2.3 Meteorology

2.3.1 Regional Climatology

The description of the general climate of the region at the time of licensing of Grand Gulf Nuclear Station Unit 1 was based primarily on climatological records for Vicksburg and Jackson, Mississippi. This description utilizes that data as appropriate and is augmented by more recent data from the Vicksburg station and the GGNS site meteorological tower.

Topographical considerations and examination of the records indicate that meteorological conditions at Vicksburg and Jackson are representative of the general climate of the region encompassing the site. Since Vicksburg is the closer of the two stations and borders the Mississippi River, the tables and figures included are based primarily on Vicksburg data when the period of record and observational procedures are considered adequate. Otherwise, Jackson data are presented.

Recent improvements in the National Oceanographic and Atmosphere Administration (NOAA) National Climatic Data Center (NCDC) data systems provide easy access to local meteorological data records since the middle of 1996. GGNS site data is also available for this period. Most of the tabular data in this section are from these recent data sources, but there was also an extensive amount of meteorological data gathered and evaluation that was performed for the licensing of Grand Gulf Unit 1 in the 1970s. In several cases, such as the reoccurrence rate of rare events based on many decades of observation, the original data is preferable. For example, the last few years have been unusually dry in the region, so it would be more accurate and more conservative, in terms of maximizing rainfall predictions, to use the Unit 1 licensing data rather than to draw long term rainfall conclusions on data from the last five years. General discussions of the regional climate dating from the Unit 1 licensing period are also still valid so the existing Unit 1 meteorological discussion and references in the GGNS Unit 1 UFSAR (Reference 4) are still applicable.

2.3.1.1 General Climate

The climate of southwestern Mississippi is humid and subtropical with a short cold season and a relatively long warm season. The predominant air mass over the region during most of the year is maritime tropical with origins over the Gulf of Mexico. In the winter, occasional southward movements of continental polar air from Canada bring colder and drier air into Mississippi. However, cold spells seldom last over 3 or 4 days.

In summer, the region is almost wholly dominated by the west- ward extension of the Bermuda High, a subtropical, semipermanent anticyclone. The prevailing southerly winds provide a generous supply of moisture and this, combined with thermal instability, produces frequent afternoon and evening showers and thundershowers over the region. The convective thundershowers of the summer season are more numerous than frontal type thunderstorms. However, the thunderstorms associated with the occasional polar front activity in late winter and early spring are more severe and sometimes produce tornadoes.

Mississippi is south of the average track of winter cyclones, but occasionally one moves over the state. In some winters a succession of such cyclones will develop in the Gulf of Mexico or in Texas and move over or near the state. Also the state is occasionally in the path of tropical storms or hurricanes (Reference 1).

It is common in wind direction data collection to divide the directions of the compass into sixteen 22.5 degree sectors centered on true north (N), north-northeast (N-NE), northeast (NE), east-northeast (E-NE), east (E), east-southeast (E-SE), southeast (SE), south-southeast (S-SE), south (S), south-southwest (S-SW), southwest (SW), west-southwest (W-SW), west (W), west-northwest (W-NW), northwest (NW) and north-northwest (N-NW). *The general airflow over the region is from the southerly sectors during much of the year, although the prevailing direction may be from one of the northerly sectors during some months.* The net air movement can be deduced from the annual resultant wind values for the GGNS site shown in Table 2.3-1. The average windspeed at the site has ranged from 3.7 mph to 4.4 mph between 1996 and 2003. The average windspeed at Vicksburg between 1997 and 2003 ranged from 7.0 mph to 7.6 mph as shown in Table 2.3-2.

The temperature regime of the site region can be described by the data that are shown in Table 2.3-3; four years of GGNS site data from 2000 to 2003, and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) design data (Reference 51) for Jackson, Mississippi. As can be seen from the table, the ASHRAE design values for the Jackson area are very close to those developed from the GGNS site data.

Climatic records of humidity in Vicksburg are shown in Table 2.3-4. These data show that relative humidity in the region is high throughout the year. Nighttime relative humidities are highest in summer and fall and lowest in winter. Daytime humidities are highest in winter. Seasonal variations are in the vicinity of 5 to 10 percent. Highest relative humidities occur in the early morning hours (00:00 – 06:00), averaging greater than 80 percent during all months. Lowest relative humidities occur during early and mid afternoon with averages ranging from about the mid-50s to the mid-60s for all months.

Mean annual precipitation in the region ranges from about 50 inches in northwestern Mississippi to 65 inches in the southeastern part of the State. During the freeze-free season, rainfall ranges from about 24 inches in the northwest to about 37 inches in the southeast, but during winter the precipitation maximum is centered in the northwest with the minimum on the coastal counties. The fall months are the driest of the year. Yearly average rainfall at the GGNS site for 2000 and 2001 is approximately 45 inches (Table 2.3-70), and at Vicksburg for the period of 1997 to 2001 was about 50 inches (Table 2.3-71).

While snowfall is not of much economic importance, it is not a rare event in Mississippi. During the 65 years from 1898 through 1957 and 1997 through 2001, measurable snow or sleet fell on some part of the state in all but 3 years. During these 65 years snow or sleet fell in January in 40 years, and in February in 32 years. Along the latitude of the site (about 32° N) snow has fallen in about 30 percent of the years. (References 1 and 3) Vicksburg snow events for the last five years are shown in Table 2.3-76.

Local (site) meteorological conditions are expected to result almost entirely from synoptic-scale atmospheric processes. That is, the local site does not have a unique micro-climate but rather the local meteorology is consistent with the wide area meteorology. There are two exceptions caused by local effects due to the Mississippi River. First, there is higher humidity directly adjacent to the Mississippi River, and so the Vicksburg humidity data is more appropriate for site estimates than the Jackson data. Second, *there is some evidence of channeling of extremely low level (less than 70 feet above grade) winds from the west into a trajectory along the river. This phenomenon has no effect on dispersion of effluents from the plant since the site is east of the area affected.*

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

2.3.1.2.1 Severe Weather Phenomena

This section describes severe weather phenomena that may require consideration in design of safety related structures, systems and components. Most recent data is taken from the NCDC Storm Event database that covers the period of 1950 through 2002 (Reference 5), but even longer data periods are used for some phenomena to try to capture the occurrence of rare events.

2.3.1.2.1.1 Hurricanes

During the period 1899 to 2000 there were 117 tropical cyclones which affected the Middle Gulf Coast (Louisiana, Mississippi, Florida, Texas and Alabama). Of these, 39 (33.3 percent) were category 1, 30 (25.6 percent) were category 2, 36 (30.8 percent) were category 3, 10 (8.5 percent) were category 4 and 2 (1.8 percent) were category 5 hurricanes. Table 2.3-5 presents a monthly breakdown of the 117 cyclones and provides a definition of the storm categories.

Tropical cyclones, including hurricanes, lose strength as they move inland from the coast and the greatest concern for an inland site is possible flooding due to excessive rainfall. The extremes for rainfall presented below include possible hurricane effects.

The small diameter, extremely intense Camille hurricane (1969), whose center passed less than 10 miles to the east of Jackson Municipal Airport, generated gusts at Jackson of only 67 mph. The top winds in this hurricane at points on the coast were estimated at over 170 mph (Reference 7).

2.3.1.2.1.2 Tornadoes and Waterspouts

Tornadoes do occur in this area. A highly destructive tornado struck Vicksburg in December 1953. In addition, on April 17, 1978, a tornado struck GGNS. A detailed report of this event was submitted to the NRC via Reference 8. The tornadoes reported during the years 1950 - 2002 in the vicinity of Claiborne, Warren and Hinds Counties in Mississippi and Tensas Parish in Louisiana are shown on Table 2.3-6.

In the period from 1950 to April 2002, a total of 108 tornadoes touched down in these four districts, which have a combined area of 2,545 square miles (Reference 9). References 10 and 11 identify that local tornadoes have a mean path area of 0.43 square miles. The site recurrence frequency of tornadoes can be calculated using the point probability method as follows:

Total area of tornado sightings = 2,545 sq. mi.

Average annual frequency = 108 tornadoes ÷ 52.3 years = 2.07 tornadoes/year

Freq/yr of a tornado striking a particular point P = (0.43) (2.07) ÷ 2545 = 0.00035

Mean recurrence interval = 1/P = 2,860 years.

*Waterspouts are similar to tornadoes but they do not form under the same meteorological conditions; they form over water bodies and do, on occasion, cross the coastline and penetrate several kilometers inland, (*Reference 12*). The water bodies in the vicinity of the Grand Gulf site area not likely to spawn waterspouts.*

2.3.1.2.1.3 Thunderstorms

Table 2.3-7 presents the thunderstorm data for the region from 1955 through 2002. About 62 percent of the thunderstorms in this area occur during the warm months (March-July), indicating that the majority are warm air-mass thunderstorms. From 1955 - 2002, 421 thunderstorms are listed for this area, with Hinds County receiving approximately 40 percent, Claiborne County receiving 12 percent, Warren County receiving 32 percent, and Tensas Parish receiving 16 percent of the thunderstorms. The total of 298 storms shown in the table is less than the sum of the individual totals (421) for each of the three counties and Tensas Parish because some of the individual storms extended into more than one county.

2.3.1.2.1.4 Lightning

Data on lightning stroke density is extremely sparse. Analysis has shown that the density per square mile is approximately one-half of the number of storm days from the isokeraunic map. This was partially confirmed by a two-year count in a region with 27 storm days per year where the average stroke density was approximately 15 strokes per square mile per year (Reference 13).

