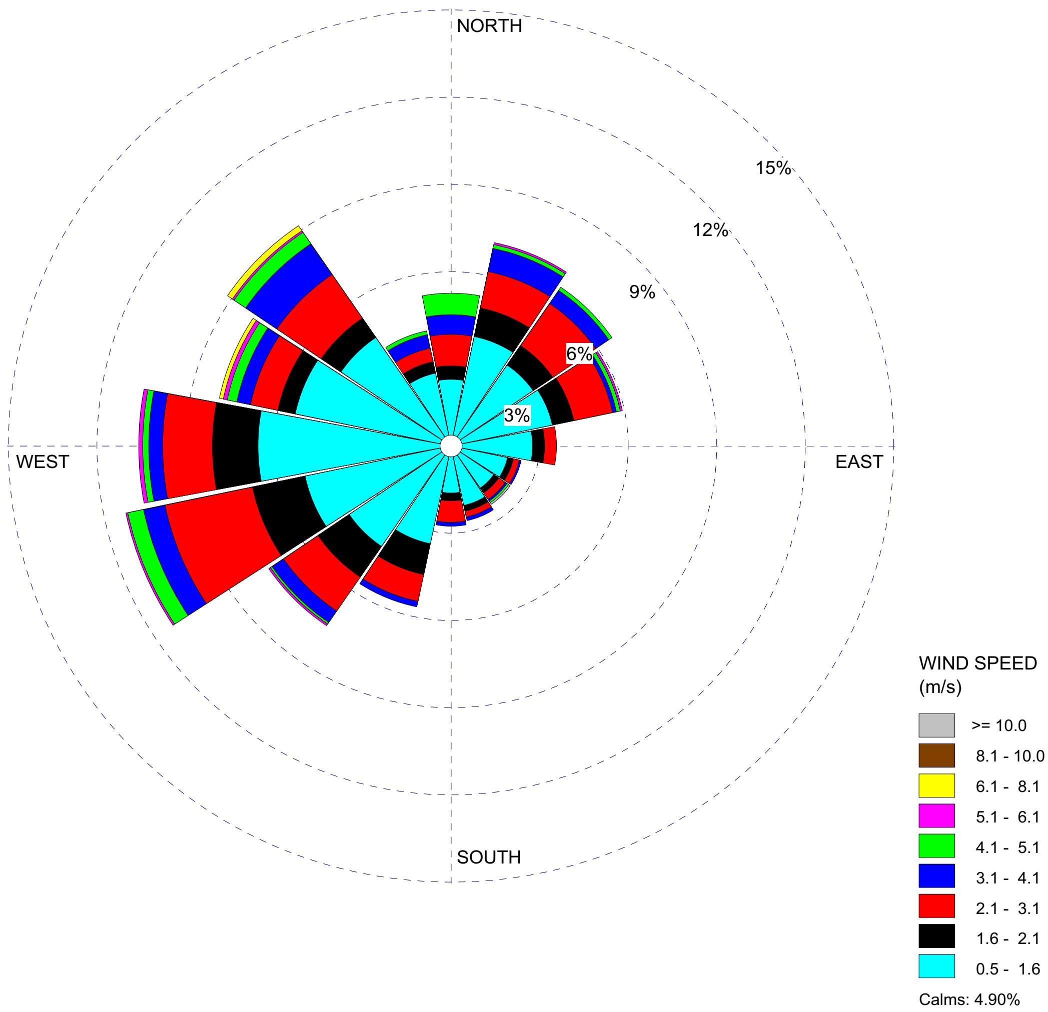


Figure 2.3.2-24. Wind Rose Clinch River Nuclear Site 60 m August

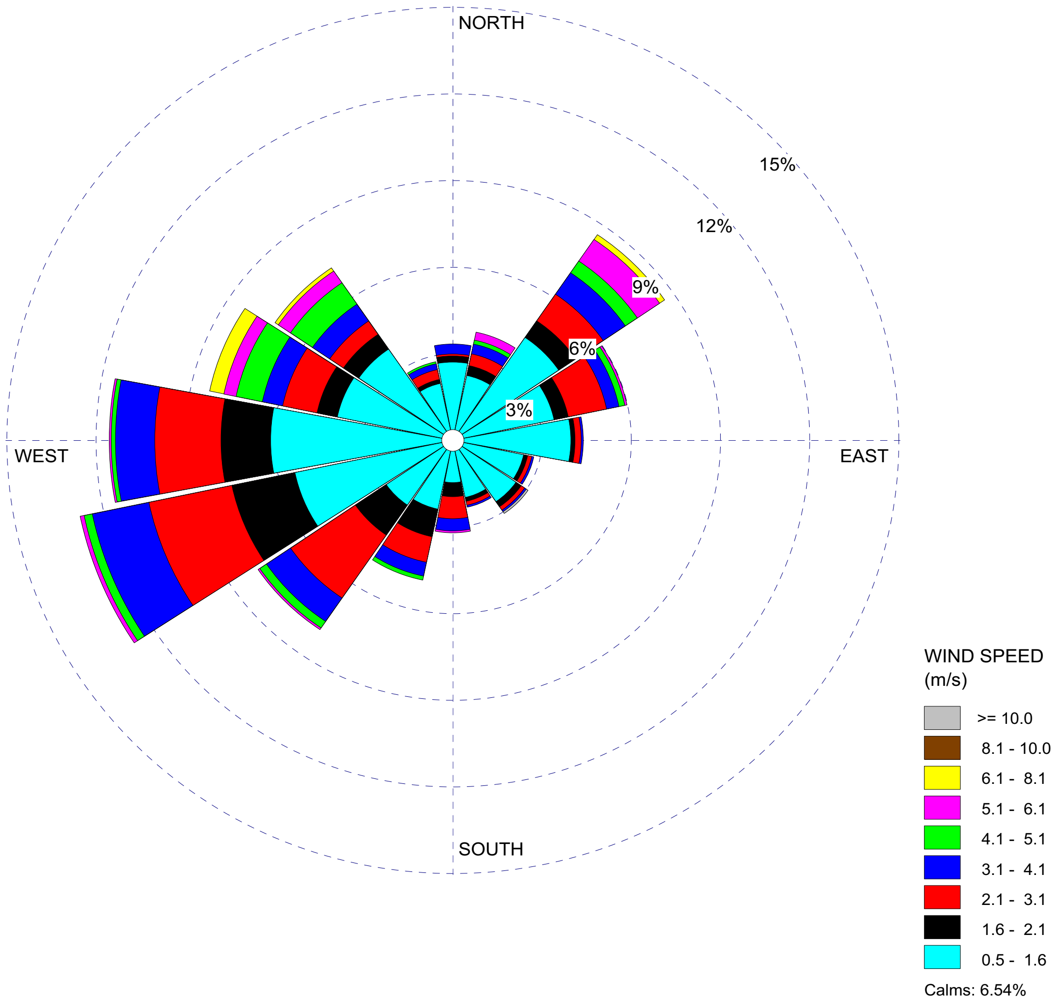


Figure 2.3.2-25. Wind Rose Clinch River Nuclear Site 60 m September

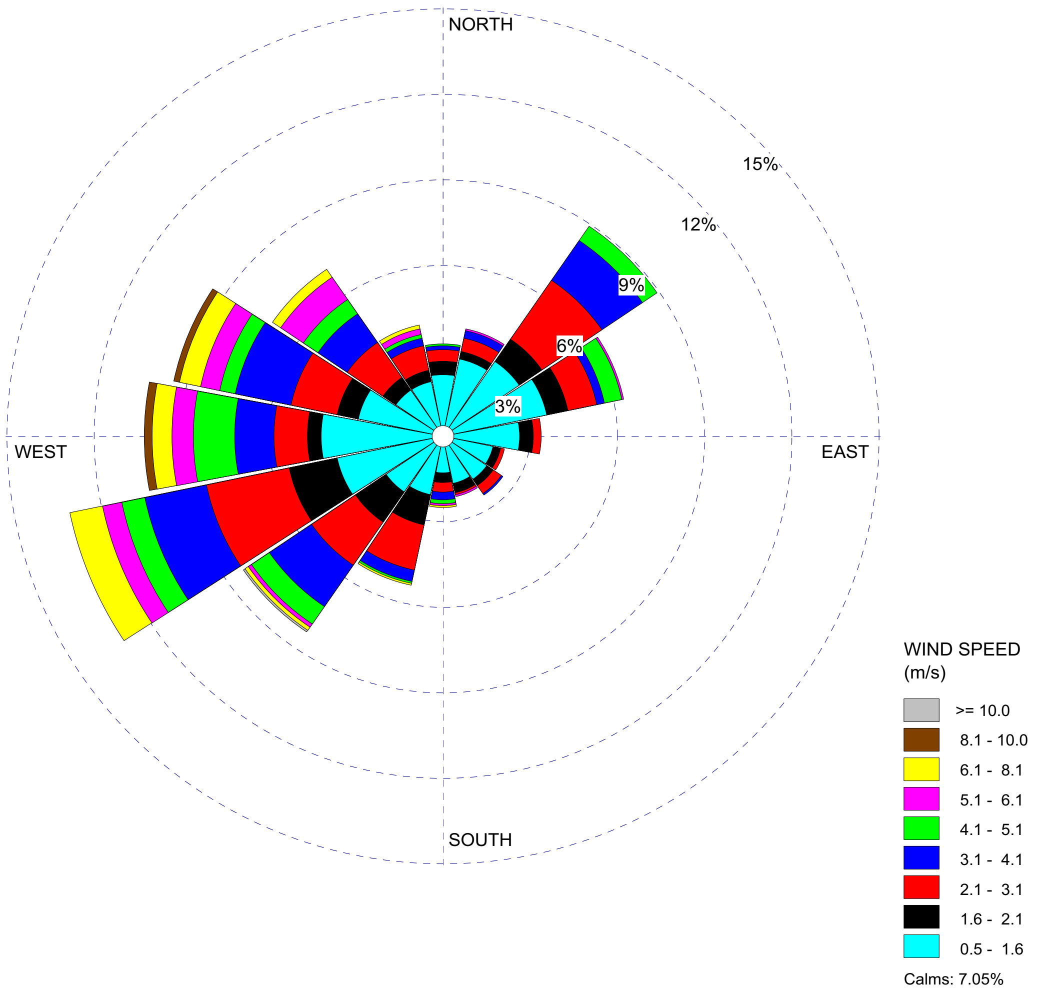


Figure 2.3.2-26. Wind Rose Clinch River Nuclear Site 60 m October

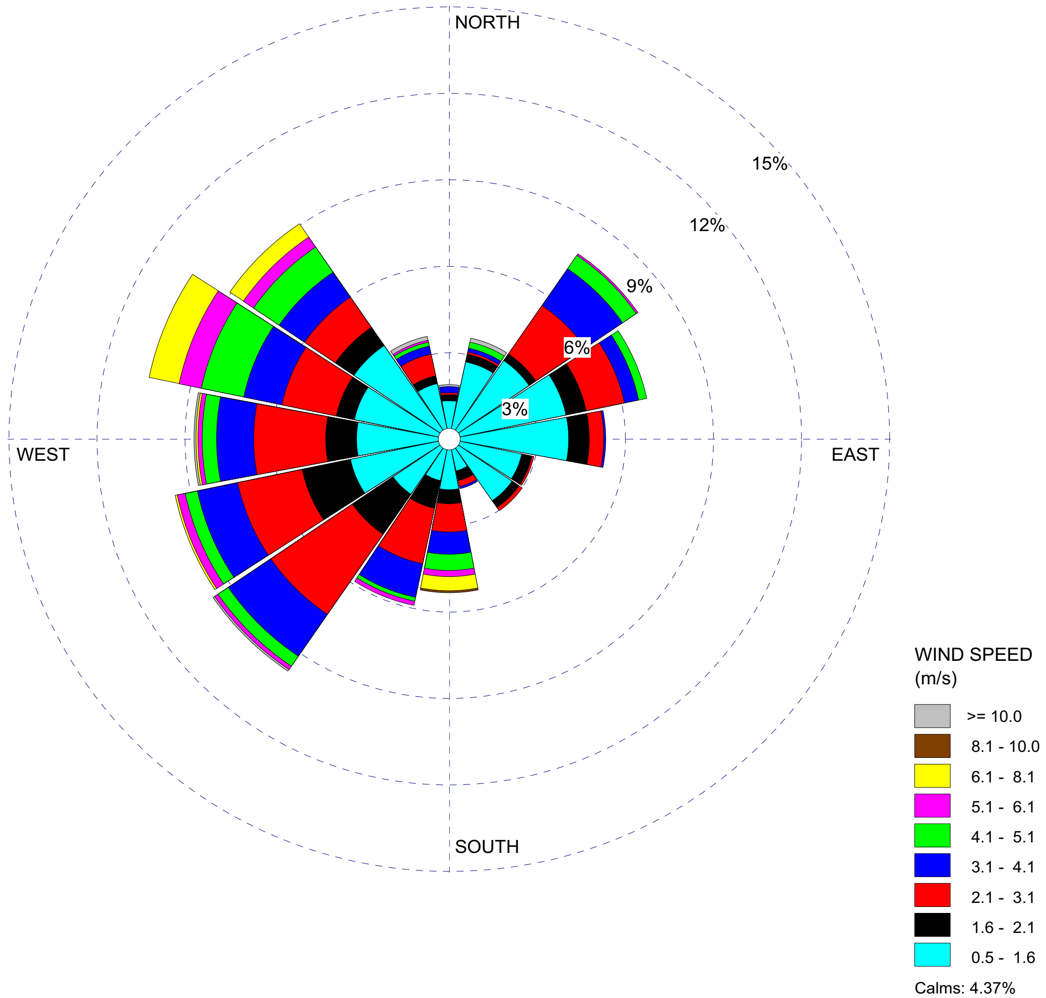


Figure 2.3.2-27. Wind Rose Clinch River Nuclear Site 60 m November

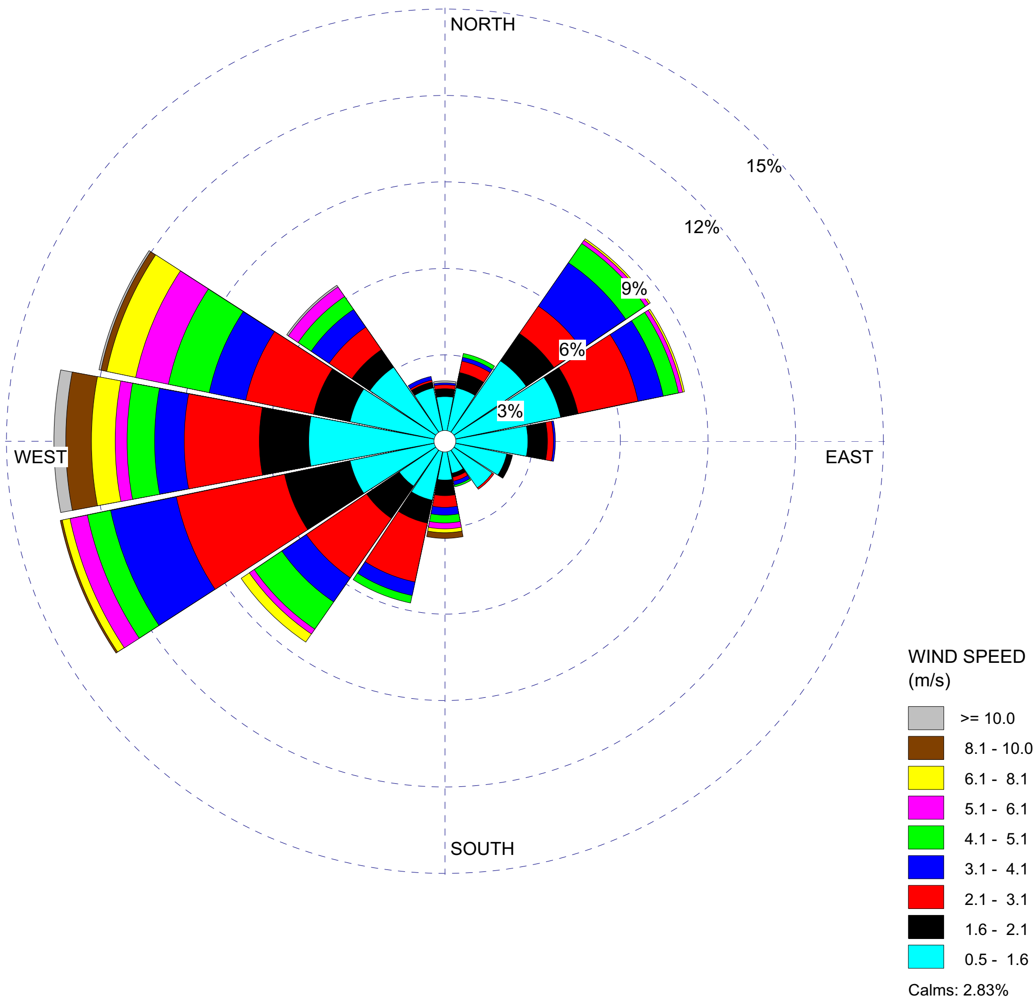


Figure 2.3.2-28. Wind Rose Clinch River Nuclear Site 60 m December

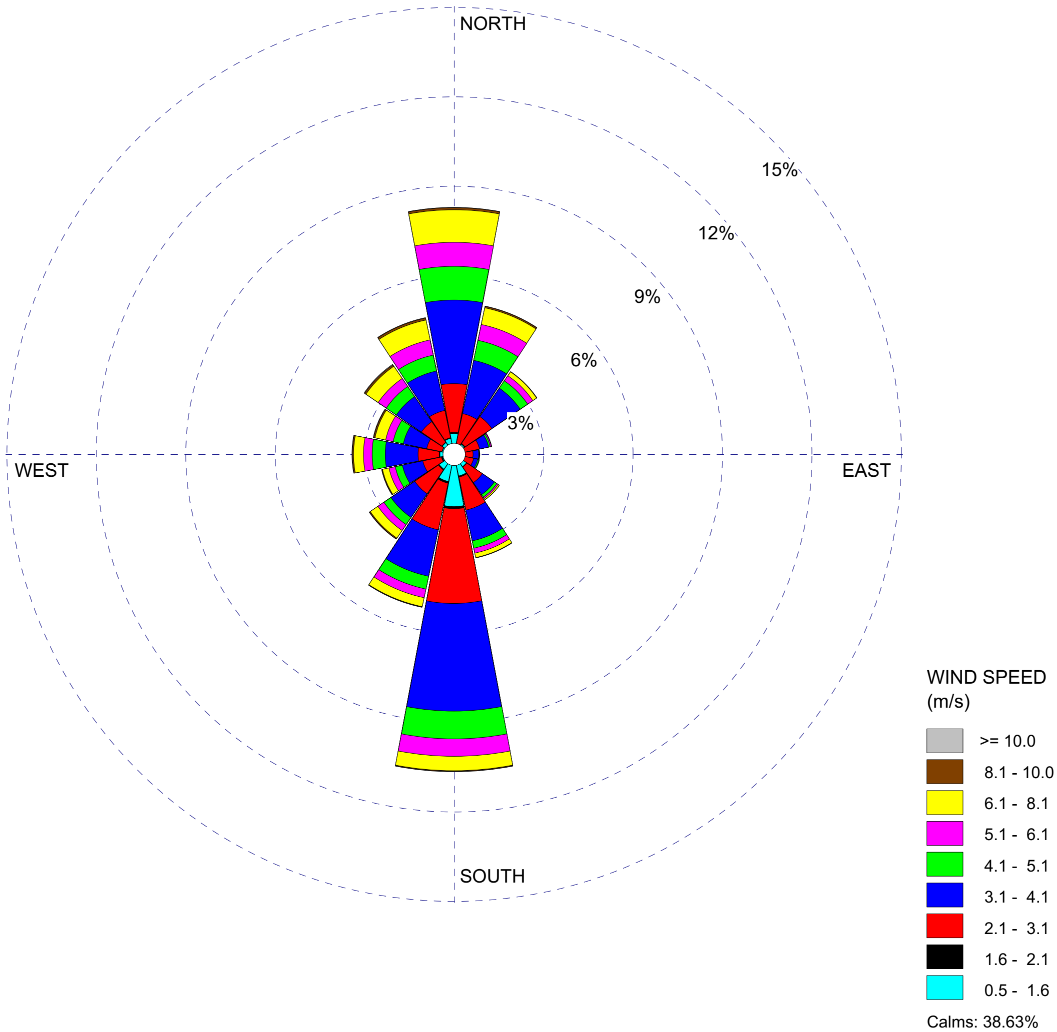


Figure 2.3.2-29. Wind Rose Chattanooga 10 Years (2000–2009) All Data

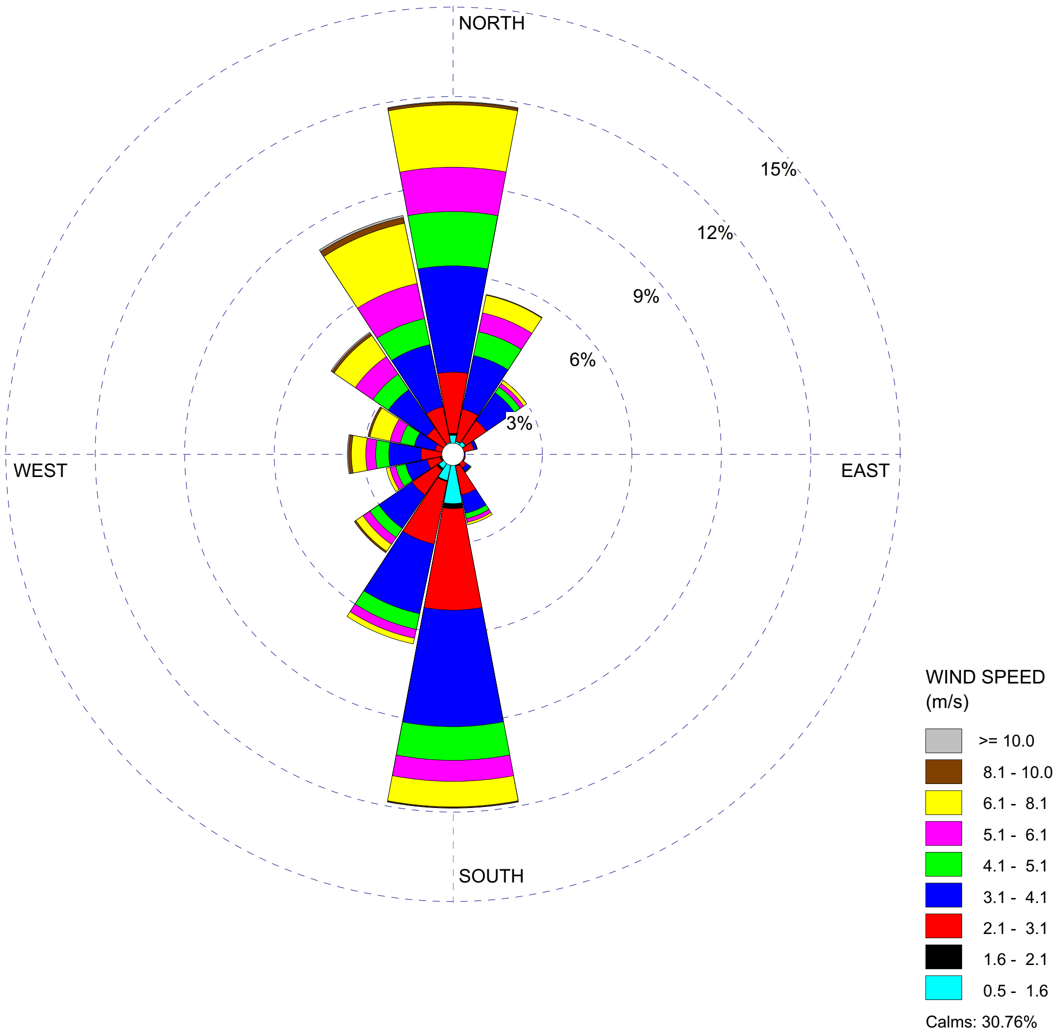


Figure 2.3.2-30. Wind Rose Chattanooga 10 Years (2000–2009) January

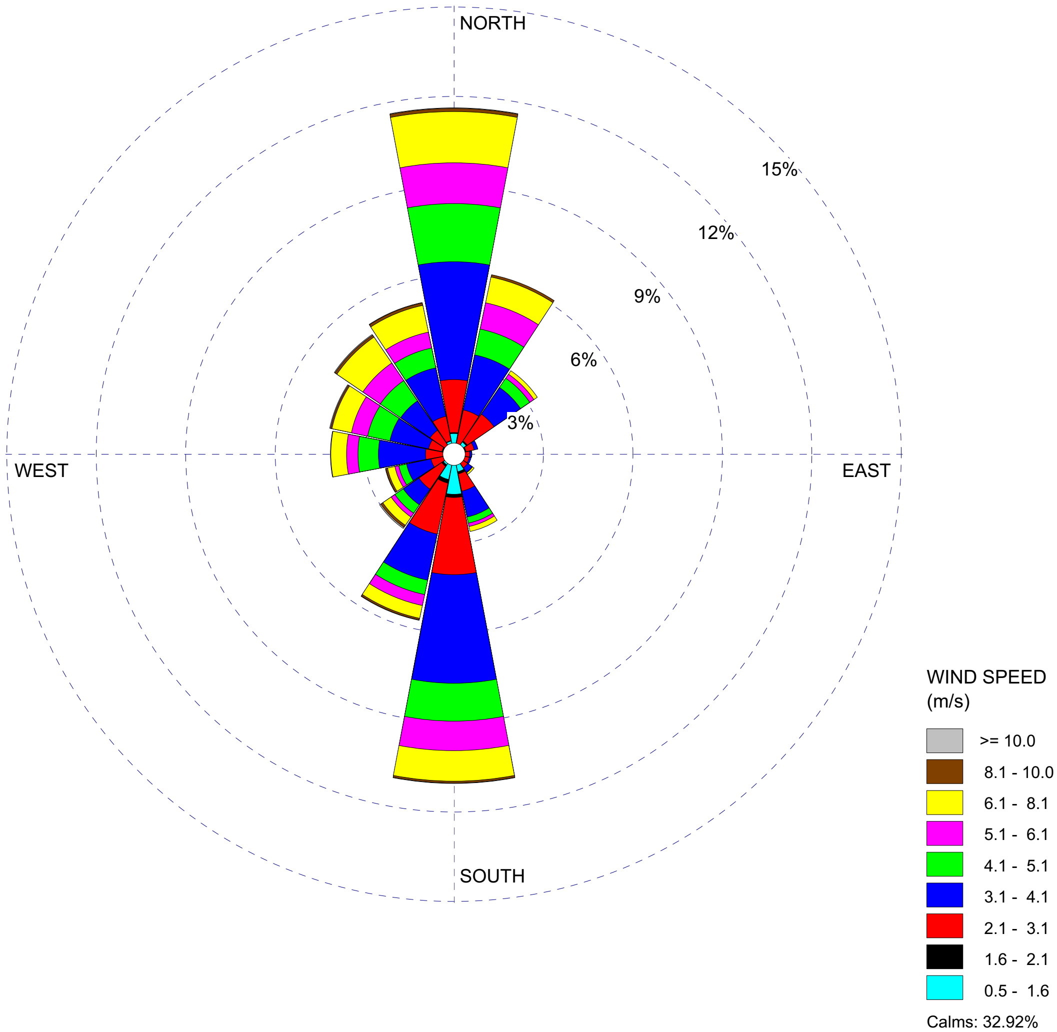


Figure 2.3.2-31. Wind Rose Chattanooga 10 Years (2000–2009) February

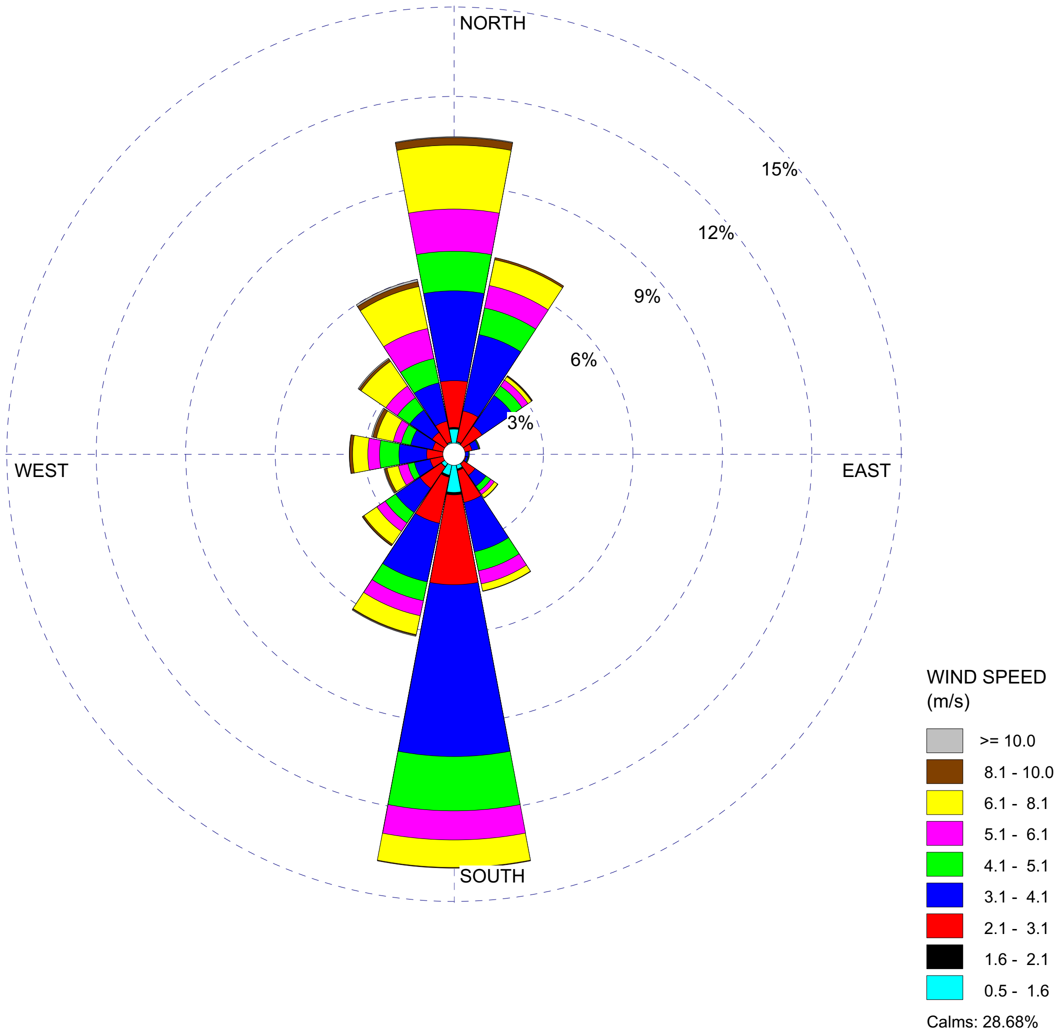


Figure 2.3.2-32. Wind Rose Chattanooga 10 Years (2000–2009) March

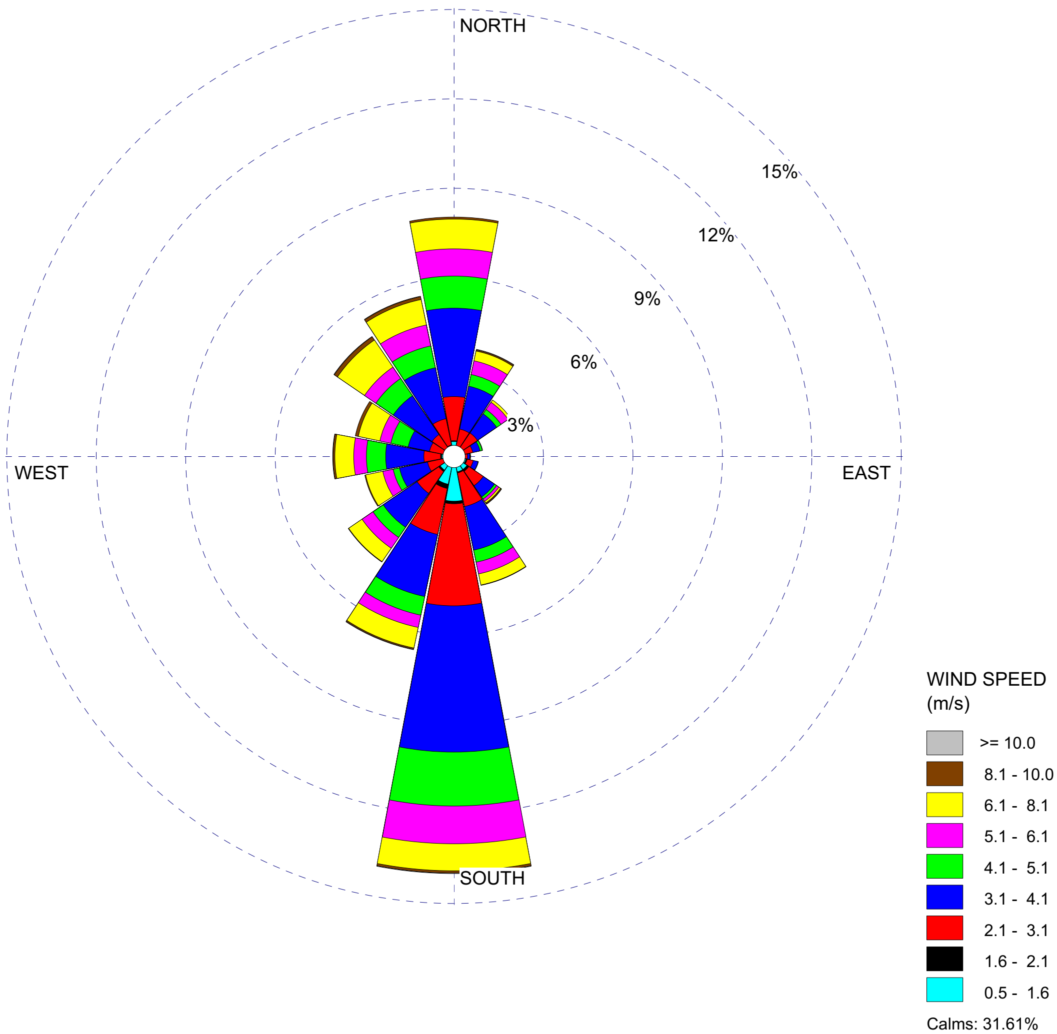


Figure 2.3.2-33. Wind Rose Chattanooga 10 Years (2000–2009) April

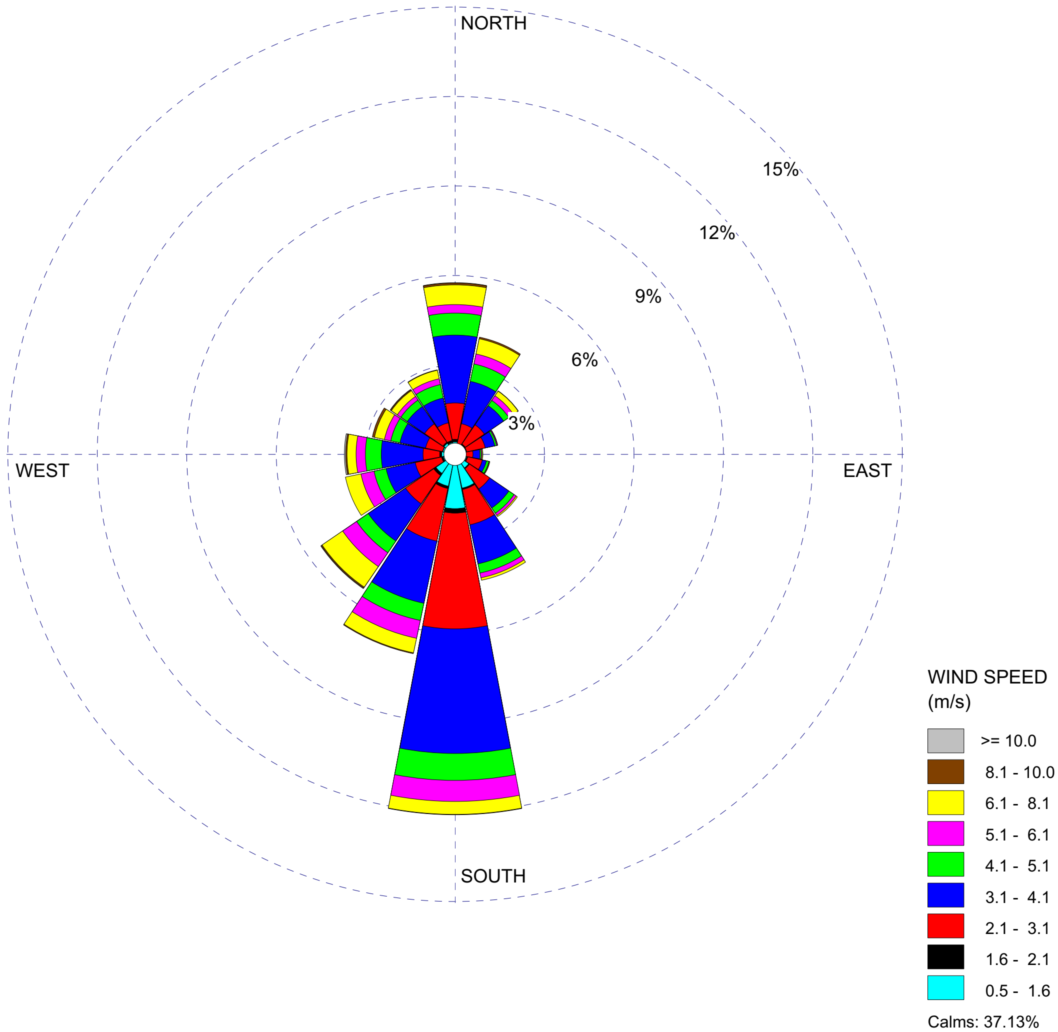


Figure 2.3.2-34. Wind Rose Chattanooga 10 Years (2000–2009) May

