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1.7 METEOROLOGY AND AIR QUALITY

1.7.1 GENERAL CLIMATE

{The Calvert Cliffs Nuclear Power Plant (CCNPP) site is located in Calvert County. Calvert County is in that portion of Maryland commonly referred to as Southern Maryland, and is located on the Coastal Plain (USEPA, 2006a). The weather data used to create this narrative is from the period 1971-2000 (USDC, 2007a).

Seasons are well defined. Winter is the dormant season for plant growth due to low temperatures rather than drought. Spring and fall are characterized by a rapid succession of warm and cold fronts associated with storm systems that generally move from a westerly direction. Summers are warm to hot. The higher humidity along the Atlantic coast causes the summer heat to feel more oppressive and the winter cold to feel more penetrating than for drier climates.

At times, the Appalachian Mountains provide some protection from arctic air outbreaks in the winter. The mountain barrier may cause warming of the air descending the eastern slopes by as much as 10°F (6°C). In situations when high pressure is located over New England and a low pressure system is over the Ohio Valley, cold low-level winds may travel southwestward and be held east of the mountains.}

1.7.1.1 Winds

{The prevailing winds at the surface are determined by the frequency and intensity of anticyclones and cyclones that persist or move over the area. The majority of anticyclonic circulation over the northern portion of North America in winter brings a high percentage of cold northwesterly winds to Maryland. Therefore, the prevailing winds are from the northwesterly quadrant from October through June. In the summer, this pattern changes as the semi-permanent Atlantic High moves northwestward and dominates the circulation of air over the eastern U.S. A flow of warm, moist air spreads over the area with winds from the southwesterly quadrant most of the time. During the summer, the northern portion of North America is dominated by low pressure and the mean storm track is displaced north of Maryland.

Surface mean wind speeds range from 9 to 10 mph (4 to 5 mps) in summer to 10 to 12 mph (5 to 5.4 mps) in winter and early spring. The highest mean wind speeds are associated with the frequent passages of well-developed cyclones and anticyclones in the early spring.}

1.7.1.2 Storm Tracks

{Almost all migrating cyclones and anticyclones cross the U.S. from west to east. The greater numbers of cyclones travel in a northeastward direction in a path about 300 to 500 mi (483 to 805 km) north of Maryland. Storms that originate in the Gulf of Mexico, the southeastern U.S. or adjacent Atlantic coastal regions, frequently move northeastward or northward along the Atlantic Coast and can bring violent, destructive weather to the Maryland region. As these storms, commonly referred to as Northeasters, approach from the south, strong easterly to northeasterly winds bring widespread rains and cause higher than normal tides along the Atlantic Coast and on the west side of the Chesapeake Bay. Tropical cyclones or hurricanes that develop in the West Indies, the Caribbean, or the Gulf of Mexico sometimes move into, but rarely pass entirely over the State of Maryland. These systems also cause cloudy weather, heavy rains, and high tides.}

1.7.1.3 Temperatures

{Mean annual temperatures range from 48°F (9°C) in Northern Maryland to 58°F (14°C) in the lower Chesapeake Bay area. The winter climate on the Coastal Plain of Maryland is intermediate between the cold of the northeast and the mild weather of the South. The average frost penetration is about 5 in (12.7 cm) in extreme Southern Maryland; in extremely cold winters, maximum frost penetration may be double the average depth. Summer is characterized by considerable warm weather with at least several hot, humid periods. Nights are usually comfortable.

On the average, temperatures of 90°F (32°C) or higher occur 15 to 25 days per year along the shores of the Chesapeake Bay. The average number of days per year with minimum temperature of 32°F (0°C) or lower is about 80 along the shores of the southern Chesapeake Bay area. Average relative humidity is lower in the winter and early spring, from February through April, and highest in the late summer and early fall, from August to October.}

1.7.1.4 Precipitation

{Annual average precipitation is about 40 to 46 in (102 to 117 cm). Distribution is uniform throughout the year. Although the heaviest precipitation occurs in the summer, this is the season when severe droughts are most frequent. Summer precipitation is less dependable and more variable than in winter. Annual precipitation deficits of over 16 in (40 cm) occurred during extreme droughts of the 1930s, 1960s, and in the period from 1998-2002. Annual average snowfall along the coast ranges from 8 to 10 in (20 to 25 cm). Annual snowfall totals vary considerably from one year to another.

The most favorable situation for rain is when there is a well-developed high pressure system over New England or the St. Lawrence Valley and a well-developed low pressure system over Georgia, Tennessee or the Ohio Valley. The reverse of this situation usually produces clear, dry weather.}

1.7.2 REGIONAL AIR QUALITY

1.7.2.1 Background

The Clean Air Act (USEPA, 1990), which was last amended in 1990, requires the U.S. Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (CFR, 2007d) for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards.

- Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
- Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. Units of measure for the standards are parts per million (ppm), milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$). Areas are either in attainment of the air quality standards or in non-attainment. Attainment means that the air quality is better than the standard.

1.7.2.2 {Calvert County

Based on U.S. EPA data, Calvert County, Maryland, is in attainment for all the National Ambient Air Quality Standards (NAAQS) except for the eight hour ozone standard (USEPA, 2006a) as of December 5, 2006. The eight hour ozone standard is 0.08 ppm and attainment is determined by whether the 3 year average of the fourth highest daily maximum 8 hour average ozone concentrations measured at each monitor within an area over each year exceeds the standard. From Figure 2.7-1, it can be seen that the fourth highest 8 hour average ozone concentration for Calvert County during 2006 is greater than 0.08 ppm and less than or equal to 1.0 ppm. Non-attainment of the eight hour ozone standard is due to Calvert County's proximity to Washington, D.C. A non-attainment designation requires a plan to be sent to the U.S. EPA describing how the area will implement air quality improvements. Note that the Maryland Department of the Environment reported that ground-level ozone levels have continued to show significant improvements since the early 1990s (MDE, 2007).

Calvert County is part of the Southern Maryland Intrastate Air Quality Control Region (AQCR), as designated in 40 CFR 81.156 (CFR, 2007a). The attainment status of the Southern Maryland Intrastate AQCR with regard to national ambient air quality standards is listed as being better than national standards for total suspended particulates, sulfur dioxide, and nitrogen dioxide, and unclassifiable/attainment for carbon monoxide, PM-2.5 (particulate matter with diameter less than 2.5 microns), and for the 8 hour ozone standard (CFR, 2007b).}

1.7.3 SEVERE WEATHER PHENOMENA

1.7.3.1 Tornadoes

{Tornadoes occur infrequently in Maryland compared with areas such as the Great Plains. Of the ones that do occur, most are small and result in nominal losses. However, two strong tornadoes hit Central and Southern Maryland within an eight month period in 2001-2002. About 25% of the tornadoes occur in Southern Maryland. Approximately 70% of the tornadoes occur between 2:00 PM and 9:00 PM with most occurring from 3:00 PM to 6:00 PM. As can be seen in Figure 2.7-2 and Figure 2.7-3, the annual average number of tornadoes and strong-violent tornadoes (F2-F5) are four and one, respectively (USDC, 2000).

In the period from January 1, 1950, through December 31, 2006, 12 tornados were reported in Calvert County (USDC, 2007b). This corresponds to an annual average of 0.2 tornados per year. The magnitude of the tornados ranged from F0 to F2, as designated by the National Weather Service. An F0 tornado has estimated wind speeds less than 73 mph (33 mps). An F1 tornado has estimated wind speeds between 73 and 112 mph (33 and 50 mps). An F2 tornado has estimated wind speeds between 113 and 157 mph (50 and 70 mps). In Calvert County, the 12 tornadoes had paths with widths estimated to range from 51 to 600 ft (16 to 183 m).

Figure 2.7-4 shows the date of maximum tornado threat for locations meeting the minimum data requirements of the study (the gray shaded areas). This figure is from a study reported in the Weather and Forecasting journal of the American Meteorological Society (AMS, 2003), in which an estimate was made of the probability of an occurrence of a tornado day near any location in the contiguous U.S. for any time during the year. The study applied Gaussian smoothers in space and time to the observed tornado days from 1980 to 1999 to produce daily maps and annual cycles at any point on a 50 mi by 50 mi (80 km by 80 km) grid. Areas with a white background signify that there was not enough information to predict the maximum tornado threat date, not that a tornado would not or could not occur. Late July is indicated as the date of maximum tornado threat for the part of Maryland that includes the CCNPP site (AMS, 2003).}

1.7.3.2 Hurricanes and Tropical Storms

{Hurricanes sometimes move into but rarely pass entirely over the CCNPP site. National Hurricane Center statistics list only two direct hits on Maryland during the period from 1851 to 2004; neither of these was a major (greater than Category 2) hurricane (NOAA, 2005). Note that the Saffir-Simpson Hurricane Scale ranks hurricanes on a scale of 1-5 based on the intensity of the storm (NOAA, 2007a). In the eastern U.S., hurricane season begins June 1st and ends November 30th.

Table 2.7-1 shows the total and average number of tropical storms and hurricanes, by month, in the U.S., for the period 1851-2004 (NOAA, 2005). Note that most tropical storms and hurricanes occur in September.