The annual mean number of thunderstorm days in the site area is estimated to be 66 based on interpolation from the isokeraunic map (Reference 14); *therefore it is estimated that the annual lightning stroke density in the Grand Gulf site area is 33 strokes per square mile.*

2.3.1.2.1.5 Hail

From 1955 - 2002, 279 hailstorms occurred in the region per year, with Hinds County receiving approximately 57 percent, Claiborne County receiving 6 percent, Warren County receiving 19 percent, and Tensas Parish receiving 18 percent of the hailstorms, as shown in Table 2.3-8. For this table, each occurrence of hail was counted as an individual event, even if two counties recorded hail simultaneously. The most probable months of occurrence of hail are March and April. Property damage occurs infrequently, with 6 recorded events in Warren County, 14 in Hinds County, 4 in Claiborne County, and 2 in Tensas Parish in this 47-year period.

2.3.1.2.1.6 High Air Pollution Potential

The atmospheric ventilation rate is numerically equal to the product of the mixing height and the wind speed within the mixing layer. Higher ventilation rates are better for dispersing pollution than lower ventilation rates.

A tabulation of daily mixing heights and mixing layer wind speeds for both morning and afternoon was obtained from the National Climatic Data Center for 1992 through 2000 at the Jackson International Airport in Jackson, Mississippi (Reference 15). This data was used to generate the morning and afternoon ventilation rates in Table 2.3-9.

Morning ventilation is less than 4600 m^2/s throughout the year, and is less than 3100 m^2/s from May through October. Afternoon ventilation is higher than 5600 m^2/s from March through September, but lower than 4900 m^2/s from October through February. Based on this and the tendency of pollutants to collect during the course of a day, the highest daily air pollution potentials exist during the lower afternoon ventilation rates from October through February. Lowest air pollution potentials occur in the spring due to the relatively high mean ventilation rates.

Other data sources provide independent checks of this conclusion, including the Grand Gulf Unit 1 UFSAR which cites data collected in 1959 through 1962 (Reference 4). *According to*

Korshover (Reference 16), *in a 35-year period from 1936 through 1970, there were 36 cases of 4 days or more of atmospheric stagnation over southwest Mississippi, … with maximum probability in October and the minimum in March.*

2.3.1.2.2 Probable Maximum Annual Frequency and Duration of Freezing Rain

An ice storm (also called glaze ice) is the accretion of ice, generally clear and smooth, formed on exposed objects by the freezing of a film of supercooled water deposited by rain, drizzle, or possibly condensed from supercooled water vapor. The weight of this ice is often sufficient to greatly damage telephone and electric power lines and poles. The ice coating on roads frequently slows down, or even completely paralyzes, transportation and makes movement of personnel and equipment extremely difficult.

Most glaze is the result of freezing rain or drizzle falling on surfaces with temperatures between 25 and 32 º F. The glaze belt of the United States includes all of the area east of the Rocky Mountains. However, in the southeast and Gulf Coast sections of the country, below freezing temperatures seldom last more than a few hours after glaze storms (Reference 17).

The occurrences and durations of recorded ice storms and heavy snow storms in the three counties and one parish around the GGNS site for the 8 year period 1993 through 2001 is shown in Table 2.3-10 (the storm database of Reference 5 contains this type of data for this location starting in 1993). From these data, conservatively including the heavy snowstorm of 1997, the frequency of ice storms in the Grand Gulf area is estimated to be 4 in eight years or 0.5 per yr.

The ice storm reported December 22, 1998 at 8:00 PM through December 25 at 5:00 AM, was the longest lasting storm with a total duration of 57 hours. Property damage was estimated at $16.6 million. It is noted that while the ice storm duration was 57 hours, that period was over an area of 27 counties. The time would have been less at a single location. Vicksburg reported the following history: 2 hours of trace rain (about 0.01 inches), followed by one dry hour, and then 8 hours of rain for a total of 0.4 inches at the start of the storm, then a period of 15 hours with only a trace of precipitation, and then 11 hours of rain totaling 0.85 inches, followed by only a trace of precipitation for the remainder of the storm. A conservative approach would be to neglect the dry/trace precipitation periods and assume this represents a 19 hour ice storm duration. Reference 4 also discussed combining periods of ice storms in this manner and developed a 12-hour maximum based on the ten years 1954 through 1963. Based on the Reference 4 maximum duration of 12 hours in 10 years of data, and this maximum value of 19 hours in 18 years of data, the maximum probable duration in 100 years would be 27 hours assuming a logarithmic extrapolation, i.e., 27 = 12 +(19-12)*log(100-10)/log(18-10).

The total number of glaze storms reported in the broad general area surrounding the plant site, during the period 1917 through 1953 inclusive, ranged from 1 to 7. It is estimated that about 30 percent of these caused ice coatings in excess of 0.5 inches in some portions of the area (Reference 17). As noted above, Vicksburg received about 1.25 inches of precipitation during the 1998 ice storm.

2.3.1.2.3 Probable Maximum Annual Frequency and Duration of Dust Storms

The occurrence of dust, blowing dust, or blowing sand is a comparatively rare phenomenon in the Jackson/Grand Gulf area. Although there are categories for dust and sand in the meteorological data collection system used at Vicksburg, no hours are identified under this category in the period 1997 to 2001. The hourly weather records for the years 1955 through 1964 cited in the Grand Gulf Unit 1 UFSAR do include 33 hours of dust blowing at the Jackson

Airport (out of this 87,600 hour period). It is conservative to continue to use these data. These statistics are shown in Tables 2.3-11 through 2.3-14.

The total hours of occurrence are shown for each month of each of the ten years in Table 2.3-11*. April had the largest total. From the yearly totals shown in this table, the probable maximum annual frequency (probability=0.01) of dust storms in the Grand Gulf area is estimated to be 14/8,760 or 0.16 percent.*

Table 2.3-12 *shows the number and duration of discrete occurrences of dust storms by month. A discrete occurrence is defined as one hour, or more than one consecutive hour, during which dust, blowing dust, or blowing sand was reported by the National Weather Service. There were no occurrences of more than one hour during the ten year period.*

Table 2.3-13 *summarizes the monthly statistics on the dust storm occurrences and* Table 2.3-14 *presents a summary of frequency and duration for each of the 10 years. From these data the probable maximum duration (probability = 0.01) of the dust storm in the Grand Gulf area is estimated to be about two hours.*

2.3.1.2.4 Estimated Weight of the 100-Year Return Snowpack

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 National Weather Service at all first order weather stations.

The density of the snowpack varies with age and the conditions to which it has been subjected. Thus, the depth of the snow- pack is not a true indication of the pressure which the snow- pack exerts on the surface which it covers. A more useful statistic for estimating the snowpack pressure is the water equivalent (in inches) of the snowpack.

To estimate the weight of the 100-year snowpack at the Grand Gulf site, the maximum reported snow and/or ice depths at Jackson and Vicksburg, Mississippi were reviewed from three sources. The current NCDC storm event database (Reference 5) identifies that the greatest snowfall in its period of data, 1993 to September 2002, occurred on December 14, 1997. That storm deposited 8 inches of snow in certain areas in a snow event that covered Claiborne, Hinds and Warren counties. Reference 29 records that a site in the Vicksburg area saw a total of 10.1 inches of snow fall in January 1919. Reference 25 identifies the maximum 24-hour snowfall at Jackson was 10.6 inches in January 1940. Since this data review covers at least 83 years back to 1919, it is possible to conclude with 83% confidence that the 100-year snowfall maximum is 10.6 inches. This is rounded up to 11 inches for greater conservatism.

Reference 19 *states that freshly fallen snow has a snow density (the ratio of the volume of melted water to the original volume of snow) of 0.07 to 0.15, and glacial ice formed from compacted snow has a maximum density of 0.91.*

In the Jackson/Grand Gulf area, snow melts and/or evaporates quickly, usually within 48 hours, and before additional snow is added; thus, the water equivalent of the snowpack can be considered equal to the water equivalent of the falling snow as reported hourly during the snowfall. The data during the period studied indicate that the water equivalent of the maximum snowpacks in the Jackson area was between 0.08 and 0.12 inches of water per inch of snow. Hence, it appears that a conservative estimate of the water equivalent of snowpack in the Grand Gulf site area would be 0.20 inches of water per inch of snowpack. Then, the water equivalent of the 100-year return snowpack would be 11 x 0.2 = 2.2 inches of water.

Since one cubic inch of water is approximately 0.0361 pounds in weight, a one inch water equivalent snowpack would exert a pressure of 5.20 pounds per square foot (0.0361 x 144).

For the 100-year return snowpack, the water equivalent would exert a pressure of 11.44 pounds per square foot (5.2 x 2.2).

2.3.1.2.5 Estimated Weight of the 48 Hour Maximum Winter Precipitation

Rainfall in the recent 5 year period discussed below are from a period of relatively low rainfall (Reference 21). Therefore, it is conservative to use earlier data periods to develop the maximum winter precipitation values. Table 2.3-74 shows that the maximum rainfalls at Vicksburg in the 5 year period 1997 through 2001 are well below the 5 year recurrence rate presented in the GGNS UFSAR (Reference 4). This UFSAR data is based on a 15-year period.

The observed maximum precipitation amounts (water equivalent) during any consecutive 48 hour period at Jackson, Mississippi for the indicated winter (November through March) seasons is given in Table 2.3-15 (Reference 20). *The data were analyzed by the Gumbel-Lieblein method described by Thorn in* Reference 18 *with the following results:*

Return Period (Years)	*Max. 48 Hr. Winter Precip. Water Equivalent (inches)*
10	*4.60*
25	*5.50*
50	*6.15*
100	*6.80*
500	*8.20*
1,000	*8.80*

Thus, it is estimated that a value of 7.0 inches (water equivalent) is ultra-conservative for the 48 hour [~~probable~~] maximum winter precipitation at the Grand Gulf site, especially since only one of the above maximum values contained a trace of frozen precipitation.

