2. SITE CHARACTERISTICS

2.1 Geography and Demography

2.1.1 Site Location and Description

2.1.1.1 Technical Information in the Application

In Section 2.1.1.1 of the site safety analysis report (SSAR) for the Grand Gulf Nuclear Station (GGNS) early site permit (ESP) site, the applicant presented information concerning site location and site area that could affect the design of structures, systems, and components (SSCs) important to the safety of a nuclear power plant(s) falling within the applicant's plant parameter envelope (PPE) that might be constructed on the proposed ESP site.

The applicant provided the following information on site location and site area:

- the site boundary for a new unit(s) in the proposed ESP site with respect to the location of GGNS, Unit 1

- the site location with respect to political subdivisions and prominent natural and manmade features of the area within the 2-mile low-population zone (LPZ) and 50-mile population zone

- the topography surrounding the proposed ESP site

- the distance from the proposed ESP site to the nearest exclusion area boundary (EAB), including the direction and distance

- the location of potential radioactive material release points associated with a proposed new unit(s)

- the distance of the proposed site from regional U.S. and State highways

- confirmation that no physical characteristics unique to the proposed ESP site were identified that could pose a significant impediment to the development of emergency plans

2.1.1.2 Regulatory Evaluation

Sections 1.4 and 2.1.1 of the SSAR identify the applicable U.S. Nuclear Regulatory Commission (NRC) regulations and guidance regarding site location and description, as defined in Title 10, Section 52.17, "Contents of Applications," of the *Code of Federal Regulations* (10 CFR 52.17); 10 CFR Part 100, "Reactor Site Criteria"; and 10 CFR 50.34(a)(1), as well as NRC Review Standard (RS)-002, "Processing Applications for Early Site Permits," issued May 2004. The staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified above.

The staff considered the following regulatory requirements in reviewing the site location and site area:

- 10 CFR Part 100, insofar as it requires consideration of factors relating to the size and location of sites

- 10 CFR 52.17, insofar as it requires the applicant's submission of information needed to evaluate factors involving the characteristics of the site environs

According to Section 2.1.1 of RS-002, an applicant has submitted adequate information if it satisfies the following criteria:

- The site location, including the exclusion area and the proposed location of a nuclear power plant(s) of specified type falling within a PPE that might be constructed on the proposed site, is described in sufficient detail to determine that the requirements of 10 CFR Part 100 and 10 CFR 52.17 are met, as discussed in Sections 2.1.2, 2.1.3, and 3.3 of this safety evaluation report (SER).

- Highways, railroads, and waterways that traverse the exclusion area are sufficiently distant from planned or likely locations of any structures of a nuclear power plant(s) of specified type falling within a PPE that might be constructed on the proposed site to ensure that routine use of these routes is not likely to interfere with normal plant operation.

2.1.1.3 Technical Evaluation

The proposed new ESP site is located within the existing GGNS site property boundary. Figure 2.1-2 of the SSAR depicts the site boundary for a new unit(s) in the proposed ESP site with respect to the existing GGNS. The applicant identified the universal transverse mercator (UTM) grid coordinates for the new unit(s) in the proposed ESP site as N3,542,873 meters and E684,021 meters. In Request for Additional Information (RAI) 2.1-1, the staff asked the applicant to provide the latitude and longitude of the proposed new reactor site, complete with UTM zone numbers. In response, the applicant stated that the UTM coordinates for UTM Zone 15 correspond to a latitude and longitude of 32E00N23.5654150 N and 91E03N06.4209080 W using the International Ellipsoid.

The applicant elected to define the EAB as a circular radius of 2760 feet (0.52 miles) and the LPZ as a circular radius of 2 miles, both from the circumference of a 630-foot circle encompassing the proposed powerblock housing the reactor containment structure for new unit(s). The EAB of a new unit(s) is wholly contained within the GGNS site property boundary. The applicant established the EAB and the LPZ to ensure that the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1) and the siting evaluation factors in Subpart B, "Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997," of 10 CFR Part 100 are met. No residents are within the proposed EAB. The staff has verified that the exclusion area distance is consistent with the distance used in the radiological consequence analyses performed by the applicant in Section 3.3 of the SSAR.

The existing GGNS and the proposed ESP site are in Claiborne County in southwestern Mississippi. The proposed ESP site is on the east side of the Mississippi River about 25 miles

south of Vicksburg, Mississippi, and 37 miles north-northeast of the town of Natchez, Mississippi. The town of Port Gibson is about 6 miles southeast of the proposed ESP site. The GGNS site, which includes one existing nuclear power unit and the proposed ESP site, encompasses approximately 2100 acres. The largest community within 50 miles of the proposed ESP site is Vicksburg with a 2000 population of 26,407. No highways, railroads, and waterways traverse the proposed ESP exclusion area site boundary.

The applicant stated that the gaseous effluent release point is assumed to be within the proposed construction area designated for the new facility powerblock, and the liquid effluent release point for the new units would apply at the river downstream of the new facility intake to preclude recirculation to the embalmment area and intake pipes. The staff finds that these release points are acceptable for determining that the radiation exposures to the public to meet the criterion “as low as is reasonably achievable,” cited in Appendix I, “Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low as is Reasonably Achievable,’ for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents,” to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities.” (See discussion of this subject in Section 5.9 of the staff’s environmental impact statement for the Grand Gulf ESP application.)

For the reasons set forth in Section 13.3 of this SER, the staff further finds that the applicant did not identify any physical characteristics unique to the proposed ESP site that could pose a significant impediment to the development of emergency plans.

2.1.1.4 Conclusions

As set forth above, the applicant has provided and substantiated information concerning site location and site area that could affect the design of SSCs important to safety of a nuclear power plant(s) of specified type falling within the applicant’s PPE that might be constructed on the proposed ESP site. The staff has reviewed the applicant’s information as described above and concludes that it is sufficient for the staff to evaluate compliance with the siting evaluation factors in 10 CFR Part 100 and 10 CFR 52.17, as well as with the radiological consequence evaluation factors in 10 CFR 50.34(a)(1). The staff further concludes that the applicant provided sufficient details about the site location and site area to allow the staff to evaluate, as documented in Sections 2.1.2, 2.1.3, and 3.3 of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 100 and 10 CFR 52.17.

2.1.2 Exclusion Area Authority and Control

2.1.2.1 Technical Information in the Application

In SSAR Section 2.1.2.1, the applicant presented information concerning its plan to obtain legal authority to determine all activities within the designated exclusion area, if it decides to proceed with the development of a new reactor unit(s) at the proposed ESP site. The applicant stated the following:

> For all practical purposes, SERI (the applicant) controls the surface right, and The applicant has authorized Entergy Operations (for GGNS, Unit 1) to maintain control of ingress to and egress from the exclusion area and provides for

> evacuation of individuals from the area in the event of an accident.... A similar arrangement would be made for exercise of authority over the area within the exclusion area for the new facility on the site property....

In RAI 2.2-1, the staff asked the applicant for additional information regarding its approach for making such arrangements before issuing the Grand Gulf ESP. In its response, the applicant stated that, "this arrangement would not be made prior to issuance of the Grand Gulf ESP. Such arrangement would be made associated with a Combined License application."

2.1.2.2 Regulatory Evaluation

In SSAR Table 1.4-1 and in RAI 1.4-1, the applicant identified the applicable NRC regulations and regulatory guidance regarding exclusion area authority and control related to Subpart A, "Early Site Permits," of 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants," and 10 CFR Part 100.

In reviewing the applicant's legal authority to determine all activities within the designated exclusion area, the staff considered the relevant requirements of 10 CFR 100.3, "Definitions," which state the following:

> Exclusion area means that area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. This area may be traversed by a highway, railroad, or waterway, provided these are not so close to the facility as to interfere with normal operations of the facility and provided appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway, in case of emergency, to protect the public health and safety.... Activities unrelated to operation of the reactor may be permitted in an exclusion area under appropriate limitations, provided that no significant hazards to the public health and safety will result.

