1.0 INTRODUCTION

1.1 The Proposed Project

This Environmental Report (ER) supports the application, of which it is a part, by System Energy Resources, Inc. (SERI), for an Early Site Permit (ESP) for possible future siting of a new nuclear power plant or plants on the existing Grand Gulf Nuclear Station (GGNS) site[1][2].

At the time of this application, SERI's general intention is that a new facility be a merchant nuclear plant, providing electrical energy to the competitive marketplace. This new marketplace was created by the Energy Policy Act of 1992 and subsequent actions by the Federal Energy Regulatory Commission (FERC) in establishing open transmission requirements for electrical energy providers. A new facility on the ESP Site would be expected to provide energy to the grid in a base-loaded manner.[3]

This Environmental Report (ER) has been prepared to meet the requirements of 10 CFR 52, Subpart A, for an Early Site Permit. 10 CFR 52.17(a)(2) requires a complete environmental report as required by 10 CFR 51.45 and 51.50, however, the environmental report must focus on the environmental effects of construction and operation of a reactor, or reactors, which have characteristics that fall within the postulated site parameters, and further the report need not include an assessment of the benefits (for example, need for power) of a action, but must include an evaluation of alternative sites to determine whether there is any obviously superior alternative to the site proposed. This report, Part 3 of the Application for an ESP, satisfies that requirement, and addresses the environmental suitability of the GGNS ESP Site, and the anticipated environmental impacts as a result of the potential future addition of one or more reactors on the existing GGNS site.

In order to evaluate the GGNS site for environmental impacts and its suitability or acceptability for possible siting of a new nuclear reactor or reactors as required by 10 CFR 52 for an Early Site Permit, it is necessary to discuss "construction and operation" of said reactor or reactors. This report may make reference to a new facility (reactor or reactors) using such terms as a project, proposed new facility, proposed facility, proposed plant, reactor or reactors to be constructed, the proposed project, ESP Facility, etc., all of which refer to a reactor or reactors, defined by the parameters in the Plant Parameters Envelope of Section 3.0 of this document. However, by this application SERI is making no commitment to the actual construction of a plant of any type on the GGNS site; rather, SERI seeks only to obtain an Early Site Permit, as

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[1] For the purposes of this Early Site Permit application, that portion of the Grand Gulf Nuclear Station site which is proposed and evaluated herein, for an Early Site Permit, may be referred to as the GGNS ESP Site or the ESP Site. The location of the site evaluated and a facility is wholly contained with the property boundary of the existing GGNS site.

[2] System Energy Resources, Inc., South Mississippi Electric Power Association (SMEPA), and Entergy Mississippi, Inc., own the GGNS site property.

[3] While the Applicant intends that a nuclear facility be operated in the open market, it is recognized that numerous commercial and regulatory issues must be addressed and resolved with state and federal agencies. The resolution of these issues would logically precede any final determination as to whether or not the facility would operate on a regulated or unregulated basis.

allowed by 10 CFR 52, Subpart A, for the potential future construction of a reactor or reactors on the site.

The GGNS site was selected for an ESP application based on an in-depth review of potential sites (Section 9.3). Criteria such as seismic characteristics, demographics, emergency planning, exclusion area, transmission access, and water availability were used in this site-selection analysis. The GGNS site meets the desired characteristics necessary to support the construction of a new nuclear plant or plants.

The Grand Gulf Nuclear Station site is located in Claiborne County in southwestern Mississippi. The plant site is on the east side of the Mississippi River about 25 miles south of Vicksburg, Mississippi, 6 miles northwest of Port Gibson, Mississippi, and 37 miles north-northeast of Natchez, Mississippi. The Grand Gulf Military Park borders a portion of the north side of the property, and the community of Grand Gulf is approximately 1-1/2 miles to the north. (Reference 2) The Universal Transverse Mercator grid coordinates for the proposed reactor(s) location for the new nuclear power plant unit(s) are approximately N3,543,261 meters and E684,018 meters.

The property boundary shown on Figure 2.1-1 encompasses approximately 2100 acres of property that makes up the Grand Gulf Nuclear Station (GGNS) site. The site and its environs consist primarily of woodlands and farms. Within this area are two lakes, Gin Lake and Hamilton Lake. These lakes were once the channel of the Mississippi River and according to Reference 2 averaged about 8 to 10 feet in depth.