In the unlikely event that the 7.0 inches maximum were entirely frozen precipitation, i.e. there was no run-off, a weight of 36.4 pounds per square foot (0.0361 lbs/in^3 x 7 in x 144 in^2/ ft^2) would result.

2.3.1.2.6 Weight of Snow and Ice on Safety-Related Structures

Since the plant site is subjected to a subtropical climate with mild winters, prolonged snowfalls or large accumulations of snow or ice on the ground and structures are not anticipated.

The estimated depth of the I00-year return snowpack is 11 inches, or 2.2 inches of water equivalent, as discussed in Section 2.3.1.2.4. Safety-related structures at the Grand Gulf ESP site would be designed to withstand 11 inches of snow. No damage from snow or ice loading on structures is expected.

2.3.1.3 Meteorological Data to be Used in Evaluating the Ultimate Heat Sink

Meteorological data is used in accident analyses and other analyses to determine the effectiveness of safety related heat removal systems; i.e., the ultimate heat sink. This section discusses GGNS site and local area meteorological data which may impact design of safety related heat removal systems.

2.3.1.3.1 Meteorological Parameters

The controlling meteorological parameters required for the analysis of cooling tower performance are the wet bulb temperature and the coincident dry bulb temperature. Table 2.3-3 presents data on these parameters from two data sources: ASHRAE data for Jackson, Mississippi (Reference 51), and data from the GGNS site meteorological tower, 2000 –2003 (Reference 2). The GGNS data relevant to this assessment covers a limited period (see discussion of site instrumentation in Section 2.3.3). However, Table 2.3-3 shows that the GGNS data are consistent with the ASHRAE published data for Jackson, MS. Therefore, the GGNS site temperatures are acceptable for UHS design purposes.

2.3.1.3.2 Worst 1-Day, 5-Day, and 30-Day High Temperature Periods

a. Worst 1-Day Period

   The hourly data for the worst 1-day, August 1, 1998, are shown in Table 2.3-16.

b. Worst 5-Day Period

   The first 5 daily average values of the wet bulb temperature were summed and divided by five to calculate the first 5-day average. Then the sixth day's data was added to the sum and the first day value was subtracted from the sum. This new sum was divided by five to get the 2nd five day average. This process was repeated until all the observations were exhausted. Each five day period of data was averaged and the maximum average was selected as the worst 5 consecutive days. The daily average wet bulb and coincident dry bulb temperatures for the worst 5-day period are shown in Table 2.3-17.

c. Worst 30-day period

   The same method of running averages as was used for the worst 5-day period was used to find the worst 30 consecutive days. The daily average wet bulb and coincident dry bulb temperatures for the worst 30 day period are shown in Table 2.3-18.

2.3.1.4 Design Basis Tornado Parameters

The Design Basis Tornado characteristics are specific to the site and region of the country in which the site is located. However, rather than conducting site research on tornado characteristics, most sites in the past licensing proceedings have relied on NRC endorsed studies that set conservative values for key design basis tornado characteristics. These characteristics were then used in the design of the subject facility.

Regulatory Guide 1.76 (Reference 41), based on WASH-1300, has been used since the 1970s by the industry to establish the appropriate design basis tornado characteristics, depending on the proposed site location in the country. Since the issuance of this guide, additional tornado data has become available by way of the National Severe Storms Forecast Center. Using this later data and Regulatory Guide 1.76 methodology, the NRC developed an interim position, establishing an update to the design basis tornado characteristics. The NRC's updated criteria were described in its safety evaluation, dated March 25, 1988 (Reference 42). The design basis tornado characteristics defined for this project, as listed below, are based on the NRC's interim position. The below listed characteristics are associated with a Region 1 site. (Per that NRC guidance, the GGNS ESP Site is located in Region 1.)

Maximum wind speed, mph	330
Rotational speed, mph	260
Maximum Translational speed, mph	70
Radius of maximum rotational, speed, ft	150
Pressure drop, psi	2.4
Rate of pressure drop, psi/sec	1.7

2.3.1.5 100-Year Return Period Fastest Mile of Wind

*The records of the National Weather Service for Jackson, Mississippi (*Reference 22*) report the fastest mile of wind to be 68 mph. This occurred in 1952. Other records (*Reference 25*) show that the height of the wind sensor in 1952 was approximately 46 feet above ground level. Reducing 69 mph from 46 feet to the standard 30 foot level gives a value of 64 mph.*

The fastest hourly averaged wind speed recorded by the Grand Gulf meteorological tower at 33 feet in the period from 1996 through 2003 was 31 mph in 1999. The fastest hourly average wind speed recorded at Vicksburg in the period from 1997 through 2001 was 33 mph, also in 1999. This more recent data covers a shorter period than that utilized in the Grand Gulf Unit 1 UFSAR, so the Grand Gulf UFSAR analysis continues to be appropriate for long term return periods for maximum wind speeds.

Reference 23 *indicates a value of approximately 83 mph for the 100-year return period fastest mile of wind in the Grand Gulf area.*

*A Gumbel-Lieblein extreme value analysis (*Reference 18*) of Jackson wind data, corrected for differences in measurement levels for the years 1960 through 1975, gave a value of 61 mph for the 30 foot level 100-year return period fastest mile of wind.*

In Reference 23*, Thom cites the often used power law as a representative estimate of the vertical wind profile. This vertical distribution of the wind velocity is expressed as,*

$$u_z = u_{30} (z/30)^{(1/n)}$$

Where z is the height above ground, u_z is the wind speed at height z, u_{30} is the wind speed at 30 feet, and n is a constant depending on surface roughness. For the Grand Gulf site the value of n is approximately 7 since the terrain characteristics can be described as being level or slightly rolling land with some obstructions.

In addition to corrections of the basic 30 feet above ground design wind for height of structures it is also necessary to apply corrections for gusts. This is normally done by means of a gust factor (gust velocity ÷ the velocity of the fastest mile of wind). A gust factor of 1.3 is used for gusts of approximately 1-second duration that, in a 90 mph basic wind, would have a length *downwind of about 130 ft. This is adequate for small structures. A gust factor of 1.1 will allow for gusts of approximately 10-second duration that, in a 90 mph basic wind, would have a length downwind of about 1,300 ft.; this factor is adequate for larger structures having a horizontal dimension, transverse to the wind of about 125 ft. (*Reference 24).

2.3.1.6 Other Regional Meteorological and Air Quality Conditions Considered

Any other regional meteorological or air quality conditions not discussed above, which need to be considered for design of safety related structures, systems and components of a new facility will be determined and evaluated as required by 10 CFR 52.

2.3.2 Local Meteorology

2.3.2.1 Normal and Extreme Values of Meteorological Parameters

The following sections contain information on wind, air temperature, atmospheric water vapor, precipitation, fog and smog, atmospheric stability, and mixing heights at the GGNS and surrounding area.

2.3.2.1.1 Winds

2.3.2.1.1.1 Wind Distributions (All Meteorological Conditions)

Wind data is available from both the Vicksburg meteorological station and the Grand Gulf meteorological tower. Both sets of data are discussed here to provide a fuller description of winds in the area.

2.3.2.1.1.1.1 Vicksburg Wind Data

Tables 2.3-19 to 2.3-30 present monthly percent joint frequency distributions for wind directions and speeds, based on a 5-year period of record from 1997 through 2001, for Vicksburg. Table 2.3-31 provides an annual summary of the data. On an annual basis, Vicksburg wind data collected in the five years 1997 through 2001 show central N is the most frequent (13.8 percent) wind direction. The wind is from SE through central S 30.8 percent of the time. Westerly (W-SW - W-NW) and easterly (E-NE - E-SE) winds are least frequent, with frequencies of 9.1 and 16.1 percent, respectively (Table 2.3-31). Southerly components prevail in spring, summer, and winter, while northerly components prevail in the fall (Tables 2.3.19 to 2.3.30).

Winds average greater than 8.1 mph from January through April, and 7.7 mph or less from May through December. Mean annual wind speed is 7.4 mph (Table 2.3-31).

The Vicksburg meteorological station winds are presented graphically in Figures 2.3-8 to 2.3-13. These wind roses cover the period from 1997 through 2001 and represent the frequency of winds coming from a particular direction by the length of the line in that direction. Vicksburg records a usual pattern of winds coming from the north or south. At Vicksburg, winds from the west occur as infrequently as winds from the east. However, the year 2001 is seen to be one where most winds come from the eastern half of the rose (Figure 2.3-13).

2.3.2.1.1.1.2 Grand Gulf Wind Data

The same wind data assessment was applied to GGNS site data collected at the Grand Gulf Meteorological Tower for the period from 2001 through 2003 (Reference 2). Monthly relative frequencies of wind direction and speed for the Grand Gulf site are shown in Tables 2.3-32 through 2.3-43, and data for all years is shown in Table 2.3-44. Winds average greater than 4.5 mph from November through April, and 4.0 mph or less from May through September. Mean annual wind speed is 4.3 mph.

Wind roses are presented for the Grand Gulf site in Figures 2.3-1 to 2.3-4 from the 3-year period 2001 through 2003. The normal wind pattern shows winds primarily from the right half of the rose (N to E to S), with the highest frequency originating in the NE or SE. In all years, few winds blew from the west. In general, the wind roses from Vicksburg and Grand Gulf show the same trend towards prevailing winds from the NE and SE.