2.1.2.3 Technical Evaluation

Figure 2.1-1 of the SSAR depicts the boundary lines of the current exclusion area and of the proposed exclusion area for the new unit(s). The exclusion area for the new unit(s) is larger than the current GGNS exclusion area and includes a majority of the GGNS exclusion area. The EAB for the new unit(s) consists of a circle of approximately 2760-feet radial distance from the circumference of a 630-foot circle encompassing the proposed powerblock housing the reactor containment structure for the new unit(s). No U.S. or State highways, railways, or waterways traverse the proposed ESP exclusion area for the new unit(s).

One county road (Grand Gulf Road) runs through the GGNS plant site property and another county road (Bald Hill Road) traverses the proposed ESP EAB. The applicant stated that Entergy Operations currently allows access to parts of the plant site property for recreational purposes and that arrangements have been made for control of traffic on the county road during a declared emergency involving GGNS Unit 1. With respect to the proposed exclusion area, the applicant stated that it would make similar arrangements with the appropriate law enforcement authorities for control of traffic on the county road in the event of a declared emergency involving the new unit(s). The emergency plan (see Section 13.3.3.3 of this SER)

describes these arrangements in more detail. The applicant further stated that because the portion of Bald Hill Road that traverses the exclusion area is also located within a potential construction usage area, it may become necessary to relocate that portion of the road during construction of any new nuclear units.

The applicant stated that it has authorized Entergy Operations to maintain control of ingress and egress from the current exclusion area for GGNS Unit 1 and to evacuate individuals from the area in the event of an emergency. The applicant further stated that it would make a similar arrangement to authorize the operator of the new unit(s) to maintain control of ingress to and egress from the new proposed ESP exclusion area and to provide for evacuation of individuals from the new proposed ESP exclusion area in the event of an emergency.

The applicant has surface ownership of the land within the plant site property boundary, with certain exceptions described herein. South Mississippi Electric Power Association (SMEPA) maintains a 10-percent undivided ownership interest in the property associated with the existing GGNS power plant and support facilities. SMEPA also maintains certain easement rights associated with the property. Pursuant to the Grand Gulf Nuclear Station Operating Agreement, signed on June 6, 1990, Systems Energy Resources, Inc. (SERI), is authorized to act as the general agent for SMEPA with respect to construction and operation of GGNS.

Additionally, Entergy Mississippi, Inc., owns the 52-acre plant switchyard area, which is partially located within the plant exclusion area. The applicant, however, has authority to exercise complete control and determine all activities in the exclusion area, including exclusion of Entergy Mississippi, Inc., personnel and third parties. The applicant has transferred such rights to Entergy Operations. The applicant stated that it would arrange to authorize the operator of the new unit(s) to exercise similar control in the exclusion area. Entergy Mississippi, Inc., also has easements or rights of way for two transmission lines, neither of which are located within the proposed exclusion area.

The applicant owns most of the mineral interests within the exclusion area. However, no evidence exists to suggest that third parties will exercise their rights to such minerals. Therefore, based on its review, the staff concludes that it is extremely unlikely that such third party interests would ever be exercised so as to create an exception to the applicant and Entergy Operation's control of the exclusion area.

The applicant has stated that for all practical purposes, it controls the surface rights within the ESP exclusion area. The applicant has further stated that at such time as it elects to apply for a combined license (COL), it intends to have entered into an agreement with the selected operator of the new unit(s) to authorize the operator to exercise complete control and determine all activities within the exclusion area, including maintaining control of ingress to and egress from the exclusion area, and to provide for the evacuation of individuals from the area in the event of an emergency. The applicant stated that this agreement will be similar to its agreement with Entergy Operations, the operator of GGNS Unit 1. The applicant stated that at the time an application for a COL is submitted, arrangements would also be in place with the selected operator and the appropriate State and local law enforcement authorities for control of traffic on county roads traversing the ESP exclusion area in the event of an emergency.

To meet the exclusion area control requirements of 10 CFR 100.21(a) and 10 CFR 100.3, the applicant does not need to demonstrate total control of the property before issuance of the

ESP. In the draft safety evaluation review (DSER), the NRC staff stated that the applicant must provide reasonable assurance that it can acquire the required control (i.e., that it has the legal right to obtain control of the exclusion area). The staff had not then obtained information sufficient to enable it to determine whether the applicant had such a legal right. Accordingly, the NRC staff identified DSER Open Item 2.1-1, which required the applicant to demonstrate that it "has control over the exclusion area or has a right to obtain such control."

In its response to the open item, the applicant indicated that at the time it applies for a COL referencing the Grand Gulf ESP to construct and operate any new unit(s) at the Grand Gulf ESP site, it will have arrangements in place authorizing the operator of the new unit(s) to exercise control within the ESP exclusion area, to maintain control of ingress to and egress from the ESP exclusion area, and to evacuate individuals from the exclusion area in the event of an emergency.

Based on the above information, the staff concludes that the applicant appears to have sufficient authority to determine all activities in the exclusion area, including the ability to exclude or remove individuals and property from the area. The staff has determined that the applicant is prepared to secure the arrangements described above, and there does not appear to be any reason why the ESP holder could not obtain control of the exclusion area in this manner. In addition, there does not appear to be any legal impediment to the applicant securing the described arrangements.

Accordingly, the NRC staff will include a condition in any ESP that might be issued regarding the Grand Gulf site to govern exclusion area control as **Permit Condition 1**. This permit condition requires an applicant for a COL referencing this ESP to demonstrate that it has been granted the right to exercise sufficient control within the exclusion area identified in the ESP, including the authority to maintain ingress to and egress from the exclusion area and to evacuate individuals from the exclusion area in the event of an emergency. The permit condition also requires a COL applicant referencing this ESP to secure any necessary arrangements to provide, in the event of a declared emergency, for the control of traffic on county roads and the evacuation of individuals within the ESP exclusion area. The condition requires that these arrangements be obtained and executed before the granting of an application referencing the ESP. Therefore, DSER Open Item 2.1-1 is closed.

2.1.2.4 Conclusions

As set forth above, the applicant has provided information concerning its plan to obtain legal authority to determine all activities within the designated exclusion area. The staff has reviewed the applicant's information and concludes that it is sufficient to assure compliance with the exclusion area control requirements of 10 CFR 100.21(a) and 10 CFR 100.3. In addition, the applicant has appropriately described the exclusion area and the methods by which it will control access and occupancy of this exclusion area during normal operation and in the event of an emergency situation.

The applicant has demonstrated that it currently has the authority to determine all activities, including exclusion or removal of personnel and property from the proposed exclusion area, as required by 10 CFR Part 100. Additionally, the staff concludes that the proposed permit

condition provides reasonable assurance that if the ESP is referenced as part of an application for a COL or construction permit (CP), the applicant has adequate control of the exclusion area.

2.1.3 Population Distribution

2.1.3.1 Technical Information in the Application

In SSAR Section 2.1.3, the applicant estimated and provided the population distribution surrounding the proposed ESP site, up to a 50-mile radius from the center of the proposed powerblock location for a new facility on the proposed ESP site, based on the most recent U.S. census. The applicant also provided in this section the resident population distribution within the LPZ, the nearest population center, and population densities up to a 30-mile radius from the proposed ESP site.

The population distribution provided by the applicant encompasses 9 concentric rings at various distances up to 50 miles and 16 directional sectors from the proposed ESP site. The applicant projected population estimates up to 2070, 5 years beyond the projected year for end of new plant life. The applicant also estimated and provided transient population based on recreational use of Grand Gulf Military Park, Warner-Tully YMCA camp, Lake Claiborne, hunting camps, and fishing.