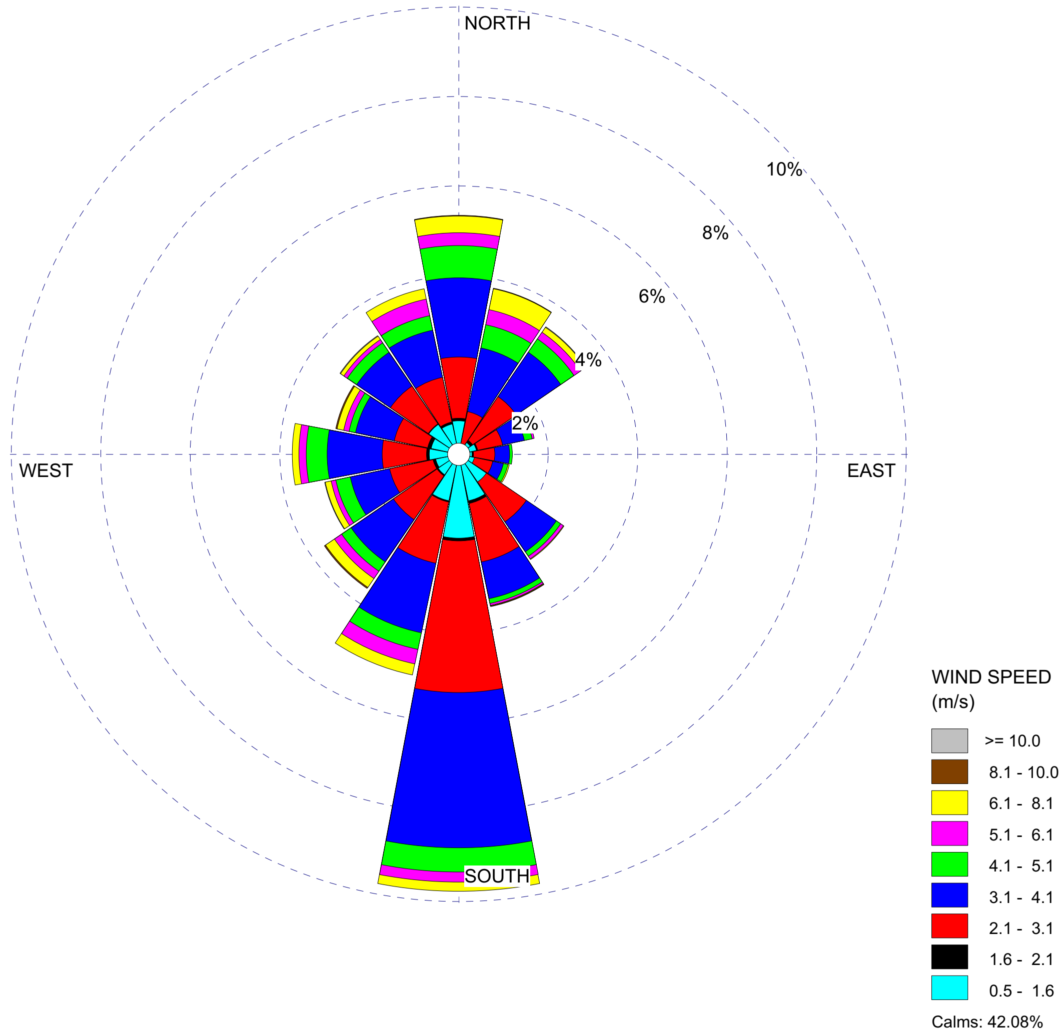


Figure 2.3.2-35. Wind Rose Chattanooga 10 Years (2000–2009) June

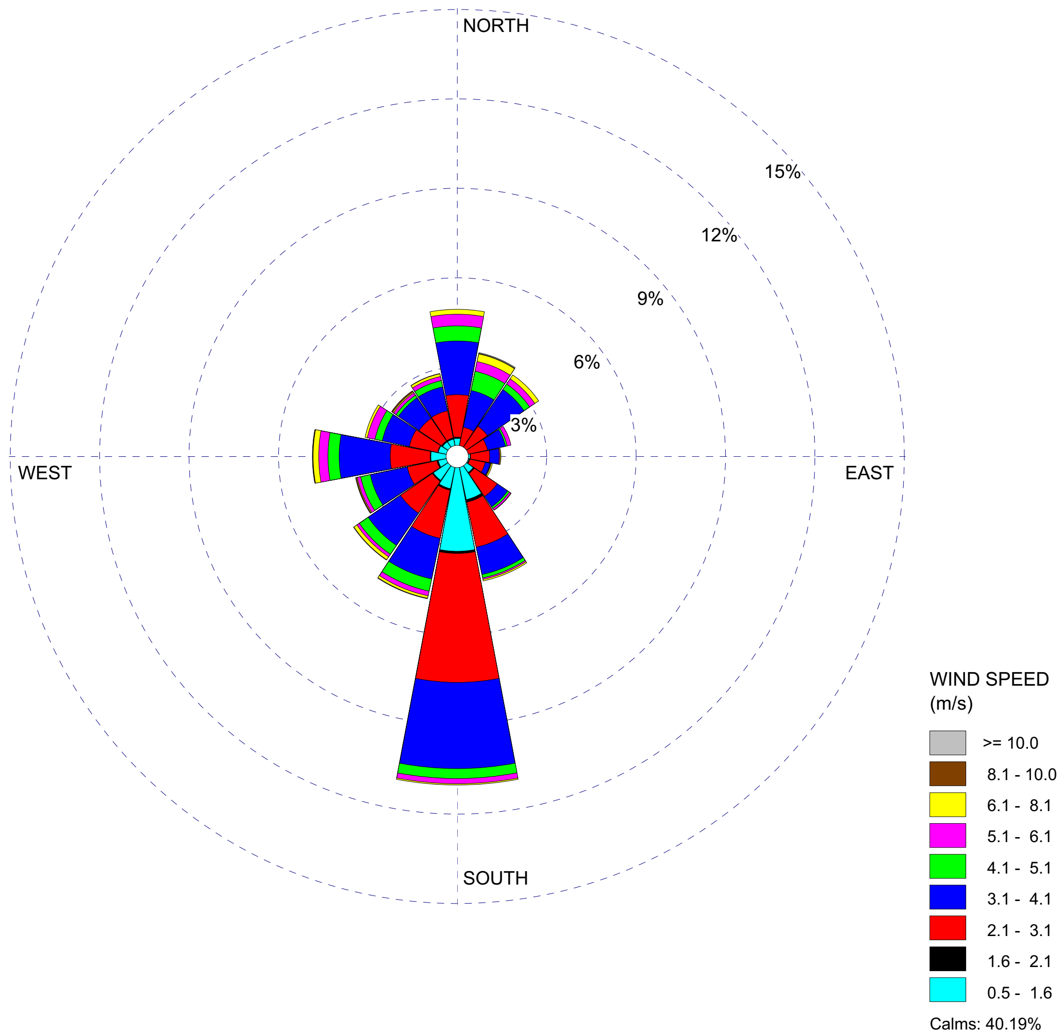


Figure 2.3.2-36. Wind Rose Chattanooga 10 Years (2000–2009) July

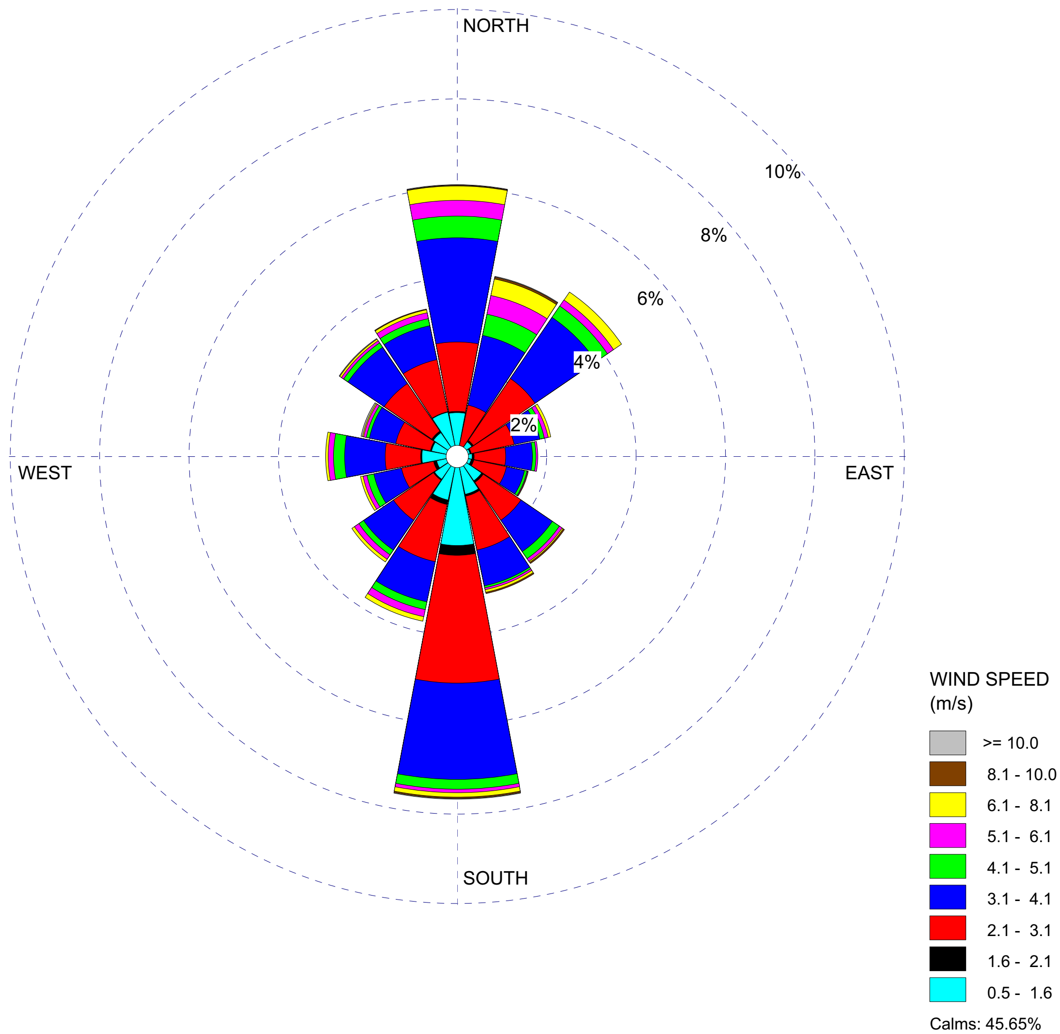


Figure 2.3.2-37. Wind Rose Chattanooga 10 Years (2000–2009) August

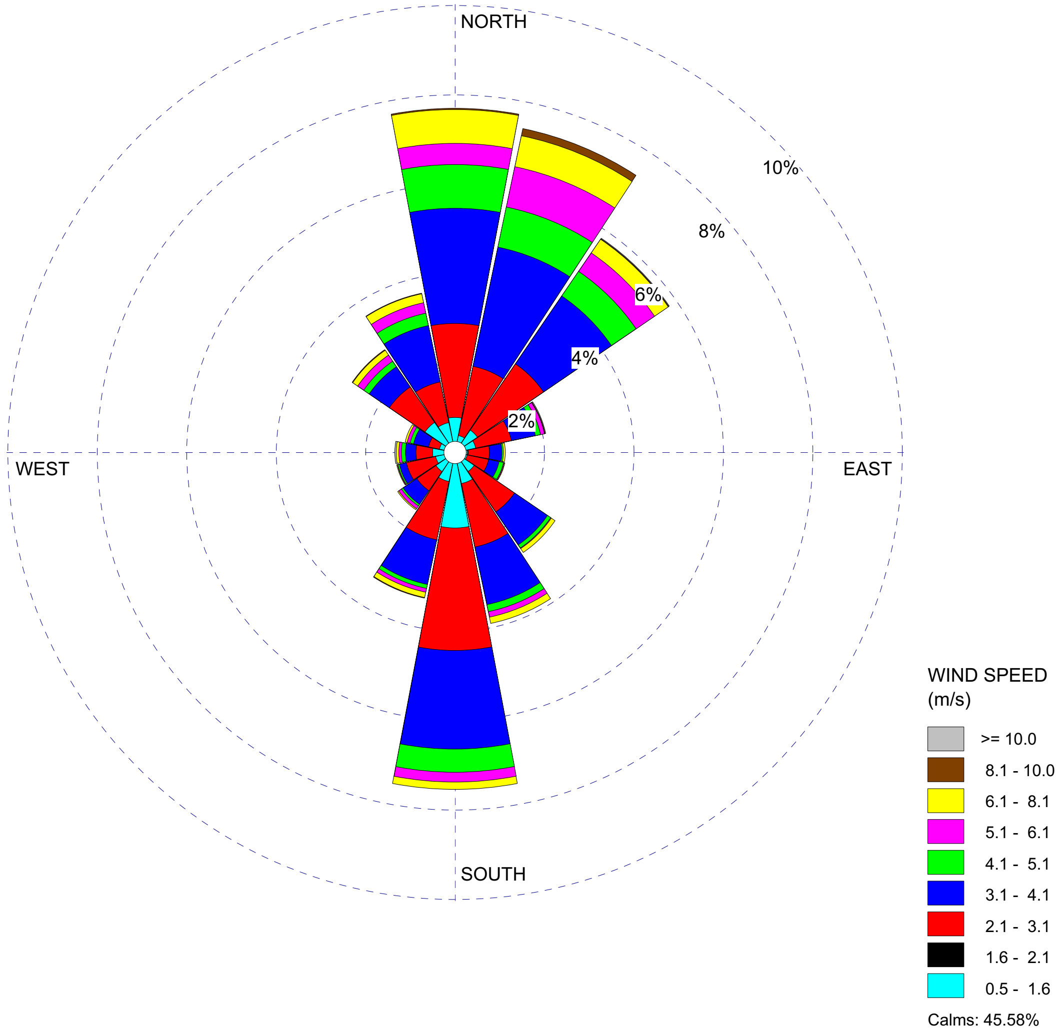


Figure 2.3.2-38. Wind Rose Chattanooga 10 Years (2000–2009) September

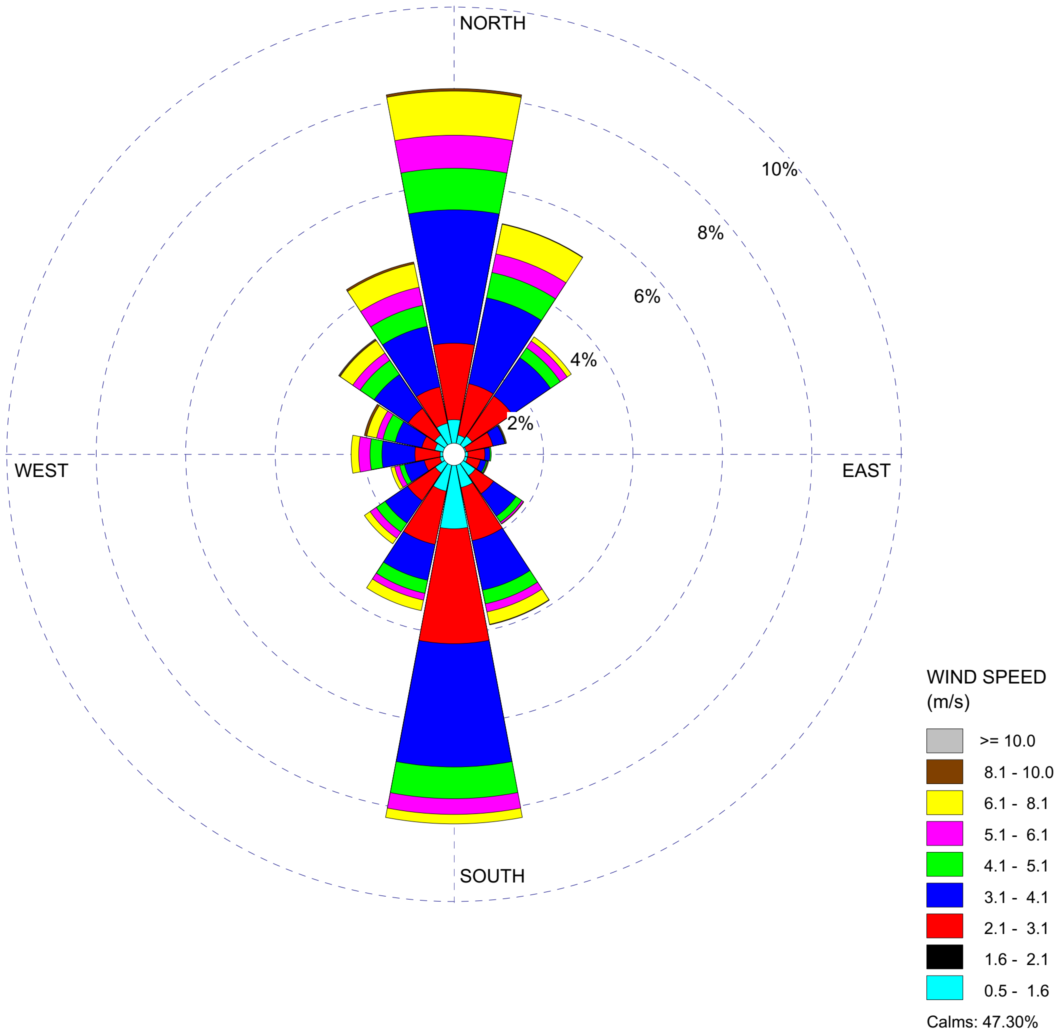


Figure 2.3.2-39. Wind Rose Chattanooga 10 Years (2000–2009) October

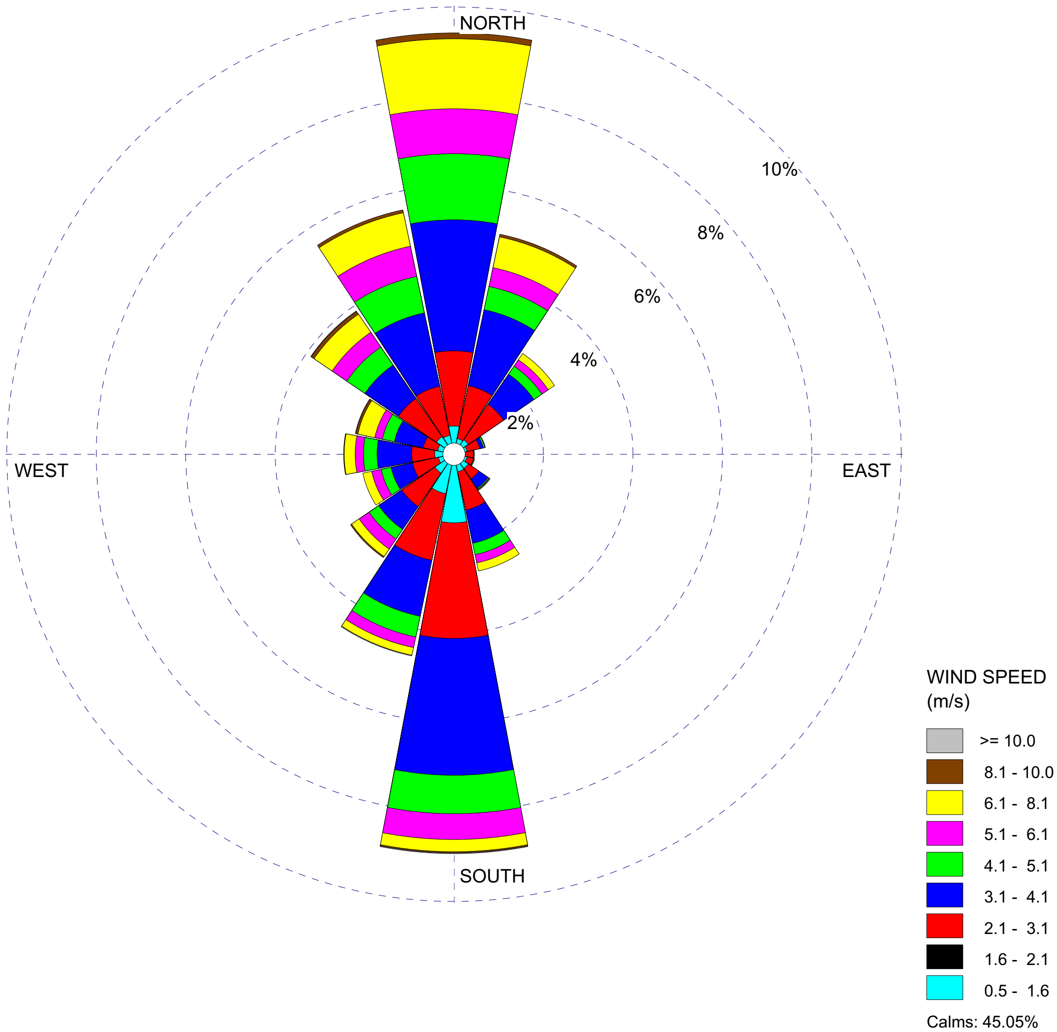


Figure 2.3.2-40. Wind Rose Chattanooga 10 Years (2000–2009) November

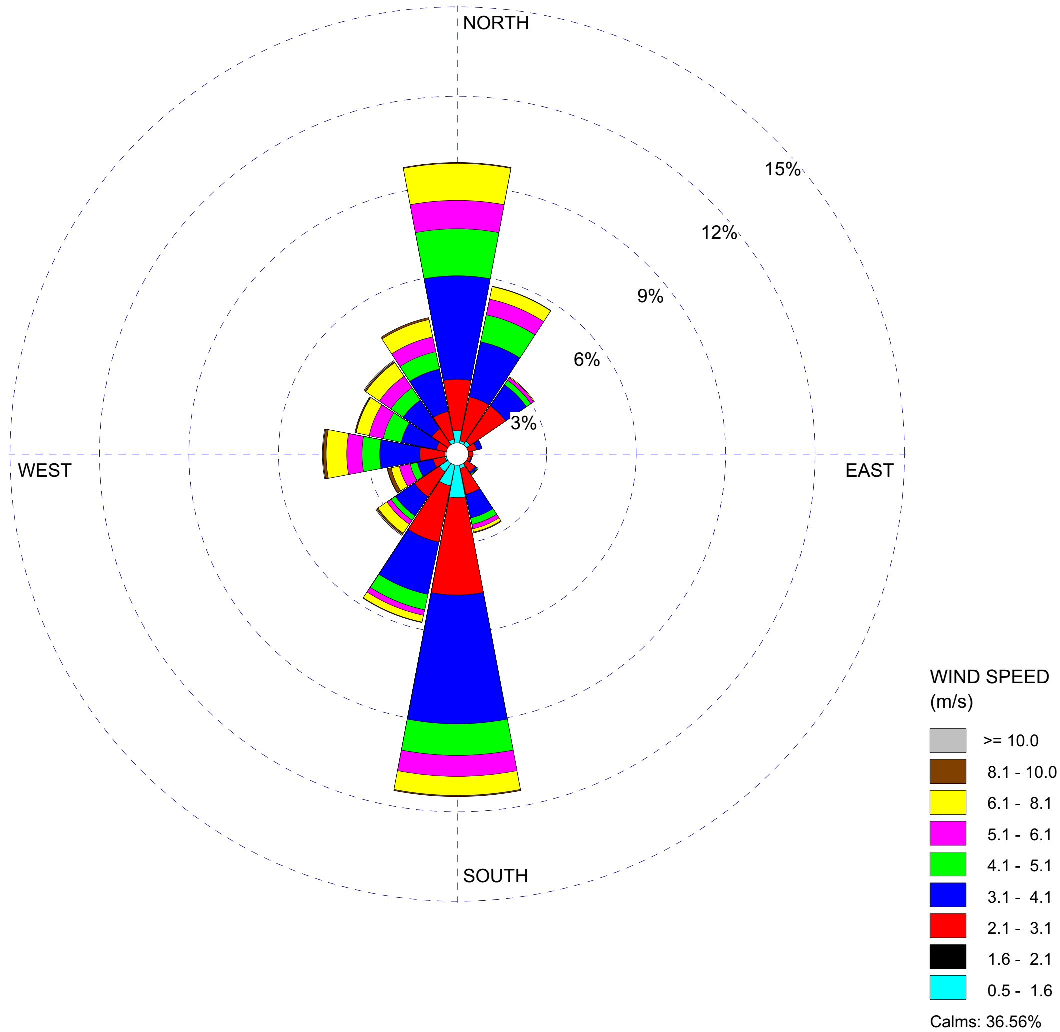


Figure 2.3.2-41. Wind Rose Chattanooga 10 Years (2000–2009) December

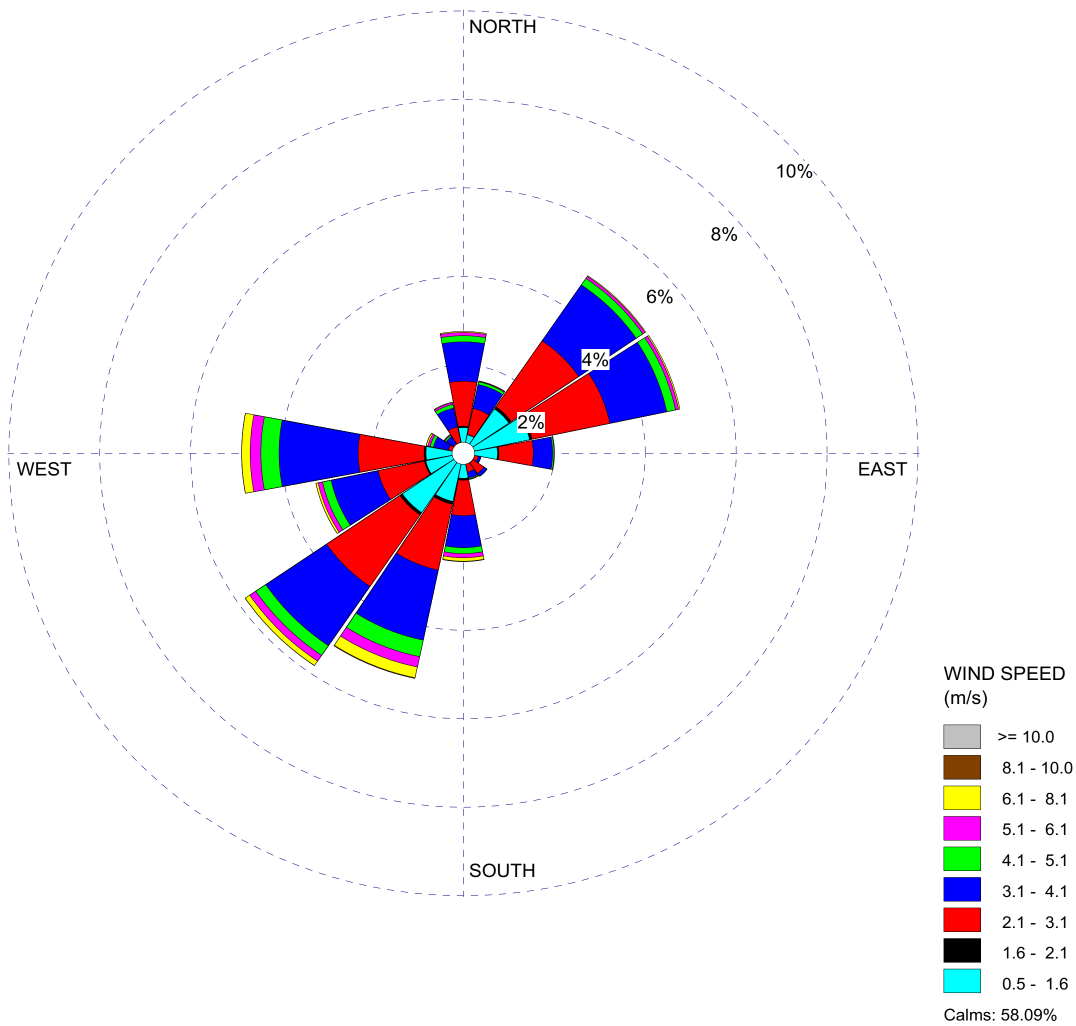


Figure 2.3.2-42. Wind Rose Oak Ridge 10 Years (2000–2009) All Data

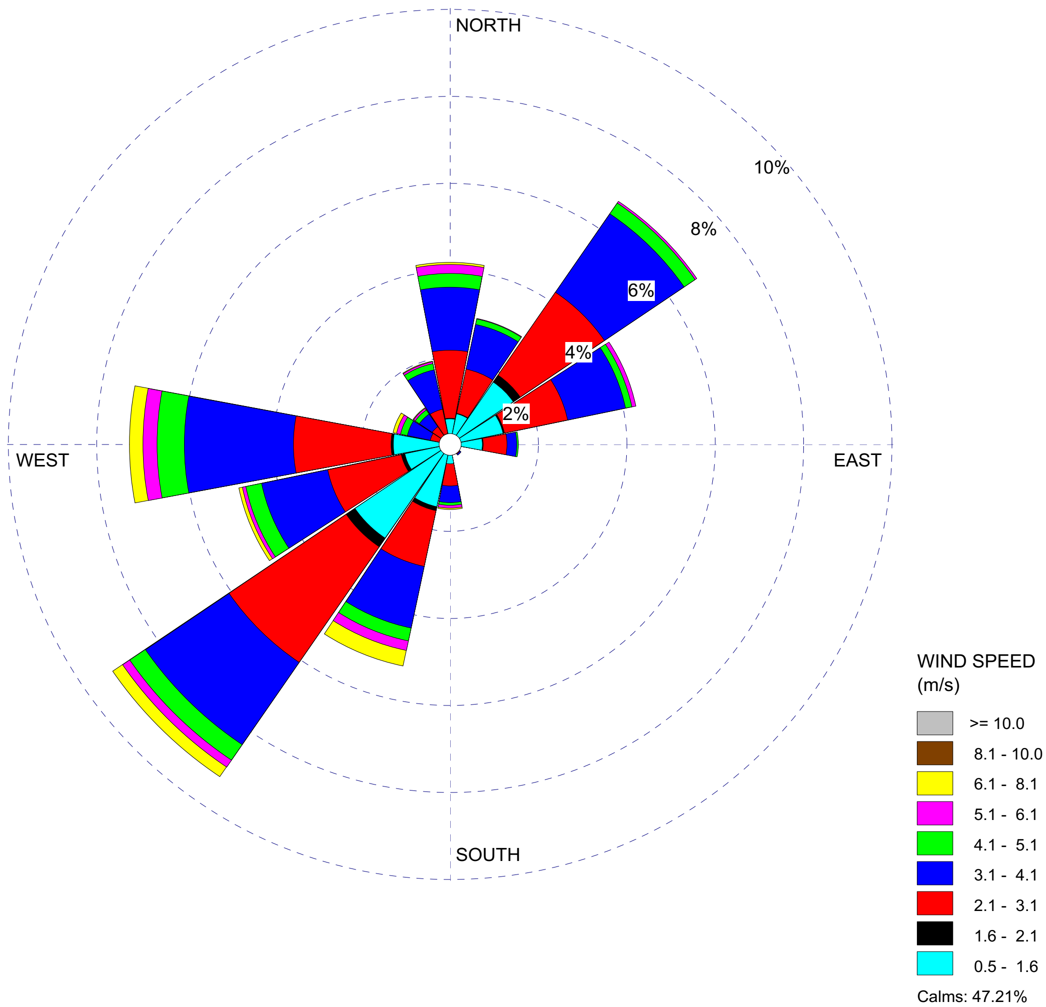


Figure 2.3.2-43. Wind Rose Oak Ridge 10 Years (2000–2009) January

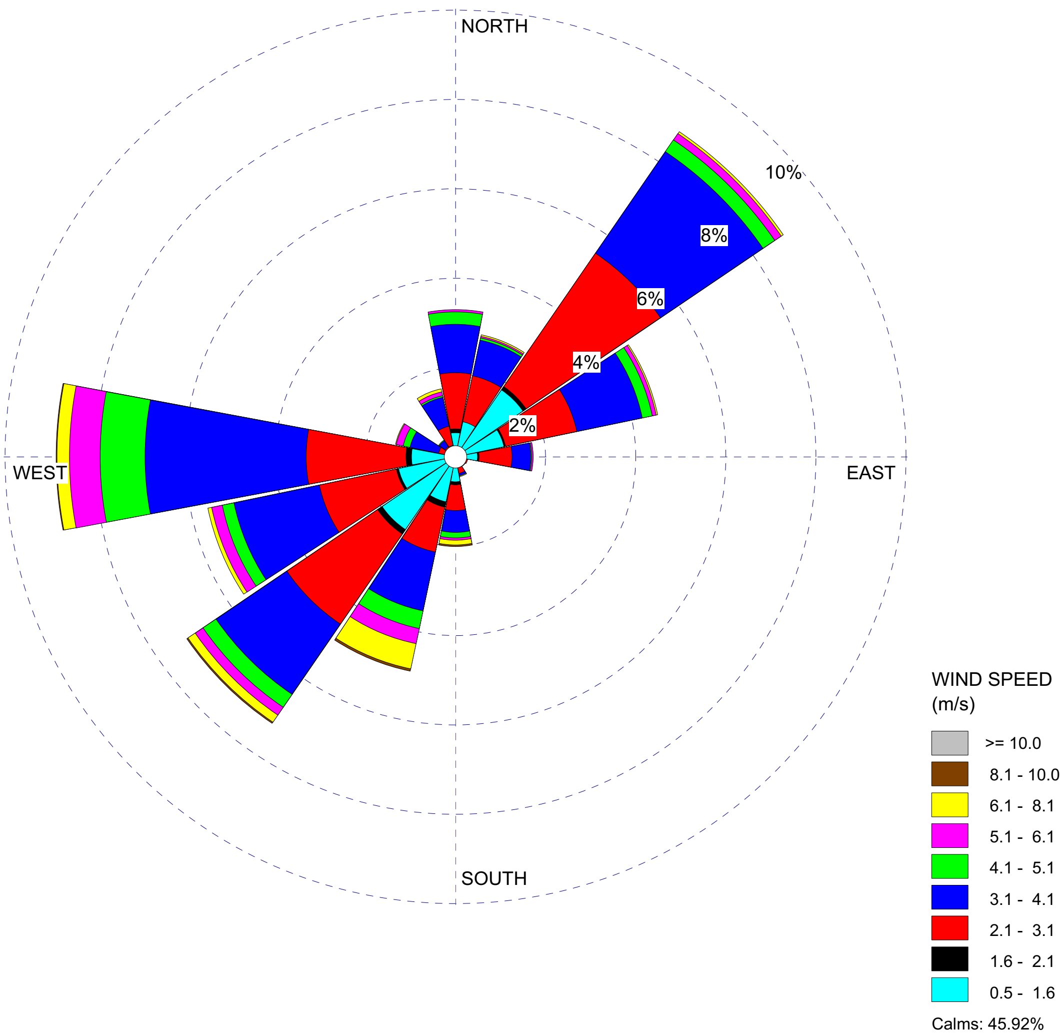


Figure 2.3.2-44. Wind Rose Oak Ridge 10 Years (2000–2009) February

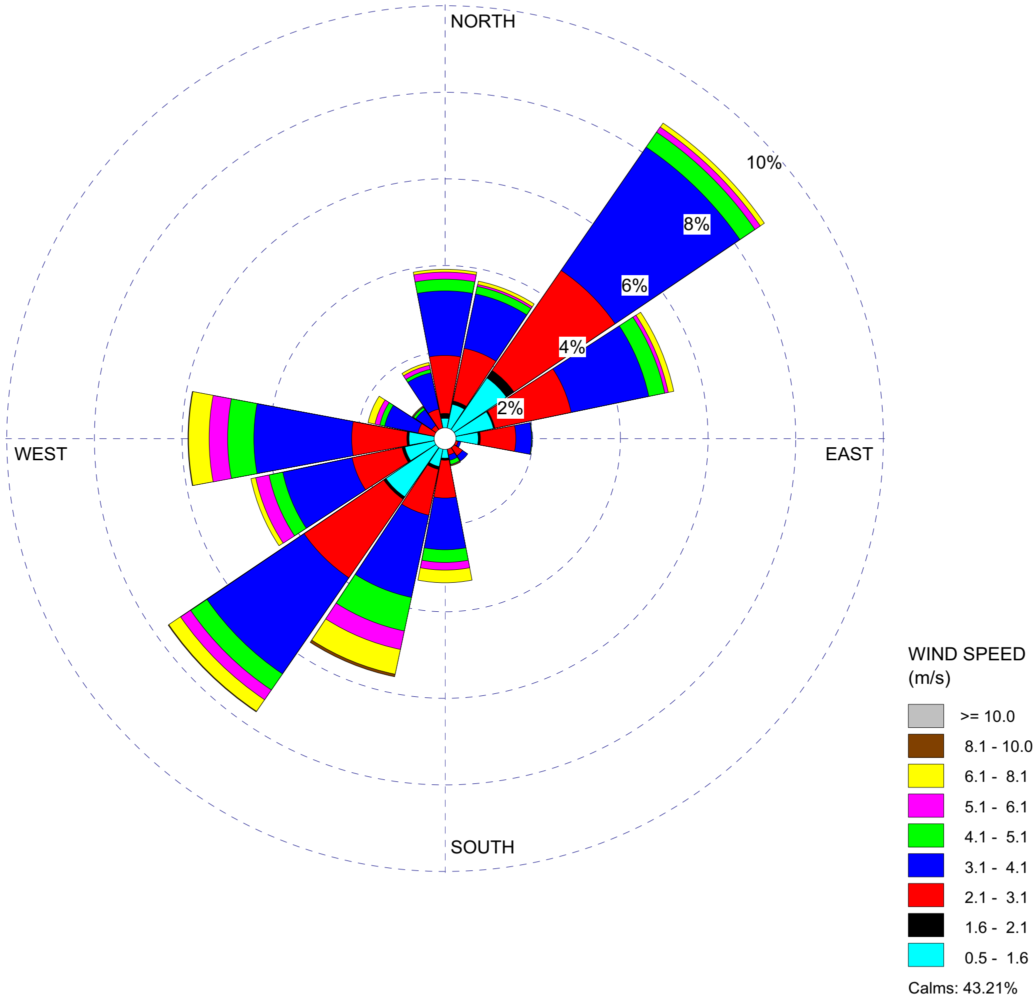


Figure 2.3.2-45. Wind Rose Oak Ridge 10 Years (2000–2009) March