The National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center reports that there were 96 tropical storms and hurricanes that passed within 100 nautical miles (185 km) of Calvert County, Maryland, during the period from 1851 through 2005. Of these 96 events, eight were Category 1 hurricanes, two were Category 2 hurricanes, and one was a Category 3 hurricane (NOAA, 2007b). The hurricanes occurred in the months of August, September, and October. The tropical storms occurred in the months of July, August, September, and October. In addition to the hurricanes and tropical storms, there were 41 extratropical storms, 33 tropical depressions, and four subtropical depressions that passed within 100 nautical miles (185 km) of Calvert County, Maryland, during the period from 1851 through 2005.

On September 1, 2006, the remnants of Tropical Storm Ernesto dropped between 7 and 10 in (18 to 28 cm) of rain in Calvert County. On July 3, 2003, the remnants of Tropical Storm Bill dropped over 2 in (5.1 cm) of rain in parts of Calvert County. On June 15, 2001, the remnants of Tropical Storm Allison dropped between 1.5 to 3.5 in (3.8 to 8.9 cm) of rain on Calvert County (USDC, 2007b).}

1.7.3.3 Thunderstorms

{Thunderstorms are reported at any given station in the vicinity of Calvert County on an average of 30 to 40 days per year based on information from the National Climatic Data Center. They occur in all months of the year, but the majority occur in May through August (75% to 80%). They occur less than once per month from November to February. Thunderstorms are most likely to occur during the afternoon and evening hours.

Table 2.7-2 presents the monthly mean number of days on which thunderstorms occurred in the region during the period from 1971 through 2002 using local climatology data from Baltimore, Maryland (USDC, 2002a), Norfolk, Virginia (USDC, 2002b), Richmond, Virginia (USDC, 2002c) and regional precipitation data (USDC, 2002d).}

1.7.3.4 Lightning

A methodology was presented (Marshall, 1973) for estimating lightning strike frequencies that includes consideration of the attractive area of structures. The method consists of determining the number of lightning flashes to earth per year per square kilometer and then defining an area over which the structure can be expected to attract a lightning strike. {There are four flashes to earth per year per square kilometer in the vicinity of the CCNPP site} (conservatively estimated using Figure 2.7-5 (NOAA, 2007c)). The total attractive area, A, of a structure with length L, width W, and height H, for lightning flashes with a current magnitude of 50% of all lightning flashes is defined (Marshall, 1973) as:

$\{A = LW + 4H (L + W) + 12.57 H^2$

The following building dimensions were used to conservatively estimate the attractive area of CCNPP Unit 3 (these values are much larger than the dimensions for the tallest building which measure approximately 58 m x 58 m x 60 m; they are also larger than the approximate dimensions of the combined containment, the four safeguards buildings, the access building, the fuel building, and the nuclear auxiliary building):

L = 215 m, W = 140 m, H = 40 m

The total attractive area is therefore equal to 0.11 square kilometers.

Consequently, the lightning strike frequency computed using Marshall's methodology for CCNPP Unit 3 is 0.44 flashes per year. }

1.7.3.5 Droughts

{Droughts in Calvert County occur most frequently during the summer season based on data from the National Climatic Data Center. Annual precipitation deficits of over 16 in (40 cm) occurred during extreme droughts of the 1930s, 1960s, and in the period of 1998-2002.}

1.7.3.6 High Winds

{Table 2.7-3 presents occurrences of winds greater than 50 knots (58 mph (26 mps)) by storm type for Calvert County. These data were retrieved from the National Climatic Data Center (USDC, 2007b). During the period from June 2, 1980, through December 31, 2006, there were 17 recorded occurrences of wind speed ranging from 50 to 90 knots (58 to 104 mph (26 to 46 mps)). The highest wind speed was recorded on April 21, 2000.}

1.7.3.7 Hail

{Table 2.7-4 presents 20 hail events reported in Calvert County between October 9, 1962, and December 31, 2006. These data were retrieved from the National Climatic Data Center (USDC, 2007b). Hail stone diameters ranged from 0.75 to 2 in (1.9 to 5.1 cm). The largest hail stone diameter was recorded on July 15, 1996.}

1.7.3.8 Ice Storms

{Table 2.7-5 presents five ice storm events reported in Calvert County between January 14, 1999, and December 31, 2006. These data were retrieved from the National Climatic Data Center (USDC, 2007b). Ice thickness ranged from 0.2 to 1 in (0.5 to 2.5 cm). The largest ice accumulation was recorded on January 30, 2000.}

1.7.3.9 Snow Storms

{Table 2.7-117 presents snow storm events which occurred in Calvert County between December 28, 1993, and December 31, 2006. These data were retrieved from the National Climatic Data Center (USDC, 2007b). Snow amounts ranged from a trace to 16.5 inches (41.9 cm).}

1.7.4 LOCAL METEOROLOGY

{The CCNPP site meteorological data was used in this analysis. These data are from the onsite meteorological monitoring program which was designed, and has been operated, according to

Regulatory Guide 1.23, Revision 0 (NRC, 1972). The data recovery goal of 90% was met for each of the six years of data (2000 through 2005).