The applicant described the LPZ and illustrated it in Figure 2.1-5 of the SSAR. The LPZ for a new unit(s) includes a 2-mile radial distance measured from the circumference of a 630-foot circle encompassing the proposed powerblock location for a new unit. The applicant listed facilities and institutions within 5 miles of the proposed ESP site in SSAR Table 2.1-3. In Tables 2.1-1 and 2.1-2 of the SSAR, the applicant provided the cumulative population in 2002 and the projected cumulative population in 2070, as functions of the 10-mile to 50-mile radial distance from the proposed ESP site.

In Tables 2.1-5 and 2.1-6 of the SSAR, the applicant provided the population densities in 2030 and 2070 at distances of 10, 20, and 30 miles from the proposed ESP site. In RAI 2.1.3-3, the staff requested that the applicant clarify whether the current and projected population data shown in SSAR Tables 2.1-1 and 2.1-2 include the weighted transient population. In its response dated August 16, 2004, the applicant stated that the data do not include the weighted transient population.

Subsequently, in its response to the Grand Gulf ESP DSER open items dated June 21, 2005, the applicant provided projections of estimated total population for 2002, 2030, and 2070, including weighted transient population, for the Grand Gulf ESP site.

The applicant described the LPZ in Section 2.1.3.4 of the SSAR. The LPZ is defined in 10 CFR 100.3 as “the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident.” The LPZ for the ESP site is essentially the same as the LPZ for the existing GGNS Unit 1; it consists of a circle with a radius of 2 miles measured from the circumference of a 630-foot circle encompassing the proposed powerblock location for a new unit. The LPZ for GGNS Unit 1 is a circle with a radius of 2 miles centered on the GGNS Unit 1 reactor.

The applicant described the population center in Section 2.1.3.5 of the SSAR. The population center is defined in 10 CFR 100.3 as a densely populated area containing more than 25,000 residents. The applicant stated that the nearest population center with a population greater than 25,000 people that is likely to exist over the lifetime of the proposed ESP site is the city of Vicksburg, Mississippi, with a 2000 population of 26,407. The closest point of Vicksburg, Mississippi, is 25 miles north-northeast of the ESP site. The next closest population center is Jackson, Mississippi, which is 55 miles to the northeast of the proposed ESP site and has a population of 184,256.

In RAI 2.1.3-2, the staff asked the applicant to describe appropriate protective measures that could be taken on behalf of the populace in the LPZ in the event of a reactor accident. In its response, the applicant stated that offsite protective measures are the responsibility of the applicable State and local governments and referred to the emergency plan included in its June 3, 2004, submission to the staff.

2.1.3.2 Regulatory Evaluation

In SSAR Table 1.4-1 and in its response to RAI 1.4-1, the applicant identified the applicable NRC regulations and regulatory guidance regarding population distribution, as described in 10 CFR 52.17; 10 CFR Part 100; Regulatory Guide (RG) 4.7, Revision 1, "General Site Suitability Criteria for Nuclear Power Stations," issued April 1998; and RS-002. The staff finds that the applicant correctly identified the applicable regulations and guidance.

The staff considered the following regulatory requirements in its review of this section of the SSAR:

- 10 CFR 52.17, as it relates to each applicant providing a description and safety assessment of the site, with special attention to the site evaluation factors identified in 10 CFR Part 100

- 10 CFR Part 100, insofar as it establishes requirements with respect to population density

In particular, the staff considered the population density and use characteristics of the site environs, including the exclusion area, LPZ, and population center distance. The regulations in 10 CFR Part 100 also provide definitions and other requirements for determining an exclusion area, LPZ, and population center distance.

As stated in Section 2.1.3 of RS-002, the applicable requirements of 10 CFR 52.17 and 10 CFR Part 100 are deemed to have been met if the population density and use characteristics of the site meet the following criteria:

- Either there are no residents in the exclusion area, or if residents do exist, they are subject to ready removal, in case of necessity.

- The specified LPZ is acceptable if it is determined that appropriate protective measures could be taken on behalf of the enclosed populace in the event of a serious accident.

- The population center distance is at least 1 1/3 times the distance from the reactor to the outer boundary of the LPZ. The population center distance is defined in 10 CFR 100.3 as "the distance from the reactor to the nearest boundary of a densely populated center consisting of more than about 25,000 residents."

- The population center distance is acceptable if there are no likely concentrations of greater than 25,000 people over the lifetime (plus the term of the ESP) of a nuclear power plant(s) of specified type or falling within a PPE that might be constructed on the proposed site closer than the distance designated by the applicant as the population center distance. The boundary of the population center will be determined upon considerations of population distribution. Political boundaries are not controlling.

- The population data supplied by the applicant in the safety assessment are acceptable if (1) they contain population data for the latest census, projected year(s) of startup of a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site (such date or dates reflecting the term of the ESP), and projected year(s) of end-of-plant life, all in the geographical format given in Section 2.1.3 of RG 1.70, Revision 3, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants—LWR Edition," issued November 1978, (2) they describe the methodology and sources used to obtain the population data, including the projections, (3) they include information on transient populations in the site vicinity, and (4) the population data in the site vicinity, including projections, are verified to be reasonable by other means, such as U.S. Census Bureau publications, publications from State and local governments, and other independent projections.

- If the population density at the ESP stage exceeds the guidelines given in RG 4.7, special attention to the consideration of alternative sites with lower population densities is necessary. A site that exceeds the population density guidelines of Regulatory Position C.4 of RG 4.7, can nevertheless be selected and approved if, on balance, it offers advantages compared with available alternative sites when all of the environmental, safety, and economic aspects of the proposed and alternative sites are considered.

2.1.3.3 Technical Evaluation

The staff reviewed the data on the population in the site environs, as presented in the applicant's SSAR, to determine whether the exclusion area, LPZ, and population center distance for the proposed ESP site comply with the requirements of 10 CFR Part 100 and the acceptance criteria in Section 2.1.3.2 of this SER. The staff also evaluated whether, consistent with Regulatory Position C.4 of RG 4.7, the applicant should consider alternative sites with lower population densities. The staff also reviewed whether appropriate protective measures could be taken on behalf of the enclosed populace within the emergency planing zone (EPZ), which encompasses the LPZ, in the event of a serious accident.

The staff compared and verified the applicant's population data against U.S. Census Bureau Internet data. As documented in Section 13.3 of this SER, the staff reviewed the projected population data provided by the applicant, including the weighted transient population for 2002, 2030, and 2070. If the NRC were to approve and issue the ESP in 2006, assuming a COL application is submitted near the end of the ESP term, with a projected startup of new units in

about 2025 and an operational period of 40 years for the new units, the projected year for end-of-plant life is about 2065. Accordingly, the staff finds that the applicant's projected population data cover an appropriate number of years and are reasonable.

The staff reviewed the transient population information provided by the applicant in SSAR Section 2.1.3.3. The transient population is based on recreational use of Grand Gulf Military Park, Warner-Tully YMCA camp, Lake Claiborne, hunting camps, and fishing. In RAI 2.1.3-3, the staff requested that the applicant clarify whether the current and projected population data shown in Tables 2.1-1 and 2.1-2 of the SSAR include the weighted transient population. In its response, the applicant stated that they do not include the weighted transient population. This was the Grand Gulf DSER Open Item 2.1-2.

Subsequently, in its response to the Grand Gulf ESP DSER open items dated June 21, 2005, the applicant provided projections of estimated total population for 2002, 2030, and 2070, including weighted transient population for the Grand Gulf ESP site. Tables 2.1-5 and 2.1-6 of the GGNS SSAR, Revision 2, present this information. Therefore, DSER Open Item 2.1-2 is closed.