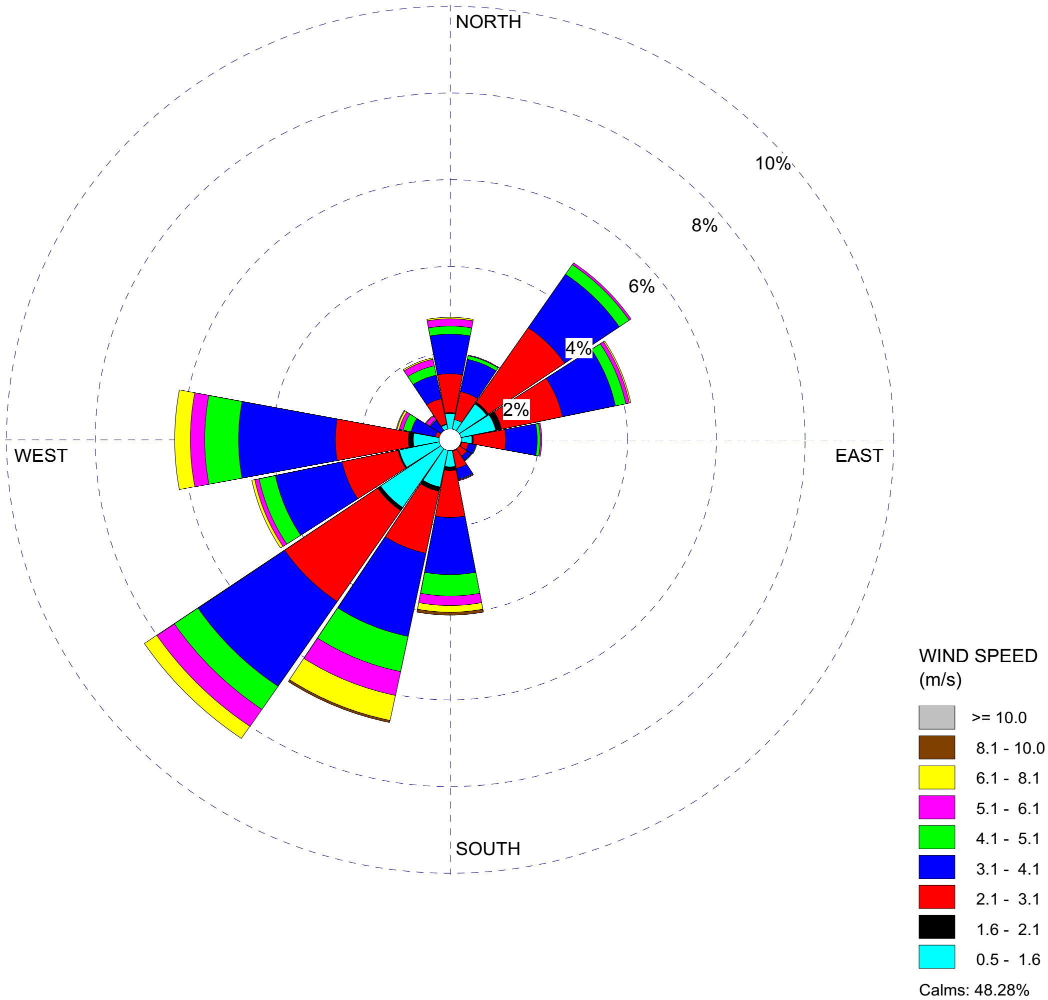


Figure 2.3.2-46. Wind Rose Oak Ridge 10 Years (2000–2009) April

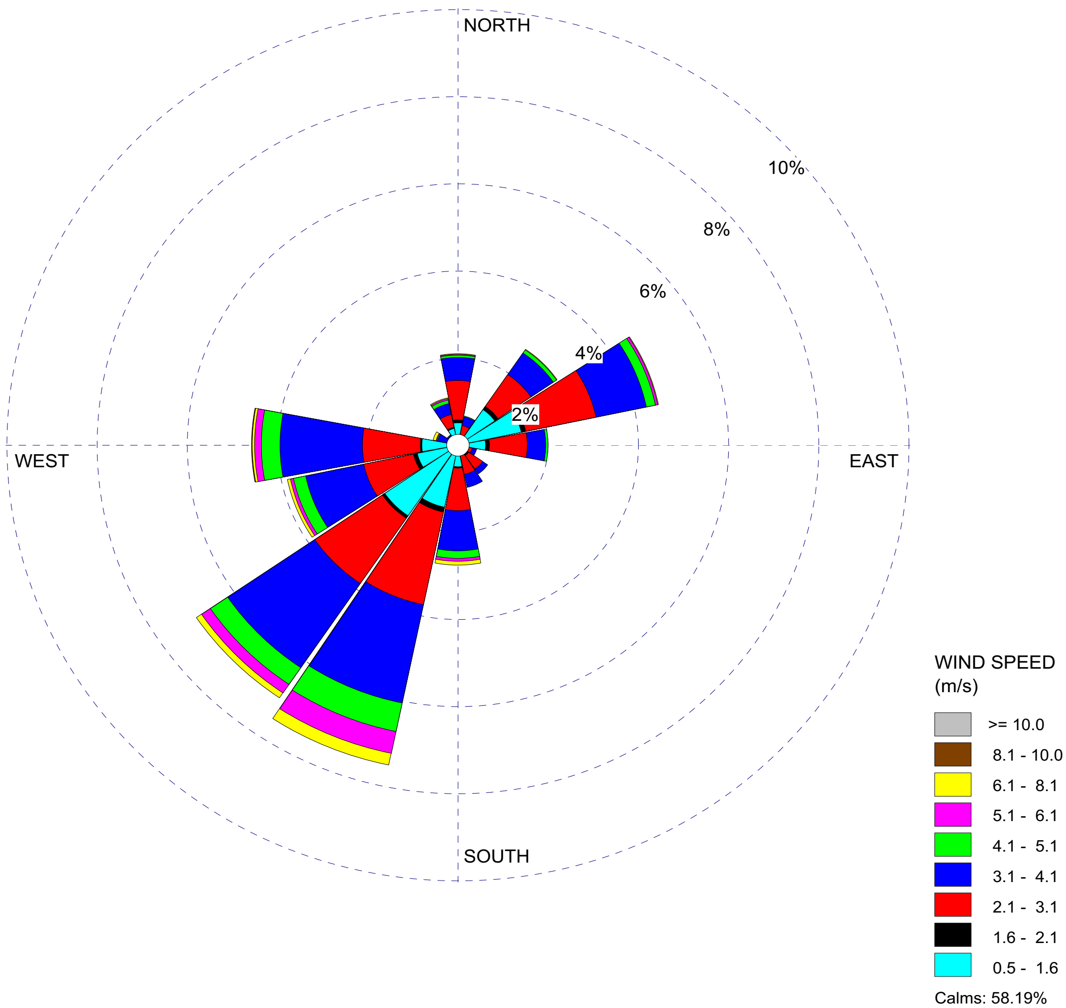


Figure 2.3.2-47. Wind Rose Oak Ridge 10 Years (2000–2009) May

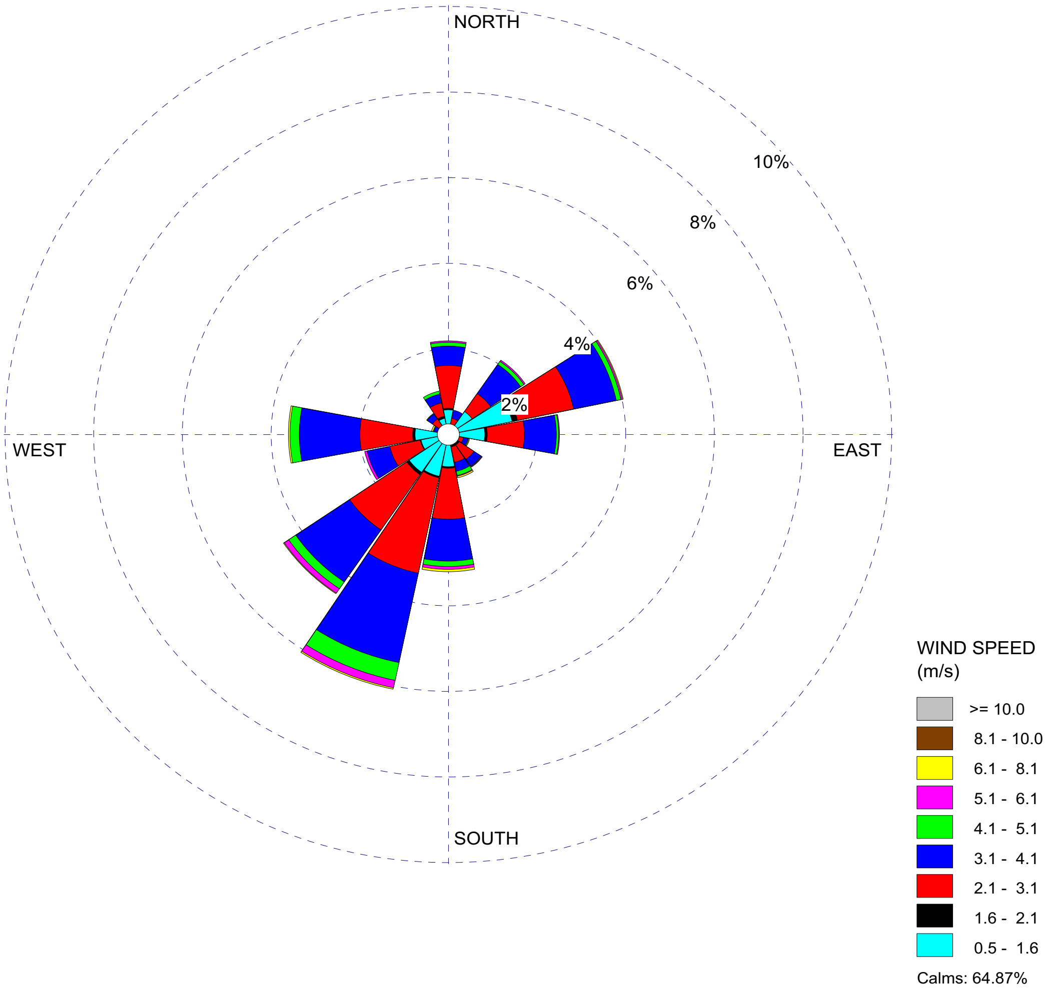


Figure 2.3.2-48. Wind Rose Oak Ridge 10 Years (2000–2009) June

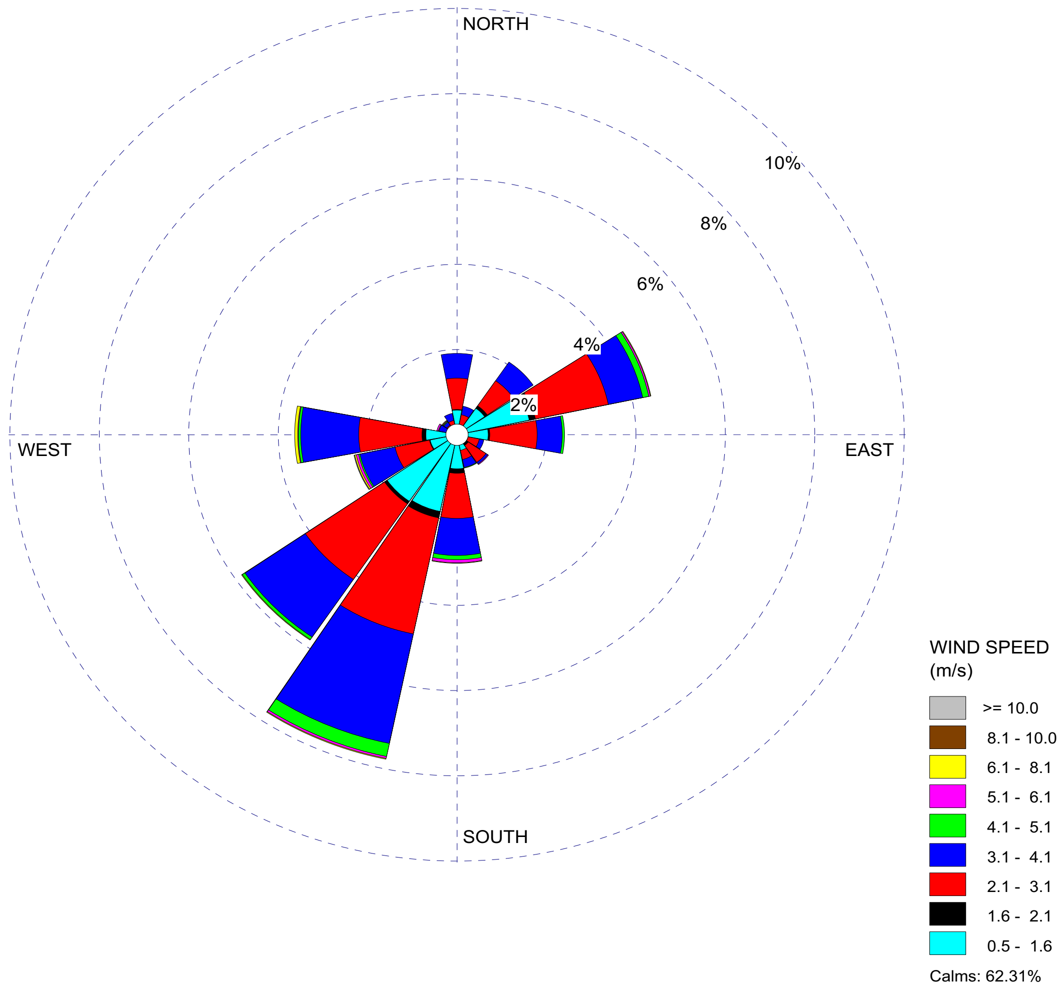


Figure 2.3.2-49. Wind Rose Oak Ridge 10 Years (2000–2009) July

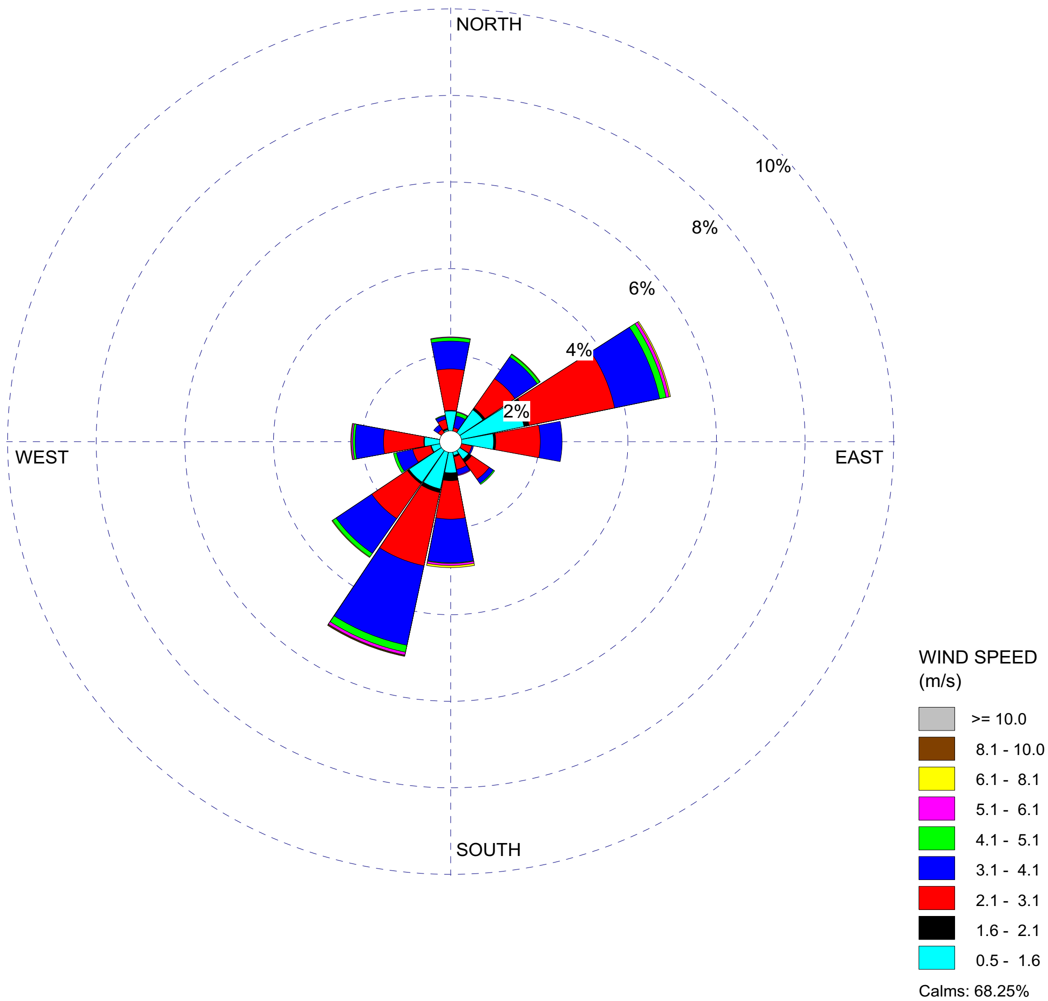


Figure 2.3.2-50. Wind Rose Oak Ridge 10 Years (2000–2009) August

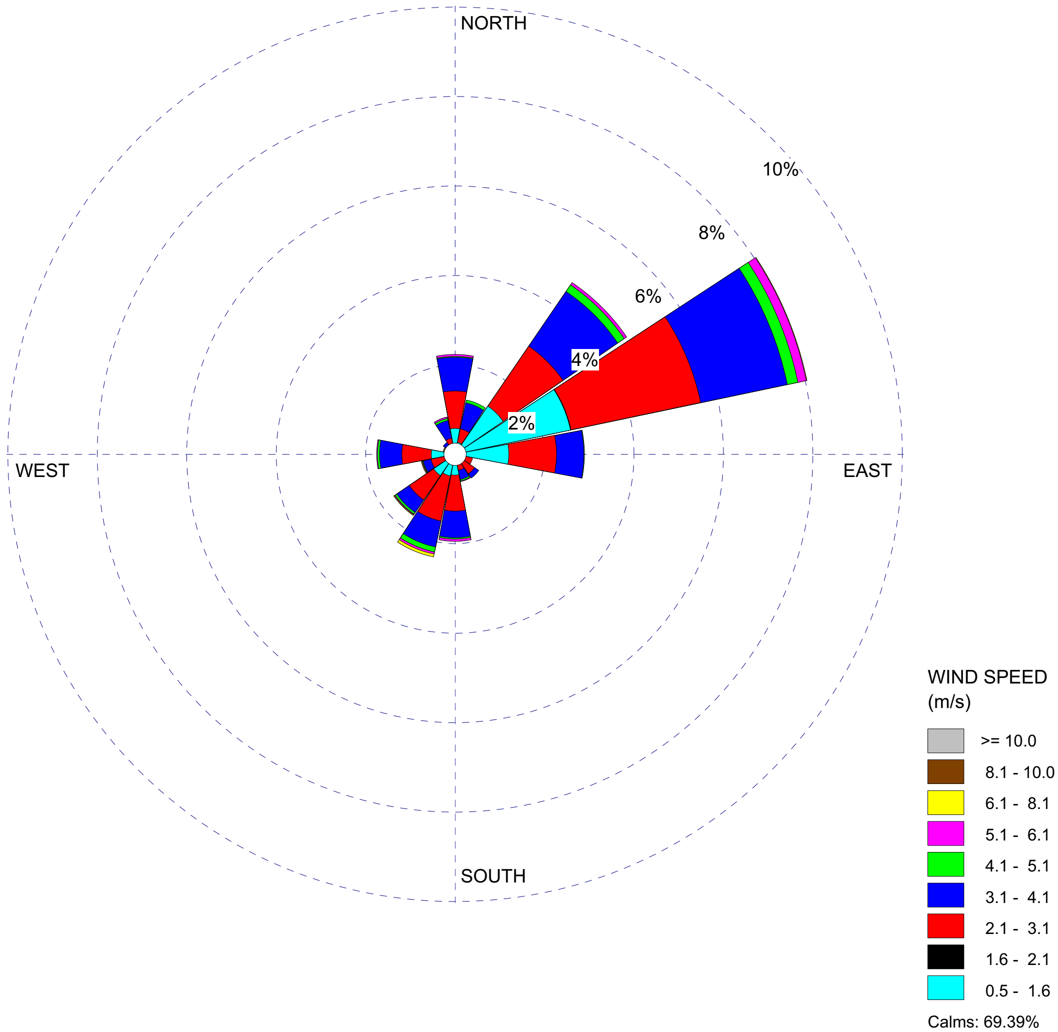


Figure 2.3.2-51. Wind Rose Oak Ridge 10 Years (2000–2009) September

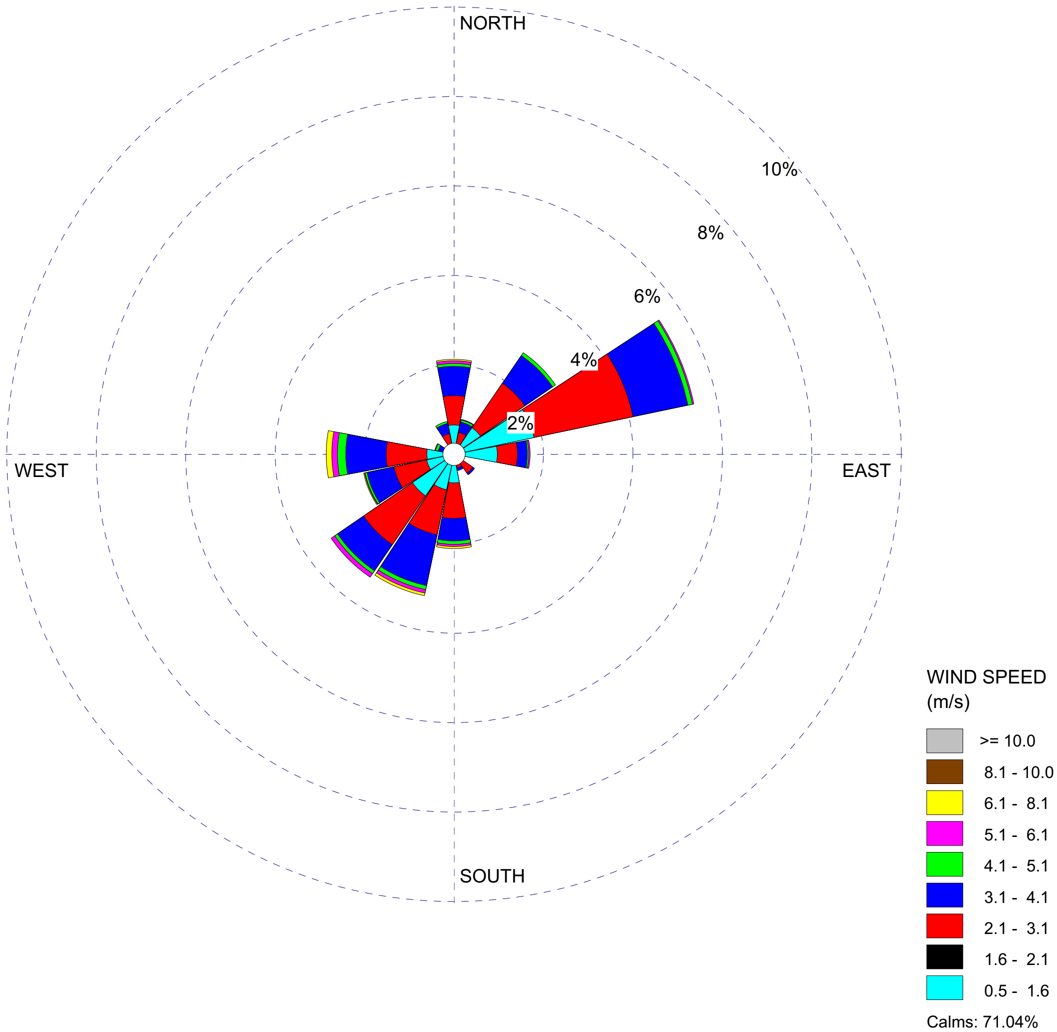


Figure 2.3.2-52. Wind Rose Oak Ridge 10 Years (2000–2009) October

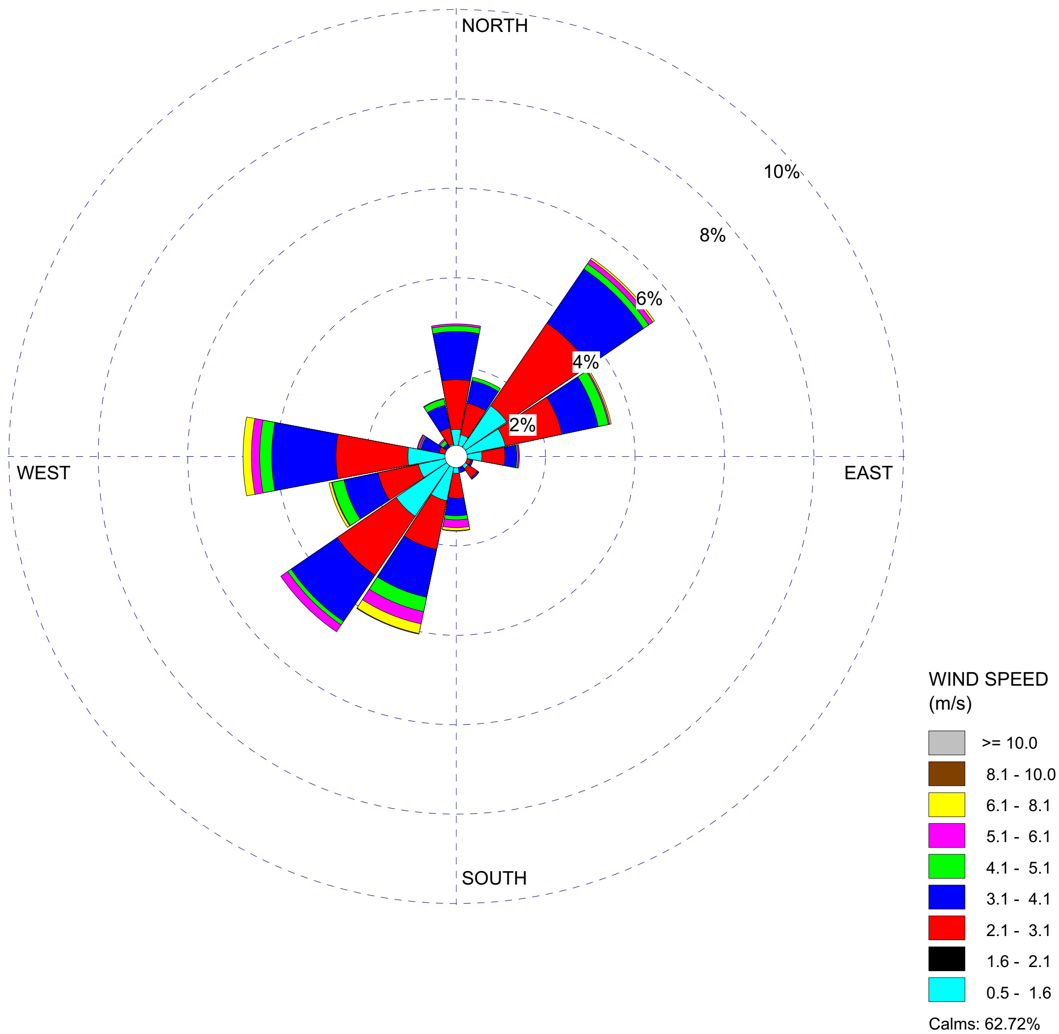


Figure 2.3.2-53. Wind Rose Oak Ridge 10 Years (2000–2009) November

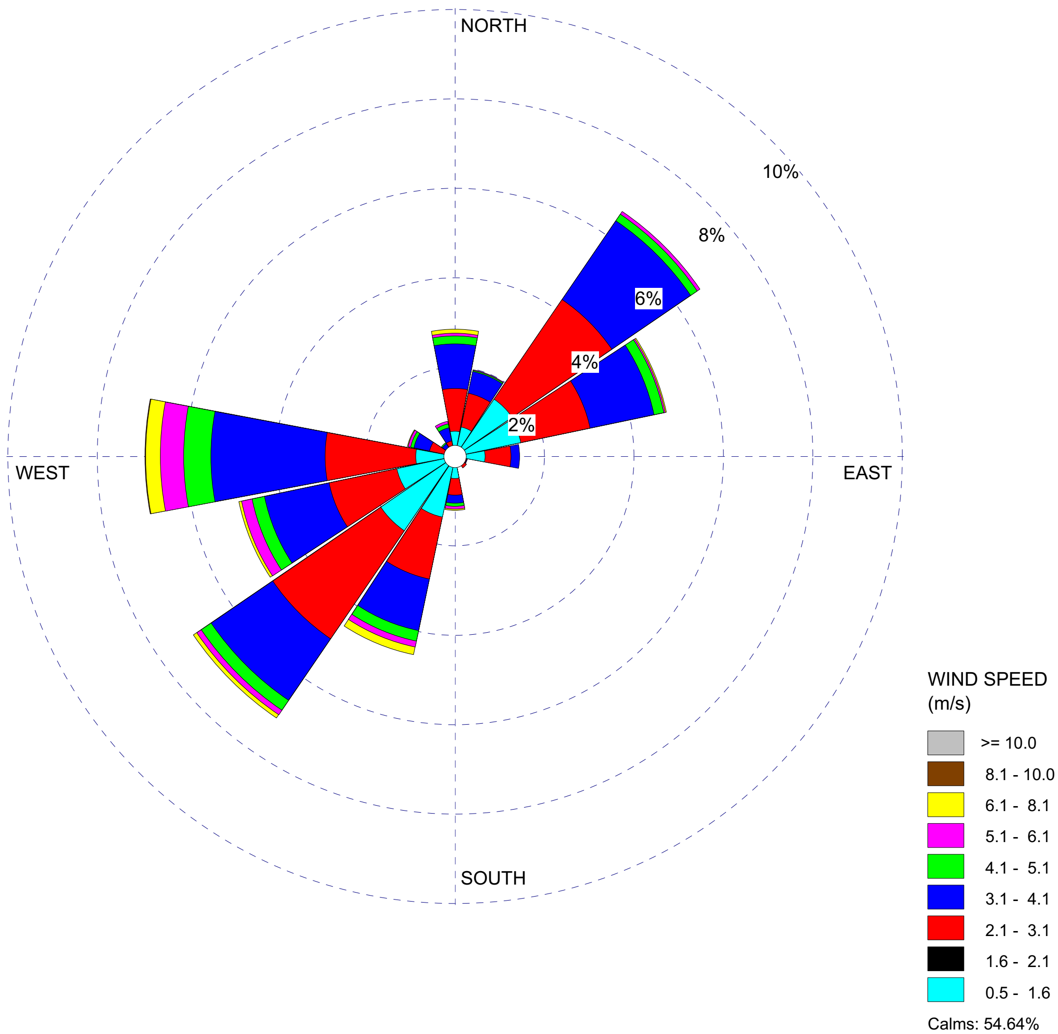


Figure 2.3.2-54. Wind Rose Oak Ridge 10 Years (2000–2009) December

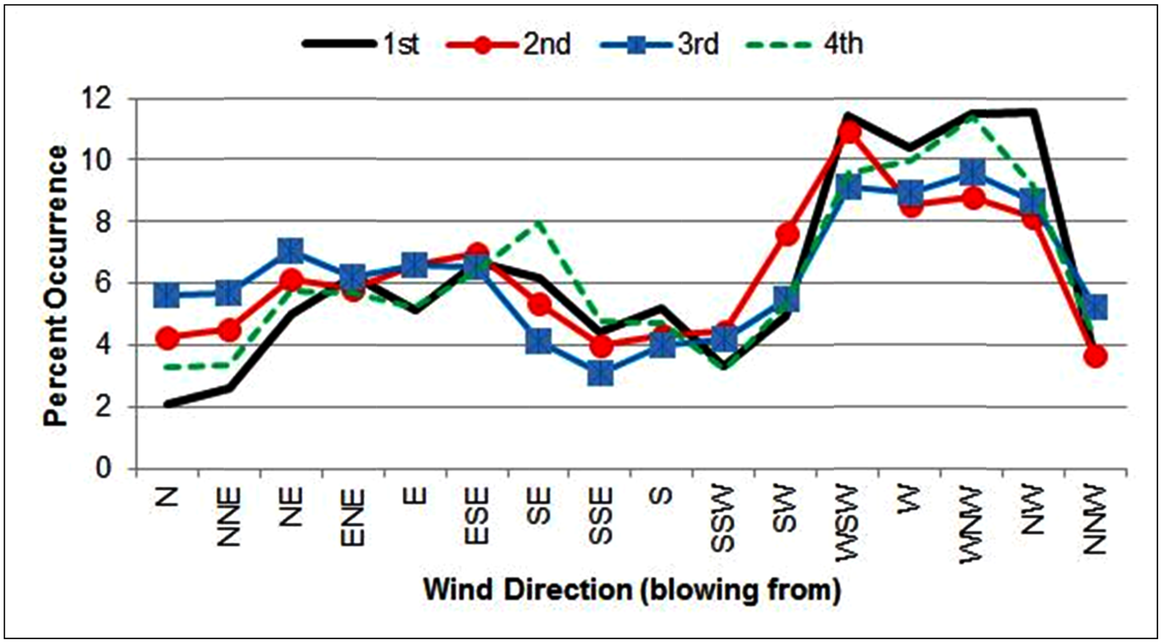


Figure 2.3.2-55. Average Wind Direction by Quarter at 10 m

CRN - Clinch River Nuclear Site
OQT - Oak Ridge, TN
TYS - Knoxville, TN

Data Period: May 1, 2011 - June 30, 2013.