The western half of the plant site consists of materials deposited by the Mississippi River and extends eastward from the river about 0.8 mile. This area is generally at elevation 55 to 75 feet above mean sea level (msl). (Reference 2)

The eastern half of the plant site is rough and irregular with steep slopes and deep-cut stream valleys and drainage courses. Elevations in this portion of the plant site range from about 80 feet above msl to more than 200 feet above msl at the inland of the site. Elevations of about 400 feet above mean sea level occur on the hilltops east and northeast of the site. (Reference 2)

The original GGNS site arrangement was designed and evaluated (References 1 and 2) for two nuclear units and two turbine generator sets. Construction of the second unit was halted prior to its completion; however, the majority of the Unit 2 power block buildings were completed, along with the outer cylindrical concrete wall of the reactor containment, which is only partially complete. The switchyard was designed and constructed to accommodate two units; construction of the second unit was never completed, but the switchyard was essentially completed for the second unit. Figure 2.1-1 shows the building layout and site property boundary.

Construction of Grand Gulf Nuclear Station (GGNS) Unit 1 (and partial completion of Unit 2) resulted in alterations to the plant site. Approximately 465 acres of the 2,100-acre site were affected by construction (Reference 1); however, permanent structures and facilities occupy only about 169 acres (Table 2.2-1), not including the heavy haul road and plant service water supply and return pipeline right of way. Since GGNS Unit 1 is located in the loessial bluff portion of the site, most site preparation and construction activities were concentrated in this area.

Construction of a new facility on the site would result in additional alterations of the site; however, much of the new construction would be conducted in areas that were previously disturbed during construction of the existing facilities (Figures 2.1-1 and 2.4-3). Construction of

2.0 ENVIRONMENTAL DESCRIPTION[1]

2.1 Station Location

The Grand Gulf Nuclear Station is located in Claiborne County in southwestern Mississippi. The site is on the east bank of the Mississippi River at river mile marker 406, approximately 25 miles south of Vicksburg, Mississippi and 37 miles north-northeast of Natchez, Mississippi. The Grand Gulf Military Park borders a portion of the north side of the property. The community of Grand Gulf is approximately 1.5 miles to the north. The town of Port Gibson is about 6 miles southeast of the site.

The Universal Transverse Mercator Grid Coordinates for the location of the new reactor(s) on the site are approximately N3,543,261 meters and E684,018 meters.

The property boundary shown on Figure 2.1-1 encompasses approximately 2100 acres of property that makes up the Grand Gulf Nuclear Station (GGNS) site. The actual site property area may be slightly less than this value due to erosion of the east bank of the Mississippi River north of the existing GGNS barge slip (Figure 2.1-2). Stabilization of this section of the river bank has been completed. A site area of 2100 acres will be used throughout this report.

The site and its environs, consisting primarily of woodlands and farms, are about equally divided between two physiographic regions. The western half of the site is in the Mississippi Alluvial Valley, consisting of materials deposited by the Mississippi River and extending eastward from the river about 0.8 mile. This area is generally at elevations of 55 to 75 feet above mean sea level (msl). Two oxbow lakes, Hamilton Lake and Gin Lake, are located in the western portion of the site. These lakes were once the channel of the Mississippi River and had an average depth of approximately 8 to 10 feet according to Reference 2. The eastern half of the plant site (in the undeveloped areas surrounding the existing plant and its facilities) is rough and irregular, with steep slopes and deep-cut stream valleys and drainage courses. Ground elevations in this portion of the plant site range from about 80 feet above msl to more than 200 feet above msl inland. Elevations of about 400 feet above mean sea level occur on the hilltops east and northeast of the site. Grade elevation for the existing Grand Gulf Nuclear Station plant structures is 132.5 feet above mean sea level. (Reference 1)

2.1.1 References

1. Grand Gulf Nuclear Station Updated Final Safety Analysis Report, UFSAR.
2. Mississippi Power and Light Company, Grand Gulf Nuclear Station Units 1 and 2, Final Environmental Report (FER), as amended through Amendment No. 8.

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[1] This ESP Environmental Report makes use of material provided in the GGNS Final Environmental Report (FER) (Reference 2) where considered appropriate. When such material (text) is used (verbatim from the FER) in this Environmental Report, it is shown in italics.

2.3 Water

The site for the Grand Gulf Nuclear Station (GGNS) is on the east bank of the Mississippi River in the vicinity of river mile 406, approximately 25 miles south of Vicksburg, Mississippi, and 6 miles northwest of Port Gibson, Mississippi. The Universal Transverse Mercator (UTM) Grid Coordinates for the center of the location of the power block area for a new facility is approximately N3,543,261 meters and E684,018 meters. The site is bounded on the west by the Mississippi River and on the east by loessial bluffs forming part of the hilly region that extends from Vicksburg to Baton Rouge, Louisiana. The barge slip used during construction of GGNS Unit 1 is located at river mile 406.4. Plant grade for the GGNS Unit 1 facility is 132.5 ft. msl.