The staff reviewed the transient population data provided by the applicant. The transient population up to a 10-mile radius includes transient work force, recreation transients, and special facilities. GGNS Unit 1 is the most significant employer within the 10-mile EPZ. Therefore, the majority of the transient workforce within 10 miles of the ESP site commutes to GGNS. No other major industry, employing more than 250 people, is located within a 10-mile radius of GGNS. Recreational transients include visitors to Grand Gulf State Park, Lake Claiborne, various other recreation areas, and hunters/fishermen. Special facilities include schools and nursing homes. The transient population up to a 30-mile radius of the ESP site includes the Vicksburg National Military Park, the National Cemetery, the historic downtown area, and numerous gambling facilities docked on the Mississippi or Yazoo Rivers.

The applicant collected information concerning transient population from a number of organizations involved in monitoring recreational tourist traffic, the Vicksburg Convention and Visitor's Bureau, and the Louisiana Office of Tourism. Based on this information, the staff finds that the applicant's estimate of the transient population is reasonable.

The applicant evaluated representative design-basis accidents (DBAs) in Section 3.3 of the SSAR. The staff independently verified the applicant's evaluation in Section 3.3 of this SER to demonstrate that the radiological consequences of DBAs at the proposed LPZ would be within the dose consequence evaluation factors set forth in 10 CFR 50.34(a)(1).

The nearest population center with a population greater than 25,000 people which is likely to exist over the lifetime of the proposed ESP site is the city of Vicksburg, Mississippi, with a 2000 population of 26,407. The closest point of Vicksburg, Mississippi, is 25 miles north-northeast of the ESP site. The next closest population center is Jackson, Mississippi, which is 55 miles to the northeast of the proposed ESP site and has a population of 184,256. The distances to Vicksburg and Jackson, the nearest population centers, are well in excess of the minimum population center distance of 2.7 miles (1 1/3 times the distance of 2.06 miles from the reactor to the outer boundary of the LPZ). In addition, no population centers are closer than the population center distance specified by the applicant.

Therefore, the staff concludes that the proposed ESP site meets the population center distance requirement, as defined in 10 CFR Part 100. The staff has determined that no realistic likelihood exists that there will be a population center with 25,000 people within the 7.8-mile

minimum population center distance during the lifetime of any new unit(s) that might be constructed on the site. The staff based this conclusion on projected cumulative resident and transient population within 10 miles of the site during the lifetime of any new unit(s) (i.e., 2025–2065).

The staff evaluated the site against the criterion in Regulatory Position C.4 of RG 4.7 regarding whether it is necessary to give special attention to the consideration of alternative sites with lower population densities. The criterion is whether the population densities in the vicinity of the proposed site, including weighted transient population, projected at the time of initial site approval and within about 5 years thereafter, would exceed 500 persons per square mile averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the area at that distance).

The staff determined that such population densities for the proposed site would be well below this criterion. Therefore, the staff concludes that the site conforms to Regulatory Position C.4 in RG 4.7. Based on the assumption that construction of a new nuclear reactor(s) at the proposed site would begin near the end of the term of the ESP, as well as its review of the applicant's population density data and projections, the staff finds that the site also meets the guidance of RS-002 regarding population densities over the lifetime of facilities that might be constructed at the site because the population density over that period would be expected to remain below 500 persons per square mile averaged out to 20 miles from the site.

The staff reviewed information provided by the applicant regarding its ability to take appropriate protective measures on behalf of the populace in the LPZ in the event of a serious accident. In RAI 2.1.3-2, the staff asked The applicant to describe appropriate protective measures that could be taken on behalf of the populace in the LPZ in the event of a reactor accident. In its response, the applicant stated that offsite protective measures are the responsibility of the applicable State and local governments and referred to the emergency plan included in its June 3, 2004, submission to the staff.

The staff finds that the applicant's response is satisfactory because it is consistent with emergency planning for the 10-mile plume exposure EPZ. The LPZ is located entirely within the 10-mile EPZ. Comprehensive emergency planning for the protection of all persons within the 10-mile EPZ, as addressed in Section 13.3 of this SER, would include those persons within the LPZ. Based on the information the applicant presented on this subject, and on the staff's conclusions discussed in Section 13.3 of this SER, the staff concludes that appropriate protective measures could be taken on behalf of the enclosed populace within the LPZ in the event of a serious accident.

2.1.3.4 Conclusions

As set forth above, the applicant has provided an acceptable description of current and projected population densities in and around the site. These densities projected at the time of initial plant operation (if one were to be constructed on the site), and within about 5 years thereafter, are within the guidelines of Regulatory Position C.4 of RG 4.7. The applicant has

properly specified the LPZ and population center distance. The staff finds that the proposed LPZ and population center distance meet the definitions in 10 CFR 100.3. Therefore, the staff concludes that the applicant's population data and population distribution are acceptable and meet the requirements of 10 CFR 52.17 and 10 CFR Part 100. In Chapter 15 of this SER, the staff documents that the radiological consequences of bounding DBAs at the outer boundary of the LPZ meet the requirements of 10 CFR 52.17.

2.2 Nearby Industrial, Transportation, and Military Facilities

2.2.1–2.2.2 Identification of Potential Hazards in Site Vicinity

For its ESP application, the applicant provided information on the relative location and separation distance of the site from industrial, military, and transportation facilities and routes. Such facilities and routes include air, ground, and water traffic; pipelines; and fixed manufacturing, processing, and storage facilities. Section 2.2 of the SSAR presents information concerning the industrial, transportation, and military facilities in the vicinity of the proposed ESP site. The NRC staff focused its review on potential external hazards or hazardous materials that are present or which may reasonably be expected to be present during the projected lifetime of a nuclear power plant(s) that might be constructed on the proposed site. The staff has prepared Sections 2.2.1–2.2.2 and 3.5.1.6 of this SER in accordance with the procedures described in RS-002 using information presented in SSAR Section 2.2, responses to staff RAIs, and the reference materials described in the applicable sections of RS-002.

2.2.1.1–2.2.2.1 Technical Information in the Application

In SSAR Section 2.2, the applicant presented information concerning the industrial, transportation, and military facilities in the vicinity of the proposed ESP site. The applicant further stated that the proposed site is located in Claiborne County, Mississippi, which is a rural and agricultural area where forest products are the leading industry. In Section 2.2.1 of the SSAR, the applicant stated that no military installations, industrial facilities, mining operations, or airports exist within 5 miles of the ESP site. Table 2.2-6 of the SSAR details the location of commercial or municipal airports in the wider region around the ESP site. The applicant stated that the Mississippi River passes 1.1 miles west of the proposed ESP facility location, and State Route 61 passes within 4.75 miles of the ESP site. The applicant also identified several airports in the region, located from 11 to 65 miles from the ESP site, as well as two commercial airways, V245 and V417, that cross the wider region around the ESP site. Airway V245 passes closest to the ESP site, about 10 miles to the southeast.

In Section 2.2.2.1 of the SSAR, the applicant stated that the closest operating industrial facilities are located 6 miles to the southeast of the ESP site in southeast Port Gibson. In Section 2.2.2.2 and Table 2.2-4 of the SSAR, the applicant reported the amount of hazardous chemicals transported by river in 2000. The applicant also discussed the operation of Port Claiborne, a small barge port at river mile 404.8, used for shipping forest and agricultural products. In SSAR Table 2.2-5, the applicant detailed the storage of hazardous chemicals at the GGNS site, including significant volumes of gaseous and liquid hydrogen, sulfuric acid, and diesel fuel, among other substances. In SSAR Table 2.2-3, The applicant identified the shipments of hazardous materials on State Route 61.