2.3.2.1.1.1.3 Wind Direction Persistence

Hourly weather observation records from the National Weather Service at Vicksburg, Mississippi for the years 1997 through 2001 were examined for wind direction persistence. The longest persistence periods from a single sector (22.5 degrees), three adjoining sectors (67.5 degrees), and five adjoining sectors (112.5 degrees) were determined for each sector (and calm) during each year. The results are shown in Tables 2.3-45 through 2.3-47. During the period, the single sector persistence was greatest (28 hours) for the central north direction. The average maximum persistence (17.6 hours) was also greatest for the central north direction. For the persistence in three adjoining sectors, the central south sector had the longest period of persistence (109 hours) and the largest average maximum persistence (63.8 hours) as shown in Table 2.3-46. The longest persistence period (105 hours) from five adjoining sectors occurred in the S-SE sector (Table 2.3-47). The central north sector showed the greatest average maximum persistence (57.2 hours).

Wind persistence data similar to the above are shown in Tables 2.3-48 through 2.3-50 for the Grand Gulf site. The statistics shown in these tables cover a three-year period from 2001 through 2003. Table 2.3-48 shows that the longest single sector persistence period was 32 hours from the northeast sector. The NE sector also had the greatest average maximum persistence in a single sector. For the longest persistence in three adjoining sectors, the N-NE sector had the longest period with 102 hours, and the greatest average maximum persistence, as shown in Table 2.3-49. The persistence data for five adjoining sectors (Table 2.3-50) shows the central N-NE sector with the longest persistence period (122 hours) and the greatest average maximum persistence.

Table 2.3-51 presents a comparison of the maximum persistence period for the GGNS site in hours with historic data from Jackson and Table 2.3-52 presents a comparison of the maximum persistence periods for Vicksburg and GGNS. While there are differences in the preferred sectors, the data demonstrate that it is not likely that any single wind direction would persist for a substantial period of time. Table 2.3-53 is the maximum wind direction persistence period for each sector at Jackson from Reference 4 to provide historic comparison.

2.3.2.1.2 Air Temperature

Table 2.3-54 shows that temperature extremes for Vicksburg have ranged from 107 ºF (August and September 2000) to 16 ºF (January 2001) (Reference 3). Table 2.3-55 shows that temperature extremes for GGNS have ranged from 104.2 ºF (August 2000) to 17.3 º F (January 2001) (Reference 2). The data shows good agreement between the two locations.

Figures 2.3-14 and 2.3-15 present the site hourly temperatures for the years 2000 and 2001 (Reference 2). A comparison of the two years is made in Figure 2.3-16, where the maximum and minimum temperatures measured in 96 hour intervals are plotted against the start date of the interval.

2.3.2.1.3 Atmospheric Water Vapor

All of Mississippi experiences high humidity during much of the year. At Vicksburg humidities of 90 percent or higher have occurred at any hour of the day. They are most frequent in the early morning hours. In the summer, at times there develops a combination of high temperatures together with high humidities; this usually builds up progressively for several days and becomes oppressive for one or more days. Humidities of less than 50 percent occur on some days each month, usually in the early afternoon hours. Humidities drop under 30 percent on about one-quarter of the October and November days; the number of days with such low humidities diminishes in the other months. In July and August there may be none. (Reference 25).

The saturation deficit tables (Tables 2.3-57 through 2.3-68) were prepared from 5 years (1997-2001) of Vicksburg hourly weather observations (Reference 3). These tables show the total monthly occurrences as a function of windspeed and wind direction segment for the 5 year period. Table 2.3-69 shows the total annual occurrences as a function of windspeed and wind direction segment.

Mean relative humidities for four time periods per day at Vicksburg are shown in Table 2.3-4 (Reference 3). Given the similarity of the two locations alongside the Mississippi River, these data are considered representative for the ESP site.

2.3.2.1.4 Precipitation

2.3.2.1.4.1 Rain

The GGNS site rainfall data covers the time period from 2000-2001 and the Vicksburg data covers the time period from 1997-2001 (References 2 and 3). Monthly and annual mean and extreme precipitation amounts for the GGNS site and Vicksburg, Mississippi are presented in Tables 2.3-70 and 2.3-71, respectively. Average monthly precipitation at the GGNS site follows a seasonal trend, reaching a maximum mean in March (10.02 inches) and a minimum mean in November (0.02 inches). Maximum annual mean precipitation has been 46.85 inches. For Vicksburg, the maximum mean precipitation is in December (9.94 inches) and a minimum mean in May (0.38 inches). The maximum annual precipitation in Vicksburg is 59.76 inches.

Table 2.3-72 and Table 2.3-73 provide monthly frequency distribution of rainfall rates at the Grand Gulf site and Vicksburg, respectively.

In general, the Vicksburg data appears to be representative of the Grand Gulf area. The variations between the two locations from month to month, particularly during the summer months, are likely reflective of the occurrence of heavy shower and thunderstorm activity common in the area.

The maximum short period precipitation was determined for the Grand Gulf Unit 1 UFSAR (Reference 4). As discussed previously, that data is still valid and conservative as compared to recent experience. Maximum point precipitation values are given in Table 2.3-74 for the 2-hour to 10-day durations shown. *These were interpolated from the maps of USWB Technical Papers 40 and 49* (References 26 and 27). Technical Memorandum NWS HYDRO-35 (Reference 52) was consulted for updated (from Technical Paper 40) 30-minute and 1-hour duration precipitation values shown in Table 2.3-74. For comparison purposes, the recent 5-year maximum short period precipitations are listed for Vicksburg, Mississippi in the table.

Table 2.3-75 *was taken from* Reference 28. *It presents maximum observed short period precipitation data for Vicksburg.*

A comparison of the two tables suggests that 100 year amounts may have occurred during the period of record (1893-1961) for precipitation amounts for periods of 3, 6, 12, and 24 hour durations.

A comparison of the more recent data record, the five years from 1997 through 2001, shows that the more recent period has had less heavy rains than expected for a random 5-year period.

2.3.2.1.4.2 Snow

Annual average snowfall in the Grand Gulf area is estimated to be 1 to 2 inches. This estimate is based on 36 years of record (1930 -1966) at Vicksburg (Reference 29) *and 39 years of record (1936-1975) at Jackson (*Reference 25*).* This data is assumed to be more representative of the long term site meteorology due to the relatively dry recent years, although, during 1997 through 2001, the Vicksburg meteorology station reported snow conditions for several hours in November through March as presented in Table 2.3-76.

The maximum monthly amount in Vicksburg was 10 inches in February 1960 and this total fell within a 24 hour period. The maximum annual amount was also 10.0 inches. At another site in the Vicksburg area a total of 10.1 inches of snow fell in January 1919.(Reference 29). The maximum recorded in the current NCDC storm event database is 8 inches in December 14, 1997 (Reference 5). This database coves snowstorms for the period 1993 through September 2002.

The maximum monthly amount at Jackson was 10.6 inches in January 1940 in a 24-hour period. The maximum annual amount was 11.6 inches and occurred in the 1939-1940 season (Reference 25).

2.3.2.1.5 Precipitation Wind Roses

Figure 2.3-17 shows an annual precipitation wind rose for Jackson, Mississippi for 10 years prior to 1972 (Reference 4 Figure 2.3-5). This data shows that rains in Jackson happen most often in the months of December through March, with the most common directions of SE through S and N-NW through NE. *Winds speeds during precipitation average 9.1 mph annually and over 7.9 mph (the average annual wind speed) during fall, winter, and spring.*

Figure 2.3-18 shows an annual precipitation wind rose for the GGNS site based on data from the years 2001 through 2003. This data is also seen in Table 2.3-77, as well as monthly rain totals in Table 2.3-70. This is a shorter data collection period than the Reference 4 precipitation wind rose, and these are relatively dry years, but the same general trends can be seen. The period of greatest rain is still December through March. The most frequent wind directions are N-NW to E-NE and SE to S.

2.3.2.1.6 Fog and Smog

Table 2.3-78 shows that over the period 1997 to 2001, Vicksburg has averaged about 93 hours/year of fog, with October through January having the greatest frequency of fog. Vicksburg records are considered representative of the Grand Gulf site due to its proximity and to its similar location relative to the bank of the Mississippi.

Note that the Grand Gulf Unit 1 UFSAR estimated that moderate fog will occur about 1 percent (88 hours) of the time at Grand Gulf, and heavy fog will occur about 0.6 percent (53 hours) of the time (Reference 4), which is consistent with the Table 2.3-78 data.

The Grand Gulf Unit 1 UFSAR also contains an evaluation of smog based on Jackson data over the years 1955 through 1964. Grand Gulf is well removed from Jackson metropolitan area and

Vicksburg, and is, therefore, not prone to heavy smog. Table 2.3-78 shows haze records by month from Vicksburg for the period of 1997 - 2001. There were about 194 hours/yr on average of haze during this period.

2.3.2.1.7 Atmospheric Stability

Atmospheric stability data for the Grand Gulf site were generated as part of a plume behavior study. This stability data was generated in Reference 32 based on three years of surface observations at the Grand Gulf site and sky cover data from the Vicksburg NCDC meteorology station. Hourly observation data were converted into stability classes and frequency by season using the SACTI software code, Reference 31. The resulting stability classes for the Grand Gulf site are presented by season and wind direction in Tables 2.3-80 through 2.3-83, and annual frequency data is presented in Table 2.3-79.