The following sections describe the hydrological, physical, chemical, and biological characteristics of the hydrologic environment in the vicinity of the Grand Gulf site. The hydrologic environment is divided into surface water and ground water environments. The characteristics of each of the two separate environments are described separately.

2.3.1 Hydrology

The existing GGNS Unit 1 plant utilizes a natural draft and an auxiliary linear mechanical draft cooling tower for dissipating the main condenser heat load. The plant makeup and service water is supplied by a series of radial collector wells located in the floodplain parallel to the Mississippi River. During normal operation of GGNS Unit 1, plant service water is discharged to the circulating water system to supply the required circulating water system makeup water. The circulating water system blowdown for the existing GGNS Unit 1 plant is discharged to the discharge basin and from there is discharged by a single pipeline to the Mississippi River. Emergency service water is provided from concrete basins. (Reference 2)

Plant makeup (cooling tower makeup and other raw water needs) for a new facility would be supplied from the Mississippi River via an intake structure located on the east bank of the river and on the north side of the existing barge slip. Emergency cooling water (ultimate heat sink) for a new facility would be provided from closed-cooling systems which utilizes enclosed basins with mechanical draft cooling towers, or similar heat removal mechanisms, and would not be reliant on the source of water from the river intake, with the possible exception of normal makeup.

Effluent from a new facility would be combined with that from the GGNS Unit 1 facility, and the combined effluent would be discharged into the river downstream of the intake such that recirculation to the embayment area and intake pipes would be precluded.

2.3.1.1 Surface Water

2.3.1.1.1 Mississippi River

The dominant hydrologic feature in the vicinity of the site is the Mississippi River (Figures 2.3-1 and 2.3-2). … *The drainage pattern of the Mississippi River is that of a river in a stage of maturity with meanders and oxbow lakes. The average water surface slope of the Mississippi River in the vicinity of the site is between 0.1 and 0.4 feet/mile.*

The Mississippi River floodplain adjacent to the site is relatively low and flat with elevations ranging from 55 to 75 ft. At the plant site, the natural floodplain is about 60 miles wide. However, the flow is confined to a width of about two to four miles by high bluffs on the east bank and man-made levees on the west bank, with a top levee elevation ranging from 101 to 103 feet. The river has a width of about one-half to one mile during dry seasons. The width can increase to about four miles during floods. (Reference 2)

2.7 Meteorology and Air Quality

This section describes the general climate of the Grand Gulf Nuclear Station (GGNS) site and the surrounding regional meteorological conditions. This section also documents the range of meteorological conditions that would likely exist during the construction and operation of a new facility. Data presented includes a climatological summary of normal and extreme values of several meteorological parameters for the National Weather Service stations located in Jackson and Vicksburg, Mississippi.

2.7.1 General Climate

General climate data provided here is based on Climatic Atlas of the United States, (U.S. Department of Commerce, 1968 - Reference 32), "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years" (U.S. Weather Bureau, 1961 - Reference 20), "Two to Ten Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States" (U.S. Weather Bureau, 1964 - Reference 21), the ASHRAE Fundamentals Handbook, 2001 (Reference 34), and "Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States" (NOAA, 1977 – Reference 35).

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 more than 3 or 4 days. (Reference 4)

In summer, climate is almost wholly dominated by the westward extension of the Bermuda High, a subtropical, semi-permanent 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. 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. (Reference 4)

Mississippi is south of the average track of winter cyclones, but occasionally one moves across 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. Mississippi is also occasionally in the path of tropical storms or hurricanes. (References 4 and 1).

Snowfall 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 three 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 (approximately 32° north), snow falls in approximately 30 percent of the years. (References 1 and 3)

An ice storm (also called glaze ice) is the accretion of generally clear and smooth ice, 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. (Reference 4)

Most glaze is the result of freezing rain or drizzle falling on surfaces with temperatures between 25 °F and 32 °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 (References 4 and 15).

2.7.2 Regional Climatology

The description of the regional climatology at the time of licensing of GGNS 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 for 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 (Reference 4).

Recent improvements in the National Oceanic and Atmospheric 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. In several cases, such as the recurrence rate of rare events based on many decades of observation, the original GGNS Unit 1 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.