An analysis of the differences between Regulatory Guide 1.23, Revision 0, and Regulatory Guide 1.23, Revision 1 (NRC, 2007), was made and it was concluded that the guidance provided in the two versions of the document are so similar that there is no adverse impact from using the onsite meteorological data monitored for CCNPP Units 1 and 2 in analyses for CCNPP Unit 3.}

1.7.4.1 Temperature and Relative Humidity

{Monthly and annual temperature summaries from the CCNPP onsite meteorological monitoring program are presented in Tables 2.7-6 through Table 2.7-13 for the period from January 2000 through December 2005.

The monthly mean temperature at the CCNPP site ranges from 34.3°F (1.3°C) in January to 75.1°F (23.9°C) in July. The monthly mean extreme maximum temperature was 78.3°F (25.7°C) in July and the monthly mean extreme minimum temperature was 29.5°F (-1.4°C) in January. The monthly mean daily maximum temperature was 81.8°F (27.7°C) in July and the monthly mean daily minimum temperature was 28.5°F (-1.9°C) in January. The maximum hourly temperature was 96.3°F (35.7°C) in July and the minimum hourly temperature was 8.5°F (-13.1°C) in December. The frequency of occurrence of hourly temperature values falling below the freezing point (32°F or 0°C) is less than 10%.

Temperature and humidity statistics from sites around the CCNPP site are presented in Tables 2.7-14 through 2.7-26 (ASHRAE, 2005) (USDC, 2002a) (USDC, 2002b) (USDC, 2002c) (USDC, 2002d). Dry bulb temperature values are from the 30 year period from 1971-2000. Wet bulb temperature values are from the 18 year period from 1983-2000. Note that the monthly mean temperatures measured at the CCNPP site show good correspondence with the values presented in these tables, for example, almost all of the mean monthly temperatures measured at the CCNPP site fall within the range of values reported by the surrounding stations.

Tables 2.7-24 through 2.7-26 present the monthly design wet bulb temperature and the mean coincident dry bulb temperature for locations in the vicinity of CCNPP. These wet bulb temperature values correspond to 0.4%, 1.0%, and 2.0% cumulative frequency of occurrence for the indicated month (ASHRAE, 2005) and were determined by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). Data for the Patuxent River Naval Air Station, Maryland, are from the period 1982-2001. Data from Salisbury Wicomico County Airport, Maryland, are from the period 1982-2001. Data from Baltimore, Maryland, are from 1972-2001.}

1.7.4.2 Precipitation and Fog

{The monthly and annual precipitation summary from the CCNPP onsite meteorological monitoring program is presented in Tables 2.7-27 through 2.7-30 for the period from 2000-2005.

Monthly and annual summaries of heavy fog (visibility less than 0.25 mi (0.2 km)) are presented in Table 2.7-34 for sites around the CCNPP site (USDC, 2002a) (USDC, 2002b) (USDC, 2002c). The fog observations were made at the National Weather Service (NWS) stations at Baltimore, MD, Norfolk, VA, and Richmond, VA. The average number of days per year with heavy fog in Baltimore, MD, Norfolk, VA, and Richmond, VA are 24.4, 19.7, and 27.1, respectively.

Precipitation statistics from NWS sites around the CCNPP site are presented in Tables 2.7-31 through 2.7-33. Monthly average precipitation at the CCNPP site ranges from 1.53 in (3.89 cm) in February to 4.53 in (11.51 cm) in July. Monthly percent frequency of occurrence of precipitation at the CCNPP site ranges from 4.26% in September to 7.87% in April. The rainfall rate distribution presented in Table 2.7-29 indicates that heavy rainfalls occur infrequently at the CCNPP site. The maximum monthly precipitation measured at the CCNPP site corresponds well with the values from the NWS sites around the plant. The minimum monthly precipitation measured at the CCNPP site, however, does not correspond well with the values from the NWS sites around the plant; this may be due to the difference in the period of records (6 years for the CCNPP site versus 30 years for the NWS sites).

Monthly precipitation wind roses at the CCNPP site for the 33 ft (10 m) and 197 ft (60 m) elevations are presented in Figures 2.7-6 through 2.7-29. These precipitation wind roses portray joint frequency distributions of wind speed and direction as a function of atmospheric stability for only the hours in which precipitation was recorded. Each of these monthly precipitation wind roses establishes that the most frequent wind direction has either a northerly or easterly component.