Section 2.2.2.3 of the SSAR described a 4-inch natural gas underground pipeline that passes as close as 4.75 miles to the east of the ESP site. No other pipelines are located within 5 miles of the ESP site. In SSAR Section 2.2.2.4, the applicant noted that Mississippi River water would be withdrawn at river mile 406 for many uses, including cooling tower and service water cooling system makeup. In Section 2.2.2.6 of the SSAR, The applicant stated that there are no plans at this time for industrial expansion or development in the ESP site vicinity or for hazardous materials handling industries within 50 miles of the ESP site.

2.2.1.2–2.2.2.2 Regulatory Evaluation

In SSAR Section 2.2, the applicant identified the following applicable NRC guidance regarding potential hazards in the vicinity of the proposed ESP site:

- RG 1.91, Revision 1, “Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plant Sites,” issued February 1978

- RG 1.78, Revision 1, “Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Chemical Release,” issued December 2001

- RG 1.70

In SSAR Section 2.2, the applicant referenced the GGNS Updated Final Safety Analysis Report (UFSAR). The staff considered the following regulatory requirements in reviewing information regarding potential site hazards that could affect the safe design and siting of a nuclear power plant(s) falling within the applicant’s PPE that might be constructed at the proposed site:

- 10 CFR 52.17(a)(1)(vii), with respect to information on the location and description of any nearby industrial, military, or transportation facilities and routes

- 10 CFR 100.20(b), with respect to information on the nature and proximity of human-related hazards

- 10 CFR 100.21(e), with respect to the evaluation of potential hazards associated with nearby transportation routes and industrial and military facilities

The following RGs identify methods acceptable to the NRC staff to meet the Commission’s regulations identified above:

- RG 1.91
- RG 1.78

Sections 2.2.1–2.2.2, 2.2.3, and 3.5.1.6 of RS-002, as well as RG 1.70, provide guidance on the information appropriate for identifying, describing, and evaluating potential manmade hazards.

2.2.1.3–2.2.2.3 Technical Evaluation

The staff evaluated the potential for manmade hazards in the vicinity of the proposed ESP site by reviewing (1) the information provided by the applicant in SSAR Section 2.2.1–2.2.2, (2) the applicant's responses to the staff's RAIs, (3) information obtained during a visit to the proposed ESP site and its vicinity, and (4) other publicly available reference material, including topographic maps (see DeLorme, *Louisiana Atlas and Gazetteer*, issued 2003, and *Mississippi Atlas and Gazetteer*, issued 1998), airport data (see GCR and Associates, "5010: Airport Summary and Activity Data," which includes 2004 data from the Federal Aviation Administration (FAA) National Flight Data Center), aerial imagery (see Topozone 2004), and geographic information system coverage files (see the Platts POWERmap GIS spatial data, issued 2004, which include map layers depicting natural gas pipelines, railroads, and electric transmission lines).

The staff reviewed the applicant's identification of potential hazards in the vicinity of the ESP site and finds that potential hazards exist from the onsite storage of hazardous and explosive materials at GGNS. The applicant identified a potential hazard in the river water intake, disruption of which could potentially affect plant operations. Section 3.5.1.6 of the SER describes the evaluation of aircraft hazards, and SER Section 2.2.3 evaluates all other manmade hazards.

2.2.1.4–2.2.2.4 Conclusions

As set forth above, the applicant provided information in the SSAR on potential site hazards, in accordance with the requirements of 10 CFR 52.17 and the guidance of RG 1.70, thereby allowing the staff to evaluate the applicant's compliance with the requirements of 10 CFR 100.20, "Factors to be Considered When Evaluating Sites," and 10 CFR 100.21, "Non-Seismic Site Criteria." The staff reviewed the nature and extent of activities involving potentially hazardous materials that are conducted at industrial, military, and transportation facilities located near the ESP site to identify any potential hazards from such activities that might pose an undue risk to the type of facility proposed under this ESP. Figure 2.2-1 of the SER illustrates the locations of such facilities in reference to the ESP site. On the basis of its evaluation of the SSAR, as well as information obtained independently, the staff concludes that the applicant has identified all potentially hazardous activities on and in the vicinity of the site.

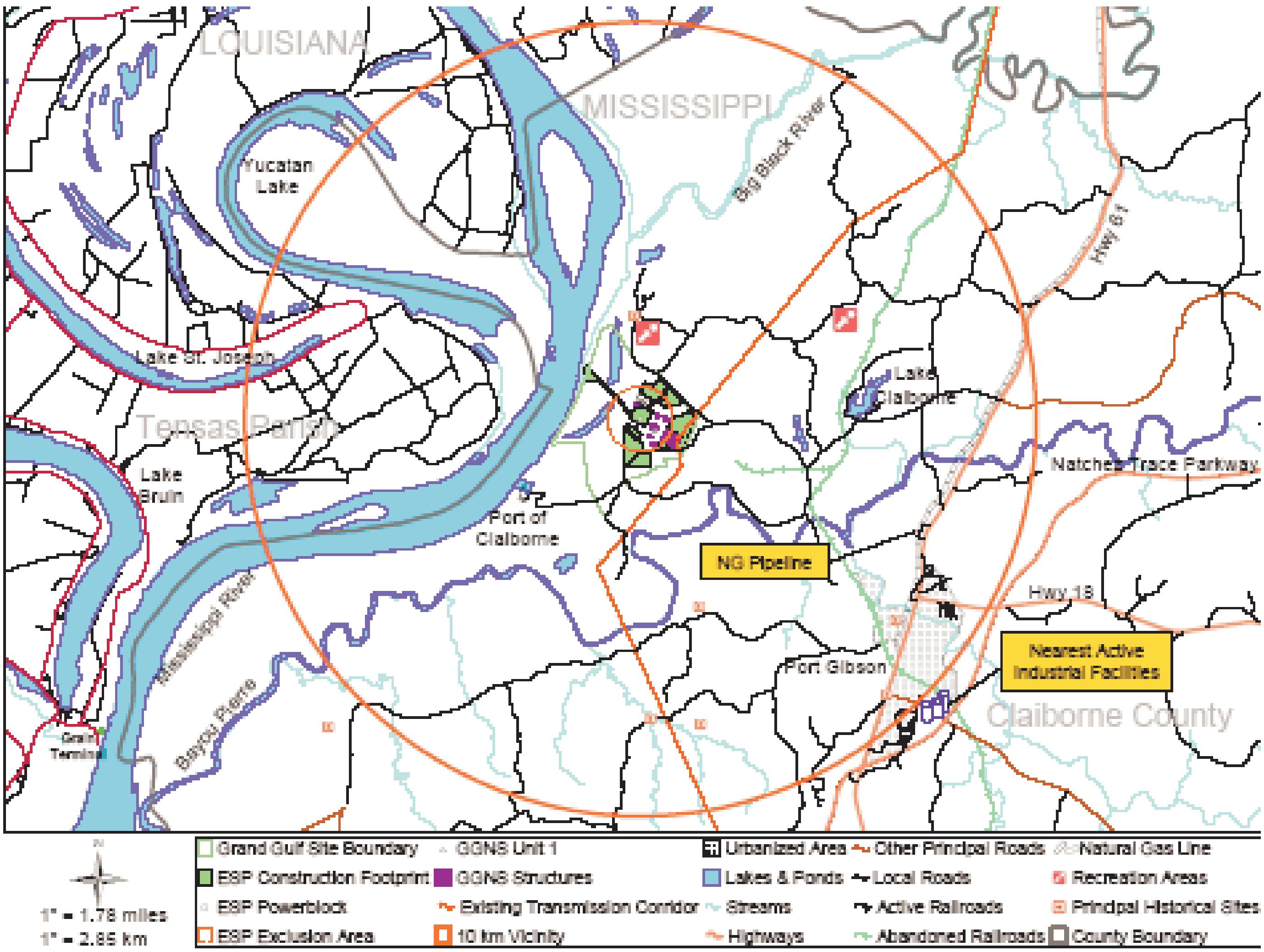

Figure 2.2-1 Industrial, military, and transportation facilities near the GGNS ESP site

2.2.3 Evaluation of Potential Accidents

In SSAR Section 2.2.3, the applicant identified potential accident situations on and in the vicinity of the ESP site. The staff reviewed this information to determine its completeness, as well as the bases upon which these potential accidents may need to be considered in the design of a nuclear power plant(s) that might be constructed on the proposed site (see SER Section 2.2.1–2.2.2).