The frequency and strength of inversion layers are also investigated with nine years of weather balloon data collected at the Jackson airport. Weather balloons are released twice daily at 6:00 a.m. and 6:00 p.m., to collect temperatures at increasing elevations. The monthly data are provided in Tables 2.3-84 through 2.3-95, and annual average data in Table 2.3-96, in terms of percentages of mornings and afternoons containing inversions, average inversion layer elevation, and the maximum strength of the inversions. An inversion is defined as any three elevation readings showing temperatures increasing with elevation. The inversion layer height is the point (found by interpolation between readings) at which temperature again starts to decrease with elevation. The maximum inversion strength is the maximum temperature rise divided by elevation difference within the inversion layer. (Reference 15)

The weather balloon data does not address how long inversion layers may persist. For this purpose, the Grand Gulf Unit 1 UFSAR data, based on the period 1955 through 1964, is used in Tables 2.3-97 through 2.3-108. *The tables show the number of discrete periods when inversion conditions existed one hour, or two or more consecutive hours. Short periods contained within a longer period are not considered as discrete occurrences. These tables show the data for each of the 10 years in order to show the variations from year to year. They also show the monthly mean distribution calculated from the 10 years.*

The monthly means are summarized in Tables 2.3-109 and 2.3-110 *and they have been added to give an annual mean.*

Tables 2.3-111 through 2.3-124 *show similar inversion data for the Grand Gulf site. These inversion occurrences were determined from E, F, or G stability classifications resulting from onsite delta-temperature measurements. The period covered by the data is from August 1972 through July 1974 and January 1976 through December 1976.*

2.3.2.1.8 Mixing Heights

Monthly mixing heights for Jackson, Mississippi are shown in Table 2.3-125. These were obtained from the NCDC and are based on the ten-year period 1992 through 2001 (Reference 15). Consistent with the mixing heights presented in the Grand Gulf UFSAR (Reference 4), which are based on a four year record at Jackson, the average mixing heights in the mornings are lowest during the fall, and the average mixing heights in the afternoon are lowest in the winter.

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

Operation of a new facility at the Grand Gulf site will influence the local climatology. A discussion of the expected extent of this influence is presented in this section.

As noted in Section 2.3.1.1, the only aspects of the Grand Gulf site that could be categorized as a unique micro-climate relate to the Mississippi River. The proximity of the river increases the local humidity by a small but measurable amount as seen when comparing Vicksburg wet bulb measurements to Jackson wet bulb measurements. There is also a slight tendency for lower level winds to be channeled along the Mississippi River.

New construction at the site is not expected to impact this climatic situation significantly. Figures 2.1-1 and 2.1-2 show the intended construction areas. Although there will be some ground leveling, there are no significant climate-shaping topographic features to be changed. The site is already a relatively flat area north of the Bayou Pierre River with more significant hills to the north and south that will not be impacted by construction (refer to SSAR Figure 2.5-10 for a depiction of topography within 5 miles of the ESP site). There will be some tree removal, but the trees within the construction footprint are small in number compared to the surrounding forested land. There are no significant changes anticipated or proposed in terms of local hydrologic features. There are no significant changes to local roadways anticipated in support of the proposed new facility. The site already contains numerous buildings, large parking areas, and traffic. The impacts of more such structures, facilities, or activities in this relatively remote, rural area are not expected to be noticeable in terms of local meteorology.

Operation of power generation units can affect local climate in three ways, additional generation of particulates (increased fog or haze), temperature effects on local water sources, and cooling tower plume effects. Since the proposed unit is nuclear, any increase in particulate emissions during operation would be due to a modest increase in automobile traffic and the rare operation of diesel generators. Nuclear power is often described as the most environmentally benign source of energy primarily because of the lack of emitted pollutants. Therefore it can be concluded that the net increase in particulates will be negligible and will not cause any noticeable climatic effects.

The impact on Mississippi River water temperature is discussed in section 2.3.2.2. In brief, the proposed new facility would utilize cooling towers, so that the vast majority of rejected heat would go to the atmosphere. The amount of heat rejected to the high volumetric flow of the Mississippi River would be relatively small, causing a concomitantly small impact on local meteorology.

The remainder of this section discusses the cooling tower plume effects. The center of the proposed cooling tower(s) location is approximately 1 mile east of the Mississippi River. From the wind rose of Figure 2.3-1, it can be seen that the prevailing winds are from the east in a wide arc extending from north to south. This means that the cooling tower plumes will usually extend out over the Grand Gulf ESP site itself towards the Mississippi River. Therefore, it can be concluded that most of the local climatological effects such as increased moisture and shading will be limited to the ESP site.

The major thrust of the following discussion is aimed at an evaluation of cooling tower plume effects. An assessment of the contribution of moisture to the ambient environment from cooling tower blowdown waste heat discharge is included. Finally, a qualitative evaluation of the effects of the cooling system on daily variations of several meteorological parameters is presented.

A number of literature sources were reviewed to determine the nature and extent of studies made of the effects of waste heat disposal systems on the meteorological environment. The literature search revealed a lack of definitive, empirical studies, and validated methods to approach the complex problems involved in quantitatively assessing the extent of the modifications of the atmosphere. Though many theoretical models have been postulated for *calculating cooling tower visible plume lengths, none of those models reviewed has been adequately verified by scientific observations*

2.3.2.2.1 Cooling Tower Plumes

Cooling systems, which depend on evaporation of water for a major portion of the heat dissipation, may create visible vapor plumes. These vapor plumes cause shadowing of nearby lands, salt deposition, and can cause fogging or icing. An assessment of potential plumes from the addition of a new power production facility with cooling towers at the Grand Gulf site and the cooling tower plume impacts was performed (Reference 32). This assessment was done using the SACTI plume modeling code (Reference 31). Grand Gulf site and Vicksburg meteorology data for the period 1997 through 2001 was used in the model.

Two different options for cooling towers were evaluated for the new facility, and each was addressed in the assessment. The first consisted of four natural draft cooling towers (NDCTs) to provide normal heat sink cooling capability. The second utilized four 20-cell linear mechanical draft cooling towers (LMDCTs) for the same function. In both cases, the total heat rejected to the atmosphere is as defined in Table 1.3-1 (condenser / heat exchangers duty). The heat load used is a bounding value and is the primary conservatism in the study. Reasonable estimates were made for cooling tower dimensions, layout, and airflow rates, since final design of the facility is not known. Maximum drift rate for cooling towers of these types, and average Mississippi River water salt concentration were used to support deposition calculations.

Table 2.3-126 describes the expected plume lengths by season and direction for the NDCT option. Each of the four individual NDCTs have less heat rejection than the existing operating GGNS Unit 1 NDCT, but the four plumes merge and carry farther than for an individual tower.

Table 2.3-127 presents the plume lengths by season and direction for the LMDCT option. These plume lengths are typically shorter, but the plumes would be closer to the ground. This increases salt deposition and the possibility of fogging.

Table 2.3-128 compares the plume lengths by frequency for the NDCT and LMDCT options.

2.3.2.2.2 Blowdown Discharge

*Configuration of surface thermal plumes resulting from the discharge of blowdown water into the Mississippi River were calculated by Pritchard (*Reference 33 *for February and June for both high- and low-water cases).*

*By applying the steam fog index method developed by Currier, et al. (*Reference 34 *for cooling ponds, steam fog occurrence probabilities over the core (+10 F isotherm) of the plume of 38 percent were obtained during extreme February morning conditions. In June, the probability is only five percent.*

Initially, the results for February appear to be extremely significant. However, it must be pointed out that the steam fog index over the ambient river water yields a probability of 13 percent and the core of the thermal plume covers an area of only 0.007 acre. The +5 F isotherm encloses an area of 2.6 acres with a steam fog occurrences probability only a few percent higher than over ambient river water. A separate approach, based on humidity increases due to evaporation, yielded even lower probabilities.

2.3.2.2.3 Cooling System Plume Effects on Ground Level Meteorological Variables

a. *Wind*

Operation of cooling towers creates a miniconvective cell above the tower. Air surrounding the tower near the surface is drawn into the base of the tower. This air is heated in the tower, rises, and, with the excess moisture picked up while passing through the tower, creates the vapor plume. Therefore, the surface winds in the vicinity of the towers are deflected toward the towers. No quantitative estimate has been made of the horizontal extent of this effect, but it certainly does not extend as far as the site boundaries.

b. *Temperature*

The vast majority of heat released to the atmosphere by the cooling system will be carried aloft with the cooling tower plumes, thereby warming considerably the air in the plumes. Surface air temperatures near the cooling tower are expected to be slightly cooler than ambient during the day and slightly warmer at night due to weak entrainment of air aloft in the convective circulation. Also, air near the heated blowdown discharge plume in the Mississippi River may be slightly above ambient. These differences are so small and local that they cannot be measured beyond a few hundred feet from the tower or thermal plume.

c. *Atmospheric Water Vapor*

In the vicinity of the vapor plumes, both the absolute and relative humidity aloft will be increased as evidenced by calculated frequency of visible plume occurrence. Absolute humidity at the surface will be increased only slightly. However, relative humidity near the tower may be increased during the colder months due to relatively low moisture-bearing capacities of cold air. As has been noted, blowdown thermal discharge influences on atmospheric humidity will be insignificant.

d. *Precipitation*

*Light drizzle and snow occasionally have been noted within a few hundred meters downwind from cooling towers (*Reference 35*), but these phenomena are very localized and should have no effect outside the site boundary. Huff compared the flux of water vapor and air from natural draft cooling towers with those occurring in natural convective showers. His results indicate that some enhancement of small rain showers might be expected, as tower fluxes are within an order of magnitude of the shower fluxes. Larger thunderstorms, with their much greater flux values, should not be significantly affected, except that formation may occur somewhat earlier in the day than would otherwise be expected, with the cooling tower plume possibly acting as a triggering mechanism.*

e. *Fog and Icing Stability*

*Studies conducted by Broehl (*Reference 36*), Zeller (*Reference 37*), and Hosler (*Reference 38*) indicate that surface fogging from natural draft towers does not present a significant problem. Broehl and Zeller found no cases of cooling tower plumes reaching the ground, while Hosler noted only one in a two year study at the Keystone Power Plant, near Shelcota, in western Pennsylvania.*

The plume study performed for a new facility on the site (Reference 32), showed no fogging would occur for the NDCTs option. The LMDCTs are predicted to cause only minimal fogging, on the order of 15 hours per year. It should be noted, however, that that the SACTI code used in the Reference 32 assessment has not been as extensively benchmarked for fogging as it has been for visible plumes and deposition (Reference 50).