Monthly precipitation wind roses by precipitation rate classes at the CCNPP site for the 33 ft (10 m) and 197 ft (60 m) elevations are presented in Figures 2.7-30 through 2.7-172. These precipitation wind roses portray joint frequency distributions of wind speed and direction as a function of precipitation rate class for only the hours in which precipitation was recorded. For April through August and neglecting figures where there is only one observation, the figures show that for the larger precipitation rate classes (0.5 in/hr (1.3 cm/hr) and greater), the most frequent wind direction may have a southerly or westerly component. This could indicate high rainfall rates due to thunderstorms rather than offshore storms and their associated northeasterly winds. }

1.7.4.3 Monthly Mixing Height Data and Inversion Summary

{Monthly average mixing height values for the period 1996-2005 were calculated from the daily average values for each month of each year based on twice daily mixing height data from the National Climatic Data Center. These data were taken from the upper air and surface NWS stations closest to the CCNPP site (i.e., Wallops Island and Patuxent River, respectively). Overall monthly average mixing height values were calculated from the individual monthly average values; for example, the January overall monthly average mixing height value of 1978 ft (603 m) is the average of all of the individual January mixing height values. On average, the number of valid days of data per month (for months with data) ranged from 23 to 30 (that is, days that had both a morning and afternoon mixing height value). There were some months with no valid data. Data were unavailable for 17 out of 120 months with the majority of these months (15 of 17) being in 1996 and 1997. Since there are six years with 12 months of valid data and two years with 11 months of valid data, the missing data do not adversely impact the determination of the monthly and annual average mixing height values.

Figure 2.7-173 presents the monthly average mixing height values. Table 2.7-35 present the monthly average mixing height values in tabular form for meters and ft, respectively. As shown, the monthly average mixing heights ranged from 1,880 ft (573 m) in December to 2,959 ft (902 m) in July. The annual average mixing height was 2,454 ft (748 m).

Frequency and persistence of temperature inversion conditions at the CCNPP site are presented in Tables 2.7-36 through 2.7-41. These tables were developed using six years of onsite meteorological data (2000-2005). The maximum temperature inversion duration was 31 hours. Approximately two-thirds of the inversions lasted less than nine hours.}

1.7.4.4 Wind Speed and Direction

{Tables 2.7-42 through 2.7-67 present monthly and annual joint frequency distributions of wind speed and direction as a function of atmospheric stability derived from the CCNPP onsite meteorological monitoring program. These tables were developed using six years of onsite meteorological data (2000-2005) following the guidance in Regulatory Guide 1.23, Revision 0 (NRC, 1972). An analysis of the differences between Regulatory Guide 1.23, Revision 0, and Regulatory Guide 1.23, Revision 1 (NRC, 2007), was made and it was concluded that the guidance provided in the two versions of the document are so similar that there is no adverse impact from using the onsite meteorological data monitored for CCNPP Units 1 and 2 in analyses for CCNPP Unit 3.

The annual prevailing wind direction (the direction from which the wind blows most often) at the CCNPP site at the 33 ft (10 m) level is from the southwest, approximately 14% of the time. Winds from the southwest through west sectors occur approximately 26% of the time. Conversely, winds from the northeast through east sectors occur approximately 14% of the time. The annual prevailing wind direction at the 197 ft (60 m) level is from the southwest, approximately 10% of the time. Winds from the southwest through west sectors occur approximately 20% of the time. Conversely, winds from the northeast through east sectors occur approximately 13% of the time. As is normally the case, there are more observations of calm winds at the lower level than at the upper level (0.33% versus 0.03%). At both the 33 ft (10 m) and 197 ft (60 m) levels, winds occur most infrequently from the east-southeast.

During the winter months (December through February), the prevailing wind direction at both levels is from the northwest, approximately 13% of the time at both levels. Winds from the southwest are the next most dominant, occurring approximately 11% of the time at the 33 ft (10 m) level and approximately 9% of the time at the 197 ft (60 m) level. During the spring months (March through May), the prevailing wind direction at both levels is from the southwest, approximately 12% of the time at the lower level and 11% of the time at the upper level.

During the summer months (June through August), the prevailing wind direction at both levels is from the southwest, approximately 18% of the time at the lower level and 14% of the time at the upper level. During the autumn months (September through November), the prevailing wind direction at the 33 ft (10 m) level is from the southwest, approximately 12% of the time. At the 197 ft (60 m) level, the prevailing wind directions are from the north-northeast and from the south-southwest, approximately 9% of the time. The north-northeast flow dominates in September and October and the south-southwest flow dominates in November.

The most prevalent wind speed class on an annual basis for the 33 ft (10 m) level is the 4 to 7 mph (1.8 to 3.1 mps) class, which occurs approximately 47% of the time. The most prevalent wind speed class on an annual basis for the 197 ft (60 m) level is the 8 to 12 mph (3.6 to 5.4 mps) class which occurs approximately 40% of the time.