2.7.2.1 Wind

The general direction of airflow across 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 2.7-1. The average windspeed at the site ranged from 3.7 miles per hour (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 2.7-2.

2.7.2.2 Temperature

The temperature regime of the site region can be described by the data shown in Table 2.7-3; four years of GGNS site data from 2000 to 2003, and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) design data (Reference 34) 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.

2.7.2.3 Atmospheric Moisture

Climatic records of humidity in Vicksburg are shown in Table 2.7-5. 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 (0000 – 0600), averaging greater than 80 percent during all months. Lowest relative humidities occur during early and mid afternoon with averages ranging from approximately the mid-50s to the mid-60s for all months.

2.7.2.4 Precipitation

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 typically the driest of the year. (Reference 4) Yearly average precipitation at the GGNS site for 2000 and 2001 is approximately 45 inches (Table 2.7-6) and at Vicksburg for the period of 1997 to 2001 was about 50 inches (Table 2.7-7).

Local site meteorological conditions are expected to result almost entirely from synoptic-scale atmospheric processes. (Reference 4) That is, the local site does not have a unique micro-climate but rather the local meteorology is consistent with the regional 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 (Reference 4).

2.7.2.5 Severe Weather

This section describes severe weather phenomena in the region. 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 in order to document the occurrence of rare events.

2.7.2.5.1 Hurricanes

During the period 1899 to 2000 there were 117 documented cyclones that 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 2.7-8 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. (Reference 4)

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 (References 4 and 7).

2.7.2.5.2 Tornadoes

Tornadoes also occur in the region. 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 (References 4 and 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 2.7-9.

During the period 1950 to April 2002, a total of 108 tornadoes touched down in these four counties/parishes that have a combined area of 2,545 square miles (Reference 9). References 10 and 11 confirm that local tornadoes have a mean path area of 0.43 square mile. 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

Annual frequency of a tornado striking a particular point P = [(0.43 mi^2) (2.07 tornadoes/year)] / 2545 sq. mi. = 0.00035

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

NUREG/CR-4461, Tornado Climatology of the Contiguous United States, Rev. 1, published in April 2005 (Reference 36) contains location-specific tornado information. This reference identifies that the Grand Gulf plant site at approximately 32ºN, 91ºW, has experienced 592 tornadoes from 1950 – 2003 in a 2 degree box (roughly 16,000 mi^2). This gives a point strike frequency by the above formula of $3.0\text{x}10^{-4}$ yr^{-1}, in good agreement with the local county data. The 95% upper limit for a point structure in the Central US is stated to be $3.9\ \text{x}10^{-4}$ yr^{-1}.

2.7.2.5.3 Thunderstorms

Table 2.7-10 presents the thunderstorm data for the region from 1955 through April 2002. Approximately 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 - April 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.

2.7.2.5.4 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 (References 4 and 12).

The annual mean number of thunderstorm days in the site area is estimated to be 66 based on interpolation from the isokeraunic map (Reference 13); therefore it is estimated that the annual lightning stroke density in the GGNS site area is 33 strokes per square mile. (Reference 4)

2.7.2.5.5 Hail

From 1955 – April 2002, 279 hailstorms occurred in the region annually, 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 2.7-11. 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.

2.7.2.5.6 Severe Winter Storm Events

The occurrences and durations of recorded ice storms and heavy snow storms in the three counties and one parish in the vicinity of the GGNS site for the eight-year period 1993-2001 is shown in Table 2.7-12. 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 8 years, or 0.5 storms per year.

The ice storm reported from 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 should be noted that, while the ice storm duration was 57 hours, that period was over an area of 27 counties. Vicksburg reported the following history: 2 hours of trace rain (~0.01 inches), followed by one dry hour, and then eight 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 a 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 approximately 30 percent of these caused ice coatings in excess of 0.5 inches in some portions of the area. (Reference 4) As noted above, Vicksburg received approximately 1.27 inches of precipitation during the 1998 ice storm.