The applicant elected to use the PPE approach for analyzing potential accidents. As such, it has not determined the specific design of the ESP facility, including control room habitability systems. Some potential accidents on or in the vicinity of the ESP site may have the ability to affect control room habitability (e.g., toxic or asphyxiating gases). The design of the actual facility that might be constructed on the proposed site must address those accidents that are to be accommodated on a design basis (as determined through a review conducted using Section 2.2.3 of RS-002). The staff will review these potential accidents at the COL stage using the guidance in Section 6.4 of NUREG-0800, Revision 3, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," issued July 1981 (also referred to as the Standard Review Plan (SRP)).

The staff reviewed the applicant's analyses of the probability of potential accidents involving hazardous materials or activities on and in the vicinity of an ESP facility that might be constructed on the proposed site to determine whether these analyses used the appropriate data and analytical models. The staff also reviewed the analyses of the consequences of accidents involving nearby industrial, military, and transportation facilities to determine if any should be identified as design-basis events (DBEs).

2.2.3.1 Technical Information in the Application

Section 2.2.3 of the SSAR presents information concerning potential accidents, including flammable vapor clouds, toxic chemicals, fires, collisions with the intake structure, and liquid spills. In general, the applicant found that the separation distances between the ESP site and the potential hazards identified in Section 2.2.1–2.2.2 of the SSAR are large enough that the effects of potential accidents would not affect the safety-related systems of the ESP facility.

Specifically, in SSAR Section 2.2.3.1.1, the applicant stated that, because of the separation distance between the closest point of State Route 61 and the ESP site (4.5 miles), under the conservative assumption of an accident involving delayed detonation of a flammable vapor cloud, the peak reflected pressure would be well below 1 pound per square inch (psi) at the ESP site. The applicant stated that the Mississippi River transportation corridor lies 1.1 miles west of the ESP site. Using the guidelines of RG 1.91, the applicant noted that the largest probable quantity of explosive material to be transported by ship is approximately 5000 tons equivalent TNT. On the basis of the river barge accident case analyzed in the GGNS UFSAR, the applicant found that, because the new plant and associated safety-related systems would be located on a bluff about 65 feet above normal river level, the bluff would provide significant shielding against the explosive effects of any potential cloud originating from river barges or ships in the shipping channel. The applicant also determined that the separation distance between the 4-inch, 225-psi natural gasline and the ESP site (closest approach of 4.75 miles) is great enough that the pipeline would pose no hazard to proposed facilities at the ESP site. The

applicant also evaluated the case of onsite delivery of liquified hydrogen by truck and determined that delivery operations would be separated from the proposed ESP facility by at least 400 feet, which is less than the minimum safe distance of 1285 feet given in RG 1.91. However, The applicant estimated the probability of an explosive event in such a case to be $4.1x10^{-7}$, which falls below the RG 1.91 threshold for considering trucked liquid hydrogen as a DBA. The applicant also evaluated the effects of onsite storage of 20,000 gallons of liquid hydrogen at the GGNS site. On the basis of analyses performed for the GGNS UFSAR, the applicant reported minimum separation distances of 737 feet for a tank explosion and 1340 feet for a gaseous cloud formation based on a pipe break or leak. The applicant indicated that the proposed ESP powerblock location and the locations of the safety-related systems are beyond these minimum distances.

Section 2.2.3.1.2 of the SSAR describes the applicant's analysis of potential accidents involving toxic chemicals. The applicant noted that no significant industrial facilities or toxic chemical storage facilities currently exist within 6 miles of the ESP site. In response to staff RAIs, the applicant analyzed toxic chemical hazards using the following guidelines in RG 1.78:

- chemicals transported on routes (including river routes) within a 5-mile radius of the site, at a frequency of 10 or more per year, and with weights outlined in RG 1.78

- chemicals stored within 0.3 miles of the control room in quantities greater than 100 pounds

For the first case above, on the basis of analyses in the UFSAR, the applicant found that the large separation distance between the ESP site and the nearest highway would mitigate any highway transportation accidents involving the release of toxic chemicals. SSAR Table 2.2-4 indicates the amount of hazardous material transported past the ESP site on the Mississippi River in 2000. The applicant based its assessment of accidents involving river barges on barge mishap analyses presented in the UFSAR. The applicant considered fuel fires from barge accidents, chlorine spills, and toxic chemical releases. In the case of gaseous chemical or hot plumes from fuel fires, The applicant stated that the separation distance and topographic barriers are sufficient to eliminate these types of accidents from further consideration. The applicant estimated that the probability of a significant chlorine spill in the river is $1.8x10^{-7}$ per year.

For the second case, SSAR Table 2.2-5 lists the hazardous materials stored at GGNS. The specific chemicals to be stored at the ESP facility are not currently known and will be evaluated at the time of the COL application. The applicant relied on the GGNS UFSAR to hypothesize the explosion of an underground diesel fuel storage tank at GGNS, concluding that, because of plume rise from fire conditions, the control room habitability systems would be affected only if extreme wind events accompanied the explosion. The UFSAR analysis of hazards from other stored chemicals at GGNS resulted in estimated concentrations affecting control room habitability that are within RG 1.78 limits. The applicant also found, on the basis of analyses in the GGNS UFSAR, that a hydrogen or oxygen release from the GGNS hydrogen water chemistry system would not adversely affect control room habitability.

In SSAR Section 2.2.3.1.3, The applicant stated that forest fires originating locally from accidents could produce a maximum concentration of 45 pounds of particulate matter per ton

and that the toxicity of such fires falls well below the acceptable limits for the GGNS control room air intake system. In SSAR Section 2.2.3.1.4, the applicant noted that the water intake structure in the Mississippi River is positioned away from the shipping channel, and that it did not consider ship impact a DBE. In Section 2.2.3.1.5 of the SSAR, the applicant found that chemical spills in the river could force the shutdown of the water intake of the ESP facility and thus the shutdown of the ESP facility itself. Such an event would require spilling toxic chemicals that would sink below the river surface and reach the water intake. The applicant stated that it will develop appropriate procedures to ensure safe shutdown in the event that raw water makeup is unavailable.

2.2.3.2 Regulatory Evaluation

In SSAR Section 2.2, The applicant identified the following applicable NRC guidance regarding potential hazards in the vicinity of the proposed ESP site:

- RG 1.91
- RG 1.78
- RG 1.70

In SSAR Section 2.2, the applicant referenced the GGNS UFSAR and RG 1.70. The staff considered the following regulatory requirements in its review of information regarding potential accidents that could affect the safe design and siting of a nuclear power plant(s) falling within the applicant's PPE that might be constructed at the proposed site:

- 10 CFR 52.17(a)(1)(vii), with respect to information on the location and description of any nearby industrial, military, or transportation facilities and routes

- 10 CFR 100.20(b), with respect to information on the nature and proximity of human-related hazards

- 10 CFR 100.21(e), with respect to the evaluation of potential hazards associated with nearby transportation routes and industrial and military facilities

The following RGs identify methods acceptable to the NRC staff to meet the Commission's regulations identified above:

- RG 1.91
- RG 1.78

Sections 2.2.1–2.2.2, 2.2.3, and 3.5.1.6 of RS-002, as well as RG 1.70, provide guidance on the information appropriate for identifying, describing, and evaluating potential accidents.