On a seasonal basis, the most prevalent wind speed class for the 33 ft (10 m) level is the 4 to 7 mph (1.8 to 3.1 mps) class which occurs approximately 42% of the time during the winter months (December through February), 45% of the time during the spring months (March through May), 54% during the summer months (June through August), and 46% during the autumn months (September through November). At the 197 ft (60 m) level, the most prevalent wind speed class is the 8 to 12 mph (3.6 to 5.4 mps) which occurs approximately 38% during the winter months (December through February), 38% during the spring months (March through May), 47% during the summer months (June through August), and 38% during the autumn months (September through November).

Tables 2.7-68 through 2.7-70 present monthly and annual summaries of wind speed and direction for three stations around the CCNPP site, i.e., Baltimore/Washington International Airport, Norfolk, Virginia, and Richmond, Virginia (USDC, 2002a) (USDC, 2002b) (USDC, 2002c). Note that the most prevalent wind speed class on an annual basis for the 33 ft (10 m) level at CCNPP is lower than the average annual wind speeds at the same measurement height presented for these three stations (8.9 mph (4.0 mps), 10.5 mph (4.7 mps), and 7.9 mph (3.5 mps), respectively); this would lead to more conservative atmospheric dispersion estimates using the CCNPP onsite meteorological data.

Figures 2.7-174 through 2.7-199 depict annual and monthly wind rose plots of the CCNPP 2000-2005 meteorological data for the 33 ft (10 m) and 197 ft (60 m) elevations.

Figures 2.7-200 through 2.7-202 depict multi-year average annual wind rose plots for three stations around CCNPP site, i.e., Baltimore/Washington International Airport, Norfolk, Virginia, and Richmond, Virginia (USEPA, 2006b).}

1.7.4.5 Wind Direction Persistence Summary

{Tables 2.7-71 through 2.7-84 present annual wind direction persistence summaries at the CCNPP site for the 33 ft (10 m) and 197 ft (60 m) elevations. They were generated using six years of onsite meteorological data (2000–2005). Table 2.7-77 and Table 2.7-84 present an average of the six individual year summaries for both elevations.

The majority of the time, approximately 86%, wind direction persistence events last for less than four hours at both measurement elevations. Wind direction persistence events lasting 12 hours occur six and eight times per year on the average for the lower and upper measurement level, respectively. Wind direction persistence events lasting greater than 24 hours occur once per year on the average for the lower and upper measurement level.}

1.7.4.6 Atmospheric Stability Persistence Summary

Depending on the amount of incoming solar radiation and other factors, the atmosphere may be more or less turbulent at any given time. Meteorologists have defined atmospheric stability classes, each representing a different degree of turbulence in the atmosphere. When moderate to strong incoming solar radiation heats air near the ground, causing it to rise and generate large eddies, the atmosphere is considered unstable, or relatively turbulent. Unstable conditions are associated with atmospheric stability classes A and B. When solar radiation is relatively weak or absent, air near the surface has a reduced tendency to rise, and less turbulence develops. In this case, the atmosphere is considered stable, or less turbulent, and the stability class would be E or F. Stability classes D and C represent conditions of more neutral stability, or moderate turbulence. Neutral conditions are associated with relatively strong wind speeds and moderate solar radiation.

Atmospheric stability is determined by the delta temperature method as defined in Regulatory Guide 1.23, Revision 0 (NRC, 1972) and Revision 1 (NRC, 2007). This methodology classifies atmospheric stability based on the temperature change with height (°C per 100 m). {At CCNPP, atmospheric stability is classified according to the difference between the temperature measurements at the 197 ft (60 m) and 33 ft (10 m) levels.

Tables 2.7-85 through 2.7-98 present annual atmospheric stability persistence summaries at the CCNPP site for the 33 ft (10 m) and 197 ft (60 m) elevations. They were generated using six years of onsite meteorological data (2000–2005). Tables 2.7-91 and 2.7-98 present an average of the six individual year summaries for both elevations.

The majority of the time, approximately 78%, stability persistence events last for less than four hours. Stability persistence events lasting 12 hours occur 19 times per year on the average and events lasting for greater than 24 hours occur nine times per year on the average.}

1.7.5 MAXIMUM TERRAIN HEIGHTS AND TOPOGRAPHIC MAPS

{Figures 2.7-203 and 2.7-204 present the maximum terrain heights from 0 to 5 mi (0 to 8 km) and from 0 to 50 mi (0 to 80 km), respectively, from the CCNPP site. Figures 2.7-205 and 2.7-206 present detailed topographic features (as modified by the plant) on a large scale within an 5 mi (8 km) radius of the station and a smaller scale map showing topography within a 50 mi (80 km) radius of the station, respectively.

These figures indicate that the highest terrain in the vicinity of the CCNPP site is in the west through north-northwest sectors. The Chesapeake Bay lies in the north through southwest sectors. The CCNPP site consists of low rolling hills. Elevations across the site range from 0 ft (0 m) msl (at the shoreline of the Chesapeake Bay) to 150 ft (46 m) msl. There is a hill approximately 110 ft (34 m) msl to the southeast of CCNPP Units 1 and 2. Another hill south-southeast of CCNPP Units 1 and 2 will be graded for CCNPP Unit 3. The terrain falls off steeply to the shore of the Chesapeake Bay.