Rainfall in the recent 5-year period discussed below is from a period of relatively low rainfall (Reference 18). Therefore, it is conservative to use earlier data periods to develop the probable maximum winter precipitation values. Table 2.7-13 shows that the maximum rainfalls at Vicksburg in the 5-year period 1997-2001 are well below the 5-year recurrence rate presented in the GGNS UFSAR Table 2.3-74. 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 2.7-14. (Reference 17) The data were analyzed by the Gumbel-Lieblein method described by Thorn in Reference 16 with the following results: (Reference 4)

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
1000	8.80

The 48-hour winter PMP, as defined in Hydrometeorological Report (HMR) No.53 dated April 1980 (Reference 55), is generated from the maximum 24-hr winter month PMP (Figure 27, March) of 30 inches, and the maximum 72-hr winter month PMP (Figure 37, March) of 39 inches. HMR 53 notes in Section 7.3 that winter point rainfall “would reasonably be not much different from the 10-mi^2 values” so no correction is applied for smaller areas. HMR 53 also recommends interpolation with a smooth depth-duration curve from (0,0) for intermediate time periods between 24 and 72 hours. Doing this gives a 48-hour winter PMP of 35 inches of rainwater.

Maximum frozen precipitation is not described in HMR 53. The NCDC storm database (Reference 5) was researched and, as documented in Section 2.3.1.2.2, there have been 4 ice storms in local counties and parishes in the 11 year period from 1993 to 2003. In these 11 years of data, the maximum precipitation during an ice storm has been 1.27” in a 1998 storm in Vicksburg. The precipitation records of Vicksburg were reviewed for the 12/14/1997 and 1/27/2000 events; the precipitation amounts reported were 0.26” and 0.86”. The 1996 storm is described in the storm database as leaving 0.5” to 1” of ice. Using the Gumbel distribution and the method of moments as suggested by Wilks (Reference 56), the 100-yr return frozen precipitation is 1.9”, based on the 11 years of ice thickness data of 1.27”, 1”, 0.86”, 0.26” and seven years of 0” of Reference 5. It is considered reasonable and conservative to use this value, 1.9” of frozen precipitation, for the 48-hour probable maximum winter precipitation (PMWP) for the ESP 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 23 records that a site in the Vicksburg area saw a total of 10.1 inches of snowfall in January 1919. Reference 19 identifies the maximum 24-hour snowfall at Jackson as 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 percent confidence that the 100-year snowfall maximum is 10.6 inches.

In the Jackson/Grand Gulf area, snow melts and/or evaporates quickly, usually within 48 hours, and before additional snow is added. 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.

2.7.3 Regional Air Quality

Air quality in the vicinity of the GGNS ESP site is generally good, including compliance with the newly promulgated U.S. Environmental Protection Agency 8-hour ozone standard of 0.08 ppm. For example, maximum ozone concentration in Hinds County, MS in 1999 was 0.08 ppm and in Warren County, MS, the maximum ozone concentration was 0.07 ppm (Reference 33). These levels are generally a reflection of the predominantly rural character of the region. Contact with the Mississippi Department of Environmental Quality indicates that these three counties are in an air quality attainment status for all criteria pollutants, including the 8-hour ozone standard.

For Jackson, MS, the closest Standard Metropolitan Statistical Area (SMSA) to the site, the fourth highest ozone concentration in 1999 was 0.083 ppm. The 10-year trend (1990-1999) in ozone concentrations in Jackson is increasing (Reference 33). The somewhat higher ozone levels in the Jackson SMSA are likely a result of increasing population and increasing economic activity.

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 2.7-100 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.

2.7.4 Local Meteorology

The following sections contain information on wind, air temperature, atmospheric water vapor, precipitation, and fog in the vicinity of the ESP site.

2.7.4.1 Wind Distribution (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.

2.7.4.1.1 Vicksburg Wind Data

Tables 2.7-62 through 2.7-73 provide 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 2.7-74 provides an annual summary of the data. On an annual basis, Vicksburg wind data collected in the five years 1997 through 2001 show central north is the most frequent (13.8 percent) wind direction. The wind is from the southeast through central south 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 percent and 16.2 percent, respectively. Southerly components prevail in spring, summer and winter, while northerly components prevail in the fall (Tables 2.7-62 through 2.7-73).

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 2.7-74).

The Vicksburg meteorological station winds are presented graphically in Figures 2.7-8 through 2.7-13. 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, in the year 2001 most winds came from the eastern half of the compass rose (Figure 2.7-13).

2.7.4.1.2 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 GGNS site are shown in Tables 2.7-75 through 2.7-86, and data for all years is given in Table 2.7-87. 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 GGNS site in Figures 2.7-1 to 2.7-4 for the 3-year period from 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.

2.7.4.1.3 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 from each sector (and calm) during each year. The results are shown in Tables 2.7-88 through 2.7-90. 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 2.7-89. The longest persistence period (105 hours) from five adjoining sectors occurred in the S-SE sector (Table 2.7-89). The central north sector showed the greatest average maximum persistence (57.2 hours).