It follows that ground-level icing should be considered insignificant at the Grand Gulf site because of the combined low probabilities of ground-level plumes from either type tower and freezing conditions.

f. Stability

No quantitative assessment can be made of the influence of the cooling system on atmospheric stability. It can be reasoned that beneath the cooling tower plumes somewhat more stable conditions might be expected than would otherwise be experienced during the day and slightly less stable at night.

g. Dew

*A study conducted at Plant Bowen, Cartersville, Georgia, (*Reference 39*) indicates that dew formation may be significantly retarded beneath the cooling tower plume, especially during the winter months.*

h. Dispersion of Radioactive Effluents

Although atmospheric ventilation may be reduced beneath the cooling tower plumes, this effect may well be more than compensated for by increases in dispersion due to cooling tower convection. When the winds carry vented effluents toward the towers, a portion of the effluents may be caught up in the influx of air at the base of the towers and carried aloft with the plume.

Based on the above discussion, it is concluded that the new facility's cooling system, i.e., the cooling tower plume (from either the NDCT or LMDCT designs) would have no significant impact on meteorological conditions at ground level at Grand Gulf.

2.3.2.3 Topographical Description

The proposed location for the new facility site lies about 6,300 feet east of the Mississippi River. The town of Port Gibson, Mississippi lies about six miles to the southeast, the town of St. Joseph, Louisiana lies about 13 miles to the southwest, and the Big Black River empties into the Mississippi River about three miles to the north.

The surrounding terrain is generally hilly and wooded to the south and east, with several hilltops over 350 feet above mean sea level to the south. To the north and west, the terrain is generally flat and wooded, lying less than 100 feet above mean sea level. Numerous lakes of various sizes and isolated marshes dot the landscape. There is a rather abrupt (irregular) 100 to 200 foot rise in terrain approximately one mile east of the riverbank. Figures 2.3-19 to 2.3-21 *present topographic cross sections and a site area map.*

According to Regulatory Guide 1.3 (Reference 49), credit for elevated release of contaminants is given only if the release point is at a height of at least 2.5 times the height of the tallest nearby structure that could affect dispersion. Since discussion of effects of topography on diffusion estimates is required only for elevated releases, and the diffusion analyses for the new facility at the Grand Gulf site assume a ground level release, these effects have not been estimated.

2.3.2.4 Local Meteorological Conditions for Design and Operating Bases

Site specific data was used for determination of atmospheric dispersion and diffusion estimates as discussed in Sections 2.3.4 and 2.3.5 of this report and is indicated for the UHS design basis. In general, however, given the size of the database from which to draw, regional rather than local meteorological and air quality conditions would be used for the design and operating bases of the ESP facility.

2.3.3 Onsite Meteorological Measurements Program

The onsite meteorological measurements program has been designed to meet requirements at least as stringent as those required by Regulatory Guide 1.23 (Reference 48).

The onsite meteorological measurement program has evolved over the years from temporary monitoring towers installed prior to construction to a state-of-the-art system installed in late 2000 and early 2001. In March of 1972 two temporary towers were installed, one on the bluff and one in flood plane, near the Mississippi River Bank. A permanent tower was installed in August 1972 approximately 5000 ft N-NW of the center of the Unit 1 reactor, adjacent to the temporary tower. Both temporary towers were removed in March of 1973.

The permanent tower was 162 ft high and supported instrumentation for wind speed and direction and temperature at 33 ft and 162 ft. The instrumentation on this tower was upgraded in 1983 to meet the requirements of NUREG-0654 as part of the initial licensing conditions for GGNS Unit 1. A back-up tower was also installed to provide data on wind speed and direction and sigma-theta.

Data collection since the startup of the system (August 1972) has met Regulatory Guide 1.23 (Rev. 0) requirements except the relative humidity data as discussed in Section 2.3.3.1. A new relative humidity sensor was installed in December 2000 as indicated in Section 2.3.3.2.

2.3.3.1 Onsite Meteorological Measurements Program – Pre-2000 Modifications

The permanent tower is 162 feet high and has the following equipment installed at each of the indicated levels (all heights above grade):

Surface	*Tipping bucket rain gauge* *Delta temperature translator* *(utilizes 33- and 162-foot temperature sensors)*
33 feet	*Wind speed sensor,* *Wind direction sensor,* *Temperature sensor,* *Dew point sensor*
162 feet	*Wind speed sensor,* *Wind direction sensor,* *Temperature sensor*

Table 2.3-129 *shows the specifications of the meteorological equipment at Grand Gulf. All data collected since the starting date of August 2, 1972, have met Regulatory Guide 1.23 requirements except the relative humidity data. Maintenance and operational difficulties were experienced with the relative humidity sensors. The sensors were replaced by two Tech-Ecology Met Set 5-T Dewpoint systems in December 1976.*

….

All parameters are measured by duplicate sensors at each level.

Meteorological data from the permanent tower will be supplemented with information from the backup meteorological system. This system will monitor wind speed, wind direction, and sigma theta. The information from the backup system will be supplied to the control room via a telemetry system. This information will be utilized to ensure data availability should a temporary loss of information from the permanent tower occur. Table 2.3-129 *outlines the specifications for the backup meteorological equipment.*

All information recorded by the meteorological instruments on the permanent tower are stored both in digital and analog forms. The analog traces serve as backup to the digital system. Data from the temporary tower instrumentation were recorded by analog trace only.

The permanent (main) tower serves as a representative observation station (i.e., meteorological conditions at that location are considered to be representative of the site). The 162-foot meteorological tower with base elevation of 156 feet (MSL) is located approximately 5,300 feet northwest of the control building of the station as shown in Figure 2.1-1*. The nearest bluffs are 362 feet to the west of the meteorological tower. There are trees 35 feet high along these bluffs. Approximately 50 feet below the bluffs the flood plain extends 4,500 feet to the west to meet the Mississippi River at an elevation of 65 feet (MSL). To the south and to the east, the nearest trees are 689 feet and 396 feet from the tower, respectively. Tree heights in these directions are between 50 to 60 feet. A country road passes the meteorological tower 400 feet to the north. The meteorological tower is surrounded by a fence which is 7 feet high and 70 feet away from the base of the tower. An instrument shack about 8 feet high is installed near the base of the tower. The immediate vicinity of the tower is covered by Bermuda grass which is mowed as necessary. The soil beneath the grass is loess. ….*

The percentage of data recovery during the first annual cycle … for [the] *combination of sensor systems used in preparation of joint frequency distributions … and used in diffusion analyses …. [50/10 meters (162/33 feet) T, 10 meters (33 feet) wind direction and speed],* [was] *98.73 percent of all possible sets of hourly values from August 1, 1972 through July 31, 1973 …. Data recovery from each of the other sensing systems exceeded 90 percent for the year.*

2.3.3.1.1 Meteorological Data Processing

2.3.3.1.1.1 Introduction

The data processing procedure for Grand Gulf meteorological data involves three basic steps:

- *a. Data collection*
- *b. Data editing and consolidation*
- *c. Data analysis*

Computer software has been developed to process the collected data according to steps b. and c. above. This section includes a summary of the data collection methods and description of the processing and analysis of the data.

2.3.3.1.1.2 Data Collection

The onsite meteorological data are recorded in both analog and digital form.

2.3.3.1.1.2.1 Analog Data

The analog traces are recorded on strip charts which act mainly as a backup and verification for the digital data. The data are recorded continuously on six chart rolls, one for each of the following sets of parameters:

1. *50-meter (162 foot) wind speed and direction (sensor A)*
2. *50-meter (162 foot) wind speed and direction (sensor B)*
3. *10-meter (33 foot) wind speed and direction (sensor A)*
4. *10-meter (33 foot) wind speed and direction (sensor B)*
5. *10-meter (33 foot) temperature and 50-meter (162 foot)/ 10-meter (33 foot) T, surface precipitation, and 10-meter (33 foot) dew point temperature (sensor A)*
6. *10-meter (33 foot) temperature and 50-meter (162 foot)/ 10-meter (33 foot) T, surface precipitation, and 10-meter (33 foot) dew point temperature (sensor B)*

All wind speeds are recorded in miles per hour. Wind directions are recorded on a 0~~*-540F*~~[360 degrees] *scale. Temperatures are recorded in F (degrees Fahrenheit). The precipitation is a step trace, each step representing 0.01 inches.*

2.3.3.1.1.2.2 Digital Data

The digital data is received by the plant data computer at a rate of one reading per second. It is recorded each time the value varies by a specified deadband. Each piece of data is checked to assure it is between the minimum and maximum instrument limits. This quality indication and the time is recorded with each value.

An average is calculated each hour from the one second readings. The quality of the samples is reflected in the quality of the average. This quality indication and the time the average was calculated is recorded with each hourly value.

The meteorological data are available to the main control room and personnel via the plant computer. A one second reading and an hourly average is available for each of the following parameters:

1. *Wind speed - 10-meter (33 foot) and 50-meter (162 foot) elevations*
2. *Wind direction - 10-meter (33 foot) and 50-meter (162 foot) elevations*
3. *Temperature - 10-meter (33 foot) elevation*
4. *Differential temperature (T) - 10-meter (33 foot) and 50-meter (162 foot) elevations*
5. *Dew point - 10-meter (33 foot) elevation*
6. *Precipitation - ground level*

2.3.3.1.1.3 Data Processing

The meteorological data is gathered from the plant data computer recordings on request. The quality of the hourly averages is used to determine the data reliability. The data is then available for correction or change and reliability is evaluated again.