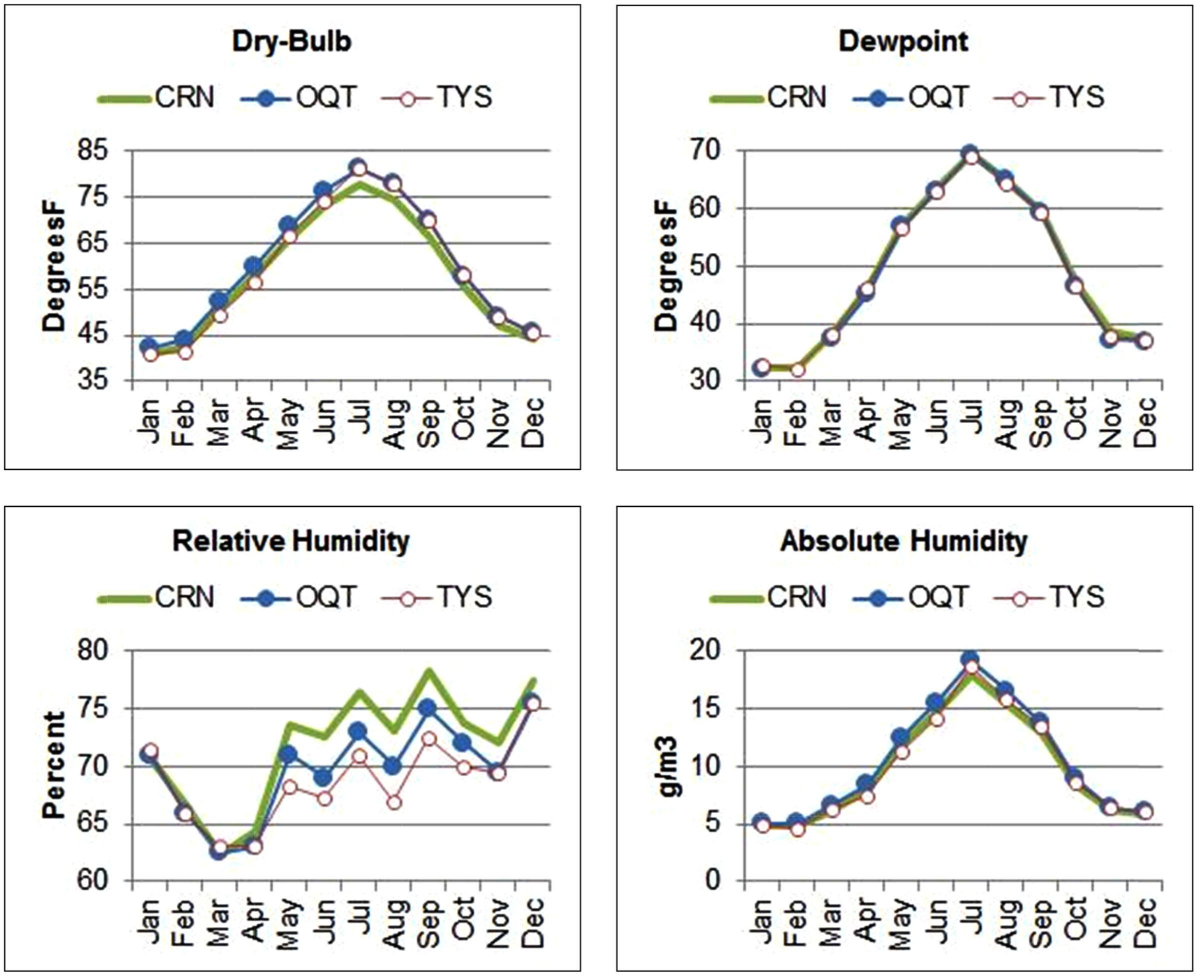
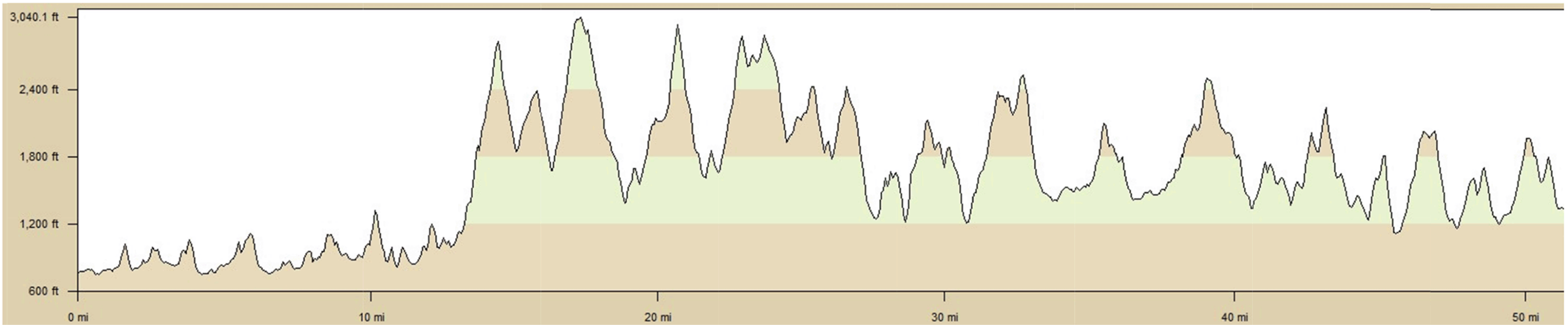
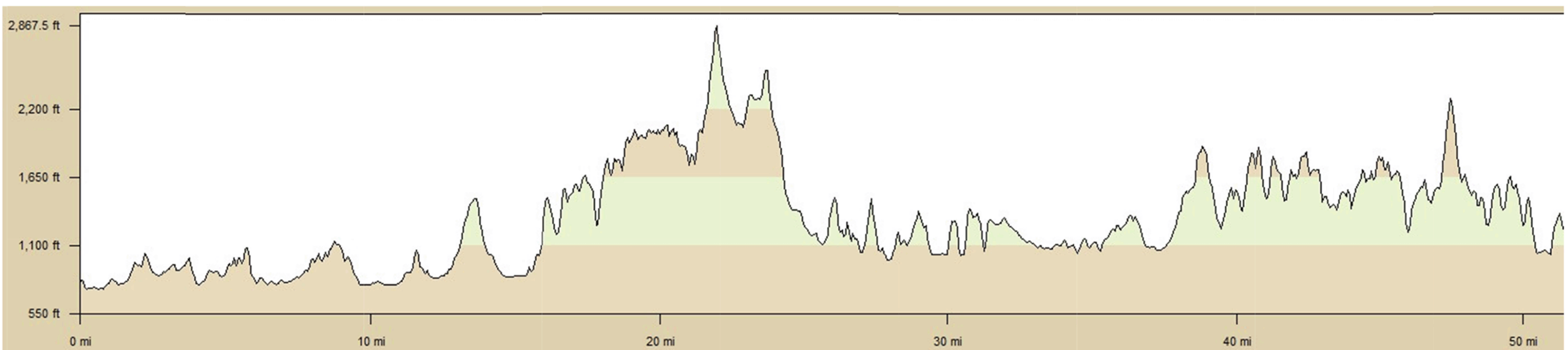


Figure 2.3.2-56. Comparison of Humidity Values for Clinch River Nuclear Site, Oak Ridge, and Knoxville

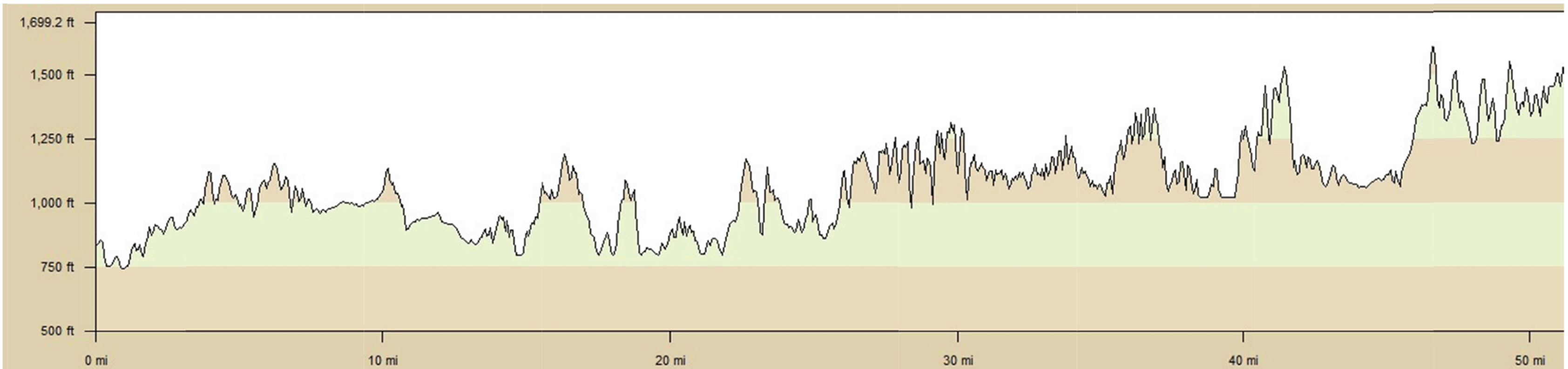


North

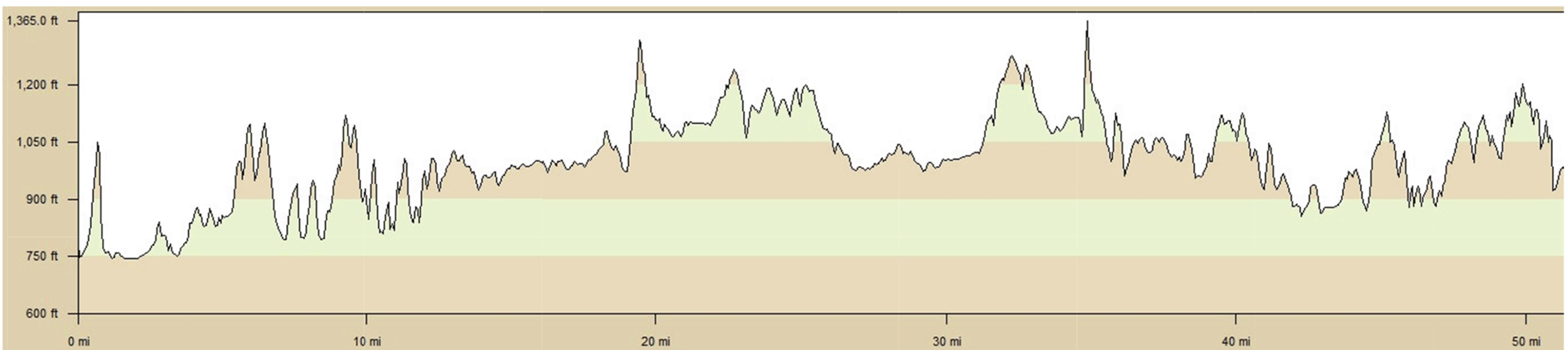


North Northeast

Figure 2.3.2-57. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

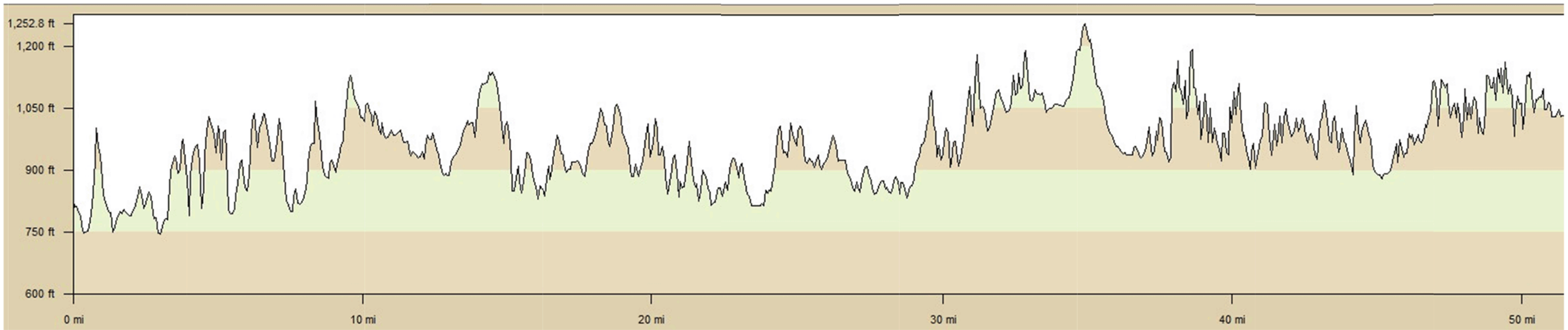


Northeast

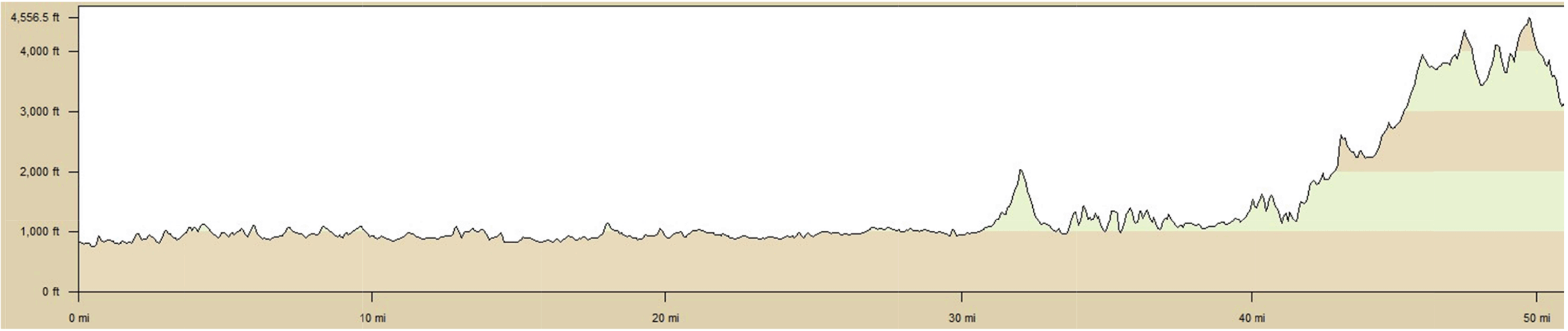


East Northeast

Figure 2.3.2-58. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

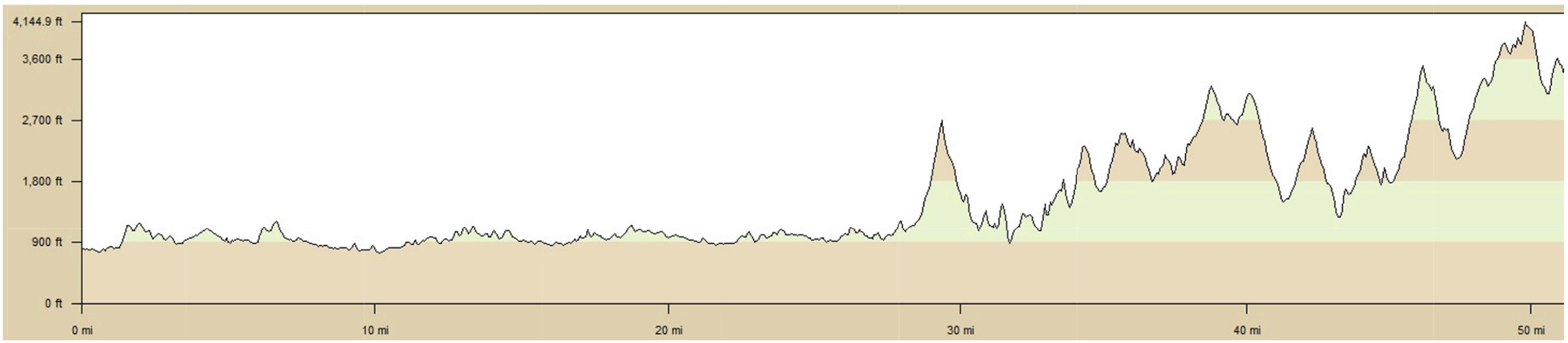


East

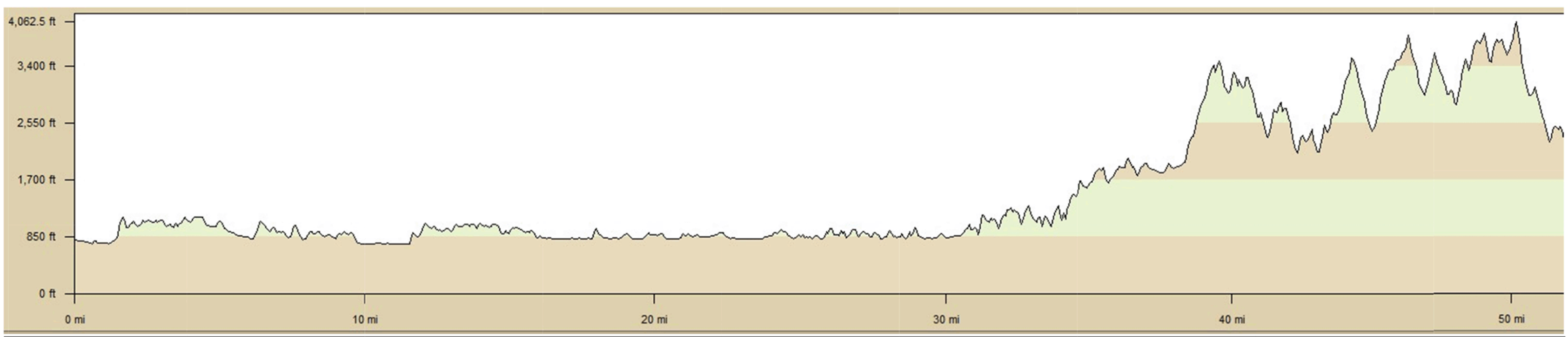


East Southeast

Figure 2.3.2-59. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

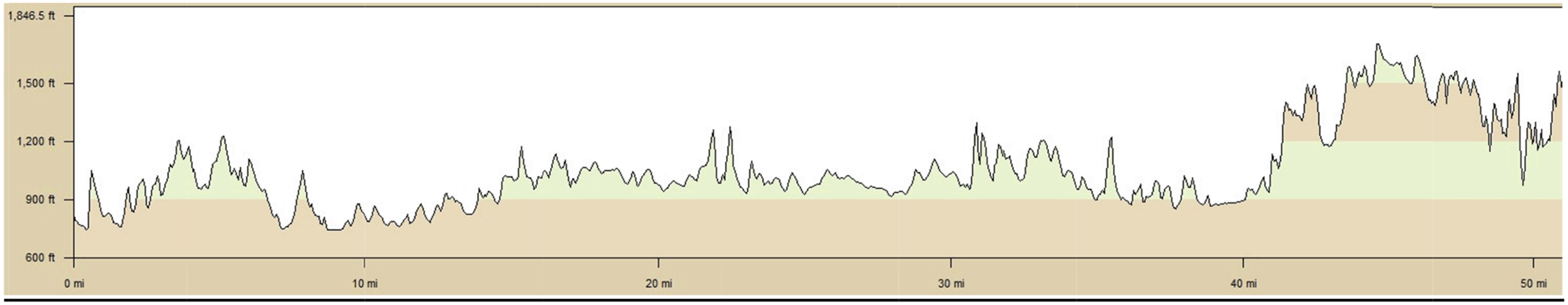


Southeast

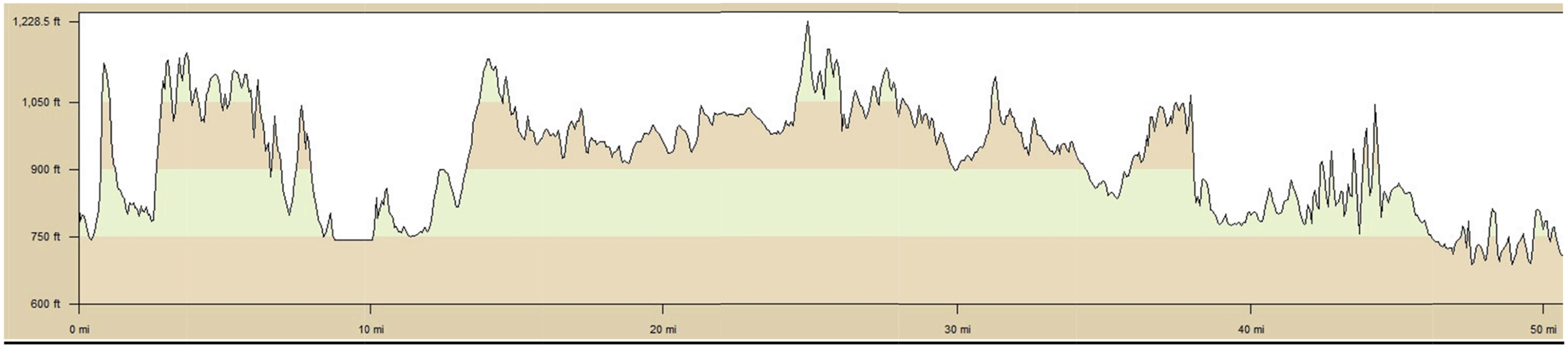


South Southeast

Figure 2.3.2-60. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

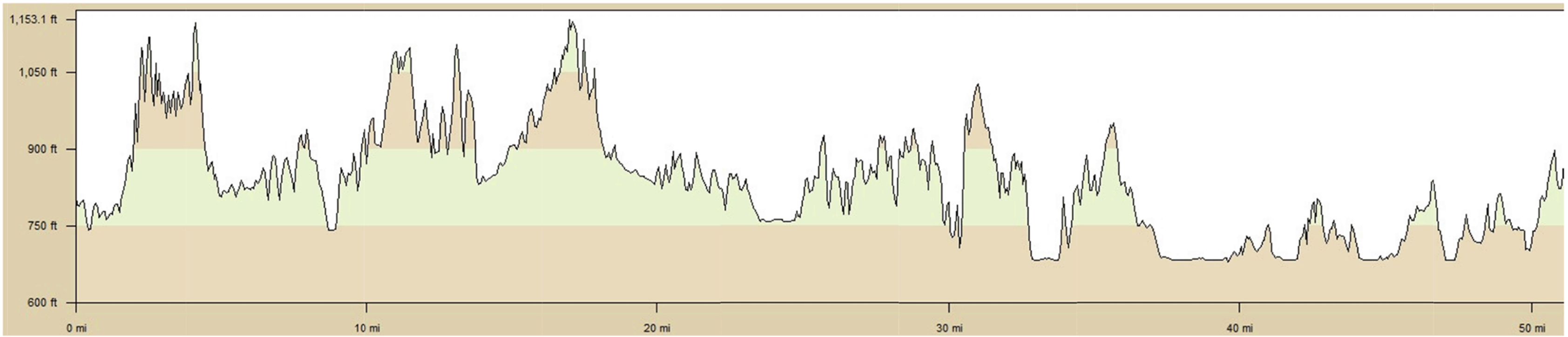


South

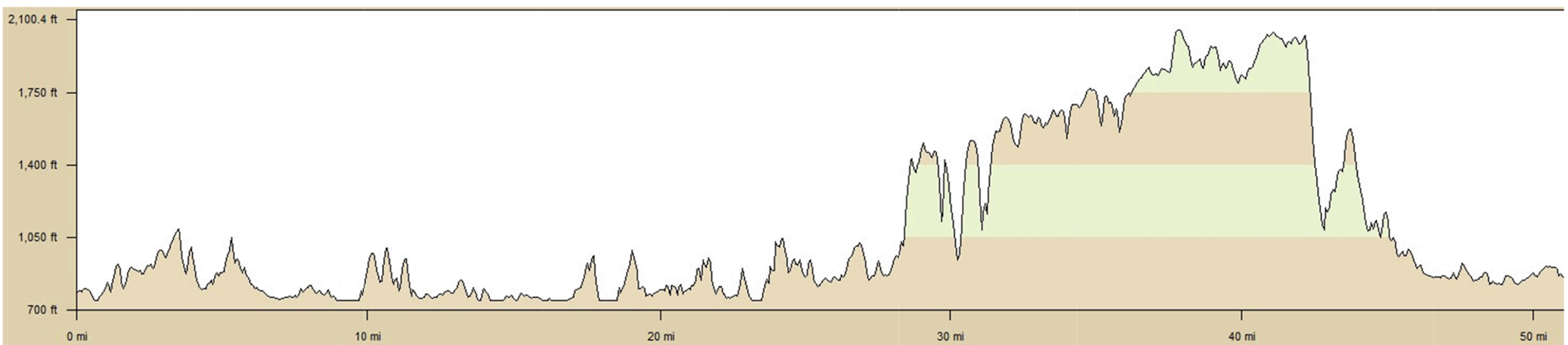


South Southwest

Figure 2.3.2-61. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

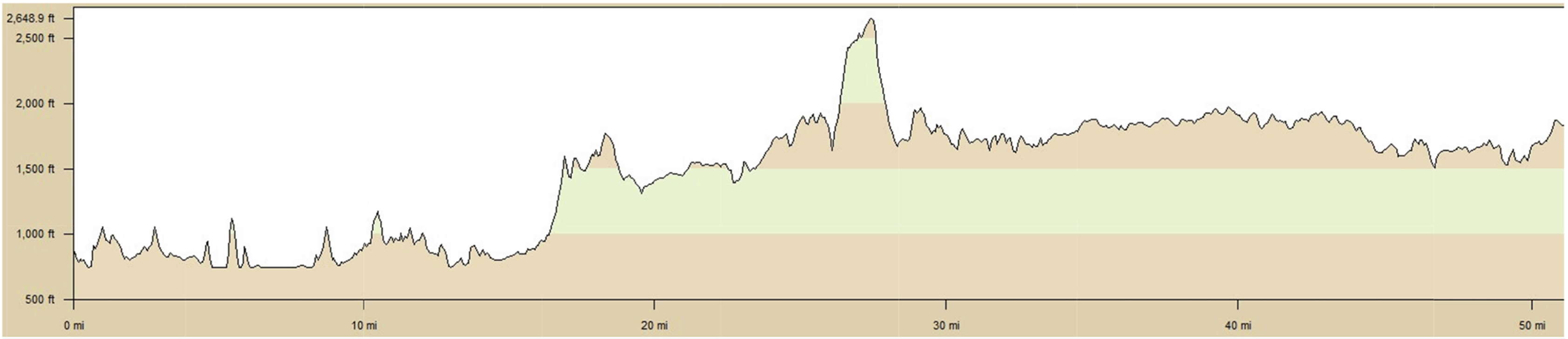


Southwest

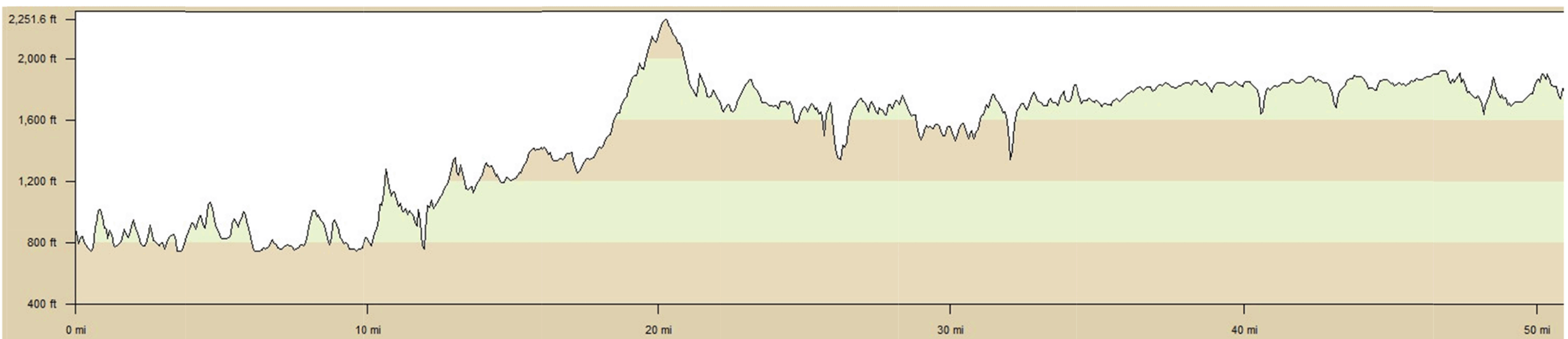


West Southwest

Figure 2.3.2-62. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

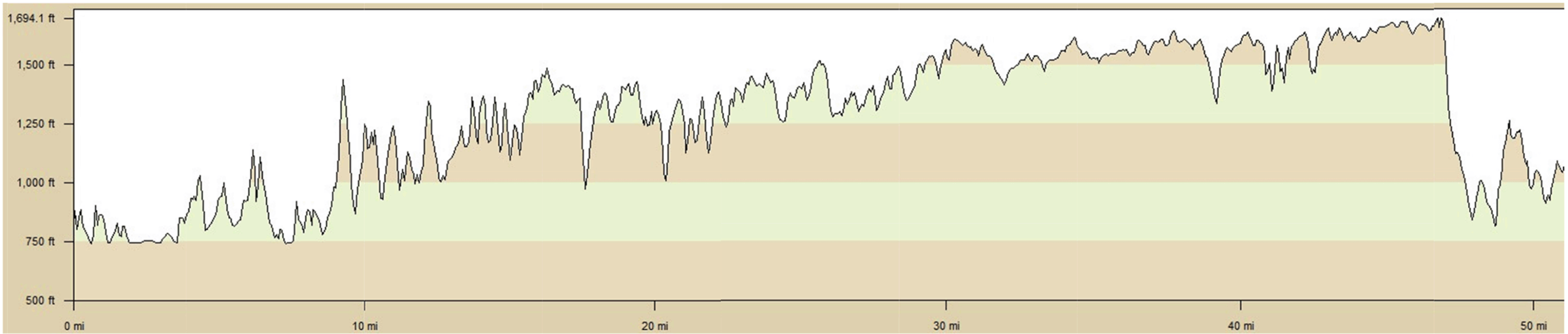


West

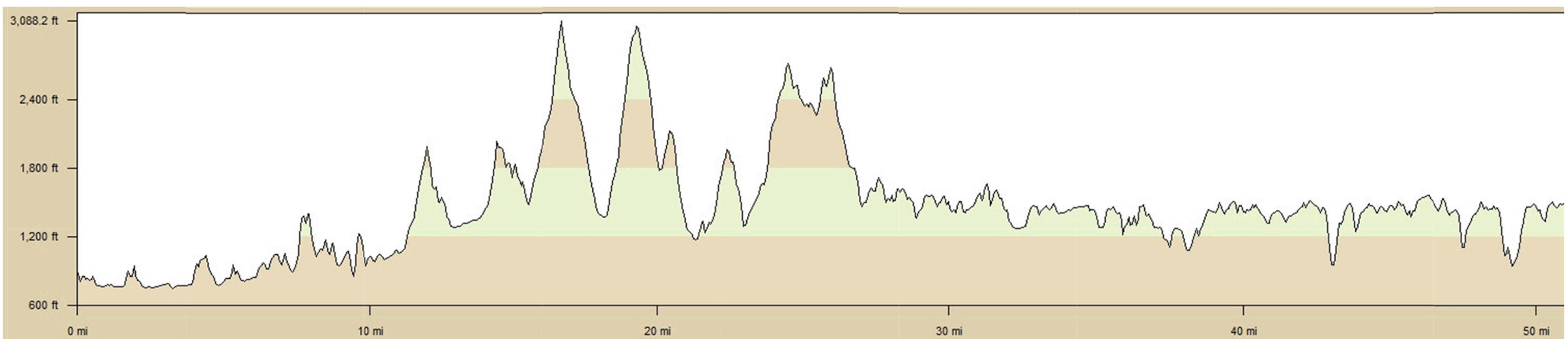


West Northwest

Figure 2.3.2-63. Elevation Profiles 0–50 miles from Clinch River Nuclear Site

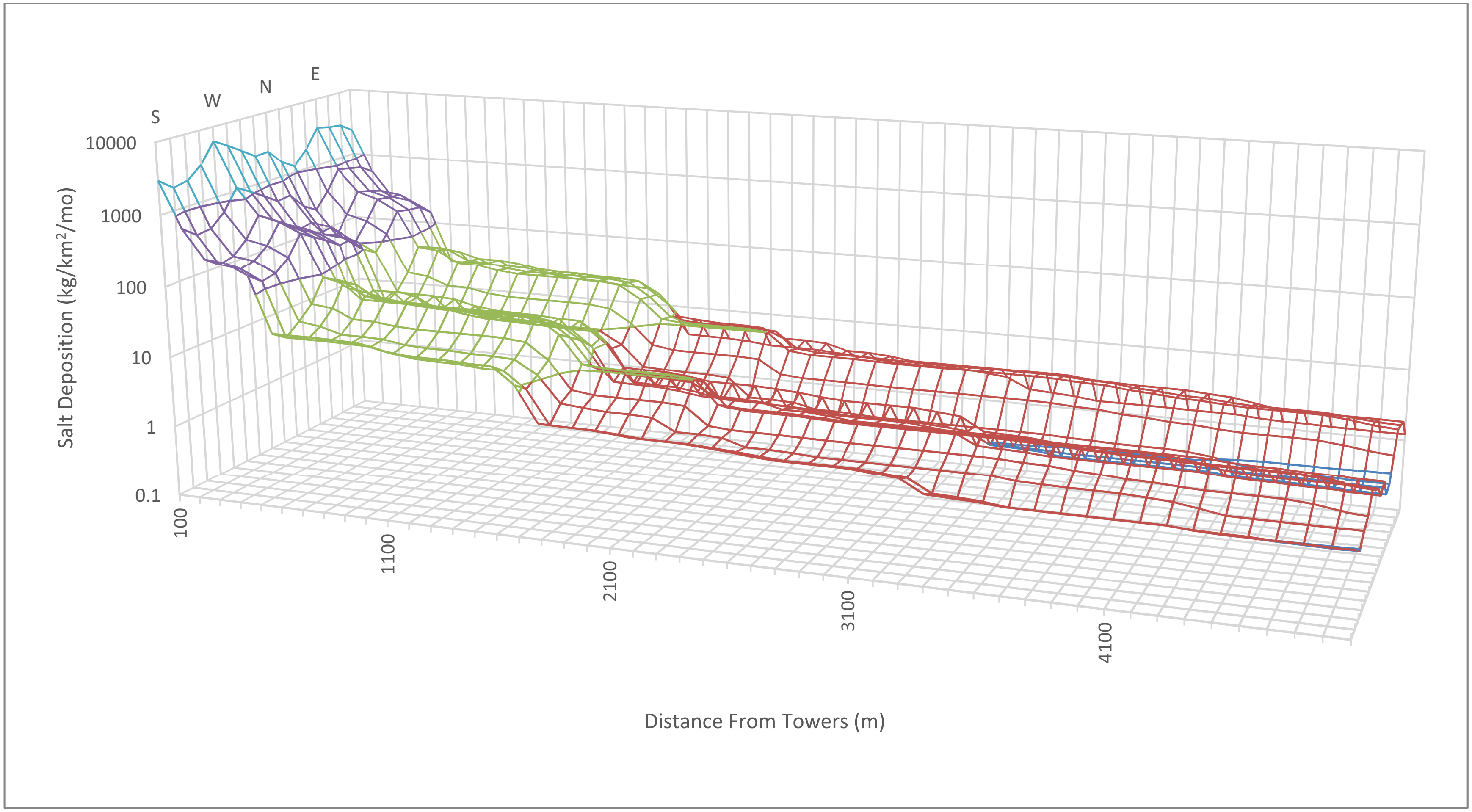


Northwest



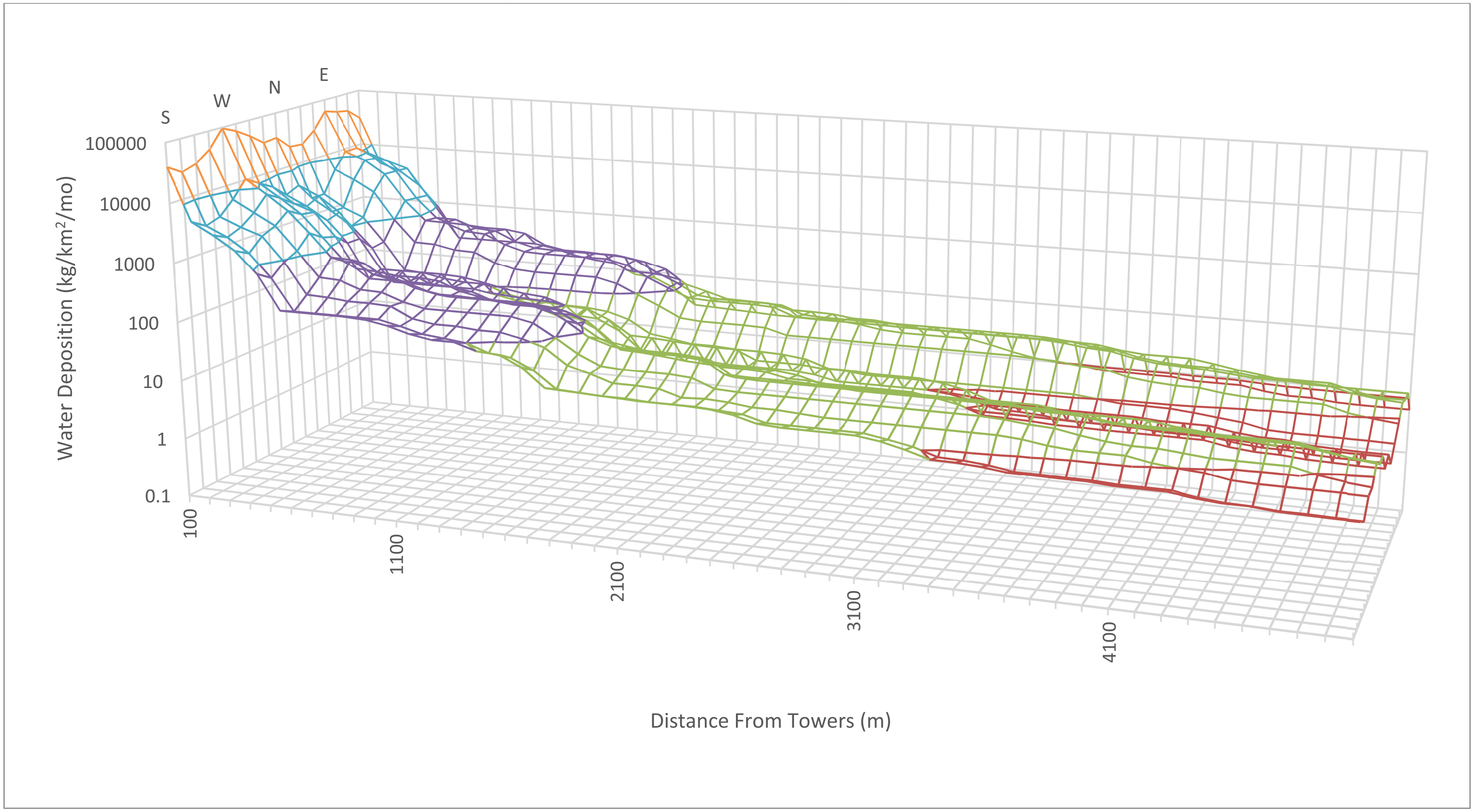
North Northwest

Figure 2.3.2-64. Elevation Profiles 0–50 miles from Clinch River Nuclear Site



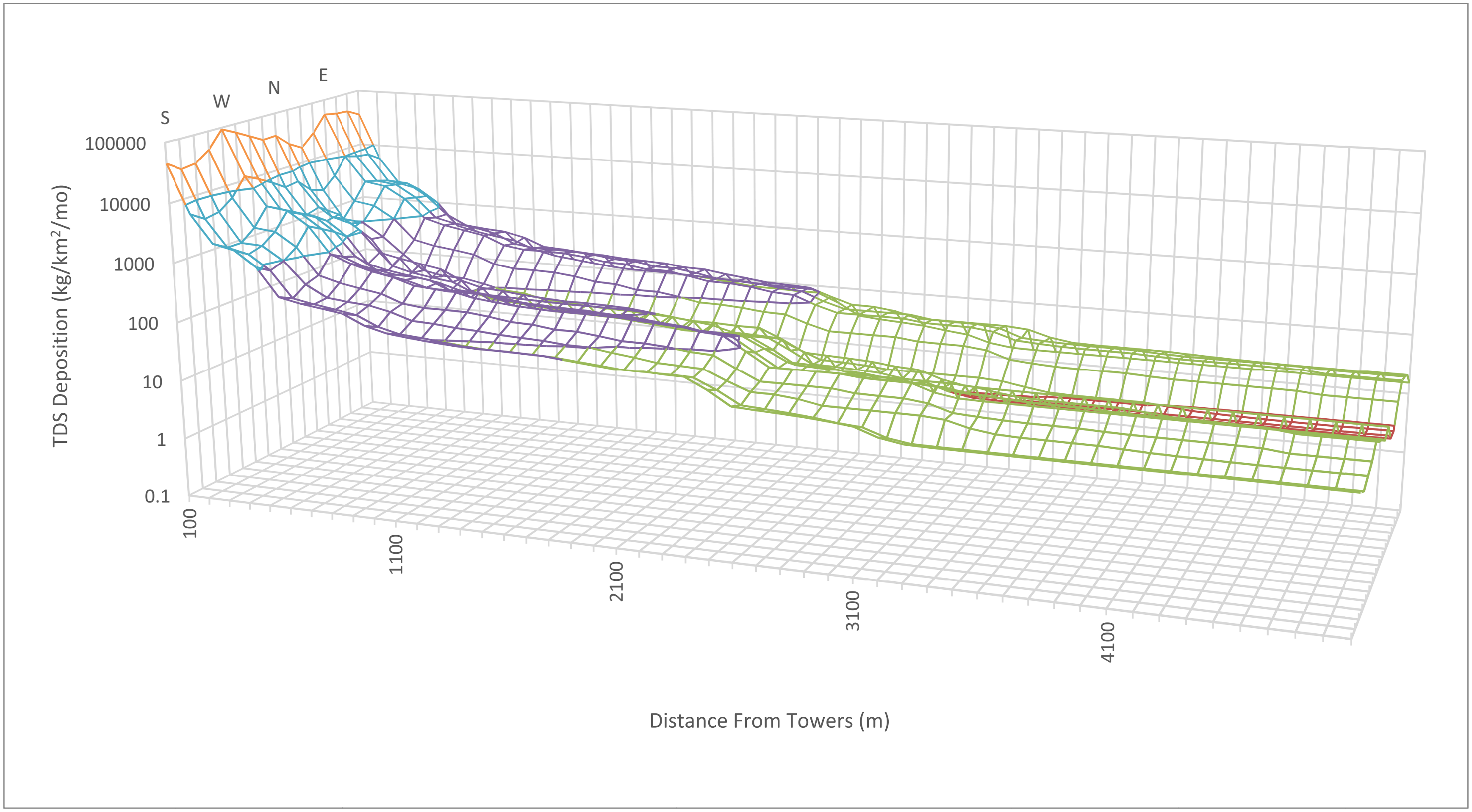
Note: Directions are downwind (direction to)