Wind persistence data similar to the above are shown in Tables 2.7-91 through 2.7-93 for the Grand Gulf site. The statistics shown in these tables cover a three-year period from 2001 through 2003. Table 2.7-91 shows that the longest single sector persistence period was 32 hours from the northeast sector. The northeast sector also had the greatest average maximum persistence. For the persistence in three adjoining sectors, the N-NE sector had the longest period of persistence (102 hours) and the largest average maximum persistence as shown in Table 2.7-92. The persistence data for five adjoining sectors (Table 2.7-93) shows the central N-NE sector with the longest persistence period (122 hours) and the greatest average maximum persistence.

Table 2.7-94 presents a comparison of the maximum persistence period for the GGNS site in hours with historic data from Jackson and Table 2.7-95 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.

2.7.4.2 Air Temperature

Table 2.7-96 indicates that recent temperature extremes for Vicksburg have ranged from 107 °F (August and September 2000) to 16 °F (January 2001) (Reference 3). Table 2.7-97 also indicates that temperature extremes for GGNS have ranged from 104.2 °F (August 2000) to 17.3 °F (January 2000) (Reference 2). The data shows good agreement between the two locations.

Figures 2.7-14 and 2.7-15 present the site hourly temperatures for the years 2000 and 2001 (Reference 2). A comparison of the two years is made in Figure 2.7-16, where the maximum and minimum temperatures measured in 96-hour intervals are plotted against the start date of the interval.

Other observed temperature extremes were sought from nearby national weather service stations to find minimum and maximum values for a longer observation period. Extreme values include 110ºF in the 1967-2004 record at the Vicksburg Military Park, 107ºF in the 1896-2003 record at Jackson, -5ºF in the Jackson data, and -8ºF in St. Joseph in a 1930-2001 database (Reference 38).

2.7.4.3 Atmospheric Moisture

Mean relative humidities for four time periods per day at Vicksburg are shown in Table 2.7-5 (Reference 3).

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 (References 4 and 19).

2.7.4.4 Precipitation

2.7.4.4.1 Rain

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 inch). The maximum annual precipitation in Vicksburg is 59.76 inches.

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 (References 2 and 3) are presented in Tables 2.7-6 and 2.7-7, respectively. Tables 2.7-98 and 2.7-99 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 GGNS site 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 GGNS Unit 1 UFSAR (Reference 4). As discussed previously, that data is still valid and conservative as compared to recent experience. The maximum point precipitation values are given in Table 2.7-13 for the 2-hour to 10-day durations shown. These were interpolated from the maps of USWB Technical Papers 40 and 49 (References 20, and 21). Technical Memorandum NWS HYDRO-35 (Reference 34) was consulted for updated (from Technical Paper 40) 30-minute and 1-hour duration precipitation values shown in Table 2.7-13. For comparison purposes, the recent 5-year maximum short period precipitations are listed in the table for Vicksburg, Mississippi.

Table 2.7-100 was obtained from Reference 22. It presents maximum observed short period precipitation data for Vicksburg. A comparison of the two tables suggests that 100-year frequency precipitation events may have occurred during the period of record (1893-1961) for periods of 3, 6, 12 and 24-hour durations. (Reference 4)

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

2.7.4.4.2 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 23) and 39 years of record (1936-1975) at Jackson (References 4 and 19). 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 2.7-101.

The maximum monthly amount in Vicksburg was 10.0 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 (References 4 and 23). The maximum recorded in the current NCDC storm event database is 8 inches on December 14, 1997 (Reference 5). This database includes snowstorms for the period 1993 through September 2002.

The maximum monthly amount at Jackson was 10.6 inches in January 1940 during a 24-hour period. The maximum annual amount was 11.6 inches and occurred in the 1939-1940 season (References 4 and 19).

2.7.4.5 Fog

Fog is an aggregate of minute water droplets suspended in the atmosphere near the surface of the earth. According to international definition, fog reduces visibility to less than 0.62 miles.

Table 2.7-102 indicates that, over the period 1997 to 2001, Vicksburg has averaged approximately 92 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 east bank of the Mississippi River.

Note that the GGNS Unit 1 UFSAR (Reference 4) estimated that moderate fog will occur approximately 1 percent (88 hours) of the time at Grand Gulf, and heavy fog will occur approximately 0.6 percent (53 hours) of the time, which is consistent with the Table 2.7-102 data.