The hourly readings are used to calculate joint frequency distributions from wind speeds and wind direction data for the 10 meter and 50 meter levels. These frequency distributions are summarized on request for each Pasquill Stability Class.

2.3.3.1.2 Meteorological Instrumentation Inspection and Maintenance

GGNS has established procedures for the inspection and maintenance of the onsite meteorological instrumentation. This responsibility is shared between the Operations and Maintenance Departments.

Routine inspections are made to ensure proper operation of equipment and that no damage to the tower, shack, or any other structure or equipment has occurred. The recording medium are checked for proper operation and changed biweekly. The standby generator is tested for auto start on a routine basis.

Semiannual visual inspections of the tower and equipment are made to determine the conditions of sensors, cabinets, wiring, structures, and individual components. Semi-annual checks for proper instrumentation readings are made at various points. A check for the "As-Found" and "Final" data condition are made to verify proper operation of the equipment. A check on the battery bank and battery charger is made along with the proper operation of the standby generator and its inverter. The tower cables are adjusted for proper tension, and the following instrumentation is calibrated:

1. *2 - Differential temperature sensor, El. 33'-162' (10-50 meters)*
2. *2 - Dew point - El. 33' (10 meters)*
3. *2 - Wind speed - El. 33', 162' (10 meters, 50 meters)*
4. *2 - Wind direction - El. 33', 162' (10 meters, 50 meters)*
5. *Rain gauge – Surface*

2.3.3.2 Onsite Meteorological Measurements Program – Post-2000 Modifications

Both the main 162 ft (50-meter) tower and backup 33 ft (10-meter) tower were replaced around December of 2000, due to obsolescence and increased maintenance costs. The 162 ft (50-meter) tower has the following equipment installed at each of the indicated levels (all heights above grade):

Surface	*Tipping bucket rain gauge* *Delta temperature (utilizes 33- and 162-foot temperature sensors)*
33 feet	*Wind speed sensor* *Wind direction sensor* *Relative humidity sensor*
162 feet	*Wind speed sensor* *Wind direction sensor* *Temperature sensor*

The specifications for the new instrumentation are provided in Table 2.3-130*.*

The main tower serves as a representative observation station (i.e., meteorological conditions at that location are considered to be representative of the site). The 162-foot meteorological tower with base elevation of 156 feet (MSL) is located approximately 5,300 feet northwest of the control building of the station as shown in Figure 2.1-1*. The nearest bluffs are 362 feet to the west of the meteorological tower. There are trees approximately 50 feet high along these bluffs. Approximately 50 feet below the bluffs, the flood plain extends 4,500 feet to the west to meet the Mississippi River at an elevation of 65 feet (MSL). To the south and to the east, the nearest trees are approximately 489 feet and 396 feet from the tower, respectively. Tree heights in these directions are between 50 to 60 feet. A country road passes the meteorological tower 600 feet to the north. The meteorological tower is surrounded by a fence which is 8 feet high. An instrument shack about 8 feet high is installed approximately 400 feet north of the tower. ….*

Data recovery from the new meteorological tower instrumentation, based on evaluation of data from March 2001 to March 2002, was 98 percent.

2.3.3.2.1 Meteorological Data Processing

The data processing procedure for Grand Gulf meteorological data involves three basic steps:

a. Data collection

b. Data editing and consolidation

c. Data analysis

Computer software has been developed to process the collected data according to steps b. and c. above. This section includes a summary of the data collection methods and description of the processing and analysis of the data.

2.3.3.2.1.1 Data Collection

The onsite meteorological data are recorded in digital form.

All wind speeds are recorded in miles per hour. Wind directions are recorded on a 0-360° scale. Temperatures are recorded in F (degrees Fahrenheit). The precipitation is a step trace, each step representing 0.01 inches. Relative humidity is recorded on a 0 100% scale. Sigma Theta is calculated and recorded in degrees.

The digital data package is received by the plant data computer every ≤ ten seconds. It is recorded each time the value varies by a specified deadband. Each piece of data is checked to assure it is between the minimum and maximum instrument limits. This quality indication and the time is recorded with each value.

An average is calculated every fifteen minutes and each hour from the readings. The quality of the samples is reflected in the quality of the average. This quality indication and the time the average was calculated is recorded with each value.

The meteorological data are available to the main control room and personnel via the plant computer. A ≤ ten second reading, a fifteen minute average, and an hourly average is available for each of the following parameters:

1. Wind speed – 10-meter (33 foot) and 50-meter (162 foot) elevations

2. Wind direction – 10-meter (33 foot) and 50-meter (162 foot) elevations

3. Temperature – 10-meter (33 foot) and 50-meter (162 foot) elevations

4. *Differential temperature (T) – 10-meter (33 foot) and 50-meter (162 foot) elevations*
5. *Relative Humidity – 10-meter (33 foot) elevation (ten second and hourly only)*
6. *Precipitation – ground level*
7. *Sigma Theta – 10-meter (33 foot) and 50-meter (162 foot) elevations (fifteen minute and hourly only)*
8. *Aspirator flow – 10-meter (33 foot) and 50-meter (162 foot) elevations (fifteen minute and hourly only)*

2.3.3.2.1.2 Data Processing

The meteorological data is gathered from the plant data computer recordings on request. The data can also be acquired from data storage modules in the MET Shack. The quality of the hourly averages is used to determine the data reliability. The data is then available for correction or change and reliability is evaluated again.

The hourly readings are used to calculate joint frequency distributions from wind speeds and wind direction data for the 10 meter and 50 meter levels. These frequency distributions are summarized on request for each Pasquill Stability Class.

2.3.3.2.2 Meteorological Instrumentation Inspection and Maintenance

GGNS has established procedures for the inspection and maintenance of the onsite meteorological instrumentation. This responsibility is shared between the Operations and Maintenance Departments.

Routine inspections are made to ensure proper operation of equipment and that no damage to the tower, shack or any other structure or equipment has occurred.

Semiannual visual inspections of the tower and equipment are made to determine the conditions of sensors, cabinets, wiring, and individual components. Semi-annual checks for proper instrumentation readings are made at various points. A check for the "As-Found" and "Final" data condition are made to verify proper operation of the equipment. A check on the batteries and battery charger is made. The tower cables are adjusted for proper tension, and the following instrumentation calibrated on the primary tower:

1. *2-Temperature sensor, El. 33'-162' (10-50 meters)*
2. *1-Relative Humidity– El, 33' (10 meters)*
3. *1-Wind speed – El, 33', 162' (10 meters, 50 meters)*
4. *1-Wind direction – El, 33', 162' (10 meters, 50 meters)*
5. *Rain gauge – Surface near primary tower*

The following instruments are calibrated on the back-up tower:

1. *1 – Temperature sensor, El. 33' (10 meters)*
2. *1 – Wind speed, El. 33' (10 meters)*
3. *1 – Wind direction, El. 33' (10 meters)*

For this ESP application, calculations to determine diffusion estimates for both short- and long-term conditions were completed using data from the meteorological instrumentation in service prior to the most recent replacement in December 2000, as described in Section 2.3.3.1. Data recovery for the period evaluated in the calculations (Sections 2.3.4 and 2.3.5) is indicated in Table 2.3-131.

2.3.4 Short Term Diffusion Estimates

2.3.4.1 General

The consequence of a design basis accident in terms of personnel exposure is a function of the atmospheric dispersion conditions at the site of the potential release. Atmospheric dispersion consists of two components: 1) atmospheric transport due to organized or mean airflow within the atmosphere and 2) atmospheric diffusion due to disorganized or random air motions. Atmospheric diffusion conditions are represented by relative air concentration (*X*/Q) values (Reference 45).

The efficiency of diffusion is primarily dependent on winds (speed and direction) and atmospheric stability characteristics. Dispersion is rapid within stability Classes A through D and much slower for Classes E through G. That is, atmospheric dispersion capabilities decrease with progression from Classes A to G, with an abrupt reduction from Classes D to E.

Relative concentrations of released gases, X/Q values, as a function of direction for various time periods at the exclusion area boundary (EAB) and the outer boundary of the low population zone (LPZ), were determined by the use of the computer code PAVAN (Reference 43). *This code implements the guidance provided in Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," August 1979.* The *X*/Q calculations are based on the theory that material released to the atmosphere will be normally distributed (Gaussian) about the plume centerline. A straight-line trajectory is assumed between the point of release and all distances for which *X*/Q values are calculated (References 43, 45).

Using joint frequency distributions of wind direction and wind speed by atmospheric stability, PAVAN provides the X/Q values as functions of direction for various time periods at the exclusion area boundary (EAB) and the low population zone (LPZ). The meteorological data needed for this calculation included wind speed, wind direction, and atmospheric stability. The meteorological data used for this analysis was collected from the on-site monitoring equipment from January 2002 through December 2003. These two years were averaged and are reported in Tables 2.3-132 through 2.3-138. Other plant specific data included tower height at which wind speed was measured (10.0m), and distances to the EAB (841m) and LPZ (3219m).

Within the ground release category, two sets of meteorological conditions are treated differently. During neutral (D) or stable (E, F, or G) atmospheric stability conditions when the wind speed at the 10-meter level is less than 6 meters per second (m/s), horizontal plume meander is considered. X/Q values are determined through the selective use of the following set of equations for ground-level relative concentrations at the plume centerline:

$$X/\mathrm{Q} = \frac{1}{\mathrm{U}_{10}\left(\pi u_y u_z + \mathrm{A}/2\right)} \qquad \text{Equation 1}$$

$$X/\mathrm{Q} = \frac{1}{\mathrm{U}_{10}\left(3\pi u_y u_z\right)} \qquad \text{Equation 2}$$

$$X/\mathrm{Q} = \frac{1}{\mathrm{U}_{10}\pi \boldsymbol{S}_{\mathrm{y}} u_{\mathrm{z}}} \qquad \text{Equation 3}$$

where:

X/Q *is relative concentration, in sec/m³,*

U_{10} *is wind speed at 10 meters above plant grade, in m/sec*

u_y *is lateral plume spread, in meters, a function of atmospheric stability and distance*

u_z *is vertical plume spread, in meters, a function of atmospheric stability and distance*

S_y *is lateral plume spread with meander and building wake effects, in meters, a function of atmospheric stability, wind speed, and distance*

A *is the smallest vertical-plane cross-sectional area of the reactor building, in meters²*

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

During all other meteorological conditions, unstable (A, B, or C) atmospheric stability and/or 10-meter level wind speeds of 6 m/s or more, plume meander is not considered. The higher value calculated from equation 1 or 2 is used as the appropriate X/Q value.