Figure 2.3.2-65. Annual Salt Deposition in kg/km^2/month



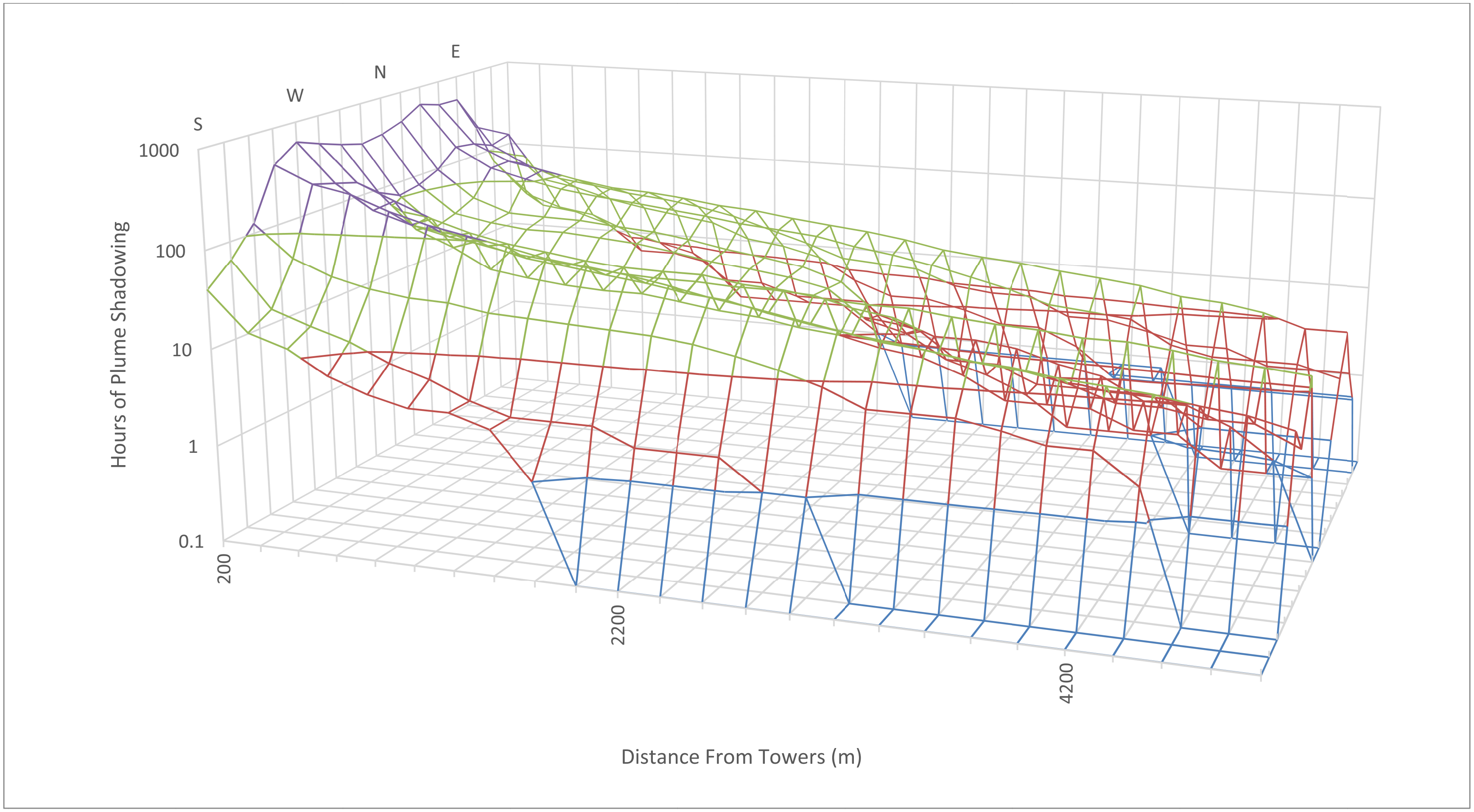
Note: Directions are downwind (direction to)

Figure 2.3.2-66. Annual Water Deposition in kg/km^2/month



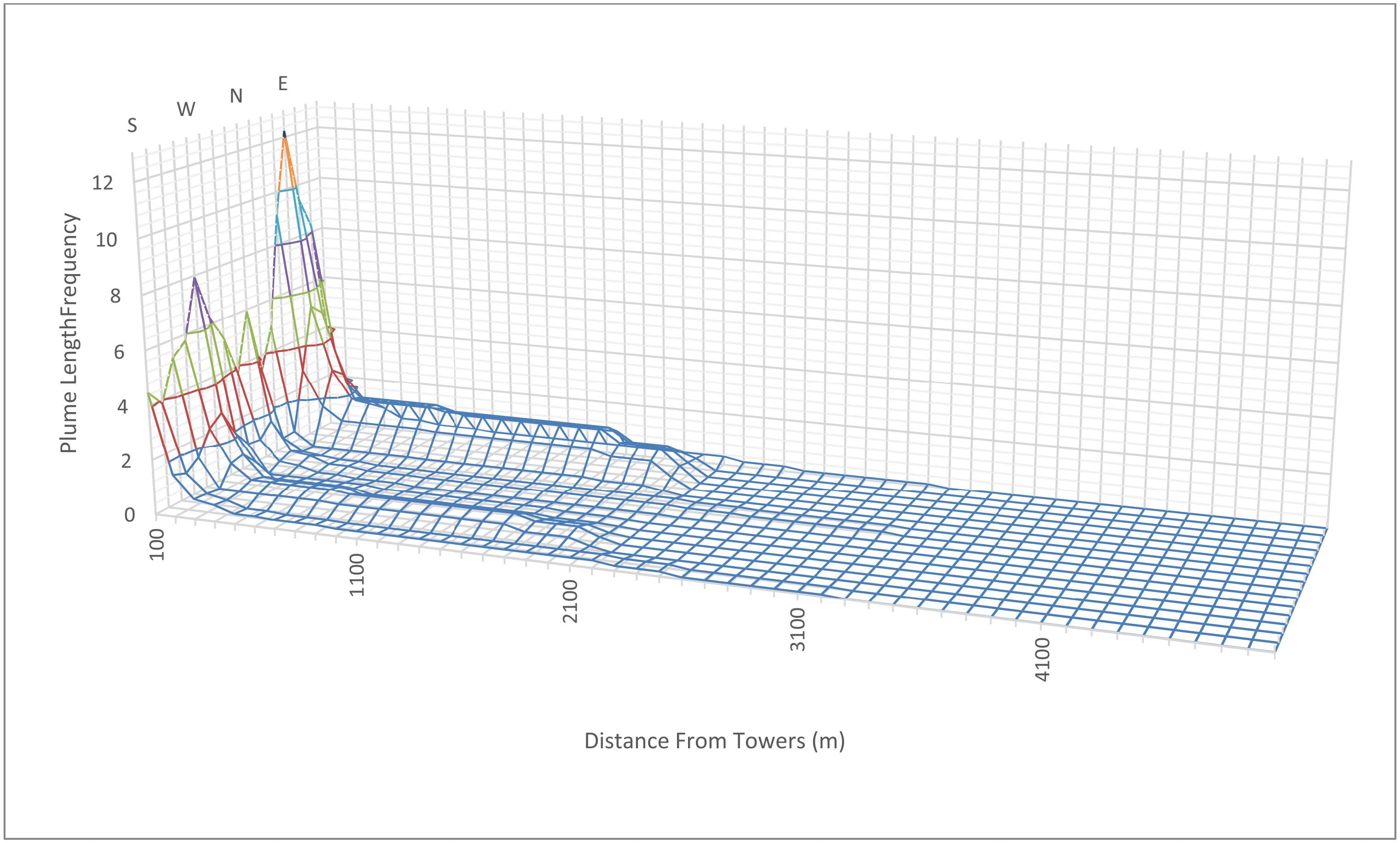
Note: Directions are downwind (direction to)

Figure 2.3.2-67. Annual Total Dissolved Solids Deposition in kg/km^2/month



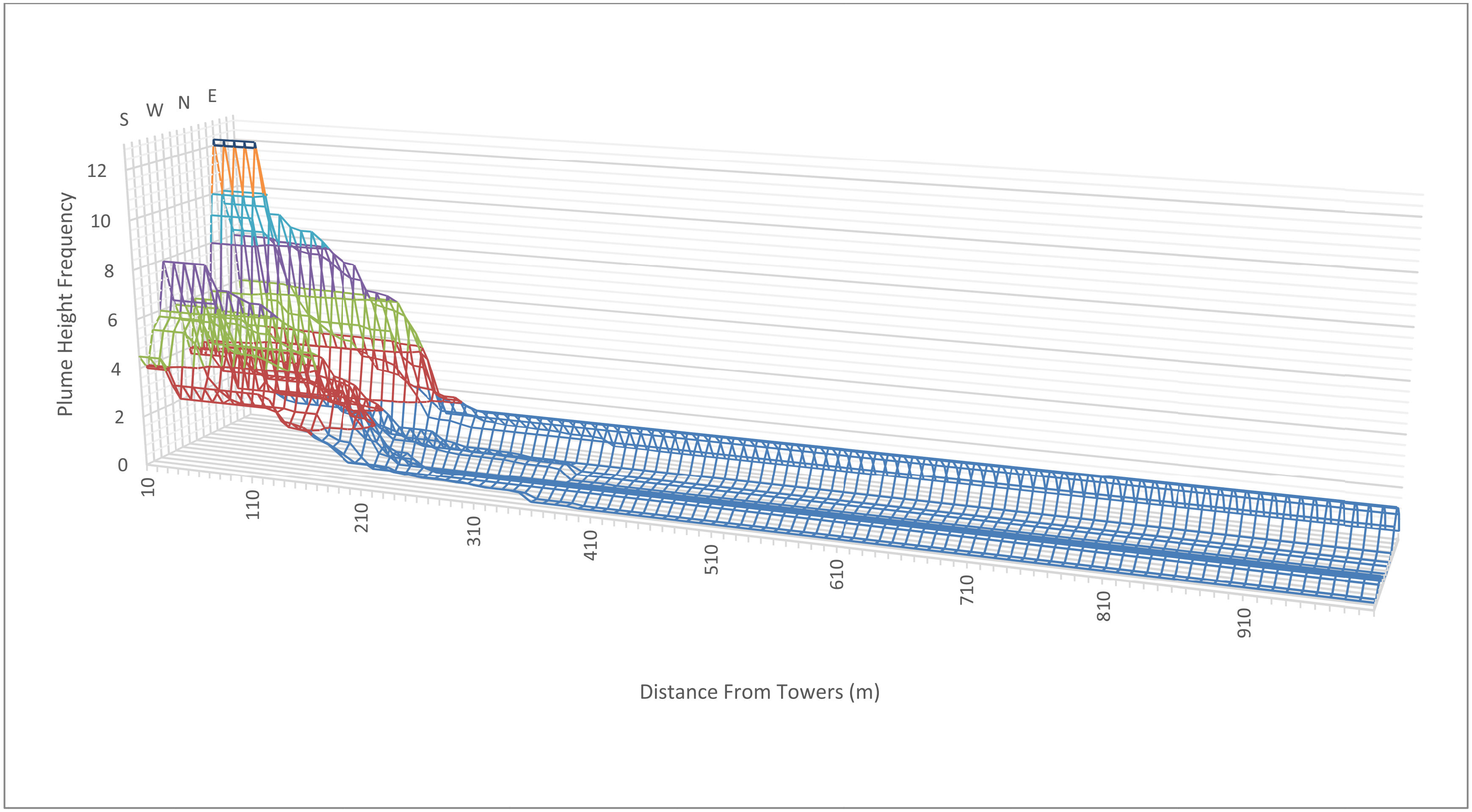
Note: Directions are downwind (direction to)

Figure 2.3.2-68. Annual Hours of Plume Shadowing



Note: Directions are downwind (direction to)

Figure 2.3.2-69. Annual Plume Length Frequency



Note: Directions are downwind (direction to)

Figure 2.3.2-70. Annual Plume Height Frequency

2.3.3 Onsite Meteorological Measurements Program

The following sections describe the historical meteorological monitoring that has been performed at the Clinch River Nuclear (CRN) Site, the meteorological monitoring program used for the Early Site Permit Application (ESPA), and the proposed operational monitoring program.

2.3.3.1 Meteorological Measurements History

Onsite meteorological monitoring was conducted at the CRN Site during three distinct periods since 1973.

- [1973–1978] A 61-meter temporary tower was operated near the plant site to collect preapplication data as part of the Clinch River Breeder Reactor Project (CRBRP).
- [1977–1978 and 1982–1983] Two meteorological towers (the primary 110-meter tower south of the plant site and a 10-meter supplemental tower north of the plant site) were operated during CRBRP construction.
- [2011–2013] The primary tower was reactivated for the lowest two data levels to support the SMR project at the CRN Site.

Data from all of the meteorological tower locations were used in examining the impacts of topographic conditions. Discussions of the impact of the topographic conditions on the site meteorological data are provided in Subsection 2.3.2. Details on each of the towers are provided in Table 2.3.2-1 and their locations are depicted in Figure 2.3.2-1. However, the primary 110-meter tower was used to collect meteorological data for the ESPA dispersion meteorology database. Because the ESPA data was collected exclusively by the primary 110-meter tower during 2011–2013, only that tower is described in detail in this section.

The primary 110-meter tower used for collecting data for the ESPA has been removed. A new tower will be installed to collect data during the CRN Site operational phase. This tower, and the associated instrumentation, will be designed to meet the requirements of NRC Regulatory Guide (RG) 1.23. Meteorological data will be collected and retained for the life of the facility once a facility becomes operational at CRN Site.

2.3.3.2 Primary Meteorological Facility

The primary meteorological facility consisted of a 110-meter open-latticed tower with wind, temperature, and dewpoint measurements at the two lowest levels (10- and 60-meters); a ground-based instrument for rainfall measurements; and an environmental data station (EDS), which housed the data processing and recording equipment. A system of lightning and surge protection circuitry and proper grounding was included in the facility design. This facility was located approximately 830 meters south-southeast of the expected plant site and had a base elevation of seven meters below plant grade.

Two obstructions to wind flow have been evaluated and determined to have minimal impact on the wind measurements. The obstructions include a lattice structure transmission tower approximately 120 meters northeast from the primary tower and a stand of trees limited to a small arc approximately 70 meters southeast of the tower. The location of the obstructions with respect to the tower is shown in Figure 2.3.3-1. The obstructions are shown in Figure 2.3.3-2.

Data collected included:

- Wind direction and wind speed at 10 and 60 meters.

- Temperature at 10 and 60 meters.
- Dewpoint at 10 and 60 meters.
- Solar radiation at tower base.
- Precipitation just below tower base (-0.3 meter).

More exact measurement heights for the wind and temperature parameters are given in the TVA EDS manual (Reference 2.3.3-1). Data collection for all variables began April 21, 2011 and ended July 9, 2013. The tower design, mounting, and exposure of the meteorological instrumentation used for the collection of meteorological data at the CRN Site followed the guidance provided in RG 1.23. The tower used to collect meteorological data for the CRN Site was an open-latticed tower. The wind sensor for each level was mounted on a boom that extends towards the southeast (~140°). The wind sensor mounting booms extended 100 inches from the tower, so the sensors were mounted 2.08 tower widths from the tower. The air temperature sensors were mounted in downward pointing radiation shields that extended towards the east. The sensor inlet was 72 inches from the tower, so the sensors were mounted 1.50 tower widths from the tower. The dewpoint sensors also had downward pointing radiation shields and were mounted approximately 1 meter directly above the air temperature sensors. Further details on the meteorological sensors are available in Reference 2.3.3-1.

2.3.3.2.1 Instrument Description

A description of the meteorological sensors follows. Sensors satisfy the RG 1.23 specifications.

Sensor	Height (Meters)	Description
Wind Direction and Wind Speed	10 and 60	Ultrasonic wind sensor
Temperature	10 and 60	Platinum wire resistance temperature and detector (RTD) with aspirated radiation shield
Dewpoint	10 and 60	Capacitive humidity sensor
Solar Radiation	1	180-degree pyranometer
Rainfall	1	Tipping bucket rain gauge

2.3.3.2.2 Data Acquisition System

The data acquisition system was located at the EDS and consisted of meteorological sensors, a computer (with peripherals), and various interface devices. These devices sent meteorological data to an offsite computer that enabled retrieval for data validation and archiving.

2.3.3.2.3 System Accuracies

The meteorological data collection system was designed to meet or exceed specifications for accuracy identified in RG 1.23.

The meteorological data collection system satisfied the RG 1.23 accuracy requirements. A detailed listing of error sources for each variable is provided in Table 2.3.3-1.

2.3.3.2.4 Data Recording and Display

Data acquisition is controlled by a computer program. The output of each meteorological sensor was scanned periodically, scaled, and the data values were stored. Meteorological sensor outputs (except rainfall) were measured every five seconds (720 per hour). Rainfall was measured continuously as it occurred.

Software data processing routines within the computer accumulated output and performed data calculations which generated the following:

- 15-minute and hourly wind direction.

  Wind direction is based on the resultant vector determined by summing, via vector addition, wind observations in a sampling period.

- 15-minute and hourly vector wind speed.

  Vector wind speed is the magnitude of the resultant vector determined by summing, via vector addition, wind observations in a sampling period that is divided by the quantity of wind observations in the sampling period.

- 15-minute and hourly average (scalar) wind speed.

  Average wind speed is the mean of wind speed observations in a sampling period without regard to wind direction.

- 15-minute and hourly horizontal wind direction sigma.

  Sigma is the standard deviation of wind direction observations in a sampling period.

- 15-minute and hourly average temperature.
- 15-minute and hourly precipitation.
- Hourly average dewpoint.

Only wind direction and average (or scalar) wind speeds are used for meteorological modeling applications.

Data were sent from the EDS to an offsite computer for validation, reporting, and archiving.

2.3.3.2.5 Equipment Servicing, Maintenance, and Calibration

The meteorological equipment at the EDS was kept in proper operating condition by staff that were trained and qualified for the necessary tasks.

Most equipment was calibrated or replaced at least every six months of service. The methods for maintaining a calibrated status for the components of the meteorological data collection system (sensors, electronics, data logger, etc.) included field checks, field calibration, and/or replacement by a laboratory calibrated component. Appropriate maintenance processes (procedures, work order/work request documents, etc.) were used to calibrate and maintain meteorological and station equipment.

2.3.3.3 Operational Meteorological Program

The meteorological program to be implemented during operation of the CRN SMR will be consistent with the guidance given in RG 1.23 to maintain 90 percent joint recoverability of the data collected to assess the relative concentrations of potential releases.

The restoration of the data collection capability of the meteorological facility in the event of equipment failure or malfunction will be accomplished by replacement or repair of affected equipment. A stock of spare parts and equipment will be maintained to minimize and shorten the periods of outages. Equipment malfunctions or outages will be detected by maintenance personnel and by data validation staff during routine or special checks. When an outage of one or more of the critical data items occurs, the appropriate maintenance personnel will be notified.

2.3.3.4 References

2.3.3-1. TVA, "Clinch River Nuclear Plant Environmental Data Station Manual," September 2012.

Table 2.3.3-1
Meteorological Data System—Accuracy vs. Specification Comparison

Variable[a]	Units	Specification		Sensor Accuracy	System Accuracy	
		ANS-3.11	RG-1.23		Instantaneous	Time-Averaged
Wind Speed (WS) • 8.9 mph • 30.0 mph • 100.0 mph	mph	±0.45 ±1.50 ±5.00	±0.45 ±1.50 ±5.00	±0.36 ±0.37 ±0.38	±0.36 ±0.37 ±0.39	±0.06 ±0.06 ±0.06
Wind Direction	°azimuth	±5.0	±5.0	±3.0	±4.3	±2.1
Air Temperature • [Day] High solar rad • [Day] Low solar rad • [Night] No solar rad	°F	±0.900 ±0.900 ±0.900	±0.900 ±0.900 ±0.900	±0.078 ±0.078 ±0.078	±0.702 -0.202 ±0.202	±0.657 -0.157 ±0.157
Vertical Temp. Diff.	°F	±0.180	±0.180	±0.105	±0.148	±0.046
Dewpoint	°F	±2.700	±2.700	±2.236	N/A	±0.507
Rainfall • 0.10 in.[b]	inches	±0.010	±0.010	±0.007	±0.009	N/A
Solar Radiation (SR) • 0.28 ly/min • 0.45 ly/min[c] • 1.50 ly/min	ly/min	±0.014 ±0.023 ±0.075	Not specified	±0.006 ±0.015 ±0.027	N/A N/A N/A	±0.021 ±0.022 ±0.026

(a) If a condition or value is listed, error values are specific for that condition/value. Otherwise, error values apply to the entire expected sampling range.
(b) ANS-3.11-2005 and RG-1.23 specify that accuracy be estimated for a specific volume (2.54 mm, 0.10 inch).
(c) 0.45 ly/min is the lowest value at which the ANS-3.11-2005 specification is satisfied.
Notes:
N/A = Not Applicable

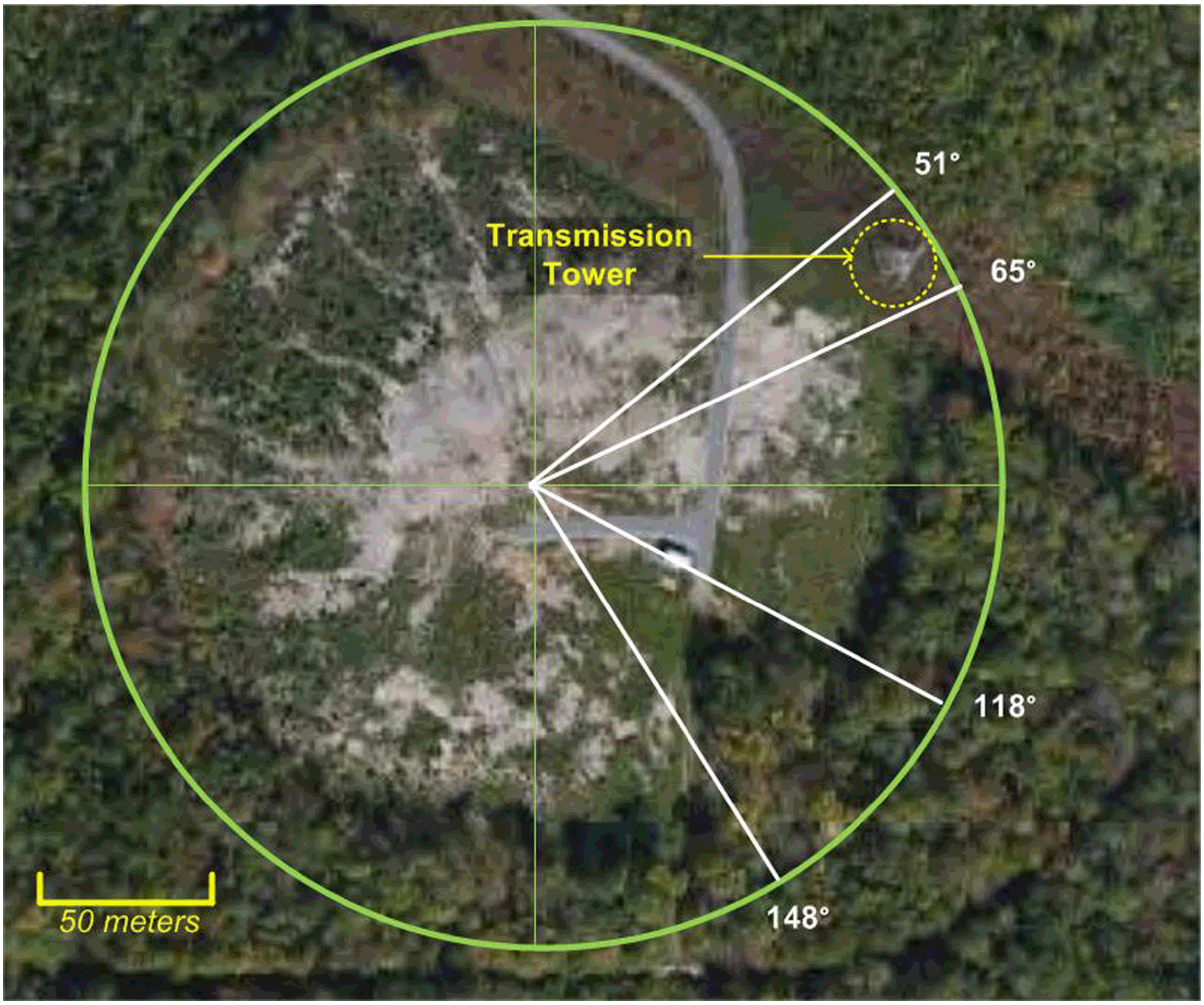


Figure 2.3.3-1. Map of Obstructions Related to Primary Met Tower

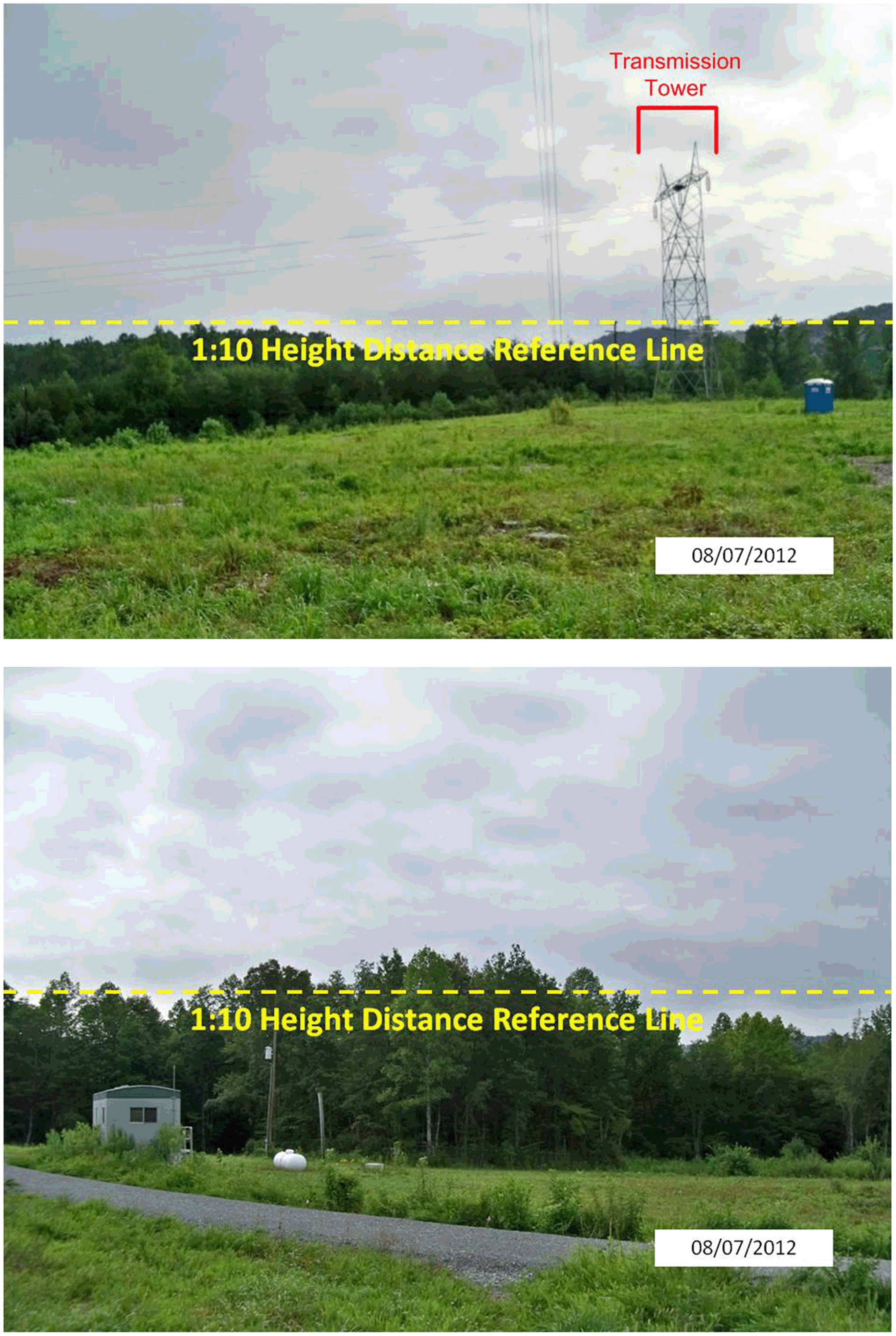


Figure 2.3.3-2. Primary Met Tower Wind Obstructions

2.3.4 Short-Term (Accident) Diffusion Estimates

To evaluate the potential health effects for design-basis accidents, a hypothetical accident was postulated to predict upper-limit concentrations and doses that might occur in the event of a containment release to the atmosphere. The consequence of a design basis accident in terms of personnel exposure is a function of the atmospheric dispersion conditions at the site. Atmospheric dispersion consists of two components: (1) atmospheric transport, or the movement of gaseous effluents through the atmosphere; and (2) atmospheric diffusion, or the spread of gaseous effluents through the atmosphere. Atmospheric dispersion conditions are represented by relative air concentration (X/Q) values. This section describes the development of conservative short-term atmospheric diffusion estimates for receptors located on the Exclusion Area Boundary (EAB) and the outer boundary of the Low Population Zone (LPZ).

2.3.4.1 Purpose and Background

According to 10 CFR 100.11, the limiting design basis fission product release and site meteorological conditions should be used to derive an exclusion area, low population zone, and a population center distance. To demonstrate compliance with 10 CFR 100, it is necessary to consider doses for various time periods immediately following the onset of a postulated accident at the exclusion distance and for the duration of exposure for the low population zone and population center distances.

As a result, estimates of atmospheric dispersion, expressed as X/Q, were calculated for accidental releases from the Clinch River Nuclear (CRN) Site for specified time intervals at the EAB and the LPZ, as required under 10 CFR 100 and 10 CFR 50.

2.3.4.2 Calculation Methodology and Assumptions

The atmospheric dispersion calculations were performed using the PAVAN computer program, NUREG/CR-2858, which was developed and is used by the U.S. Nuclear Regulatory Commission (NRC) (Reference 2.3.4-2). The PAVAN program implements the guidance provided in Regulatory Guide (RG) 1.145. The PAVAN model calculates X/Q values based on the theory that material released to the atmosphere would be normally distributed (Gaussian) about the plume centerline. Therefore, a straight-line trajectory is modeled between the point of release and distances for which X/Q values are calculated in accordance with NUREG/CR-2858 and RG 1.145.

RG 1.206 states that the Applicant should provide meteorological data from at least two consecutive annual cycles, including the most recent one-year period for calculating the short-term and long-term atmospheric dispersion estimates. RG 1.23 recommends using meteorological data from a consecutive 24-month period. Site-specific meteorological data covering the two year period of record from June 1, 2011 through May 31, 2013 was used to quantitatively evaluate such a hypothetical accident at the CRN Site. This data was used to calculate joint frequency distributions (JFDs) of wind direction (vector), average (scalar) wind speed, and atmospheric stability class. The stability classes were based on the classification system given in Table 1 of RG 1.23, as listed in Table 2.3.4-1.

The CRN Site meteorological data were validated for the entire 2011-2013 period, meeting the requirements of NUREG-0917 (Reference 2.3.4-1) and RG 1.23. A combined total of 17,380 hours of valid wind direction, average (scalar) wind speed, and stability observations were used for the two-year period. One hundred sixty-four hours of data were considered invalid because at least one of the following variables was missing or bad for that hour: lower wind speed, lower wind direction, or stability class. RG 1.23 recommends that a data recovery goal of 90 percent be achieved for meteorological instruments. Joint data recoveries of 98.85 percent and 99.28

percent were achieved for the first 12 months and the second 12 months, respectively, resulting in a data recovery of 99.07 percent for the entire period.

JFDs are based on lower wind direction (vector), 9.78 meters (m) (32.1 feet) (nominal 10 m), lower (scalar) wind speed 9.78 m (32.1 feet) (nominal 10 m), and temperature differential between the 59.22 m (194.3 feet) (nominal 60 m) and 8.44 m (27.7 feet) (nominal 10 m) temperature measurements. According to RG 1.145, calms are classified as hourly average wind speeds below the vane or anemometer starting speed, whichever is higher. Calms were distributed into the first wind speed category in the JFDs, so they were not manually distributed in the PAVAN input file.

PAVAN produces the most accurate results if wind speeds are classified into a large number of categories at the lower wind speeds (Reference 2.3.4-2). Therefore, 13 wind speed categories were defined in the JFDs and used in the PAVAN analyses. The wind speed categories used in the PAVAN analysis are provided in the JFD tables (Tables 2.3.4-2 through 2.3.4-8). For the two years of data under consideration, there were no hourly recordings of wind speeds greater than 18.0 mph (8.0 m/s) as shown in Tables 2.3.4-2 through 2.3.4-8. The JFD tables for each stability class are given in Tables 2.3.4-2 through 2.3.4-8. The number of hours of wind direction and wind speed in each stability class is given in Table 2.3.4-9.