2.7.4.6 Atmospheric Stability

Atmospheric stability data for the GGNS site were generated as part of a plume behavior study. This stability data was generated in Reference 24, based on three years of surface observations at the GGNS 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 25). The resulting stability classes for Grand Gulf are presented by season and wind direction in Tables 2.7-16 through 2.7-19, and annual frequency data is presented in Table 2.7-15.

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 2.7-20 through 2.7-31 in terms of percentages of mornings and afternoons containing inversions, average inversion layer elevation, and the maximum strength of the inversions. Table 2.7-32 provides annual average data for the period. 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 14).

The weather balloon data does not address how long inversion layers may persist. For this purpose, the GGNS UFSAR data, based on the period 1955 through 1964, is used in Tables 2.7-33 through 2.7-44. 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. (Reference 4)

The monthly means are summarized in Tables 2.7-45 and 2.7-46. They have been summed to provide an annual mean.

Tables 2.7-47 through 2.7-60 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. (Reference 4)

2.7.4.7 Mixing Heights

Monthly mixing heights for Jackson, Mississippi are shown in Table 2.7-61. These were obtained from the NCDC and are based on the ten-year period 1992 through 2001 (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.

2.7.4.8 Topographical Description of the Surrounding Area

The proposed location for a new facility is approximately 6,300 feet east of the Mississippi River. The Town of Port Gibson, Mississippi is located approximately six miles to the southeast; the Town of St. Joseph, Louisiana is approximately 13 miles to the southwest, and the Big Black River discharges into the Mississippi River approximately 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 (MSL) to the south. To the north and west, the terrain is generally flat and wooded, with an elevation 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 river bank. Figures 2.7-17 through 2.7-19 present topographic cross sections and a site area map. (Reference 4)

According to Regulatory Guide 1.3, credit for elevated release of contaminants is allowed 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 a new facility at the Grand Gulf site assume a ground level release, these effects have not been estimated.

2.7.5 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.

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 2.7.5.1. A new relative humidity sensor was installed in December 2000 as indicated in Section 2.7.5.2.

2.7.5.1 Onsite Meteorological Measurements Program – Pre-2000 Modifications

The following describes the GGNS site meteorological tower and instrumentation as of 1983 and prior to modifications in year 2000 (text in Section 2.7.5.1 is taken from a previous revision of Reference 4, GGNS UFSAR).

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 2.7-103 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 2.7-103 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.

….

2.7.5.1.1 Meteorological Data Processing

2.7.5.1.1.1 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.

2.7.5.1.1.2 Data Collection

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

2.7.5.1.1.2.1 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-[360 degree] scale. Temperatures are recorded in F (degrees Fahrenheit). The precipitation is a step trace, each step representing 0.01 inches.

2.7.5.1.1.2.2 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

2.7.5.1.1.2.3 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.

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2.7.5.1.2 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

2.7.5.2 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):

The following describes the GGNS site meteorological tower and instrumentation as of implementation of modifications in year 2000 (text in this Section 2.7.5.2 is taken from Reference 4, GGNS UFSAR).

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 2.7-104.

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.

2.7.5.2.1 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.

2.7.5.2.1.1 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)

2.7.5.2.1.2 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 meteorological monitoring tower 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.

2.7.5.2.2 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 2.7.5.1. Data recovery for the period evaluated in the calculations (Sections 2.7.6 and 2.7.7) is indicated in Table 2.7-105.

2.7.6 Short-Term Diffusion Estimates

2.7.6.1 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 28).

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 Classes A to G, with an abrupt reduction from Classes D to E. (Reference 4)

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 (LPZ), were determined by the use of the computer code PAVAN (Reference 26). 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. (Reference 4) 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 26 and 28).

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. (Reference 4) The meteorological data used for this analysis was collected from the onsite monitoring equipment from January 2002 through December 2003. These two years were averaged and are reported in Tables 2.7-106 through 2.7-112 for Stability Classes A through G, respectively. Other plant specific data included tower height at which wind speed was measured (10.0 m) and distances to the EAB (841 m) and LPZ (3219 m).

The following text is taken from the GGNS UFSAR, Reference 4.

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:

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

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

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

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 square meters

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 28). All direction-dependent sector values are also calculated.

2.7.6.2 Calculations and Results

Reference 28 divides release configurations into two modes, ground release and stack release. A ground level 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 site meteorological data collected from 2002 through 2003.

The stability classes were based on the classification system given in Table 2 of Regulatory Guide 1.23 (Safety Guide 23), as follows:

Classification of Atmospheric Stability
(Reference 31, 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 level release includes all release points that are effectively lower than two and one-half times the height of adjacent solid structures (Reference 28). 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 2.7-113. Table 2.7-114 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.