2.2.3.3 Technical Evaluation

The staff evaluated potential accidents in the vicinity of the proposed ESP site by reviewing (1) the information provided by the applicant in SSAR Section 2.2.3, (2) the applicant's responses to staff RAIs, (3) information obtained during a visit to the proposed ESP site and its vicinity, and (4) other publicly available reference material, including topographic maps (see DeLorme 2003 and *Mississippi Atlas and Gazetteer* 1998), airport data (see GCR and

Associates), aerial imagery (Topozone 2004), and GIS coverage files (see the Platts POWER map GIS spatial data, 2004).

Section 2.2.1–2.2.2 of this SER describes potential hazards that might be identified in the future in association with a currently vacant industrial development in Claiborne County Port, just south-west of the ESP site.

The staff reviewed the applicant's analysis of the effects of potential explosions and the formation of flammable vapor clouds. Using the guidance provided in RG 1.91, the staff found that the distance of U.S. Highway 61 is sufficiently far from the potential ESP facility that no significant damage is expected with respect to safety-related SSCs that may be located on the ESP site for the worst-case truck-tank explosion accident scenario.

Table 2.2-4 of the SSAR characterizes the type of commodities typically transported on the Mississippi River by listing specific hazardous materials and quantities. The hazards posed by these materials are in the form of potential explosions, fires, or the release of airborne gases that are toxic.

The GGNS UFSAR addresses hazards caused by potential explosions. The nearest bank of the river is 1.34 miles from the power station. Using RG 1.91, the largest probable quantity of explosive material to be transported on the river (approximately 5000 tons equivalent TNT) would require a safe standoff distance of about 11,000 feet, or about 2.1 miles. However, the GGNS safety-related structures are on top of a bluff, approximately 65 feet above the normal river level. The UFSAR notes that the bluff will provide a partial shield against the explosions of potential river-traffic cargo. Hence, it was not anticipated that potential explosions would be a hazard at a distance of 1.34 miles. The staff agreed that the combined effect of the 1.34-mile distance and the shielding effect of the bluffs was sufficient, such that an explosion hazard resulting from the shipments of hazardous materials along the river past GGNS was acceptably low.

The proposed ESP site would be about 1.1 miles from the nearest bank of the river. The location of a facility on the proposed ESP site would also be located on the bluffs, about 65 feet above the normal river level. Current analyses of blast mitigation with respect to buildings support the expectation that blast barriers of comparable height can reduce the overpressure behind the barrier by at least a factor of 2 (Arthur D. Little, "Facility Siting—Case Study Demonstrating Benefit of Analyzing Blast Dynamics," *Proceedings of the International Conference and Workshop on Process Safety Management and Inherently Safer Processes*, October 1996). At a distance of 1.1 miles, an explosion of a 5000 ton TNT-equivalent charge would produce a peak positive normal reflected pressure of about 4 psi. The effect of the 65-foot bluffs would be to reduce this by at least a factor of 2, so that the peak reflected incident pressure would be less than 2 psi. This is equivalent to a peak incident pressure of 1 psi, which is the acceptance threshold of RG 1.91. This estimate is conservative since the expected pressure reduction effect of the 65-foot bluffs is greater than a factor of 2. There is also conservatism associated with the assumption that all explosions would have the maximum efficiency of TNT equivalency associated with the 5000-ton charge assumed in RG 1.91. As noted in the study by Arthur D. Little cited above, explosions of dispersed vapor clouds, even under the most favorable dispersion conditions, will be relatively inefficient, so that the actual TNT-equivalent quantity would be significantly less than the assumed 5000 tons. In view of the

above, the staff agrees that the explosion hazard from potential accidents involving shipping on the Mississippi in the vicinity of the proposed ESP site is acceptably low.

With respect to potential fires caused by accidental releases of flammable substances on the river, the staff estimates that the incident thermal flux is sufficiently low so as not to pose a hazard to safety-related structures. Specifically, using the methodology of NUREG/CR-3330, "Vulnerability of Nuclear Power Plant Structures to Large External Fires," dated August 1983, the staff estimates that the incident thermal flux at 1.1 miles from a large gasoline vapor cloud fire would be less than 5 kilowatts per square meter (kW/m^2). At this thermal flux, the allowable wall exposure time is well in excess of 12 hours in duration. Hence, potential fires caused by accidents on the river do not pose a significant hazard to a plant on the proposed ESP site.

The staff reviewed the applicant's analysis of potential toxic chemical accidents. The applicant used the UFSAR inventory of toxic chemicals in its analysis. The staff notes that the principal commodities posing a potential hazard are shipments of anhydrous ammonia and chlorine. The applicant analyzed the potential for the release of these chemicals for GGNS and found the estimated toxicity levels at the control room to be acceptably low. However, the staff finds that, since the PPE does not specify a control room design, it cannot make a determination with respect to control room habitability in the event of a toxic chemical accident at the site or in its vicinity. Accidents involving such materials cannot be evaluated for the ESP facility at the ESP stage without a specific set of plant design parameters. Therefore, the staff will evaluate such accidents at the COL application stage. This is **COL Action Item 2.2-1**.

2.2.3.4 Conclusions

As set forth above, the applicant identified potential accidents related to the presence of hazardous materials or activities on or near the proposed ESP site that could affect a nuclear power plant(s) falling within the applicant's PPE. The staff finds that the applicant selected those potential accidents that should be considered as DBEs at the COL stage, in accordance with 10 CFR Part 100. The applicant identified and evaluated hazards from nearby facilities and the staff concludes that such facilities pose no undue risk to the type of facility proposed for the site, subject to confirmation at the COL stage regarding design-specific hazard interactions. Therefore, the staff concludes that the ESP site location is acceptable with regard to potential accidents that could affect such a facility or facilities built on the site, and that it meets the requirements of 10 CFR 52.17(a)(1)(vii), 10 CFR 100.20(b), and 10 CFR 100.21(e).

2.3 <u>Meteorology</u>

To ensure that a nuclear power plant or plants could be designed, constructed, and operated on an applicant's proposed ESP site in compliance with the Commission's regulations, the NRC staff evaluates regional and local climatological information, including climate extremes and severe weather occurrences that may affect the design and siting of a nuclear plant. The staff reviews information concerning the atmospheric dispersion characteristics of a nuclear power plant site to determine whether the radioactive effluents from postulated accidental releases, as well as routine operational releases, are within Commission guidelines. The staff has prepared Sections 2.3.1 through 2.3.5 of this SER in accordance with the review procedures described in RS-002, using information presented in SSAR Section 2.3, responses to staff RAIs and open

items, and generally available reference materials, as described in the applicable sections of RS-002.