Using the JFDs, PAVAN provides the X/Q values as functions of direction for various time periods at the EAB and LPZ. According to RG 4.7, an applicant is required by 10 CFR 100.21(a) to designate an exclusion area and to have authority to determine all activities within that area, including removal of personnel and property. The exclusion area is required to be of such a size that an individual assumed to be located at any point on its boundary would not receive a radiation dose in excess of 25 rem total effective dose equivalent (TEDE) over any 2-hour period following a postulated fission product release. The required exclusion area size involves consideration of the atmospheric characteristics of the site as well as plant design.

RG 1.145 requires that, for each of the 16 compass sectors, the distance to the EAB should be the minimum distance between the effluent 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. A circular analytical EAB is established 1100 ft (335 m) from the ERB. For X/Q modelling (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 Figure 2.3.4-1 (note that although the nuclear islands for vendors 1 and 4 are depicted in the figure, the nuclear islands, associated ERBs, and analytical EABs for vendors 1, 2, 3, and 4 fit within the EAB ellipse). The analytical EABs can be encompassed by an ellipse fixed completely within the CRN Property boundary, i.e. the actual EAB (Figure 2.3.4-1), which demonstrates that dispersion factor computations are conservative.

The site center point is determined as the centerline midpoint of the EAB ellipse (Figure 2.3.4-1). The ellipse has a short axis of 0.326 mi (524 m) from the site center point and long axis of 0.535 mi (864 m) from the center point.

Although radioactive release from the turbine islands is possible, the effects of postulated releases from nuclear islands will bound those of the turbine island. Additional discussion regarding postulated accidents is provided in Section 15.1.

The various analytical EABs can be encompassed by an ellipse fixed completely within the CRN Property boundary, which demonstrates that the actual EAB conservatively bounds the analytical EAB for radiation dose computations. The ellipse has a short axis of 0.326 mi (524 m) from the

site center point and long axis of 0.535 mi (861 m) from the center point. The site center point was determined by the centerline midpoint of the Release Zone EABs.

According to RG 4.7, an applicant is also required by 10 CFR 100 to designate an area immediately beyond the exclusion area as an LPZ. The size of the LPZ must be such that the distance to the nearest boundary of a densely populated center containing more than about 25,000 residents (population center distance) must be at least one and one-third times the distance from the reactor to the outer boundary of the LPZ. The boundary of the population center should be determined upon consideration of population distribution, not political boundaries. In addition, the LPZ must be of such a size that an individual located on its outer radius for the course of the postulated accident (assumed to be 30 days) would not receive a radiation dose in excess of 25 rem TEDE.

The LPZ was defined by a circular area with a radius of 1 mi (1609 m) from the center point of the site (Figure 2.3.4-2). For receptor locations remote from the site, such as the LPZ, using the center point as the release location is a reasonable assumption because of the proximity of the potential release locations is small in comparison to the receptor distances. This distance was used in the PAVAN model. The variable inputs used in the PAVAN model are listed in Table 2.3.4-10.

Other plant specific data considered for PAVAN include minimum building cross-sectional area, building height, and meteorological tower height at which the wind speed was measured. The building height and minimum cross-sectional area are used in the determination of building wake effects. Building cross-sectional area is defined in RG 1.145 as the smallest vertical-plane cross-sectional area of the containment structure, in square meters. RG 1.111 identifies the tallest adjacent building, either up- or downwind from the release point(s), as appropriate for use. For conservatism, no building wake credit was used in the PAVAN model (e.g., the building height and cross-sectional area were both set to zero in the model).

Based on RG 1.145, a ground release includes release points that are effectively less than two and one-half times the height of adjacent solid structures. Compared to an elevated release, a ground-level release usually results in higher ground-level concentrations at downwind receptors due to less dilution from shorter traveling distances. Because the ground-level release scenario provides a bounding case, elevated releases are not considered in this model.

The meteorological tower height used in PAVAN is the height above ground level at which the wind speed was measured. For a ground-level release, the lower wind speed measurement height of 10 m (32.8 feet) is used.

Because a ground-level release scenario provides the most conservative X/Q values at the site boundary, a ground-level release was used in the modeling. As detailed in RG 1.145, Section C.1.1.3.1, for release modes that are effectively lower than two and one-half times the height of adjacent solid structures (ground-release mode), two sets of meteorological conditions are treated differently in order to consider the effects of building wake mixing and ambient plume meander. During neutral (D) or stable (E, F, or G) atmospheric stability conditions when the average (scalar) wind speed is less than six meters per second (m/s), horizontal plume meander is considered. The PAVAN model calculates the relative concentration (X/Q) values through the selective use of the following set of equations for ground-level relative concentrations at the plume centerline.

$$\frac{X}{Q} = \frac{1}{\bar{U}_{10}\left(\pi\sigma_y\sigma_z + \frac{A}{2}\right)} \qquad \text{Equation 2.3.4-1}$$

$$\frac{X}{Q} = \frac{1}{\bar{U}_{10}(3\pi\sigma_y\sigma_z)}$$ Equation 2.3.4-2

$$\frac{X}{Q} = \frac{1}{(\bar{U}_{10}\pi\Sigma_y\sigma_z)}$$ Equation 2.3.4-3

Where:

- X/Q = centerline ground-level relative concentration (s/m^3).
- σ_y = lateral plume spread as a function of atmospheric stability and distance (m).
- σ_z = vertical plume spread as a function of atmospheric stability and distance (m).
- A = minimum vertical-plane containment cross-sectional area (m^2).
- $\bar{U}_{10}$ is the average (scalar) wind speed at ten meters above plant grade (m/s).
- Σ_y is the lateral plume spread with meander and building wake effects, in meters, a function of atmospheric stability, average (scalar) wind speed, and distance.

The PAVAN model calculates X/Q values using Equations 2.3.4-1, 2.3.4-2, and 2.3.4-3. The model compares the values from Equations 2.3.4-1 and 2.3.4-2, and the higher value is selected. This value is then compared with the value from Equation 2.3.4-3, and the lower value of these two is selected as the appropriate X/Q value.

During unstable (A, B, or C) atmospheric stability and/or 10-m level average (scalar) wind speeds of six m/s or more, plume meander (Equation 2.3.4-3) is not considered. The higher value calculated from Equation 2.3.4-1 or 2.3.4-2 is then used as the appropriate X/Q value.

The RG 1.145 requires that the X/Q values at the EAB and LPZ be calculated based on both a directionally dependent methodology (maximum sector) and a directionally independent methodology (overall site limit) and that the most conservative (highest) values be chosen. Therefore, consistent with RG 1.145, the PAVAN model calculates the maximum sector X/Q by taking the X/Q value exceeded 0.5 percent of the time based on a cumulative probability distribution of X/Q values for each sector. Also in accordance with RG 1.145, the model calculates an overall site X/Q value by selecting the X/Q value that is exceeded five percent of the total time based on an overall cumulative probability distribution for the sixteen directions combined. The higher of the two values was then chosen to be the bounding X/Q value for each of the time periods analyzed.

2.3.4.3 Summary of Results and Conclusions

The PAVAN results for the dispersion factors computed at the LPZ and analytical EAB, based on the 2011-2013 meteorological data, are given in Tables 2.3.4-12 through 2.3.4-14. Table 2.3.4-14 provides the bounding values for the EAB and LPZ, respectively.

The results of these computations indicated that the highest concentrations are found in the sectors that lie to the west-northwest (WNW) of the plant, which is consistent with the relatively high percentage of stable (F and G) conditions associated with light winds that blow from the southeast (Subsection 2.3.2).

2.3.4.4 References

2.3.4-1. NUREG-0917, “Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data,” July 1982.

2.3.4-2. NUREG/CR-2858, PNL-4413, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations," Richland, WA, November 1982.

2.3.4-3. TVA, "Clinch River Nuclear Plant Environmental Data Station Manual," Modules 1-IV, September 2012.

Table 2.3.4-1
Classification of Atmospheric Stability

Stability Classification	**Pasquill Categories**	**Temperature change with height (°C/100m)**
Extremely unstable	A	$\Delta T \leq -1.9$
Moderately unstable	B	$-1.9 < \Delta T \leq -1.7$
Slightly unstable	C	$-1.7 < \Delta T \leq -1.5$
Neutral	D	$-1.5 < \Delta T \leq -0.5$
Slightly stable	E	$-0.5 < \Delta T \leq 1.5$
Moderately stable	F	$1.5 < \Delta T \leq 4.0$
Extremely stable	G	$\Delta T > 4.0$

Notes:

This table is listed as Table 1 in RG 1.23.

Table 2.3.4-2
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class A
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)														
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	0	0	1	0	3	3	9	16	2	0	0	0	0	34
NNE	0	0	0	1	1	4	10	23	23	0	0	0	0	0	62
NE	0	0	0	0	3	5	4	22	37	5	0	0	0	0	76
ENE	0	0	0	2	1	2	3	13	19	9	0	0	0	0	49
E	0	0	0	0	1	0	0	7	4	0	0	0	0	0	12
ESE	0	0	0	0	3	0	0	3	3	0	0	0	0	0	9
SE	0	0	0	0	0	2	0	1	0	0	0	0	0	0	3
SSE	0	0	0	1	0	0	1	0	2	1	0	0	0	0	5
S	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
SSW	0	0	0	1	1	0	0	1	0	0	0	0	0	0	3
SW	0	0	0	0	1	1	1	1	1	1	0	0	0	0	6
WSW	0	0	0	1	1	3	0	8	9	9	2	0	0	0	33
W	0	0	0	0	0	1	1	4	14	6	4	4	1	0	35
WNW	0	0	0	0	0	0	0	1	9	18	5	3	1	0	37
NW	0	0	0	1	2	0	1	6	21	48	23	4	0	0	106
NNW	0	0	0	1	0	1	0	5	9	4	0	0	0	0	20
SUBTOTAL	**0**	**0**	**0**	**9**	**16**	**22**	**24**	**104**	**167**	**103**	**34**	**11**	**2**	**0**	**492**

Notes:
Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 5.73 mph.

Table 2.3.4-3
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class B
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)													
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	0	0	0	1	3	7	9	9	0	0	0	0	0	29
NNE	0	0	0	0	0	1	12	20	5	0	0	0	0	0	38
NE	0	0	0	0	1	8	12	24	36	3	0	0	0	0	84
ENE	0	0	0	0	0	5	7	10	16	1	0	0	0	0	39
E	0	0	0	0	0	0	5	12	8	0	0	0	0	0	25
ESE	0	0	0	0	0	1	1	6	1	0	0	0	0	0	9
SE	0	0	0	0	0	1	2	1	0	0	0	0	0	0	4
SSE	0	0	0	0	0	0	2	7	5	0	0	0	0	0	14
S	0	0	0	0	0	0	3	5	10	0	1	2	0	0	21
SSW	0	0	0	0	0	0	1	2	4	1	0	0	0	0	8
SW	0	0	0	0	0	0	2	11	13	4	0	0	0	0	30
WSW	0	0	0	0	0	1	8	23	41	18	5	1	0	0	97
W	0	0	0	0	0	1	3	18	14	2	1	2	1	0	42
WNW	0	0	0	0	0	0	4	7	20	17	6	2	1	0	57
NW	0	0	0	0	0	0	5	12	26	31	10	1	0	0	85
NNW	0	0	0	0	0	0	4	10	11	3	0	0	0	0	28
SUBTOTAL	**0**	**0**	**0**	**0**	**2**	**21**	**78**	**177**	**219**	**80**	**23**	**8**	**2**	**0**	**610**

Notes:
Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 5.17 mph.

Table 2.3.4-4
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class C
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)													
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	0	0	0	3	7	15	6	13	0	0	0	0	0	44
NNE	0	0	0	1	0	13	12	21	3	0	0	0	0	0	50
NE	0	0	0	1	6	13	23	26	10	1	0	0	0	0	80
ENE	0	0	0	1	5	8	12	16	9	1	0	0	0	0	52
E	0	0	0	1	2	4	11	12	5	0	0	0	0	0	35
ESE	0	0	0	0	3	6	6	9	3	0	0	0	0	0	27
SE	0	0	0	0	2	8	2	6	5	0	0	0	0	0	23
SSE	0	0	0	0	1	3	10	4	2	1	0	2	0	0	23
S	0	0	0	0	1	4	4	13	15	4	2	1	0	0	44
SSW	0	0	0	0	1	6	9	12	12	3	0	0	0	0	43
SW	0	0	0	0	1	10	14	26	43	12	0	0	0	0	106
WSW	0	0	0	0	0	9	33	60	70	13	5	1	0	0	191
W	0	0	0	0	2	4	27	34	35	7	6	3	0	0	118
WNW	0	0	0	0	1	4	10	21	26	15	4	2	0	0	83
NW	0	0	0	0	0	1	11	14	38	20	7	0	0	0	91
NNW	0	0	0	0	2	4	4	9	8	4	3	0	0	0	34
SUBTOTAL	**0**	**0**	**0**	**4**	**30**	**104**	**203**	**289**	**297**	**81**	**27**	**9**	**0**	**0**	**1044**

Notes:
Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 4.54 mph.

Table 2.3.4-5
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class D
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)													
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	1	14	57	33	27	17	22	21	2	0	0	0	0	194
NNE	0	0	6	53	49	39	25	42	11	0	0	0	0	0	225
NE	0	0	16	41	55	65	77	82	71	3	1	0	0	0	411
ENE	0	0	12	42	38	59	54	71	68	8	1	1	0	0	354
E	0	1	8	19	42	33	29	21	10	1	0	0	0	0	164
ESE	0	0	6	19	15	15	13	12	5	0	0	0	0	0	85
SE	0	0	6	10	17	21	19	10	1	1	0	1	0	0	86
SSE	0	0	4	9	12	25	11	12	10	4	7	1	0	0	95
S	0	0	3	13	23	37	44	51	56	30	25	7	3	0	292
SSW	0	1	8	16	23	39	41	44	49	6	0	0	0	0	227
SW	0	0	2	14	38	59	75	123	116	29	4	0	0	0	460
WSW	0	0	0	16	54	95	93	219	254	83	29	8	0	0	851
W	0	0	13	34	48	79	87	132	99	46	31	20	1	0	590
WNW	0	0	10	43	42	72	49	98	140	79	36	9	4	0	582
NW	0	0	19	48	43	58	48	85	139	75	35	6	0	0	556
NNW	0	0	16	41	30	33	30	27	35	11	4	0	0	0	227
SUBTOTAL	**0**	**3**	**143**	**475**	**562**	**756**	**712**	**1051**	**1085**	**378**	**173**	**53**	**8**	**0**	**5399**

Notes:

Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 4.01 mph.

Table 2.3.4-6
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class E
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)													
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	0	86	73	27	14	9	3	3	0	0	0	0	0	215
NNE	0	3	84	58	29	14	4	3	1	0	0	0	0	0	196
NE	0	3	79	63	30	27	16	24	7	1	1	0	0	0	251
ENE	0	2	57	60	34	39	22	17	12	1	0	0	0	0	244
E	0	2	67	55	29	23	15	7	7	0	0	0	0	0	205
ESE	0	5	54	58	18	10	9	3	2	0	0	0	0	0	159
SE	0	1	46	68	16	12	5	2	2	1	0	0	0	0	153
SSE	0	0	43	32	21	19	11	11	12	4	2	0	0	0	155
S	0	2	22	43	34	24	21	12	8	7	0	0	0	0	173
SSW	0	0	18	41	28	17	17	16	5	1	1	0	0	0	144
SW	0	1	26	44	30	35	33	16	12	5	0	0	0	0	202
WSW	0	2	39	52	44	51	54	49	39	12	3	0	0	0	345
W	0	2	54	63	65	65	47	59	50	8	1	1	1	0	416
WNW	0	3	90	118	60	48	35	54	68	29	5	2	0	0	512
NW	0	3	111	96	36	40	29	46	57	20	4	0	0	0	442
NNW	0	2	82	66	21	24	11	16	4	0	0	0	0	0	226
SUBTOTAL	**0**	**31**	**958**	**990**	**522**	**462**	**338**	**338**	**289**	**89**	**17**	**3**	**1**	**0**	**4038**

Notes:
Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 2.32 mph.

Table 2.3.4-7
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class F
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)													
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	14	90	12	1	1	1	0	0	0	0	0	0	0	119
NNE	0	14	83	23	2	3	2	1	0	0	0	0	0	0	128
NE	0	10	97	24	2	2	0	0	0	0	0	0	0	0	135
ENE	0	17	138	29	14	5	2	0	1	0	0	0	0	0	206
E	0	14	187	74	15	2	2	0	1	0	0	0	0	0	295
ESE	0	15	185	87	22	2	4	0	0	0	0	0	0	0	315
SE	0	14	153	76	15	3	1	1	0	0	0	0	0	0	263
SSE	0	5	79	32	8	4	1	1	0	0	0	0	0	0	130
S	0	11	49	29	6	5	3	2	1	0	0	0	0	0	106
SSW	0	7	32	23	11	0	2	0	2	0	0	0	0	0	77
SW	0	2	38	26	12	4	2	3	0	0	0	0	0	0	87
WSW	0	5	42	24	10	3	8	3	1	0	0	0	0	0	96
W	0	1	91	39	15	17	4	5	3	0	0	0	0	0	175
WNW	0	10	131	101	33	9	4	6	4	2	0	0	0	0	300
NW	0	16	156	59	15	13	3	2	1	0	0	0	0	0	265
NNW	0	14	99	25	3	2	0	0	0	0	0	0	0	0	143
SUBTOTAL	**0**	**169**	**1650**	**683**	**184**	**75**	**39**	**24**	**14**	**2**	**0**	**0**	**0**	**0**	**2840**

Notes:

Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 1.16 mph.

Table 2.3.4-8
Joint Frequency Distribution (Hours) of Wind Speed and Direction by Atmospheric Stability Class – Stability Class G
June 1, 2011 - May 31, 2013

WIND DIRECTION	WIND SPEED (MPH)													
	CALM	≤0.50	>0.50 ≤1.10	>1.10 ≤1.70	>1.70 ≤2.20	>2.20 ≤2.80	>2.80 ≤3.40	>3.40 ≤4.50	>4.50 ≤6.70	>6.70 ≤8.90	>8.90 ≤11.20	>11.20 ≤13.40	>13.40 ≤18.00	>18.00	TOTAL
N	0	10	34	3	2	0	0	0	0	0	0	0	0	0	49
NNE	0	5	27	1	0	0	0	1	0	0	0	0	0	0	34
NE	0	7	31	5	2	1	1	0	0	0	0	0	0	0	47
ENE	0	10	103	15	5	2	0	1	0	0	0	0	0	0	136
E	0	27	226	53	13	0	0	0	1	0	0	0	0	0	320
ESE	0	32	372	164	14	0	0	1	0	0	0	0	0	0	583
SE	0	21	334	139	7	1	2	1	0	0	0	0	0	0	505
SSE	0	17	209	41	4	1	0	0	0	0	0	0	0	0	272
S	0	15	101	21	5	0	0	0	0	0	0	0	0	0	142
SSW	0	5	73	19	5	1	0	1	0	1	0	0	0	0	105
SW	0	9	46	13	2	1	0	1	0	0	0	0	0	0	72
WSW	0	7	94	21	5	0	1	0	0	0	0	0	0	0	128
W	0	8	104	56	2	4	2	1	1	0	0	0	0	0	178
WNW	0	15	120	65	16	5	2	2	0	0	0	0	0	0	225
NW	0	9	73	19	1	1	0	0	0	0	0	0	0	0	103
NNW	0	12	40	6	0	0	0	0	0	0	0	0	0	0	58
SUBTOTAL	**0**	**209**	**1987**	**641**	**83**	**17**	**8**	**9**	**2**	**1**	**0**	**0**	**0**	**0**	**2957**

Notes:

Wind speed, direction measured at 10 meters (32.8 feet); mean wind speed = 1.00 mph.

Table 2.3.4-9
Total Hour Distribution in Each Stability Class
June 1, 2011 - May 31, 2013

2011-2013 JFDs	Class A	Class B	Class C	Class D	Class E	Class F	Class G
Hours	492	610	1044	5399	4038	2840	2957

Table 2.3.4-10
List of Inputs used in the PAVAN Modeling

PAVAN Model Input Variable	Value
Number of Wind Speed Categories (NVEL)	13
Type of Release	Ground
Building Minimum Cross-Sectional Area (A)	0.0 m^2
Containment Building Height (D)	0.0 m
Release Height (HS)	10.0 m
Wind Sensor Height (TOWERH)	9.78 m
Conversion Correction Factor (UCOR)	150
Lower-T Sensor Height	8.44 m
Upper-T Sensor Height	59.22 m
Distance from Effluent Release Boundary to Analytical Exclusion Area Boundary	335 m
Distance to Low Population Zone	1609 m

Notes:

A release height (HS) of 10 m is used for ground level release, consistent with NUREG/CR-2858.

Table 2.3.4-11
Distances for the EAB and LPZ in the 16 Wind Direction Sectors

Wind Direction Sector	Distance from Effluent Release Boundary to Analytical EAB		LPZ Distance	
	(feet)	(meters)	(miles)	(meters)
S	1100	335	1	1609
SSW	1100	335	1	1609
SW	1100	335	1	1609
WSW	1100	335	1	1609
W	1100	335	1	1609
WNW	1100	335	1	1609
NW	1100	335	1	1609
NNW	1100	335	1	1609
N	1100	335	1	1609
NNE	1100	335	1	1609
NE	1100	335	1	1609
ENE	1100	335	1	1609
E	1100	335	1	1609
ESE	1100	335	1	1609
SE	1100	335	1	1609
SSE	1100	335	1	1609

Notes:

The Effluent Release Boundary includes the nuclear island, which consists of the reactor service building and associated buildings that are potential sources of radioactive releases.

The low population zone (LPZ) was determined as an area with a 1-mi (1609 m) radius from the site center point.

EAB = exclusion area boundary

Table 2.3.4-12
CRN SMR Short-Term Exclusion Area Boundary Accident Release X/Q Values

0.5% and 5% X/Q Values (s/m^3) at the EAB				
Effluent Release Boundary to Analytical EAB	**Time Period**	**Direction-Dependent X/Q**		**Direction Independent X/Q**
		0.5% Maximum	**Sector**	**5% Site Limit**
Effluent Release Boundary (335 m)	0–2 Hours	4.96E-03	WNW	4.33E-03

Notes:

Modeling results reflect no building wake credit.

A circular, analytical exclusion area boundary (EAB) was defined at a fixed distance. The distance used from the Effluent Release Boundary to the analytical EAB was 1100 ft (335 m).

The Effluent Release Boundary includes the nuclear island, which contains the reactor building and associated structures that are potential sources of radioactive releases.

Table 2.3.4-13
Clinch River Nuclear Site Small Modular Reactor Short-Term Low Population Zone Accident Release X/Q Values

0.5% and 5% X/Q Values (s/m^3) at the LPZ			
	Direction-Dependent X/Q		Direction Independent X/Q
Time Period	0.5% Maximum	Sector	5% Site Limit
0–8 Hours	3.10E-04	WNW	2.76E-04
8–24 Hours	2.26E-04	WNW	2.04E-04
1–4 Days	1.14E-04	WNW	1.06E-04
4–30 Days	4.30E-05	WNW	4.12E-05

Notes:

The low population zone (LPZ) was determined as a circle with a 1-mile (1609-m) radius from the center point of the site.

Modeling results reflect no building wake credit.

Table 2.3.4-14
Clinch River Nuclear Site Enveloping Power Block Accident Release Bounding X/Q Values

Bounding X/Q Values (s/m^3) at the EAB and LPZ					
Location	**0–2 Hours**	**0–8 Hours**	**8–24 Hours**	**1–4 Days**	**4–30 Days**
Effluent Release Boundary to EAB	4.96E-03	2.94E-03	2.26E-03	1.28E-03	5.67E-04
LPZ	NA	3.10E-04	2.26E-04	1.14E-04	4.30E-05

Notes:

A circular, analytical exclusion area boundary (EAB) was defined at a fixed distance from the Effluent Release Boundary. The distance used from the Effluent Release Boundary to the analytical EAB was 1100 ft (335 m).

The low population zone (LPZ) was determined as an area with a 1-mi (1609-m) radius, centered on the site.

The Effluent Release Boundary includes the nuclear island, which contains the reactor building and associated structures that are potential sources of radioactive releases.

NA = Not Applicable

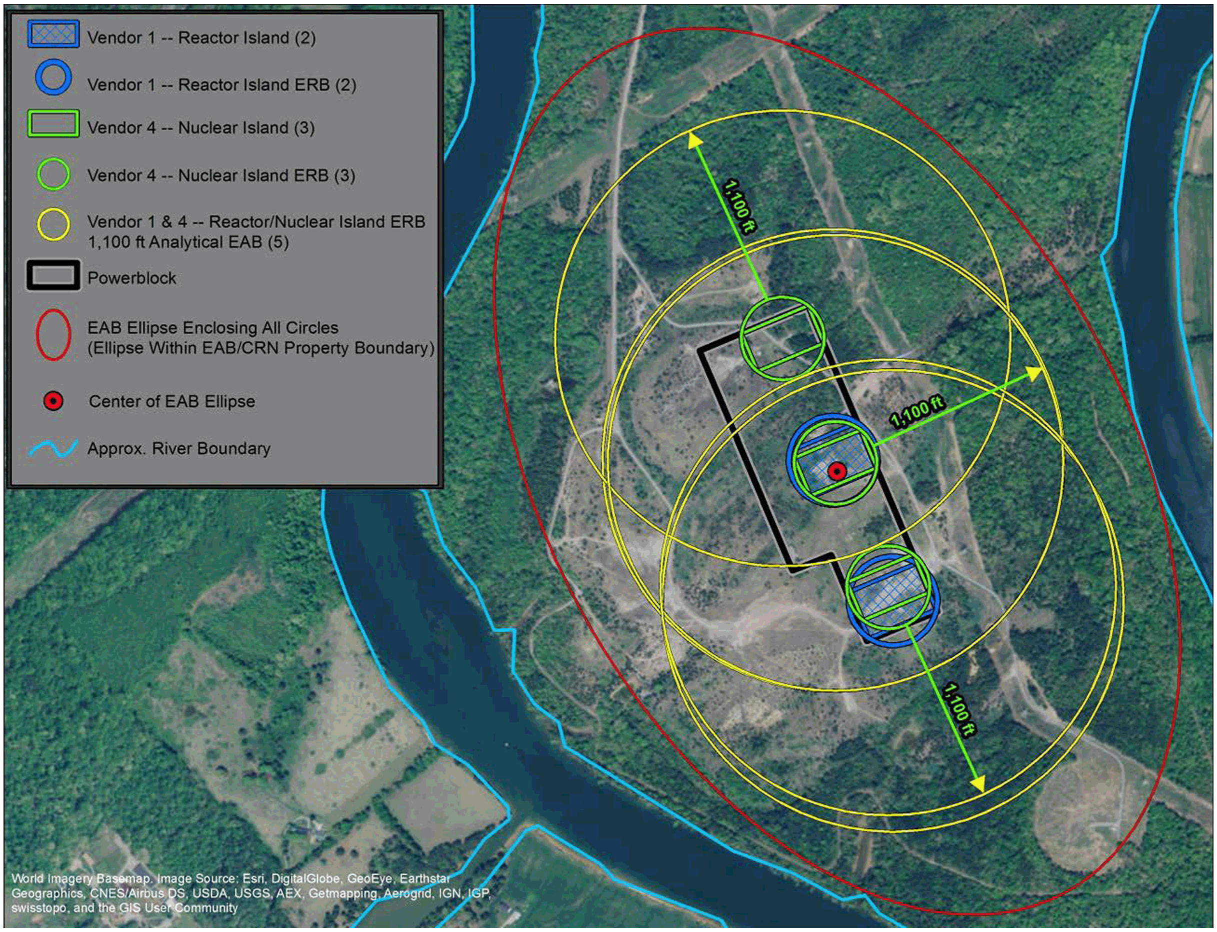
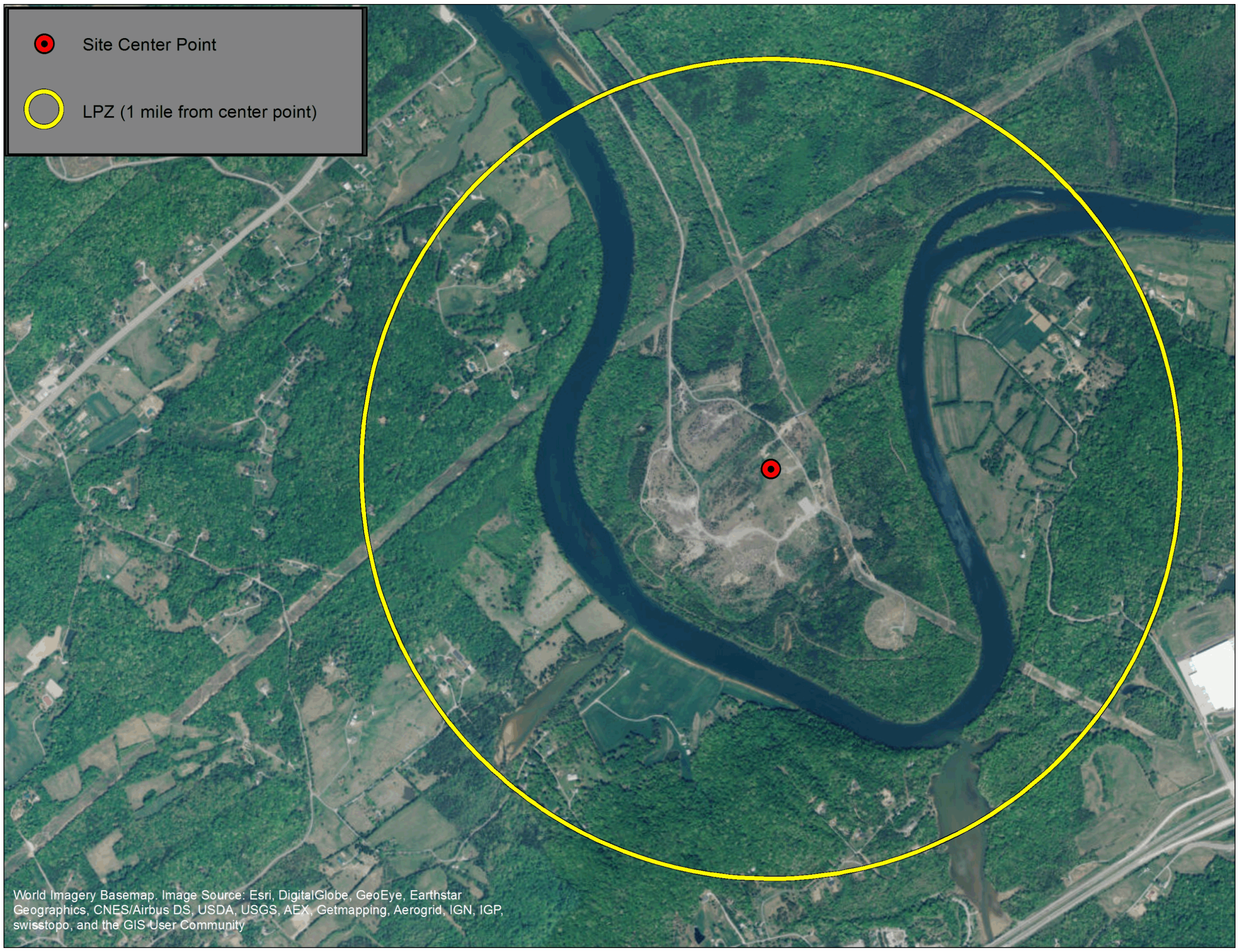


Figure 2.3.4-1. Effluent Release Boundary with Analytical EABs



Notes:

LPZ = Low Population Zone

Figure 2.3.4-2. Site Center Point and Distance to the LPZ

2.3.5 Long-Term (Routine) Diffusion Estimates

For routine releases, the concentration of radioactive material in the surrounding region depends on the amount of effluent released, the height of the release, the momentum and buoyancy of the emitted plume, the wind speed, atmospheric stability, airflow patterns of the site, and various effluent removal mechanisms. Annual average relative concentration, X/Q, and annual average relative deposition, D/Q, for gaseous effluent routine releases were calculated for the Clinch River Nuclear (CRN) Site. This section describes the development of the long-term diffusion and deposition estimates.

2.3.5.1 Purpose and Background

As required by 10 CFR 100 and 10 CFR 50, estimates of atmospheric dispersion, expressed as X/Q, and relative deposition values, D/Q, were calculated for routine releases from the CRN Site at long-term (annual) time intervals for the Exclusion Area Boundary (EAB), at points of maximum individual exposure, and at points within a radial grid of sixteen 22.5 degree sectors extending to a distance of 50 miles (80.5 kilometers [km]). The XOQDOQ-82 (XOQDOQ) modeling program is the NRC-recommended dispersion model, NUREG/CR-2919 (Reference 2.3.5-2), which implements the assumptions outlined in Regulatory Guide (RG) 1.111. Using joint frequency distributions (JFDs) of wind direction (vector), wind speed, and atmospheric stability class, the program provides annual average X/Q and D/Q calculations at the required distances and sectors. Radioactive decay and dry deposition are considered, and a straight-line Gaussian trajectory is modeled between the point of release and all distances for which X/Q values are calculated.

2.3.5.2 Calculation Methodology and Assumptions

RG 1.206, states that the Applicant should provide meteorological data from at least two consecutive annual cycles, including the most recent 1-year period for calculating the short-term and long-term atmospheric dispersion estimates. RG 1.23, recommends using meteorological data from a consecutive 24-month period. Site-specific, validated meteorological data covering the 2-year period of record from June 1, 2011 through May 31, 2013 was used to quantitatively evaluate routine releases at the CRN Site. The meteorological data needed for the X/Q and D/Q calculations in XOQDOQ included average (scalar) wind speed, wind direction (vector), and atmospheric stability, in terms of JFDs (Table 2.3.4-2 through Table 2.3.4-8). Fourteen wind speed categories were defined in the JFDs and used in the XOQDOQ analyses.

Using the JFDs, XOQDOQ provides the X/Q values as functions of direction for various time periods at the EAB, at points of maximum individual exposure, and at points within a radial grid of sixteen 22.5 degree sectors extending to a distance of 50 miles (80.5 km). According to RG 4.7, an applicant is required by 10 CFR 100.21(a) to designate an exclusion area and to have authority to determine all activities within that area, including removal of personnel and property. For assessing releases at the site boundary, 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. A circular analytical EAB is established 1100 ft (335 m) from the ERB. For X/Q modelling (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 Figure 2.3.4-1 (note that although the nuclear islands for vendors 1 and 4 are depicted in the figure, the nuclear islands, associated ERBs, and analytical EABs for vendor 1, 2, 3, and 4 fit within the EAB ellipse). The analytical EABs can be encompassed by an ellipse fixed completely within the CRN Property boundary, i.e. the actual EAB (Figure 2.3.4-1), which demonstrates that dispersion factor computations are conservative.

The site center point is determined as the centerline midpoint of the EAB ellipse (Figure 2.3.4-1). The ellipse has a short axis of 0.326 mi (524 m) from the site center point and long axis of 0.535 mi (864 m) from the center point.

Both X/Q and D/Q estimates were also calculated for the nearest residence, the nearest vegetable garden, and the nearest beef animal at each of the 16 wind direction sectors. The locations of the sensitive receptors were determined from the land use surveys conducted in January and April 2014 (Figure 2.3.5-1).

Other plant specific data used in the XOQDOQ model include building minimum cross-sectional area, building height, and meteorological tower height at which wind speed was measured. The building height and cross-sectional area are considered in the calculation of building wake effects. RG 1.111 identifies the tallest adjacent building as appropriate for use. Building area is defined as the smallest vertical-plane, cross-sectional area of the affected building, in square meters. The dose calculation at the EAB and the low population zone (LPZ) are both located beyond the building wake influence zone, so the height and cross-sectional area had little effect in building wake X/Q values. Therefore, for conservatism, no building wake credit was used in the XOQDOQ model (e.g., cross-sectional area and building height were both set to zero).

Based on RG 1.145, a ground release includes all release points that are effectively less than 2.5 times the height of adjacent solid structures. Compared to an elevated release, a ground-level release usually results in higher ground-level concentrations at downwind receptors due to less dilution from shorter traveling distances. Because the ground-level release scenario provides a bounding case, elevated releases were not considered.

Other inputs to the model included a release height and a representative wind height. NUREG/CR-2919 indicates that for a ground level release, average vent velocity (EXIT) and stack diameter (DIAMTR) must be set to zero, while the wind release height (SLEV) must be set to 32.8 feet (10 meters). Vent height was set equal to wind height in the XOQDOQ model (see Reference 2.3.5-3). For a ground-level release, the lower wind speed measurement height 32.09 feet (9.78 meters) (nominal 10 meters) was used. The inputs used in the XOQDOQ model are listed in Table 2.3.5-1.