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

Tables 2.7-115 and 2.7-116 report the directional-dependent sector *X*/Q values at the EAB and LPZ respectively.

2.7.6.3 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, therefore, determination of dispersion and diffusion coefficients at the Control Room emergency intake has not been completed.

2.7.6.4 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.

2.7.7 Long Term Diffusion Estimates

2.7.7.1 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.

2.7.7.2 Calculation Methodology and Assumptions

The XOQDOQ Computer Program (Reference 27) 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 30) 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 maximum potential concentration outside the site boundary, at points of maximum individual exposure and at points within a radial grid of sixteen 22 1/2° 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 site short-term (accident) diffusion X/Q calculation discussed above, and the GGNS Offsite Dose Calculation Manual (ODCM) meteorological evaluation (Reference 29). 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 X/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 30). 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, a new facility's routine releases 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 30) 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 30) 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 30) as stated in the UFSAR (Section 3A). 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 30).

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."

2.7.7.3 Results

Results of the analysis, based on 2 years of data collected on site, are presented in Tables 2.7-117 through 2.7-120.

2.7.8 References

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4.5 Radiation Exposure to Construction Workers

This section evaluates the potential radiological dose impacts to construction workers at the proposed new facility locations on the Grand Gulf site resulting from the operation of the Grand Gulf Unit 1 nuclear plant.

4.5.1 Site Layout

The Universal Transverse Mercator Grid Coordinates for the proposed location of the power block area of the new facility on the GGNS ESP Site are approximately N3,543,261 meters and E684,018 meters (Figure 2.1-1). The location of the centerline coordinates between the GGNS Unit 1 and Unit 2 reactor locations is N3,542,550 and E684,360 meters (MS Grid coordinates of N549,033 ft and E278,462 ft) (Reference 1). The approximate center of the GGNS Unit 1 Turbine Building is located at MS Grid coordinates of N548,770 and E278,552 ft. Other designated construction areas for a new facility are illustrated on Figure 2.1-1.

4.5.2 Radiation Sources

Construction workers at a new facility on the ESP site could be exposed to direct radiation, and to gaseous radioactive effluents emanating from the routine operation of Grand Gulf Unit 1.

Radiation dose to construction workers is expected to be due mostly to the skyshine from the nitrogen-16 (N-16) source present in the operating Grand Gulf Unit 1 main turbine steam cycle. However, exposure from the Grand Gulf Unit 1 condensate water storage tank (CST) and from airborne effluents from Grand Gulf Unit 1 must also be considered.

The N-16 activity present in the reactor steam in the main steam lines, turbines, and moisture separators provides an air-scattered radiation dose contribution to locations outside the Grand Gulf Unit 1 structures as a result of the high energy gamma rays which it emits as it decays. A N-16 specific activity of 50 μCi/gm was used in the GGNS Unit 1 UFSAR N-16 skyshine dose analysis presented in UFSAR Sections 12.4.2.2 and 12.4.3 (Reference 1).

The radiation source term used in the GGNS Unit 1 UFSAR Section 12.4.2.1 analysis of dose from the CST is 1.8×10^{-4} μCi/cc. (Reference 1, Section 12.4.2.1)

Grand Gulf Unit 1 releases airborne effluents via four gaseous effluent release points to the environment. These are the radwaste building vent, the turbine building vent, the containment vent, and the auxiliary building vent. The mechanical vacuum pump exhausts to the turbine building vent, and the offgas system exhausts to the radwaste building vent (Reference 1, Section 11.3.3.2). The expected radiation sources (nuclides and activities) in the gaseous effluents are listed the Grand Gulf Unit 1 UFSAR in Table 11.3-9.

Grand Gulf Unit 1 releases radioactive liquid effluents via the radwaste discharge pipe which are diluted by mixing with the cooling tower blowdown flow of approximately 11,000 gpm. The annual expected releases of activity to the environment in liquid effluents are presented in Reference 1 Table 11.2-10. These effluents are released directly to the Mississippi River via an underground pipe from the Unit 1 site to the river. Construction activities for a new facility, at the river, would primarily be upstream of the GGNS Unit 1 release point for liquid effluents. Therefore, it is expected that there would be minimal impact to construction workers from radioactivity contained in liquid effluents.

4.5.3 Measured Radiation Dose Rates and Airborne Concentrations

Environmental radiological monitoring data obtained from the Grand Gulf Nuclear Station (GGNS) Annual Radiological Environmental Operating Report, January 1, 2001 through