From here, PAVAN constructs a cumulative probability distribution of X/Q values for each of the 16 directional sectors. This distributions is the probability of the given X/Q values being exceeded in that sector during the total time. The sector X/Q values and the maximum sector X/Q value are determined by effectively "plotting" the X/Q versus probability of being exceeded and selecting the X/Q value that is exceeded 0.5% of the total time. This same method is used to determine the 5% overall site X/Q value.

The X/Q value for the EAB or LPZ boundary evaluations will be the maximum sector X/Q or the 5% overall site X/Q, whichever is greater (Reference 45). *All direction-dependent sector values are also calculated.*

2.3.4.2 Calculations and Results

Reference 45 divides release configurations into two modes, ground release and stack release. A ground release includes all release points that are effectively lower than two and one-half times the height of the adjacent solid structures. Since specific building arrangement details (i.e., building height and area) are unknown until a specific plant type is selected, the building area and height were not used in the calculation. This is conservative since the building wake effect will tend to reduce the calculated *X*/Q. Also, since the release point, or stack height, is unknown until a specific plant type is selected, the release mode was classified as a ground release.

PAVAN requires the meteorological data in the form of joint frequency distributions of wind direction and wind speed by atmospheric stability class. The meteorological data used was obtained from the GGNS meteorological data collected from 2002 and 2003.

The stability classes were based on the classification system given in Table 2 of Regulatory Guide 1.23 (Reference 48), as follows:

CLASSIFICATION OF ATMOSPHERIC STABILITY

(Reference 48, Table 2)

STABILITY Classification	Pasquill Categories	σ_{θ}^{*}	Temperature change with height (°C/100m)
Extremely unstable	A	25.0°	<-1.9
Moderately unstable	B	20.0°	-1.9 to -1.7
Slightly unstable	C	15.0°	-1.7 to -1.5
Neutral	D	10.0°	-1.5 to -0.5
Slightly stable	E	5.0°	-0.5 to 1.5
Moderately stable	F	2.5°	1.5 to 4.0
Extremely stable	G	1.7°	> 4.0

* Standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour.

Joint frequency distribution tables were developed from the meteorological data with the assumption that if data required as input to the PAVAN program (i.e., lower level wind direction, lower wind speed, and temperature differential) was missing from the hourly data record, all data for that hour was discarded. Also, the data in the joint frequency distribution tables was rounded for input into the PAVAN code.

Building area is defined as the smallest vertical-plane cross-sectional area of the reactor building, in square meters. As stated above, this parameter was not used and the building area was entered as zero.

Building height is the height above plant grade of the containment structure used in the building-wake term for the annual-average calculations. As stated above, this parameter was not used and the building height was entered as zero.

The tower height is the height at which the wind speed was measured. Based on the lower measurement location, the tower height used was 10 meters.

A ground release includes all release points that are effectively lower than two and one-half times the height of adjacent solid structures (Reference 45). Therefore, as stated above, a ground-release analysis was assumed.

The cumulative frequency of *X*/Q at the EAB (841 m) can be found in Table 2.3-139. Table 2.3-140 presents the cumulative frequency at the LPZ (3219 m). A summary of results is provided below. Median (50 percent) values may be used in making realistic estimates of the environmental effects of potential radiological accidents; conservative estimates may be based on calculated 5 percent values.

Tables 2.3-141 and 2.3-142 report the directional-dependent sector *X*/Q values at the EAB and LPZ respectively.

ESP *X*/Q VALUES (sec/m^3)
(Based on 2002-2003 Meteorological Data)

	0 – 2 hrs	0 – 8 hrs	8 – 24 hrs	24 – 96 hrs	96 – 720 hrs
EAB (841 M, SW)	5.95E-04				
LPZ (3219 M, SW)		8.83E-05	6.16E-05	2.82E-05	9.15E-06

2.3.4.3 Relative Concentration Estimates at the Control Room Emergency Intake

A specific plant design has not yet been selected for construction at the GGNS ESP Site for this Early Site Permit application; therefore, determination of dispersion and diffusion coefficients at the Control Room emergency intake has not been done.

2.3.4.4 Ingress/Egress Diffusion Estimates

A specific plant design has not yet been selected for construction at the GGNS ESP Site for this early site permit application; therefore, determination of diffusion estimates for site ingress/egress has not been done.

2.3.4.5 Toxic Chemical Diffusion Estimates

See Section 2.2.3.1.

2.3.5 Long Term Diffusion Estimates

2.3.5.1 General

For a routine release, 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 effluents removal mechanisms. Annual average relative concentration, *X*/Q, and annual average relative deposition, D/Q, for gaseous effluent routine releases were, therefore, calculated.

2.3.5.2 Calculation Methodology and Assumptions

The XOQDOQ Computer Program (Reference 44) which implements the assumptions outlined in Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Release from Light-Water-Cooled Reactors" (Reference 47) developed by the USNRC, was used to generate the annual average relative concentration, *X*/Q, and annual average relative deposition, D/Q. Values of *X*/Q and D/Q were determined at points of potential maximum concentration, outside the site boundary, at points of maximum individual exposure and at points within a radial grid of sixteen 22 ½° sectors and extending to a distance of 50 miles. Radioactive decay and dry deposition were considered.

Meteorological data for the period from 2002 through 2003 was used, and receptor locations were determined from the locations given in the GGNS 2001 Land Use Census. Hourly meteorological data was used in the development of joint frequency distributions, in hours, of wind direction and wind speed by atmospheric stability class. The wind speed categories used were consistent with the GGNS short-term (accident) diffusion χ/Q calculation discussed above, and the GGNS Offsite Dose Calculation Manual (ODCM) meteorological evaluation (Reference 46). Calms were distributed as the first wind speed class.

Joint frequency distribution tables were developed from the hourly meteorological data with the assumption that if data required as input to the XOQDOQ program (i.e., lower level wind direction and wind speed, and temperature differential as opposed to upper level wind direction and wind speed) was missing from the hourly data record, all data for that hour would be discarded. This assumption maximizes the data being included in the calculation of the χ/Q and D/Q values.

The analysis assumed a combined vent located at the center of the proposed facility location. At ground level locations beyond several miles from the plant, the annual average concentration of effluents are essentially independent of release mode; however, for ground level concentrations within a few miles, the release mode is very important. Gaseous effluents released from tall stacks generally produce peak ground-level air concentrations near or beyond the site boundary. Near ground level releases usually produce concentrations that decrease from the release point to all locations downwind. Guidance for selection of the release mode is provided in Regulatory Guide 1.111 (Reference 47). In general, in order for an elevated release to be assumed, either the release height must be at least twice the height of adjacent buildings or detailed information must be known about the wind speed at the height of the release. For this analysis, routine releases from a new facility were conservatively modeled as ground level releases.

Building cross-sectional area and building height are used in calculation of building wake effects. Regulatory Guide 1.111 (Reference 47) identifies the tallest adjacent building, in many cases the reactor building, as appropriate for use. Several plant types were evaluated for the GGNS early site permit and building dimensions vary; therefore, for conservatism, building wake effects were not considered.

Consistent with Regulatory Guide 1.111 (Reference 47) guidance regarding radiological impact evaluations, radioactive decay and deposition were considered. For conservative estimates of radioactive decay, an overall half-life of 2.26 days is acceptable for short-lived noble gases and a half-life of 8 days for all iodines released 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. Therefore, in this analysis only the effects of dry deposition of iodines were considered. The calculation results with and without consideration of dry deposition are identified in the output as "depleted" and "undepleted."

No terrain recirculation factor was applied. This is consistent with the GGNS position on Regulatory Guide 1.111 (Reference 47) as stated in the UFSAR (Section 3A) (Reference 4). This regulatory position states that since the meteorological data does not show any conclusive or systematic up and down or cross valley flow, it would be inappropriate to apply recirculation factors as indicated in Regulatory Guide 1.111 (Reference 47).

Receptor locations for the Grand Gulf site were evaluated as specified in NUREG 1555 which states: "*X*/Q and/or D/Q at points of potential maximum concentration outside the site boundary, at points of maximum individual exposure, and at points within a radial grid of sixteen 22½ degree sectors (centered on true north, north-northeast, northeast, etc.) and extending to a distance of 80 km (50 mi) from the station. A set of data points should be located within each sector at increments of 0.4 km (0.25 mi) to a distance of 1.6 km (1 mi) from the plant, at increments of 0.8 km (0.5 mi) from a distance of 1.6 km (1 mi) to 8 km (5 mi), at increments of 4 km (2.5 mi) from a distance of 8 km (5 mi) to 16 km(10 mi), and at increments of 8 km (5 mi) thereafter to a distance of 80 km (50 mi). Estimates of *X*/Q (undecayed and undepleted; depleted for radioiodines) and D/Q radioiodines and particulates should be provided at each of these grid points."

2.3.5.3 Results

Results of the analysis, based upon 2 years of data collected onsite, are presented in Tables 2.3-143 through 2.3-146.

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