Consistent with RG 1.111 in regard to the radiological impact evaluations, radioactive decay and deposition were considered. For conservative estimates of radioactive decay, an overall half-life of 2.26 days for short-lived noble gases, a half-life of 101 days for long-lived noble gases, and a half-life of 8 days for all iodines are acceptable for releases to the atmosphere. At sites where there is not a well-defined rainy season associated with a local grazing season, wet deposition does not have a significant impact. In addition, the dry deposition rate of noble gases is so slow that the depletion is negligible within 50 miles (80.5 km). Therefore, in this analysis, only the effects of dry deposition of iodines were considered. The calculations considering dry/no deposition are identified in the output as depleted and undepleted.

2.3.5.3 Complex Terrain Modeling Analysis

As detailed in Subsection 2.3.2, 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 flow (NE-ENE) 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 site. In stable air with light winds, pockets of stagnation may develop at the base of nearby hills or near the Clinch River, which could cause short-term increases in pollutant concentrations. However, due to the wind meander patterns observed, the plume effluent could spread over an angle of 180 degrees or more (recirculation). Furthermore, there is some

uncertainty as to the degree of influence of complex terrain on long-term diffusion estimates. Normally, irregular terrain would promote mechanical turbulence and enhance dispersion, but with light average wind speeds being predominant and periods of stagnation common at the site, the net effect could be higher concentrations.

For complex terrain sites where these nonlinear dispersion effects are highly apparent, adjustments to a linear trajectory model are possibly warranted; specifically, adjustment factors for terrain confinement and recirculation effects on annual average dispersion concentrations at boundary locations must be considered. In the XOQDOQ model, the computed ground-level concentrations can be adjusted to account for nonlinear trajectories (plume recirculation or stagnation). As outlined in NUREG/CR-2919, the adjustments can be accomplished in two ways. First, a standard default correction factor that is a function of distance can be applied to the X/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. The models were used to estimate concentrations at discrete receptor locations for each of the 16 wind 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 approach used for the CRN Site analysis involved a comparison of estimated long-term X/Q values between the CALPUFF modeling system and the XOQDOQ model at the LPZ and an analytical EAB. The CALPUFF Version 6.42 dispersion modeling system is an advanced, non-steady-state, meteorological and air quality modeling system used by the U.S. Environmental Protection Agency (EPA) in its Guideline on Air Quality Models that can be applied in near-field applications involving complex meteorological conditions (References 2.3.5-5, 2.3.5-6). The modeling system is comprised of a meteorological processor, CALMET, Version 6.334, which develops hourly wind and temperature fields on a three-dimensional gridded modeling domain, with two-dimensional fields of mixing height, surface characteristics, and dispersion properties (Reference 2.3.5-4). The CALPUFF model is a multi-layer, multi-species, non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal. The concentrations and deposition files produced from CALPUFF are post-processed by the CALPOST, Version 6.292, processor into tables and plot files of concentrations at given receptors. The latest version of CALPUFF was used in order to incorporate the latest chemistry mechanisms and modeling updates.

Both the CALPUFF modeling system and the XOQDOQ model simulated the meteorological data encompassing the June 1, 2011–May 31, 2013 period in which the CRN Site meteorological tower was in operation. For the meteorological processing, CALMET requires comprehensive surface, precipitation, and upper air data. The surface data was processed from the CRN Site Meteorological tower. Because of repeated problems with the CRN Site rain gauge measurements, the rainfall data was taken from hourly data collected from the Oak Ridge Automated Surface Observing System (ASOS) for use in the CALPUFF model. Upper air data was taken from the Nashville National Weather Service (NWS) station which is the nearest station to the CRN Site that collects upper air data. Finally, 22 vertical layers were used in the CALMET model in to provide enhanced stratification of the upper air field. For the XOQDOQ model, JFDs of CRN Site onsite meteorological wind and stability data during the same period was used as input.

The CALPUFF modeling system has the ability to model up to 23 radioactive species, each with a default-assigned decay half-life. It also allows the user to assign the associated mass lost to one or more other modeled species using a mass yield factor (Reference 2.3.5-6). As XOQDOQ provides default estimates of radioactive decay using an overall half-life of 2.26 days for

short-lived noble gases, 8 days for iodines, and up to 101 days for long-lived noble gasses; the following 3 radioactive species were modeled in CALPUFF: Xenon-133m (Xe-133m), Iodine-131 (I-131), and Krypton-85 (Kr-85). Xenon-133m has an overall half-life of 2.16 days, I-131 has an overall half-life of 8 days, and Kr-85 has a half-life of 11 years. Kr-85 was selected as the long-lived noble gas because its long half-life and resistance to dry and wet deposition would provide a more conservative estimate of undepleted decay (Reference 2.3.5-7). Furthermore, wet and dry deposition of I-131 was not considered in CALPUFF, which also allowed for a more conservative estimate of final concentrations.

Both the CALPUFF and XOQDOQ models used a single ground-level point source located at the center point of the site with no building wake credit given. To model a ground-level release in CALPUFF, all stack parameters must be set to nonzero values, with the exception of stack height. Therefore, to closely simulate a ground-level release that would be dominated by plume momentum, a stack diameter of 3.28 ft (1.0 m) and an exit velocity of 0.224 mi/hr (0.1 m/s) was assumed. A stack height of 32.8 ft (10 m) was used to maintain consistency with the XOQDOQ default stack height for ground-level releases (Reference 2.3.5-3). As indicated in NUREG/CR-2919, nuclear power vents generally have ambient temperature plumes, so the source exit temperature in CALPUFF was set to 68°F (293 K). The American Nuclear Society (ANS)-2.15 guidance document, *Criteria for Modeling and Calculating Atmospheric Dispersion of Routine Radiological Releases from Nuclear Facilities*, was also referenced in the modeling setup of the CALPUFF system (Reference 2.3.5-1). With the center point of the site as the source location, both models included discrete receptors at an analytical EAB with radius equal to the shorter distance of the EAB ellipse (0.326 mi (524 m)) and at the 1.0 mi (1609 m) LPZ distance for each of the 16 wind direction sectors (Figure 2.3.5-2). The CALPUFF input options are summarized in Table 2.3.5-2.

The multiple-year average X/Q values[1] for the undepleted case, the 2-day decay case, and the 8-day decay case at the EAB and LPZ were compared between the two models, and the results are summarized in Tables 2.3.5-3 and 2.3.5-4, respectively. The X/Q values at both distances from the models showed that the highest X/Q values were estimated by the XOQDOQ model for all 16 wind direction sectors. Therefore, it was concluded that the XOQDOQ model did not underestimate the annual average X/Q values, and no nonlinear adjustment factors would be applied to the annual average X/Q and D/Q values at the CRN Site.

2.3.5.4 Summary of Results and Conclusions

Consistent with RG 1.111, the long-term, routine-release X/Q and D/Q values were evaluated with the XOQDOQ model for the analytical EABs, at receptor points of maximum individual exposure, and at points within a radial grid of sixteen 22.5 degree sectors extending to a distance of 50 miles (80.5 km) from the site. A set of data points were located within each sector at increments of 0.25 miles (0.4 km) to a distance of 1 mile (1.61 km) from the site; at increments of 0.5 miles (0.805 km) from a distance of 1 mile (1.61 km) to 5 miles (8.05 km); at increments of 2.5 miles (4.02 km) from a distance of 5 miles (8.05 km) to 10 miles (16.09 km); and at increments of 5 miles (8.05 km) up to a distance of 50 miles (80.5 km). Estimates of X/Q (undecayed and undepleted; depleted for radioiodines) and D/Q (radioiodines and particulates) are provided at each of these points. The results of the modeling analysis, based on two years of onsite meteorological data, are presented in Tables 2.3.5-6 through 2.3.5-10.

The offsite receptor locations and distances within a 5-mile radius are given in Table 2.3.5-5. As seen from the results, the highest concentrations at the EAB, nearest garden, and nearest residence are found in the sectors that lie to the west-northwest (WNW) of the plant, which is

1. The long-term average values reflect the CRN Site 2011–2013 meteorological episode.

consistent with the relatively high percentage of stable (F and G) conditions associated with light winds that blow from the southeast (see Subsection 2.3.2).

The two complete years of onsite meteorological data used for the long-term (routine) release calculations were representative of the overall site conditions and long-term trends for the CRN Site. As documented in Subsection 2.3.2, the location of the meteorological tower was sufficiently removed from the proposed power block area or significant topographic features to ensure that adequate data was provided to represent onsite meteorological conditions and to describe the local and regional atmospheric transport and diffusion characteristics. The representativeness of observed meteorology at the site was assessed, and no long-term trends were observed which would bias the X/Q and D/Q estimates. Therefore, the long-term, routine-release X/Q and D/Q values correspond to conditions that would be estimated using climatological (30-year) data.

2.3.5.5 References

2.3.5-1. ANSI/ANS-2.15-2013, Criteria for Modeling and Calculating Atmospheric Dispersion of Routine Radiological Releases from Nuclear Facilities, American Nuclear Society, February 2013.

2.3.5-2. NUREG/CR-2919, “XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations,” Richland, WA, September 1982.

2.3.5-3. Paynter, D., 2006, XOQDOQ Calculation – Method, Tools, and Pitfalls, NUMUG Conference Presentation, Operations Management Group, Ltd (OMG), Seattle, WA, October 13, 2006.

2.3.5-4. Scire, J., D. Strimaitis, and R.Yamartino, A User’s Guide for the CALMET Meteorological Model (Version 5), Earth Tech, Inc., Concord, Massachusetts, January 2000.

2.3.5-5. Scire, J., F. Robe, M. Fernau, and R.Yamartino, A User’s Guide for the CALPUFF Dispersion Model (Version 5), Earth Tech, Inc., Concord, Massachusetts, January 2000.

2.3.5-6. Scire, J., D. Strimaitis, F. Robe, M. Phadnis, J. Popovic, CALPUFF Modeling System Version 6 User Instructions, Earth Tech, Inc., Concord, Massachusetts, April 2011.

2.3.5-7. Scott, E.M., 2003, Modelling Radioactivity in the Environment, Volume 4, Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington, Oxford, OX5 / GB, UK. ISBN 0-08-043663-3, Chapter 2, Page 28, A. Mayall – author, Environment Agency, England.

Table 2.3.5-1
List of Inputs Used in the XOQDOQ Modeling for Complex Terrain Analysis

XOQDOQ Input Variable	Value
Wind Sensor Height (PLEV)	9.78 m
Conversion Correction Factor (UCOR)	150
Lower-T Sensor Height	8.44 m
Upper-T sensor Height	59.22 m
Type of Release	Ground
Vent Average Velocity (EXIT)	0.0 m/s
Vent Inside Diameter (DIAMTR)	0.0 m
Vent Release Height (HSTACK)	10.0 m
Containment Building Height (HBLDG)	0.0 m
Building Min. Cross-Sectional Area (CRSEC)	0.0 m^2
Wind Height (SLEV)	10.0 m
Distance From Site Center Point to Analytical EAB	524 m

Notes:

No building wake credit was used in the modeling. Therefore, the building height and cross-sectional area were set to zero.

For a ground-level release, the exit velocity and diameter are set to zero, while the wind height is set to 10 m, consistent with NUREG/CR-2919 (Reference 2.3.5-2).

Vent height is set equal to wind height in the XOQDOQ model (see Reference 2.3.5-3).

Table 2.3.5-2
CALPUFF Model Input Configuration for Complex Terrain Analysis

CALPUFF Parameter	Input Value or Source
Episode Modeled	June 1, 2011–May 31, 2013
Domain Size	10-mi (16.09 km) radius
# of Grid Cells	111 x 111
Grid Spacing	382.8 yd (350 m)
# of Vertical (Height) Levels	22
Upper Air Data	Nashville NWS Station
Precipitation Data	Oak Ridge Automated Surface Observing System
Surface Data	Clinch River Met Tower
Source Location	Site Center Coordinates
Base elevation	820.9 ft (250.2 m)
Distance From Site Center Point to Analytical EAB	1719.2 ft (524 m) radius
Distance to LPZ	5278.9 ft (1609 m) radius
# of Stacks (Vents)	1
Stack #1 Height	32.8 ft (10.0 m)
Stack #1 Diameter	3.28 ft (1.0 m)
Stack #1 Exit Velocity	0.3281 ft/s (0.1 m/s)
Stack #1 Exit Temperature	68°F (293 K)

Notes:

For the complex terrain modeling, the analytical exclusion area boundary (EAB) was defined as an area with a 0.326-mi (524-m) radius from the center point of the site. The low population zone (LPZ) was defined as an area with a 1-mi (1609-m) radius from the center point of the site.

Table 2.3.5-3
Long-Term Average X/Q Values at the Exclusion Area Boundary

Long-Term Average X/Q Values (s/m^3)									
Analytical EAB Sector	Undepleted			2-Day Decay			8-Day Decay		
	XOQDOQ	CALPUFF	Ratio	XOQDOQ	CALPUFF	Ratio	XOQDOQ	CALPUFF	Ratio
S	2.70E-05	2.01E-06	0.07	2.70E-05	2.01E-06	0.07	2.50E-05	2.01E-06	0.08
SSW	2.40E-05	1.95E-06	0.08	2.40E-05	1.95E-06	0.08	2.30E-05	1.95E-06	0.08
SW	2.80E-05	1.32E-06	0.05	2.80E-05	1.32E-06	0.05	2.60E-05	1.32E-06	0.05
WSW	4.20E-05	1.17E-06	0.03	4.10E-05	1.17E-06	0.03	3.80E-05	1.17E-06	0.03
W	6.70E-05	1.15E-06	0.02	6.60E-05	1.14E-06	0.02	6.10E-05	1.15E-06	0.02
WNW	9.10E-05	6.51E-07	0.01	9.10E-05	6.49E-07	0.01	8.40E-05	6.51E-07	0.01
NW	7.80E-05	1.38E-06	0.02	7.70E-05	1.38E-06	0.02	7.20E-05	1.38E-06	0.02
NNW	4.60E-05	3.01E-06	0.07	4.50E-05	3.01E-06	0.07	4.20E-05	3.01E-06	0.07
N	3.10E-05	2.93E-06	0.09	3.10E-05	2.92E-06	0.09	2.90E-05	2.92E-06	0.10
NNE	2.20E-05	3.75E-06	0.17	2.20E-05	3.74E-06	0.17	2.00E-05	3.75E-06	0.19
NE	2.20E-05	2.11E-06	0.10	2.20E-05	2.11E-06	0.10	2.00E-05	2.11E-06	0.11
ENE	3.30E-05	2.26E-06	0.07	3.30E-05	2.26E-06	0.07	3.10E-05	2.26E-06	0.07
E	4.10E-05	2.78E-06	0.07	4.10E-05	2.77E-06	0.07	3.80E-05	2.78E-06	0.07
ESE	5.70E-05	3.68E-06	0.06	5.60E-05	3.67E-06	0.07	5.20E-05	3.68E-06	0.07
SE	4.60E-05	2.23E-06	0.05	4.60E-05	2.23E-06	0.05	4.20E-05	2.23E-06	0.05
SSE	2.90E-05	2.57E-06	0.09	2.90E-05	2.57E-06	0.09	2.70E-05	2.57E-06	0.10

Notes:

Long-term average values are reflective of a multi-year average from the Clinch River Nuclear Site June 1, 2011– May 31, 2013 meteorological episode. Both the XOQDOQ and CALPUFF X/Q values reflect the undepleted, 2-day decay, and 8-day decay cases.

For the complex terrain analysis, the analytical exclusion area boundary (EAB) was defined as an area with a 0.326-mi (524-m) radius from the center point of the site.

The ratio is determined by the CALPUFF concentration divided by the XOQDOQ concentration.

Table 2.3.5-4
Long-Term Average X/Q Values at the Low Population Zone

Long-Term Average X/Q Values (s/m^3)									
LPZ Sector	Undepleted			2-Day Decay			8-Day Decay		
	XOQDOQ	CALPUFF	Ratio	XOQDOQ	CALPUFF	Ratio	XOQDOQ	CALPUFF	Ratio
S	3.80E-06	4.52E-07	0.12	3.70E-06	4.50E-07	0.12	3.30E-06	4.52E-07	0.14
SSW	3.40E-06	6.31E-07	0.19	3.40E-06	6.28E-07	0.19	3.00E-06	6.30E-07	0.21
SW	4.00E-06	6.86E-07	0.17	3.90E-06	6.82E-07	0.18	3.50E-06	6.85E-07	0.19
WSW	5.80E-06	3.71E-07	0.06	5.70E-06	3.68E-07	0.06	5.10E-06	3.70E-07	0.07
W	9.30E-06	3.38E-07	0.04	9.10E-06	3.36E-07	0.04	8.10E-06	3.38E-07	0.04
WNW	1.30E-05	2.28E-07	0.02	1.20E-05	2.26E-07	0.02	1.10E-05	2.28E-07	0.02
NW	1.10E-05	2.35E-07	0.02	1.10E-05	2.33E-07	0.02	9.40E-06	2.34E-07	0.02
NNW	6.30E-06	5.51E-07	0.09	6.20E-06	5.48E-07	0.09	5.50E-06	5.50E-07	0.10
N	4.40E-06	8.74E-07	0.20	4.30E-06	8.69E-07	0.20	3.80E-06	8.72E-07	0.23
NNE	3.10E-06	4.92E-07	0.16	3.00E-06	4.90E-07	0.16	2.70E-06	4.91E-07	0.18
NE	3.10E-06	6.10E-07	0.20	3.00E-06	6.08E-07	0.20	2.70E-06	6.09E-07	0.23
ENE	4.60E-06	6.05E-07	0.13	4.60E-06	6.03E-07	0.13	4.00E-06	6.05E-07	0.15
E	5.80E-06	6.55E-07	0.11	5.70E-06	6.52E-07	0.11	5.00E-06	6.54E-07	0.13
ESE	7.90E-06	5.65E-07	0.07	7.80E-06	5.62E-07	0.07	6.90E-06	5.64E-07	0.08
SE	6.50E-06	8.66E-07	0.13	6.40E-06	8.63E-07	0.14	5.60E-06	8.65E-07	0.15
SSE	4.20E-06	5.96E-07	0.14	4.10E-06	5.94E-07	0.15	3.60E-06	5.95E-07	0.16

Notes:

Long-term average values are reflective of a multi-year average from the CRN Site June 1, 2011–May 31, 2013 meteorological episode. Both the XOQDOQ and CALPUFF X/Q values reflect the undepleted, 2-day depletion, and 8-day depletion cases.

For the complex terrain analysis, the low population zone (LPZ) was defined as an area with a 1.0-mile (1609-meters) radius from the center point.

The ratio is determined by the CALPUFF concentration divided by the XOQDOQ concentration.

Table 2.3.5-5
CRN Site Offsite Receptor Locations

Sector	Nearest Residence		Nearest Garden		Nearest Beef Animal	
	Distance (meters)	Elevation (meters)	Distance (meters)	Elevation (meters)	Distance (meters)	Elevation (meters)
S	1359	283	4254	259	3144	254
SSW	1113	240	1113	240	4488	250
SW	995	240	1522	230	4695	264
WSW	1136	246	2203	297	1138	246
W	1470	301	2861	255	4984	250
WNW	1066	285	1848	253	1120	298
NW	992	273	1978	233	1627	239
NNW	6997	312	7833	233	7833	233
N	7814	236	none	none	none	none
NNE	none	none	none	none	none	none
NE	1072	239	1072	239	none	none
ENE	1149	243	none	none	none	none
E	1118	249	3802	259	4629	245
ESE	1117	253	1482	249	4492	254
SE	1288	252	3111	347	4171	303
SSE	1304	250	1486	241	3106	313

Notes:

Distances and elevations, in meters, from the site center point to the nearest receptor of each type for a given sector to a maximum of 5 mi.

Table 2.3.5-6 (Sheet 1 of 3)
Annual Average X/Q for No Decay, Undepleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for No Decay, Undepleted											
Sector	**Distance (miles)**										
	0.25	**0.5**	**0.75**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**
S	4.31E-05	1.26E-05	6.14E-06	3.79E-06	1.99E-06	1.29E-06	9.23E-07	7.08E-07	5.67E-07	4.69E-07	3.97E-07
SSW	3.91E-05	1.14E-05	5.58E-06	3.44E-06	1.81E-06	1.16E-06	8.34E-07	6.38E-07	5.11E-07	4.22E-07	3.57E-07
SW	4.53E-05	1.32E-05	6.45E-06	3.98E-06	2.08E-06	1.34E-06	9.60E-07	7.34E-07	5.87E-07	4.84E-07	4.09E-07
WSW	6.66E-05	1.94E-05	9.41E-06	5.82E-06	3.07E-06	1.99E-06	1.43E-06	1.10E-06	8.84E-07	7.33E-07	6.22E-07
W	1.07E-04	3.10E-05	1.50E-05	9.26E-06	4.91E-06	3.20E-06	2.32E-06	1.79E-06	1.44E-06	1.20E-06	1.02E-06
WNW	1.47E-04	4.25E-05	2.04E-05	1.27E-05	6.73E-06	4.39E-06	3.19E-06	2.47E-06	1.99E-06	1.66E-06	1.41E-06
NW	1.25E-04	3.61E-05	1.74E-05	1.08E-05	5.73E-06	3.74E-06	2.71E-06	2.10E-06	1.69E-06	1.41E-06	1.20E-06
NNW	7.30E-05	2.12E-05	1.02E-05	6.30E-06	3.35E-06	2.19E-06	1.59E-06	1.23E-06	9.89E-07	8.23E-07	7.01E-07
N	5.03E-05	1.46E-05	7.06E-06	4.37E-06	2.31E-06	1.50E-06	1.09E-06	8.37E-07	6.73E-07	5.59E-07	4.75E-07
NNE	3.53E-05	1.03E-05	4.96E-06	3.07E-06	1.62E-06	1.05E-06	7.59E-07	5.84E-07	4.69E-07	3.89E-07	3.30E-07
NE	3.53E-05	1.03E-05	4.98E-06	3.08E-06	1.62E-06	1.04E-06	7.49E-07	5.75E-07	4.60E-07	3.80E-07	3.22E-07
ENE	5.33E-05	1.55E-05	7.51E-06	4.64E-06	2.44E-06	1.57E-06	1.13E-06	8.64E-07	6.92E-07	5.72E-07	4.84E-07
E	6.60E-05	1.92E-05	9.32E-06	5.76E-06	3.03E-06	1.96E-06	1.41E-06	1.08E-06	8.70E-07	7.20E-07	6.11E-07
ESE	9.08E-05	2.65E-05	1.29E-05	7.94E-06	4.19E-06	2.71E-06	1.96E-06	1.50E-06	1.21E-06	1.00E-06	8.48E-07
SE	7.34E-05	2.15E-05	1.05E-05	6.46E-06	3.40E-06	2.19E-06	1.58E-06	1.21E-06	9.68E-07	8.00E-07	6.77E-07
SSE	4.72E-05	1.38E-05	6.72E-06	4.15E-06	2.19E-06	1.41E-06	1.02E-06	7.79E-07	6.24E-07	5.17E-07	4.38E-07

Table 2.3.5-6 (Sheet 2 of 3)
Annual Average X/Q for No Decay, Undepleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for No Decay, Undepleted											
Sector	**Distance (miles)**										
	5	**7.5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
S	3.42E-07	1.95E-07	1.32E-07	7.67E-08	5.25E-08	3.92E-08	3.09E-08	2.53E-08	2.13E-08	1.83E-08	1.60E-08
SSW	3.07E-07	1.75E-07	1.18E-07	6.81E-08	4.65E-08	3.46E-08	2.73E-08	2.23E-08	1.88E-08	1.61E-08	1.41E-08
SW	3.53E-07	2.00E-07	1.35E-07	7.80E-08	5.32E-08	3.96E-08	3.12E-08	2.55E-08	2.15E-08	1.84E-08	1.61E-08
WSW	5.37E-07	3.09E-07	2.10E-07	1.23E-07	8.46E-08	6.35E-08	5.03E-08	4.13E-08	3.49E-08	3.01E-08	2.63E-08
W	8.82E-07	5.12E-07	3.51E-07	2.08E-07	1.44E-07	1.09E-07	8.64E-08	7.13E-08	6.04E-08	5.22E-08	4.59E-08
WNW	1.23E-06	7.15E-07	4.92E-07	2.93E-07	2.04E-07	1.54E-07	1.23E-07	1.02E-07	8.63E-08	7.47E-08	6.57E-08
NW	1.04E-06	6.08E-07	4.18E-07	2.49E-07	1.73E-07	1.31E-07	1.05E-07	8.64E-08	7.33E-08	6.35E-08	5.58E-08
NNW	6.08E-07	3.55E-07	2.44E-07	1.45E-07	1.01E-07	7.62E-08	6.08E-08	5.03E-08	4.26E-08	3.69E-08	3.25E-08
N	4.11E-07	2.38E-07	1.63E-07	9.60E-08	6.64E-08	5.00E-08	3.97E-08	3.28E-08	2.77E-08	2.40E-08	2.10E-08
NNE	2.86E-07	1.65E-07	1.12E-07	6.59E-08	4.55E-08	3.42E-08	2.71E-08	2.23E-08	1.89E-08	1.63E-08	1.43E-08
NE	2.78E-07	1.59E-07	1.08E-07	6.26E-08	4.29E-08	3.21E-08	2.54E-08	2.09E-08	1.76E-08	1.51E-08	1.33E-08
ENE	4.18E-07	2.39E-07	1.62E-07	9.41E-08	6.45E-08	4.83E-08	3.82E-08	3.14E-08	2.65E-08	2.28E-08	2.00E-08
E	5.27E-07	3.03E-07	2.05E-07	1.20E-07	8.26E-08	6.19E-08	4.90E-08	4.03E-08	3.40E-08	2.93E-08	2.57E-08
ESE	7.33E-07	4.21E-07	2.86E-07	1.68E-07	1.15E-07	8.66E-08	6.86E-08	5.64E-08	4.76E-08	4.10E-08	3.59E-08
SE	5.84E-07	3.34E-07	2.26E-07	1.31E-07	8.98E-08	6.71E-08	5.30E-08	4.34E-08	3.66E-08	3.14E-08	2.75E-08
SSE	3.78E-07	2.16E-07	1.46E-07	8.51E-08	5.83E-08	4.36E-08	3.44E-08	2.82E-08	2.38E-08	2.05E-08	1.79E-08

Table 2.3.5-6 (Sheet 3 of 3)
Annual Average X/Q for No Decay, Undepleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for No Decay, Undepleted										
Sector	Distance (miles)									
	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	6.53E-06	2.08E-06	9.34E-07	5.70E-07	3.98E-07	2.00E-07	7.82E-08	3.94E-08	2.54E-08	1.84E-08
SSW	5.93E-06	1.88E-06	8.44E-07	5.13E-07	3.58E-07	1.79E-07	6.95E-08	3.48E-08	2.24E-08	1.61E-08
SW	6.85E-06	2.17E-06	9.71E-07	5.90E-07	4.11E-07	2.05E-07	7.96E-08	3.99E-08	2.56E-08	1.85E-08
WSW	1.00E-05	3.20E-06	1.45E-06	8.89E-07	6.23E-07	3.16E-07	1.25E-07	6.38E-08	4.14E-08	3.01E-08
W	1.60E-05	5.12E-06	2.34E-06	1.45E-06	1.02E-06	5.23E-07	2.11E-07	1.09E-07	7.15E-08	5.23E-08
WNW	2.19E-05	7.01E-06	3.22E-06	2.00E-06	1.42E-06	7.29E-07	2.97E-07	1.55E-07	1.02E-07	7.48E-08
NW	1.86E-05	5.96E-06	2.74E-06	1.70E-06	1.20E-06	6.20E-07	2.53E-07	1.32E-07	8.66E-08	6.36E-08
NNW	1.09E-05	3.49E-06	1.60E-06	9.94E-07	7.03E-07	3.62E-07	1.47E-07	7.66E-08	5.04E-08	3.70E-08
N	7.54E-06	2.41E-06	1.10E-06	6.76E-07	4.76E-07	2.43E-07	9.76E-08	5.03E-08	3.28E-08	2.40E-08
NNE	5.30E-06	1.69E-06	7.67E-07	4.71E-07	3.31E-07	1.68E-07	6.71E-08	3.44E-08	2.24E-08	1.63E-08
NE	5.31E-06	1.69E-06	7.58E-07	4.62E-07	3.23E-07	1.62E-07	6.38E-08	3.23E-08	2.09E-08	1.52E-08
ENE	8.00E-06	2.54E-06	1.14E-06	6.95E-07	4.85E-07	2.44E-07	9.59E-08	4.86E-08	3.15E-08	2.28E-08
E	9.93E-06	3.16E-06	1.43E-06	8.74E-07	6.12E-07	3.09E-07	1.22E-07	6.23E-08	4.04E-08	2.94E-08
ESE	1.37E-05	4.37E-06	1.98E-06	1.21E-06	8.50E-07	4.31E-07	1.71E-07	8.71E-08	5.65E-08	4.11E-08
SE	1.11E-06	3.54E-06	1.59E-06	9.72E-07	6.79E-07	3.41E-07	1.34E-07	6.75E-08	4.35E-08	3.15E-08
SSE	7.15E-06	2.28E-06	1.03E-06	6.28E-07	4.39E-07	2.21E-07	8.68E-08	4.39E-08	2.83E-08	2.05E-08

Table 2.3.5-7 (Sheet 1 of 3)
Annual Average X/Q for 2.26 Day Decay, Undepleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for 2.26 Day Decay, Undepleted											
Sector	Distance (miles)										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	4.29E-05	1.25E-05	6.05E-06	3.72E-06	1.93E-06	1.24E-06	8.79E-07	6.67E-07	5.29E-07	4.33E-07	3.63E-07
SSW	3.89E-05	1.13E-05	5.50E-06	3.38E-06	1.76E-06	1.12E-06	7.96E-07	6.03E-07	4.78E-07	3.91E-07	3.28E-07
SW	4.51E-05	1.31E-05	6.36E-06	3.91E-06	2.03E-06	1.30E-06	9.19E-07	6.97E-07	5.52E-07	4.52E-07	3.78E-07
WSW	6.63E-05	1.92E-05	9.29E-06	5.72E-06	2.99E-06	1.92E-06	1.37E-06	1.04E-06	8.30E-07	6.82E-07	5.73E-07
W	1.06E-04	3.07E-05	1.47E-05	9.09E-06	4.77E-06	3.08E-06	2.21E-06	1.69E-06	1.35E-06	1.11E-06	9.35E-07
WNW	1.46E-04	4.21E-05	2.01E-05	1.24E-05	6.55E-06	4.24E-06	3.05E-06	2.34E-06	1.87E-06	1.54E-06	1.30E-06
NW	1.24E-04	3.58E-05	1.71E-05	1.06E-05	5.58E-06	3.61E-06	2.60E-06	1.99E-06	1.59E-06	1.32E-06	1.11E-06
NNW	7.27E-05	2.10E-05	1.00E-05	6.19E-06	3.26E-06	2.11E-06	1.52E-06	1.16E-06	9.28E-07	7.66E-07	6.46E-07
N	5.01E-05	1.45E-05	6.96E-06	4.28E-06	2.25E-06	1.45E-06	1.03E-06	7.89E-07	6.29E-07	5.17E-07	4.35E-07
NNE	3.52E-05	1.02E-05	4.90E-06	3.02E-06	1.58E-06	1.02E-06	7.28E-07	5.55E-07	4.43E-07	3.64E-07	3.06E-07
NE	3.51E-05	1.02E-05	4.92E-06	3.03E-06	1.58E-06	1.01E-06	7.20E-07	5.48E-07	4.35E-07	3.57E-07	3.00E-07
ENE	5.31E-05	1.54E-05	7.43E-06	4.57E-06	2.38E-06	1.53E-06	1.09E-06	8.27E-07	6.58E-07	5.40E-07	4.53E-07
E	6.58E-05	1.91E-05	9.22E-06	5.68E-06	2.97E-06	1.91E-06	1.36E-06	1.04E-06	8.28E-07	6.81E-07	5.73E-07
ESE	9.04E-05	2.63E-05	1.27E-05	7.82E-06	4.09E-06	2.63E-06	1.88E-06	1.43E-06	1.14E-06	9.39E-07	7.90E-07
SE	7.31E-05	2.13E-05	1.03E-05	6.35E-06	3.31E-06	2.12E-06	1.51E-06	1.15E-06	9.13E-07	7.48E-07	6.28E-07
SSE	4.70E-05	1.37E-05	6.62E-06	4.07E-06	2.12E-06	1.36E-06	9.66E-07	7.34E-07	5.82E-07	4.77E-07	4.00E-07

Table 2.3.5-7 (Sheet 2 of 3)
Annual Average X/Q for 2.26 Day Decay, Undepleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for 2.26 Day Decay, Undepleted											
Sector	**Distance (miles)**										
	5	**7.5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
S	3.10E-07	1.68E-07	1.08E-07	5.71E-08	3.55E-08	2.42E-08	1.75E-08	1.31E-08	1.02E-08	8.06E-09	6.50E-09
SSW	2.80E-07	1.52E-07	9.76E-08	5.16E-08	3.22E-08	2.20E-08	1.60E-08	1.20E-08	9.35E-09	7.43E-09	6.01E-09
SW	3.23E-07	1.76E-07	1.13E-07	6.02E-08	3.78E-08	2.60E-08	1.89E-08	1.43E-08	1.12E-08	8.94E-09	7.27E-09
WSW	4.91E-07	2.70E-07	1.76E-07	9.42E-08	5.96E-08	4.12E-08	3.01E-08	2.29E-08	1.79E-08	1.43E-08	1.16E-08
W	8.02E-07	4.45E-07	2.91E-07	1.57E-07	9.99E-08	6.92E-08	5.06E-08	3.85E-08	3.01E-08	2.41E-08	1.96E-08
WNW	1.12E-06	6.25E-07	4.11E-07	2.25E-07	1.44E-07	1.00E-07	7.38E-08	5.64E-08	4.43E-08	3.56E-08	2.90E-08
NW	9.55E-07	5.34E-07	3.52E-07	1.93E-07	1.24E-07	8.65E-08	6.38E-08	4.88E-08	3.84E-08	3.09E-08	2.52E-08
NNW	5.56E-07	3.10E-07	2.04E-07	1.11E-07	7.09E-08	4.93E-08	3.62E-08	2.76E-08	2.17E-08	1.74E-08	1.41E-08
N	3.73E-07	2.06E-07	1.34E-07	7.20E-08	4.55E-08	3.14E-08	2.30E-08	1.74E-08	1.36E-08	1.09E-08	8.85E-09
NNE	2.63E-07	1.45E-07	9.51E-08	5.16E-08	3.29E-08	2.29E-08	1.69E-08	1.29E-08	1.02E-08	8.17E-09	6.69E-09
NE	2.56E-07	1.41E-07	9.15E-08	4.92E-08	3.13E-08	2.17E-08	1.60E-08	1.22E-08	9.61E-09	7.74E-09	6.35E-09
ENE	3.88E-07	2.14E-07	1.40E-07	7.56E-08	4.83E-08	3.37E-08	2.49E-08	1.92E-08	1.52E-08	1.22E-08	1.01E-08
E	4.91E-07	2.72E-07	1.78E-07	9.72E-08	6.24E-08	4.37E-08	3.24E-08	2.50E-08	1.98E-08	1.60E-08	1.32E-08
ESE	6.77E-07	3.74E-07	2.45E-07	1.33E-07	8.48E-08	5.92E-08	4.37E-08	3.35E-08	2.64E-08	2.13E-08	1.75E-08
SE	5.37E-07	2.94E-07	1.91E-07	1.02E-07	6.47E-08	4.48E-08	3.28E-08	2.49E-08	1.96E-08	1.57E-08	1.28E-08
SSE	3.42E-07	1.86E-07	1.20E-07	6.33E-08	3.94E-08	2.69E-08	1.95E-08	1.46E-08	1.13E-08	8.99E-09	7.26E-09