CCNPP Unit 3 will be south of CCNPP Units 1 and 2. Some portions of the CCNPP site will be cleared of existing vegetation and graded to accommodate CCNPP Unit 3 and its ancillary structures. These terrain modifications would be limited to the CCNPP Unit 3 site and the immediately surrounding area. Therefore, it will not represent a significant alteration to the topographic character of the region around the CCNPP site.}

1.7.6 ATMOSPHERIC DISPERSION FACTORS

1.7.6.1 Long-Term Routine Effluent Atmospheric Dispersion and Deposition Values

{Tables 2.7-99 through 2.7-114 present atmospheric dispersion factors (χ/Q 's) determined using methodologies from Regulatory Guide 1.111, Revision 1 (NRC, 1977) as implemented in the AREVA NP computer code AEOLUS3. The values are normal effluent annual average atmospheric dispersion and deposition factors determined using the following input data (expressed in metric units as required by the computer model) and assumptions:

- Six years of onsite meteorological data (2000–2005)
- Type of release: mixed mode
- Wind sensor height: 10 m
- Vertical temperature difference: 60 m temperature – 10 m temperature
- Number of wind speed categories: 12
- Release height: 62 m
- Cross-sectional area of building adjacent to the release point causing building wake effects: 2,940 m^2
- Height of containment building: 60 m

- Distance from the stack to the nearest site boundary: 429.4 m
- Distance from the stack to the nearest resident: 1,770.0 m
- Distance from the stack to the nearest vegetable garden: 1,770.0 m

Computer code AEOLUS3 is based on a straight-line trajectory Gaussian plume model with an optional "sea breeze" model (which evaluates the effects of the thermal internal boundary layer on plume vertical diffusion) and an optional "valley" model (which evaluates the effects of the valley configuration on plume transport and horizontal diffusion). The user may select to consider plume depletion by wet deposition, dry deposition, and radioactive decay. The computed ground-level concentration can be modified to account for plume recirculation or stagnation. The code computes an effective plume height that accounts for physical height, aerodynamic downwash, plume rise, and terrain heights.

AEOLUS3 generates the following types of atmospheric dispersion factors:

- Concentration χ/Q values that can be used to convert effluent release rates to ground-level concentrations at receptors of interest;
- Gamma χ/Q values that can be used to determine external gamma doses from finite clouds of radioactive material; and
- Deposition D/Q values that can be used for assessing ground-shine and ingestion radiation exposure.

The largest undepleted, undecayed χ/Q value determined at the site boundary is 1.362E-05 sec/m3 in the NE sector. The largest undepleted, undecayed χ/Q value determined at the locations of nearest residents is 4.969E-07 sec/m3 in the SW sector 5,807 ft (1,770 m) downwind. The largest undepleted, undecayed χ/Q value determined at the locations of nearest vegetable gardens is 4.969E-07 sec/m3 in the SW sector 5,807 ft (1,770 meters) downwind. There are no meat animals within 5 mi (8 km) of the CCNPP site.}

1.7.6.2 Fiftieth Percentile Atmospheric Dispersion Factors

Table 2.7-115 presents fiftieth percentile atmospheric dispersion factors for use in evaluating the environmental impact of design basis accidents using realistic values per Section 7.1. These factors were determined using the methodology of Regulatory Guide 1.145, Revision 1 (NRC, 1982) {as implemented in the AREVA NP computer code AEOLUS3}.

{The fiftieth percentile atmospheric dispersion factor for the 0-2 hour time period at the Low Population Zone (LPZ) is 1.542E-05 sec/m^3.}

1.7.7 NOISE

{The principal noise sources associated with normal operation of CCNPP Unit 3 are the switchyard, transformers, and Circulating Water Supply System cooling tower. In addition, two of the four Emergency Service Water System cooling towers will normally be in operation. Previous environmental assessments, however, excluded noise measurements made at the CCNPP site and surrounding environs that could be used to establish a baseline noise level (BGE, 1970) (BGE, 1971) (BGE, 1998). For this reason, a survey was conducted in November 2006 to measure ambient environmental community noise levels.

CCNPP Unit 3 will use the existing transmission lines used for CCNPP Units 1 and 2 as discussed in Section 3.7. The environmental impact of noise associated with the transmission lines was previously assessed in the CCNPP Units 1 and 2 license renewal application (BGE, 1998) and the NRC's application review (NRC, 1999). In NUREG-1437 (NRC, 1996), the NRC defined the environmental issue of noise associated with the transmission lines as small for all plants. Therefore, no additional data for transmission lines has been provided.}

1.7.7.1 Environmental Noise Survey

{Environmental sound levels were measured continuously at eight area-wide locations over a 45 hour period during leaf-off seasonal conditions. As a result, any noise emissions from CCNPP Units 1 and 2 would be highest due to the lack of tree leaf noise reduction.