Table 2.3.5-7 (Sheet 3 of 3)
Annual Average X/Q for 2.26 Day Decay, Undepleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for 2.26 Day Decay, Undepleted										
Sector	Distance (miles)									
	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	6.44E-06	2.02E-06	8.89E-07	5.31E-07	3.64E-07	1.73E-07	5.88E-08	2.45E-08	1.33E-08	8.11E-09
SSW	5.85E-06	1.84E-06	8.06E-07	4.81E-07	3.29E-07	1.56E-07	5.32E-08	2.23E-08	1.21E-08	7.47E-09
SW	6.77E-06	2.12E-06	9.31E-07	5.55E-07	3.80E-07	1.81E-07	6.20E-08	2.63E-08	1.44E-08	8.99E-09
WSW	9.91E-06	3.12E-06	1.39E-06	8.35E-07	5.75E-07	2.77E-07	9.69E-08	4.16E-08	2.30E-08	1.44E-08
W	1.58E-05	4.98E-06	2.23E-06	1.35E-06	9.38E-07	4.56E-07	1.62E-07	7.00E-08	3.88E-08	2.42E-08
WNW	2.16E-05	6.83E-06	3.08E-06	1.88E-06	1.31E-06	6.40E-07	2.30E-07	1.01E-07	5.68E-08	3.57E-08
NW	1.84E-05	5.82E-06	2.63E-06	1.60E-06	1.11E-06	5.47E-07	1.98E-07	8.73E-08	4.91E-08	3.10E-08
NNW	1.08E-05	3.40E-06	1.53E-06	9.33E-07	6.48E-07	3.17E-07	1.14E-07	4.98E-08	2.78E-08	1.74E-08
N	7.44E-06	2.34E-06	1.05E-06	6.32E-07	4.36E-07	2.11E-07	7.40E-08	3.18E-08	1.76E-08	1.09E-08
NNE	5.24E-06	1.65E-06	7.36E-07	4.45E-07	3.07E-07	1.49E-07	5.29E-08	2.32E-08	1.30E-08	8.21E-09
NE	5.25E-06	1.65E-06	7.29E-07	4.38E-07	3.01E-07	1.45E-07	5.06E-08	2.20E-08	1.23E-08	7.78E-09
ENE	7.92E-06	2.49E-06	1.10E-06	6.61E-07	4.55E-07	2.20E-07	7.76E-08	3.41E-08	1.93E-08	1.23E-08
E	9.84E-06	3.10E-06	1.38E-06	8.33E-07	5.75E-07	2.79E-07	9.98E-08	4.42E-08	2.51E-08	1.61E-08
ESE	1.35E-05	4.27E-06	1.90E-06	1.15E-06	7.92E-07	3.84E-07	1.36E-07	5.98E-08	3.37E-08	2.14E-08
SE	1.10E-05	3.46E-06	1.53E-06	9.17E-07	6.30E-07	3.02E-07	1.05E-07	4.53E-08	2.51E-08	1.58E-08
SSE	7.05E-06	2.22E-06	9.77E-07	5.85E-07	4.01E-07	1.91E-07	6.52E-08	2.73E-08	1.48E-08	9.04E-09

Table 2.3.5-8 (Sheet 1 of 3)
Annual Average X/Q for 8 Day Decay, Depleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for 8 Day Decay, Depleted											
Sector	Distance (miles)										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	4.00E-05	1.14E-05	5.45E-06	3.30E-06	1.68E-06	1.05E-06	7.38E-07	5.53E-07	4.34E-07	3.52E-07	2.92E-07
SSW	3.63E-05	1.04E-05	4.95E-06	3.00E-06	1.52E-06	9.53E-07	6.67E-07	4.99E-07	3.91E-07	3.17E-07	2.63E-07
SW	4.21E-05	1.20E-05	5.72E-06	3.46E-06	1.76E-06	1.10E-06	7.68E-07	5.75E-07	4.50E-07	3.64E-07	3.03E-07
WSW	6.19E-05	1.76E-05	8.36E-06	5.07E-06	2.59E-06	1.63E-06	1.15E-06	8.62E-07	6.78E-07	5.51E-07	4.59E-07
W	9.92E-05	2.81E-05	1.33E-05	8.06E-06	4.14E-06	2.62E-06	1.85E-06	1.40E-06	1.10E-06	8.99E-07	7.51E-07
WNW	1.36E-04	3.85E-05	1.81E-05	1.10E-05	5.67E-06	3.60E-06	2.55E-06	1.93E-06	1.53E-06	1.25E-06	1.04E-06
NW	1.16E-04	3.28E-05	1.54E-05	9.38E-06	4.83E-06	3.07E-06	2.17E-06	1.64E-06	1.30E-06	1.06E-06	8.88E-07
NNW	6.79E-05	1.92E-05	9.03E-06	5.49E-06	2.82E-06	1.79E-06	1.27E-06	9.59E-07	7.58E-07	6.19E-07	5.18E-07
N	4.68E-05	1.33E-05	6.26E-06	3.80E-06	1.95E-06	1.23E-06	8.67E-07	6.54E-07	5.15E-07	4.20E-07	3.50E-07
NNE	3.28E-05	9.31E-06	4.41E-06	2.68E-06	1.37E-06	8.63E-07	6.07E-07	4.57E-07	3.60E-07	2.93E-07	2.44E-07
NE	3.28E-05	9.31E-06	4.43E-06	2.68E-06	1.36E-06	8.57E-07	6.00E-07	4.50E-07	3.53E-07	2.87E-07	2.39E-07
ENE	4.96E-05	1.41E-05	6.67E-06	4.04E-06	2.06E-06	1.29E-06	9.04E-07	6.78E-07	5.32E-07	4.32E-07	3.59E-07
E	6.13E-05	1.74E-05	8.28E-06	5.02E-06	2.56E-06	1.61E-06	1.13E-06	8.51E-07	6.69E-07	5.44E-07	4.53E-07
ESE	8.44E-05	2.40E-05	1.14E-05	6.92E-06	3.54E-06	2.23E-06	1.57E-06	1.18E-06	9.27E-07	7.54E-07	6.28E-07
SE	6.83E-05	1.95E-05	9.29E-06	5.63E-06	2.86E-06	1.80E-06	1.26E-06	9.46E-07	7.43E-07	6.03E-07	5.01E-07
SSE	4.39E-05	1.25E-05	5.97E-06	3.62E-06	1.84E-06	1.16E-06	8.11E-07	6.08E-07	4.78E-07	3.88E-07	3.22E-07

Table 2.3.5-8 (Sheet 2 of 3)
Annual Average X/Q for 8 Day Decay, Depleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for 8 Day Decay, Depleted											
Sector	Distance (miles)										
	5	7.5	10	15	20	25	30	35	40	45	50
S	2.48E-07	1.32E-07	8.37E-08	4.37E-08	2.73E-08	1.88E-08	1.37E-08	1.04E-08	8.21E-09	6.61E-09	5.42E-09
SSW	2.23E-07	1.18E-07	7.49E-08	3.90E-08	2.43E-08	1.67E-08	1.22E-08	9.31E-09	7.33E-09	5.90E-09	4.84E-09
SW	2.56E-07	1.36E-07	8.61E-08	4.49E-08	2.80E-08	1.93E-08	1.41E-08	1.08E-08	8.49E-09	6.85E-09	5.63E-09
WSW	3.90E-07	2.09E-07	1.34E-07	7.07E-08	4.45E-08	3.09E-08	2.27E-08	1.74E-08	1.38E-08	1.12E-08	9.20E-09
W	6.40E-07	3.47E-07	2.23E-07	1.19E-07	7.55E-08	5.25E-08	3.88E-08	2.99E-08	2.37E-08	1.92E-08	1.59E-08
WNW	8.90E-07	4.85E-07	3.14E-07	1.69E-07	1.07E-07	7.51E-08	5.57E-08	4.30E-08	3.42E-08	2.78E-08	2.30E-08
NW	7.58E-07	4.13E-07	2.67E-07	1.44E-07	9.17E-08	6.41E-08	4.76E-08	3.68E-08	2.93E-08	2.39E-08	1.98E-08
NNW	4.42E-07	2.41E-07	1.56E-07	8.34E-08	5.31E-08	3.71E-08	2.75E-08	2.12E-08	1.69E-08	1.37E-08	1.14E-08
N	2.98E-07	1.61E-07	1.03E-07	5.48E-08	3.46E-08	2.40E-08	1.77E-08	1.36E-08	1.08E-08	8.72E-09	7.19E-09
NNE	2.08E-07	1.12E-07	7.18E-08	3.81E-08	2.41E-08	1.68E-08	1.24E-08	9.54E-09	7.57E-09	6.15E-09	5.08E-09
NE	2.02E-07	1.08E-07	6.89E-08	3.63E-08	2.28E-08	1.58E-08	1.16E-08	8.91E-09	7.05E-09	5.71E-09	4.71E-09
ENE	3.05E-07	1.63E-07	1.04E-07	5.49E-08	3.46E-08	2.40E-08	1.77E-08	1.36E-08	1.08E-08	8.77E-09	7.25E-09
E	3.85E-07	2.07E-07	1.33E-07	7.02E-08	4.44E-08	3.09E-08	2.29E-08	1.76E-08	1.40E-08	1.14E-08	9.42E-09
ESE	5.34E-07	2.87E-07	1.84E-07	9.74E-08	6.15E-08	4.27E-08	3.15E-08	2.43E-08	1.93E-08	1.56E-08	1.29E-08
SE	4.25E-07	2.27E-07	1.45E-07	7.59E-08	4.76E-08	3.29E-08	2.42E-08	1.85E-08	1.46E-08	1.18E-08	9.74E-09
SSE	2.73E-07	1.46E-07	9.27E-08	4.85E-08	3.03E-08	2.09E-08	1.53E-08	1.16E-08	9.15E-09	7.37E-09	6.05E-09

Table 2.3.5-8 (Sheet 3 of 3)
Annual Average X/Q for 8 Day Decay, Depleted for Specified Distances at each Sector

Annual Average X/Q (s/m^3) for 8 Day Decay, Depleted										
Sector	Distance (miles)									
	0.5–1	1–2	2–3	3–4	4–5	5–10	10–20	20–30	30–40	40–50
S	5.82E-06	1.76E-06	7.48E-07	4.36E-07	2.93E-07	1.36E-07	4.53E-08	1.90E-08	1.05E-08	6.64E-09
SSW	5.29E-06	1.60E-06	6.76E-07	3.94E-07	2.64E-07	1.22E-07	4.05E-08	1.70E-08	9.39E-09	5.93E-09
SW	6.11E-06	1.84E-06	7.79E-07	4.53E-07	3.04E-07	1.41E-07	4.66E-08	1.96E-08	1.09E-08	6.89E-09
WSW	8.95E-06	2.71E-06	1.16E-06	6.82E-07	4.61E-07	2.16E-07	7.31E-08	3.12E-08	1.75E-08	1.12E-08
W	1.43E-05	4.34E-06	1.87E-06	1.11E-06	7.54E-07	3.57E-07	1.23E-07	5.32E-08	3.01E-08	1.93E-08
WNW	1.95E-05	5.94E-06	2.58E-06	1.53E-06	1.05E-06	4.99E-07	1.74E-07	7.59E-08	4.33E-08	2.79E-08
NW	1.66E-05	5.06E-06	2.20E-06	1.31E-06	8.91E-07	4.25E-07	1.48E-07	6.49E-08	3.70E-08	2.40E-08
NNW	9.71E-06	2.96E-06	1.28E-06	7.62E-07	5.20E-07	2.48E-07	8.60E-08	3.75E-08	2.14E-08	1.38E-08
N	6.72E-06	2.04E-06	8.79E-07	5.18E-07	3.52E-07	1.66E-07	5.66E-08	2.43E-08	1.37E-08	8.76E-09
NNE	4.73E-06	1.43E-06	6.15E-07	3.62E-07	2.45E-07	1.15E-07	3.94E-08	1.70E-08	9.61E-09	6.18E-09
NE	4.74E-06	1.43E-06	6.09E-07	3.56E-07	2.39E-07	1.12E-07	3.75E-08	1.60E-08	8.97E-09	5.74E-09
ENE	7.14E-06	2.16E-06	9.16E-07	5.36E-07	3.61E-07	1.68E-07	5.68E-08	2.43E-08	1.37E-08	8.81E-09
E	8.87E-06	2.69E-06	1.15E-06	6.74E-07	4.55E-07	2.13E-07	7.26E-08	3.13E-08	1.77E-08	1.14E-08
ESE	1.22E-05	3.71E-06	1.59E-06	9.33E-07	6.31E-07	2.96E-07	1.01E-07	4.33E-08	2.44E-08	1.57E-08
SE	9.93E-06	3.01E-06	1.28E-06	7.47E-07	5.03E-07	2.34E-07	7.86E-08	3.33E-08	1.86E-08	1.19E-08
SSE	6.38E-06	1.93E-06	8.22E-07	4.81E-07	3.24E-07	1.51E-07	5.02E-08	2.11E-08	1.17E-08	7.41E-09

Table 2.3.5-9 (Sheet 1 of 3)
Annual Average D/Q at Specified Distances for each Sector

Annual Average D/Q (m^{-2})											
Sector	Distance (miles)										
	0.25	0.5	0.75	1	1.5	2	2.5	3	3.5	4	4.5
S	2.28E-08	7.71E-09	3.96E-09	2.43E-09	1.21E-09	7.35E-10	4.97E-10	3.60E-10	2.74E-10	2.16E-10	1.75E-10
SSW	2.44E-08	8.26E-09	4.24E-09	2.60E-09	1.30E-09	7.87E-10	5.32E-10	3.86E-10	2.93E-10	2.31E-10	1.87E-10
SW	3.61E-08	1.22E-08	6.27E-09	3.85E-09	1.92E-09	1.16E-09	7.87E-10	5.70E-10	4.34E-10	3.42E-10	2.77E-10
WSW	3.60E-08	1.22E-08	6.25E-09	3.84E-09	1.91E-09	1.16E-09	7.85E-10	5.69E-10	4.33E-10	3.41E-10	2.76E-10
W	3.52E-08	1.19E-08	6.11E-09	3.75E-09	1.87E-09	1.13E-09	7.67E-10	5.56E-10	4.23E-10	3.33E-10	2.70E-10
WNW	3.95E-08	1.34E-08	6.87E-09	4.22E-09	2.10E-09	1.28E-09	8.62E-10	6.25E-10	4.75E-10	3.74E-10	3.03E-10
NW	3.46E-08	1.17E-08	6.00E-09	3.68E-09	1.84E-09	1.11E-09	7.53E-10	5.46E-10	4.15E-10	3.27E-10	2.65E-10
NNW	2.31E-08	7.82E-09	4.01E-09	2.47E-09	1.23E-09	7.45E-10	5.04E-10	3.65E-10	2.78E-10	2.19E-10	1.77E-10
N	2.60E-08	8.79E-09	4.51E-09	2.77E-09	1.38E-09	8.38E-10	5.66E-10	4.10E-10	3.12E-10	2.46E-10	1.99E-10
NNE	2.02E-08	6.84E-09	3.51E-09	2.16E-09	1.08E-09	6.52E-10	4.41E-10	3.19E-10	2.43E-10	1.91E-10	1.55E-10
NE	3.21E-08	1.09E-08	5.57E-09	3.42E-09	1.71E-09	1.03E-09	6.99E-10	5.07E-10	3.85E-10	3.04E-10	2.46E-10
ENE	5.80E-08	1.96E-08	1.01E-08	6.18E-09	3.08E-09	1.87E-09	1.26E-09	9.16E-10	6.97E-10	5.49E-10	4.44E-10
E	5.17E-08	1.75E-08	8.98E-09	5.52E-09	2.75E-09	1.67E-09	1.13E-09	8.17E-10	6.21E-10	4.90E-10	3.96E-10
ESE	5.98E-08	2.02E-08	1.04E-08	6.38E-09	3.18E-09	1.93E-09	1.30E-09	9.45E-10	7.19E-10	5.66E-10	4.58E-10
SE	5.49E-08	1.86E-08	9.53E-09	5.85E-09	2.92E-09	1.77E-09	1.20E-09	8.67E-10	6.59E-10	5.19E-10	4.21E-10
SSE	2.45E-08	8.29E-09	4.26E-09	2.61E-09	1.30E-09	7.90E-10	5.34E-10	3.87E-10	2.95E-10	2.32E-10	1.88E-10

Table 2.3.5-9 (Sheet 2 of 3)
Annual Average D/Q at Specified Distances for each Sector

Annual Average D/Q (m^{-2})											
Sector	Distance (miles)										
	5	7.5	10	15	20	25	30	35	40	45	50
S	1.44E-10	7.08E-11	4.44E-11	2.24E-11	1.36E-11	9.11E-12	6.53E-12	4.90E-12	3.81E-12	3.04E-12	2.48E-12
SSW	1.55E-10	7.58E-11	4.76E-11	2.41E-11	1.46E-11	9.76E-12	6.99E-12	5.25E-12	4.08E-12	3.26E-12	2.66E-12
SW	2.29E-10	1.12E-10	7.04E-11	3.56E-11	2.15E-11	1.44E-11	1.03E-11	7.76E-12	6.04E-12	4.82E-12	3.94E-12
WSW	2.28E-10	1.12E-10	7.02E-11	3.55E-11	2.15E-11	1.44E-11	1.03E-11	7.74E-12	6.02E-12	4.81E-12	3.93E-12
W	2.23E-10	1.09E-10	6.85E-11	3.46E-11	2.10E-11	1.41E-11	1.01E-11	7.56E-12	5.88E-12	4.70E-12	3.84E-12
WNW	2.51E-10	1.23E-10	7.70E-11	3.89E-11	2.36E-11	1.58E-11	1.13E-11	8.50E-12	6.61E-12	5.28E-12	4.31E-12
NW	2.19E-10	1.07E-10	6.73E-11	3.40E-11	2.06E-11	1.38E-11	9.89E-12	7.43E-12	5.78E-12	4.61E-12	3.77E-12
NNW	1.47E-10	7.18E-11	4.50E-11	2.28E-11	1.38E-11	9.24E-12	6.62E-12	4.97E-12	3.87E-12	3.09E-12	2.52E-12
N	1.65E-10	8.07E-11	5.06E-11	2.56E-11	1.55E-11	1.04E-11	7.44E-12	5.59E-12	4.34E-12	3.47E-12	2.83E-12
NNE	1.28E-10	6.28E-11	3.94E-11	1.99E-11	1.21E-11	8.08E-12	5.79E-12	4.35E-12	3.38E-12	2.70E-12	2.20E-12
NE	2.03E-10	9.96E-11	6.25E-11	3.16E-11	1.91E-11	1.28E-11	9.19E-12	6.90E-12	5.36E-12	4.28E-12	3.50E-12
ENE	3.68E-10	1.80E-10	1.13E-10	5.71E-11	3.46E-11	2.32E-11	1.66E-11	1.25E-11	9.70E-12	7.75E-12	6.32E-12
E	3.28E-10	1.61E-10	1.01E-10	5.10E-11	3.08E-11	2.07E-11	1.48E-11	1.11E-11	8.65E-12	6.91E-12	5.64E-12
ESE	3.79E-10	1.86E-10	1.17E-10	5.89E-11	3.57E-11	2.39E-11	1.71E-11	1.29E-11	1.00E-11	7.99E-12	6.52E-12
SE	3.48E-10	1.71E-10	1.07E-10	5.41E-11	3.27E-11	2.19E-11	1.57E-11	1.18E-11	9.18E-12	7.33E-12	5.98E-12
SSE	1.55E-10	7.61E-11	4.78E-11	2.41E-11	1.46E-11	9.80E-12	7.02E-12	5.27E-12	4.10E-12	3.27E-12	2.67E-12

Table 2.3.5-9 (Sheet 3 of 3)
Annual Average D/Q at Specified Distances for each Sector

Annual Average D/Q (m^{-2})										
Sector	**Distance (miles)**									
	0.5–1	**1–2**	**2–3**	**3–4**	**4–5**	**5–10**	**10–20**	**20–30**	**30–40**	**40–50**
S	4.11E-09	1.27E-09	5.05E-10	2.76E-10	1.76E-10	7.54E-11	2.34E-11	9.27E-12	4.95E-12	3.06E-12
SSW	4.41E-09	1.36E-09	5.42E-10	2.96E-10	1.88E-10	8.08E-11	2.51E-11	9.93E-12	5.30E-12	3.28E-12
SW	6.52E-09	2.01E-09	8.01E-10	4.38E-10	2.78E-10	1.20E-10	3.71E-11	1.47E-11	7.84E-12	4.85E-12
WSW	6.50E-09	2.01E-09	7.99E-10	4.37E-10	2.77E-10	1.19E-10	3.70E-11	1.47E-11	7.82E-12	4.84E-12
W	6.35E-09	1.96E-09	7.80E-10	4.26E-10	2.71E-10	1.16E-10	3.61E-11	1.43E-11	7.64E-12	4.73E-12
WNW	7.13E-09	2.20E-09	8.77E-10	4.79E-10	3.05E-10	1.31E-10	4.06E-11	1.61E-11	8.59E-12	5.32E-12
NW	6.23E-09	1.93E-09	7.66E-10	4.19E-10	2.66E-10	1.14E-10	3.55E-11	1.41E-11	7.50E-12	4.64E-12
NNW	4.17E-09	1.29E-09	5.13E-10	2.80E-10	1.78E-10	7.65E-11	2.37E-11	9.40E-12	5.02E-12	3.11E-12
N	4.69E-09	1.45E-09	5.76E-10	3.15E-10	2.00E-10	8.60E-11	2.67E-11	1.06E-11	5.64E-12	3.49E-12
NNE	3.65E-09	1.13E-09	4.49E-10	2.45E-10	1.56E-10	6.69E-11	2.08E-11	8.22E-12	4.39E-12	2.72E-12
NE	5.79E-09	1.79E-09	7.12E-10	3.89E-10	2.47E-10	1.06E-10	3.29E-11	1.31E-11	6.97E-12	4.31E-12
ENE	1.05E-08	3.23E-09	1.29E-09	7.03E-10	4.47E-10	1.92E-10	5.95E-11	2.36E-11	1.26E-11	7.80E-12
E	9.33E-09	2.88E-09	1.15E-09	6.27E-10	3.99E-10	1.71E-10	5.31E-11	2.10E-11	1.12E-11	6.95E-12
ESE	1.08E-08	3.34E-09	1.33E-09	7.25E-10	4.61E-10	1.98E-10	6.14E-11	2.43E-11	1.30E-11	8.04E-12
SE	9.91E-09	3.06E-09	1.22E-09	6.65E-10	4.23E-10	1.82E-10	5.63E-11	2.23E-11	1.19E-11	7.38E-12
SSE	4.42E-09	1.37E-09	5.44E-10	2.97E-10	1.89E-10	8.11E-11	2.52E-11	9.97E-12	5.33E-12	3.30E-12

Table 2.3.5-10 (Sheet 1 of 4)
X/Q and D/Q Values for No Decay, Decay, and Undepleted, at Each Receptor Location

RECEPTOR	SECTOR	DISTANCE		X/Q Values (s/m³)			D/Q
				No Decay	2.26 Day Decay	8.00 Day Decay	
		(Miles)	(Meters)	Undepleted	Undepleted	Depleted	(m^{-2})
Analytical EAB	**S**	0.21	335	6.000E-05	5.900E-05	5.600E-05	3.000E-08
Analytical EAB	**SSW**	0.21	335	5.400E-05	5.400E-05	5.100E-05	3.200E-08
Analytical EAB	**SW**	0.21	335	6.300E-05	6.300E-05	5.900E-05	4.700E-08
Analytical EAB	**WSW**	0.21	335	9.200E-05	9.200E-05	8.600E-05	4.700E-08
Analytical EAB	**W**	0.21	335	1.500E-04	1.500E-04	1.400E-04	4.600E-08
Analytical EAB	**WNW**	0.21	335	2.000E-04	2.000E-04	1.900E-04	5.200E-08
Analytical EAB	**NW**	0.21	335	1.700E-04	1.700E-04	1.600E-04	4.500E-08
Analytical EAB	**NNW**	0.21	335	1.000E-04	1.000E-04	9.500E-05	3.000E-08
Analytical EAB	**N**	0.21	335	7.000E-05	7.000E-05	6.500E-05	3.400E-08
Analytical EAB	**NNE**	0.21	335	4.900E-05	4.900E-05	4.600E-05	2.700E-08
Analytical EAB	**NE**	0.21	335	4.900E-05	4.900E-05	4.600E-05	4.200E-08
Analytical EAB	**ENE**	0.21	335	7.400E-05	7.400E-05	6.900E-05	7.600E-08
Analytical EAB	**E**	0.21	335	9.200E-05	9.100E-05	8.500E-05	6.800E-08
Analytical EAB	**ESE**	0.21	335	1.300E-04	1.300E-04	1.200E-04	7.900E-08
Analytical EAB	**SE**	0.21	335	1.000E-04	1.000E-04	9.500E-05	7.200E-08
Analytical EAB	**SSE**	0.21	335	6.500E-05	6.500E-05	6.100E-05	3.200E-08

Table 2.3.5-10 (Sheet 2 of 4)
X/Q and D/Q Values for No Decay, Decay, and Undepleted, at Each Receptor Location

RECEPTOR	SECTOR	DISTANCE		X/Q Values (s/m^3)			D/Q
				No Decay	2.26 Day Decay	8.00 Day Decay	
		(Miles)	(Meters)	Undepleted	Undepleted	Depleted	(m^{-2})
GARDEN	S	2.64	4254	8.500E-07	8.100E-07	6.800E-07	4.500E-10
GARDEN	SSW	0.69	1113	6.400E-06	6.300E-06	5.700E-06	4.900E-09
GARDEN	SW	0.95	1522	4.400E-06	4.300E-06	3.800E-06	4.200E-09
GARDEN	WSW	1.37	2203	3.500E-06	3.400E-06	3.000E-06	2.200E-09
GARDEN	W	1.78	2861	3.800E-06	3.700E-06	3.200E-06	1.400E-09
GARDEN	WNW	1.15	1848	1.000E-05	9.900E-06	8.700E-06	3.300E-09
GARDEN	NW	1.23	1978	7.800E-06	7.600E-06	6.700E-06	2.600E-09
GARDEN	NNW	4.87	7833	6.300E-07	5.800E-07	4.600E-07	1.500E-10
GARDEN	NE	0.67	1072	6.100E-06	6.100E-06	5.500E-06	6.800E-09
GARDEN	E	2.36	3802	1.500E-06	1.500E-06	1.200E-06	1.200E-09
GARDEN	ESE	0.92	1482	9.100E-06	9.000E-06	8.000E-06	7.300E-09
GARDEN	SE	1.93	3111	2.300E-06	2.200E-06	1.900E-06	1.900E-09
GARDEN	SSE	0.92	1486	4.700E-06	4.600E-06	4.100E-06	3.000E-09

Table 2.3.5-10 (Sheet 3 of 4)
X/Q and D/Q Values for No Decay, Decay, and Undepleted, at Each Receptor Location

RECEPTOR	SECTOR	DISTANCE		X/Q Values (s/m³)			D/Q
				No Decay	2.26 Day Decay	8.00 Day Decay	
		(Miles)	(Meters)	Undepleted	Undepleted	Depleted	(m^{-2})
RESIDENCE	S	0.84	1359	5.000E-06	4.900E-06	4.400E-06	3.200E-09
RESIDENCE	SSW	0.69	1113	6.400E-06	6.300E-06	5.700E-06	4.900E-09
RESIDENCE	SW	0.62	995	9.100E-06	9.000E-06	8.200E-06	8.600E-09
RESIDENCE	WSW	0.71	1136	1.000E-05	1.000E-05	9.300E-06	6.900E-09
RESIDENCE	W	0.91	1470	1.100E-05	1.100E-05	9.400E-06	4.400E-09
RESIDENCE	WNW	0.66	1066	2.500E-05	2.500E-05	2.300E-05	8.500E-09
RESIDENCE	NW	0.62	992	2.500E-05	2.500E-05	2.200E-05	8.300E-09
RESIDENCE	NNW	4.35	6997	7.300E-07	6.800E-07	5.500E-07	1.900E-10
RESIDENCE	N	4.86	7814	4.300E-07	3.900E-07	3.100E-07	1.700E-10
RESIDENCE	NE	0.67	1072	6.100E-06	6.100E-06	5.500E-06	6.800E-09
RESIDENCE	ENE	0.71	1149	8.200E-06	8.100E-06	7.300E-06	1.100E-08
RESIDENCE	E	0.69	1118	1.100E-05	1.100E-05	9.500E-06	1.000E-08
RESIDENCE	ESE	0.69	1117	1.500E-05	1.500E-05	1.300E-05	1.200E-08
RESIDENCE	SE	0.8	1288	9.400E-06	9.200E-06	8.300E-06	8.500E-09
RESIDENCE	SSE	0.81	1304	5.900E-06	5.800E-06	5.200E-06	3.700E-09

Table 2.3.5-10 (Sheet 4 of 4)
X/Q and D/Q Values for No Decay, Decay, and Undepleted, at Each Receptor Location

RECEPTOR	SECTOR	DISTANCE		X/Q Values (s/m^3)			D/Q
				No Decay	2.26 Day Decay	8.00 Day Decay	
		(Miles)	(Meters)	Undepleted	Undepleted	Depleted	(m^{-2})
BEEF ANIMAL	**S**	1.95	3144	1.300E-06	1.300E-06	1.100E-06	7.700E-10
BEEF ANIMAL	**SSW**	2.79	4488	7.100E-07	6.700E-07	5.600E-07	4.400E-10
BEEF ANIMAL	**SW**	2.92	4695	7.600E-07	7.300E-07	6.000E-07	6.000E-10
BEEF ANIMAL	**WSW**	0.71	1138	1.000E-05	1.000E-05	9.300E-06	6.900E-09
BEEF ANIMAL	**W**	3.1	4984	1.700E-06	1.600E-06	1.300E-06	5.300E-10
BEEF ANIMAL	**WNW**	0.7	1120	2.300E-05	2.300E-05	2.100E-05	7.800E-09
BEEF ANIMAL	**NW**	1.01	1627	1.100E-05	1.000E-05	9.200E-06	3.600E-09
BEEF ANIMAL	**NNW**	4.87	7833	6.300E-07	5.800E-07	4.600E-07	1.500E-10
BEEF ANIMAL	**E**	2.88	4629	1.200E-06	1.100E-06	9.100E-07	8.800E-10
BEEF ANIMAL	**ESE**	2.79	4492	1.700E-06	1.600E-06	1.300E-06	1.100E-09
BEEF ANIMAL	**SE**	2.59	4171	1.500E-06	1.400E-06	1.200E-06	1.100E-09
BEEF ANIMAL	**SSE**	1.93	3106	1.500E-06	1.400E-06	1.200E-06	8.400E-10

Notes:
A circular, analytical exclusion area boundary (EAB) was defined at a fixed distance from an effluent release boundary. The distance used between the boundaries was 1100 ft (335 m).
The nearest garden is defined as the minimum distance from the center point of the site.
The nearest residence is defined as the minimum distance from the center point of the site.
There were no milk-producing animals within 5 mi (8.05 km) of the site. Therefore, the nearest beef animal was analyzed.
Sectors without applicable receptors are not shown.

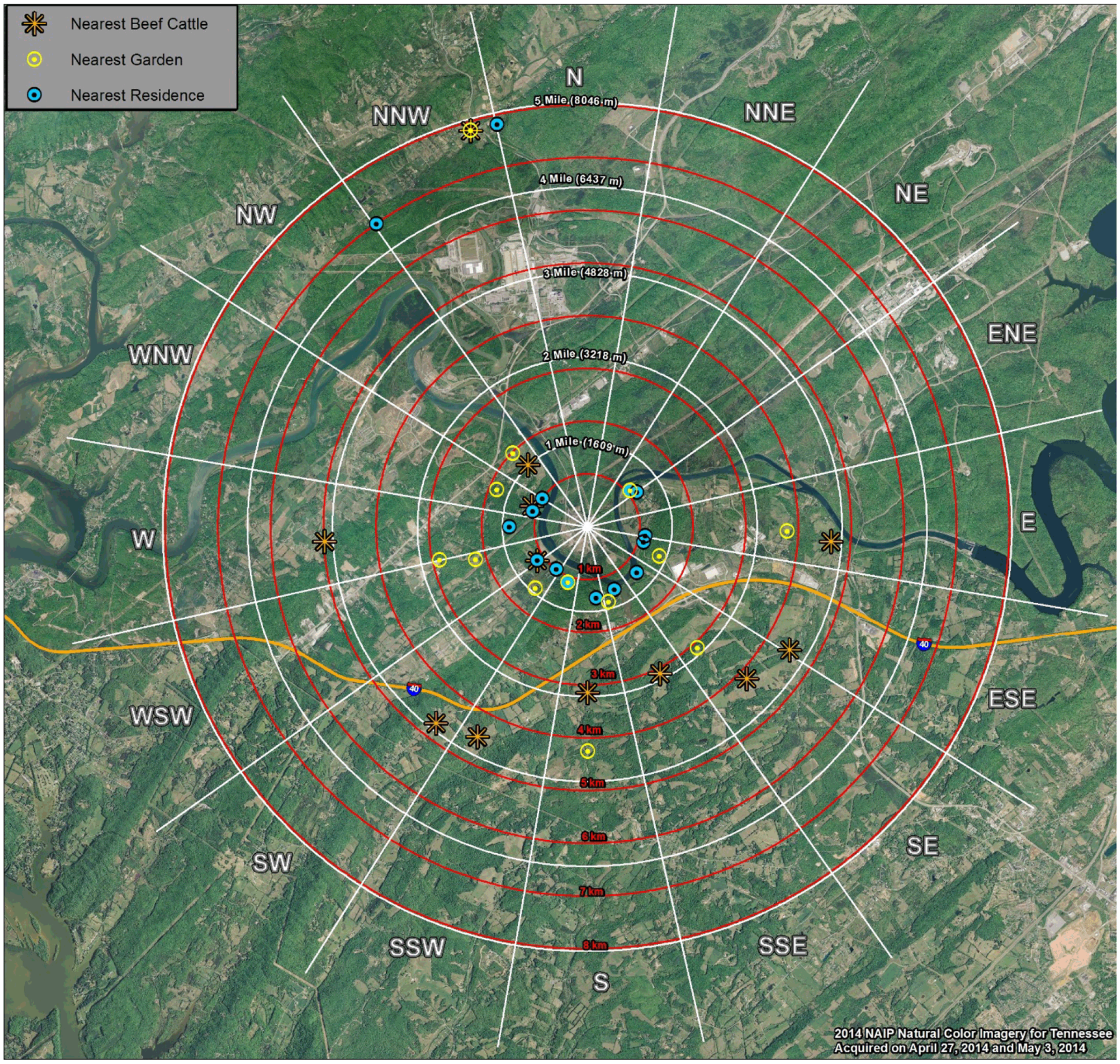


Figure 2.3.5-1. Location of Sensitive Receptors (Land Use Survey)

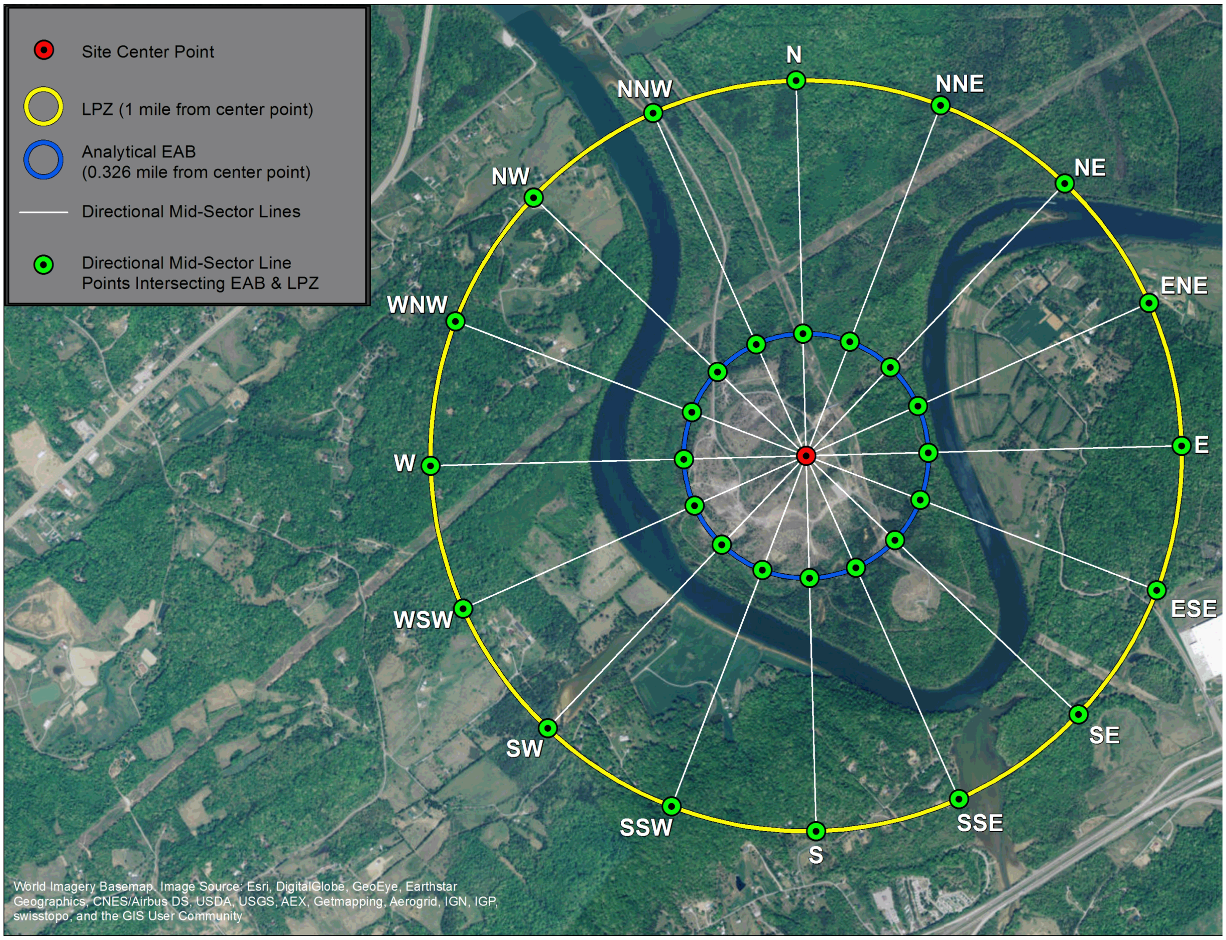


Figure 2.3.5-2. LPZ and Analytical EAB Distances Used for Terrain Analysis