Figure 2.7-207 shows the location of the eight monitoring sites. There are single-family residences at locations N1 through S3, except for location P1, which are representative of the closest potentially sensitive receptors in all directions from the CCNPP site. P1 was placed near where CCNPP Units 1 and 2 are audible and dominant. In addition, four eagle nest sites are situated in the site vicinity: two to the south in areas of expected low ambient sound levels, one to the north near the site, and one in the laydown area. The closest potentially sensitive receptors represent existing conditions and can be used to assess potential noise impacts from CCNPP Unit 3.

The instantaneous sound level was measured at each location on a continuous and simultaneous basis over the 45 hour period using precision data loggers. In addition, attended measurements were carried out at each location during day and night periods using hand-held precision data loggers.}

1.7.7.2 Metrics for Noise Assessment

{The universal measure of noise in decibels is the A-weighted sound level, abbreviated dB(A) or dBA. The overall sound level is defined as the summed level in decibels over the entire audible frequency range of approximately 20 to 20,000 cycles/second (Hertz). The A-weighted sound level is a convenient single number to quantify the entire spectrum of a sound.

Percentile levels, or exceedence levels, designated L1, L10, L50 and L90 are statistically derived units over the sampling period. They are the levels exceeded for 1%, 10%, 50% and 90% of the sampling time. The L90 percentile level is the most common for evaluating community noise in residential environments. L90 is the "residual" sound level, which is the quasi-steady level that occurs in the absence of all identifiable sporadic sound levels occurring over the interval. The vast majority of all residual sound levels found in communities come from far away, unidentifiable steady levels from traffic or industrial sources.

The average, designated Leq, is the equivalent steady sound level that has the same acoustic energy as the actual time varying signal. It is the energy average, not the arithmetic average over the period. The 24 hour day-night sound level, or Ldn, is calculated from the average hourly Leq sound level over a 24 hour period, with a 10 dBA weighting factor added to all levels during the nighttime period from 10 PM to 7 AM to account for greater sensitivity to noise at night. The State of Maryland (MD, 2007) regulates the maximum allowable noise levels at residential receptors to 65 dBA during the daytime (7 AM to 10 PM) and 55 dBA during the nighttime (10 PM to 7 AM). These regulatory limits are intended to achieve environmental "goals," which for a residential area is a Ldn value equal to 55 dBA (MD, 2007). This level is the same as recommended by the U.S. Environmental Protection Agency (EPA) to the Department of Housing and Urban Development (HUD) as a goal for outdoors in residential areas as part of noise abatement and control (CFR, 2007c). However, for the purposes of the HUD regulation, sites with a Ldn value of 65 dBA and below are acceptable and allowable (CFR, 2007c).

1.7.7.3 Results

Figure 2.7-208 plots the hourly residual (L90) sound levels at the residential locations for the survey period. The plot illustrates that sound levels follow increasing wind speed, which is due to higher tree branch and grass movement sounds created at all of the heavily wooded locations. The plot also shows that the levels are highest close to the four-lane Maryland State Highway 2/4 and quietest at remote locations. This indicates that the residual sound level in the CCNPP site area is dominated by traffic noise. On the other hand, there was no observed audible plant noise from the existing plant at any of the locations, day or night, although both units were operating continuously. Therefore, all measured ambient sound levels can be attributed to normal, current environmental sources, such as traffic noise, and are not related to CCNPP Units 1 and 2.

Table 2.7-116 tabulates the major survey results at all locations for commonly used sound level metrics to assess noise impact. Location P1 is at the plant and can be considered the control point. The other locations are at or near residences. Whether the Maryland environmental goal of Ldn equal to 55 dB(A) is realized depends on location and environmental conditions. More remote locations (S2 and S3), for example, are within the environmental goal. Conversely, locations near noise sources, such as Maryland State Highway 2/4 (W2) or an existing saw mill (W3), are above or near the environmental goal. Wind conditions also have an effect, as the Ldn increases with increased wind speed. Apart from these effects, Ldn noise levels of below 60 to 65 dB(A) are considered to be of small significance, as noted in Section 4.3.7 of NUREG-1437 (NRC, 1996). All measurements taken had a Ldn value below 65 db(A) except near the highway (W2) and on the plant site (P1).

The survey results document existing conditions for a typical and representative period during the leaf-off season. During leaf-on season, fully leafed trees would attenuate or reduce traffic noise from Maryland State Highway 2/4 and any existing plant emissions, both factors tending to decrease residual sound levels.}

1.7.8 REFERENCES

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