2.3.1 Regional Climatology

2.3.1.1 Technical Information in the Application

In Section 2.3.1 of the SSAR, the applicant presented information concerning the averages and the extremes of climatic conditions and regional meteorological phenomena that could affect the design and siting of a nuclear power plant that falls within the applicant's PPE and that might be constructed on the proposed site. Specifically, the applicant provided the following information:

- a description of the general climate of the region with respect to types of air masses, synoptic features (high- and low-pressure systems and frontal systems), general airflow patterns (wind direction and speed), temperature and humidity, precipitation (rain, snow, and sleet), and relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions

- seasonal and annual frequencies of severe weather phenomena, including tornadoes, thunderstorms, lightning, hail (including probable maximum size), and high air pollution potential

- meteorological site characteristics to be used as minimum design and operating bases, including the following:

  - the maximum snow and ice load (water equivalent) on the roofs of safety-related structures

  - the ultimate heat sink (UHS) meteorological conditions resulting in the maximum evaporation and drift loss of water and minimum water cooling

  - the tornado parameters, including translational speed, rotational speed, and the maximum pressure differential with the associated time interval

  - the 100-year return period straight-line winds

  - other meteorological conditions to be used for design- and operating-basis considerations

The applicant characterized the regional climatology pertinent to the Grand Gulf ESP site using data reported by the National Weather Service (NWS) at the Vicksburg, Mississippi, and Jackson, Mississippi, first-order weather stations, as well as the Port Gibson, Mississippi, cooperative observer station. The applicant also used data recorded by the GGNS onsite meteorological tower. The applicant considered the Vicksburg and Jackson weather stations to be representative of the climate at the Grand Gulf ESP site because of topographic considerations and their proximity to the site. Since Vicksburg is the closer of the two stations and borders the Mississippi River, the applicant based the climatic summaries primarily on Vicksburg data when the period of record and observational procedures were considered adequate. Otherwise, it presented Jackson data. The applicant also obtained information on

severe weather, including extreme conditions, from a variety of sources, such as publications by the National Climatic Data Center (NCDC), the Structural Engineering Institute (SEI), the

American Society of Civil Engineers (ASCE), and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).

The Grand Gulf ESP site is located in the southwest climatic division of Mississippi. The applicant described the climate as 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.

The applicant noted that the westward extension of the Bermuda High, a subtropical, semipermanent anticyclone, dominates the region in summer. 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 the frontal-type thunderstorms. However, the thunderstorms associated with the occasional polar front activity in late winter and early spring are more severe, sometimes producing tornadoes.

The applicant stated that 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. Mississippi is also occasionally in the path of tropical storms or hurricanes.

The applicant noted that, for the most part, the general synoptic conditions predominate with regard to the climactic characteristics of the site region. However, the applicant considered the Vicksburg humidity data to be more appropriate for site estimates than the Jackson data, because of Vicksburg’s proximity and similar location relative to the Mississippi River. A slight tendency exists for lower level winds at the Grand Gulf ESP site to be channeled along the Mississippi River.

The applicant stated that the general airflow over the Grand Gulf ESP site 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 average wind speed at the Grand Gulf ESP site ranged from 3.7 miles per hour (mi/h) to 4.4 mi/h between 1996 and 2003, whereas the average wind speed at Vicksburg ranged from 7.0 mi/h to 7.6 mi/h between 1997 and 2003.

Revision 0 of the SSAR presented various dry-bulb and wet-bulb temperature statistics for Jackson, Vicksburg, and the GGNS site. These statistics included 97.75 and 99 percent maximum summer exceedance dry-bulb and wet-bulb temperatures and 97.75 and 99 percent minimum winter exceedance dry-bulb temperatures. The applicant based the percentage exceedances on the summer months of June through September (2928 total hours) and the winter months of December through February (2160 total hours). In RAI 2.3.1-5, the staff asked the applicant to provide various dry-bulb and wet-bulb temperature statistics based on annual exceedances (for example, the dry-bulb temperatures that will be exceeded no more than 2.0 and 0.4 percent of the time annually). By doing so, these data will be more consistent with the recent ASHRAE design guidelines, “2001 ASHRAE Handbook—Fundamentals,” issued

July 2001, for the design of heating, ventilation, air-conditioning, and dehumidification equipment.

In response to RAI 2.3.1-5, the applicant provided the requested temperature and humidity statistics, including the historic highest and lowest dry-bulb temperatures (107 EF and !5 EF, respectively) recorded at Jackson during the 108-year period 1896–2003. The applicant used these historic dry-bulb temperatures to represent 100-year return period temperatures for the Grand Gulf ESP site. The staff found a higher temperature, 110 EF, that was recorded at Vicksburg (August 31, 2000) during the 38-year period 1967–2004, and a lower temperature, !8 EF, that was recorded at St. Joseph, Louisiana (January 27, 1940), during the 72-year period 1930–2001. In Open Item 2.3-1, the staff stated that the applicant had not conservatively identified the historic highest and lowest dry-bulb temperatures recorded in the Grand Gulf ESP site region for use as the 100-year return period temperatures.

In its submittal dated June 21, 2005, the applicant responded to Open Item 2.3-1 by statistically generating 100-year return period temperatures (108 EF and !6 EF) using data recorded at Port Gibson during the 73-year period 1930–2001. The applicant proposed using the 108 EF and !6 EF values as the 100-year return period temperature site characteristics. The applicant also noted that the maximum and minimum temperatures recorded at Port Gibson during this same period were 105 EF and !6 EF, respectively. The applicant discussed this information in Section 2.3.2.1.2 of Revision 2 to the SSAR.

Table 2.3.1-1 presents the applicant's proposed ambient air temperature and humidity site characteristics.

Table 2.3.1-1 Applicant's Proposed Ambient Air Temperature and Humidity Site Characteristics

SITE CHARACTERISTIC		VALUE
Maximum Dry-Bulb Temperature	98% annual exceedance	92 EF
	99.6% annual exceedance	95 EF
	average of annual highest	98 EF
	100-year return period	108 EF
Minimum Dry-Bulb Temperature	99% annual exceedance	25 EF
	99.6% annual exceedance	21 EF
	average of annual lowest	14 EF
	100-year return period	!6 EF
Maximum Wet-Bulb Temperature	98% annual exceedance	78 EF
	99.6% annual exceedance	80 EF

Using the exceedance criteria in Table 2.3.1-1, the applicant also evaluated the GGNS site 2000–2003 dry-bulb and 2001–2003 wet-bulb temperature data and found that the site values

generally match the Jackson values, except that the minimum dry-bulb temperatures reported for Jackson are several degrees cooler than the compatible minimum dry-bulb temperatures reported for GGNS. The applicant attributed the slightly warmer GGNS minimum dry-bulb temperatures to the mitigating effects of the Mississippi River at the GGNS site.

The applicant reported that the relative humidity in the Grand Gulf ESP site region is high throughout the year, with an annual average relative humidity of approximately 75 percent recorded at Vicksburg during the period 1997–2001. The highest relative humidities occur in the early morning hours (00:00–06:00) during the summer (June–August), averaging more than 90 percent. The lowest relative humidities occur during the afternoon hours (12:00–18:00) in the autumn (September–November), averaging less than 55 percent.

The applicant reported that, while snowfall is not of much economic importance, it is not a rare event in Mississippi. During the 65 years from 1898–1957 and 1997–2001, measurable snow or sleet fell on some part of the State in all but 3 years. Along the latitude of the site (about 32E N), snow fell during approximately 30 percent of the years.

According to the applicant, 117 hurricanes affected the Middle Gulf Coast (Florida, Alabama, Mississippi, Louisiana, and Texas) during the period 1899–2000. Table 2.3.1-2 presents the storm classifications and respective frequencies of these hurricane occurrences over this period.

Table 2.3.1-2 Frequency of Hurricanes for the States of Florida, Alabama, Mississippi, Louisiana, and Texas from 1899–2000

CLASSIFICATION	NUMBER OF OCCURRENCES	MAXIMUM SUSTAINED WIND SPEED RANGE
Category 5 Hurricane	2	> 155 mi/h
Category 4 Hurricane	10	131–155 mi/h
Category 3 Hurricane	36	111–130 mi/h
Category 2 Hurricane	30	96–110 mi/h
Category 1 Hurricane	39	74–95 mi/h

Tropical storms, including hurricanes, lose strength as they move inland from the coast. Typically, the greatest concern for an inland site, such as the Grand Gulf ESP site, is possible flooding resulting from excessive rainfall. As an example, the applicant reported that the small-diameter, extremely intense hurricane Camille (August 1969) had top winds estimated at more than 170 mi/h at the coast, but, as the center passed less than 10 miles to the east of Jackson, it only generated gusts of 67 mi/h at Jackson.

The applicant reported that a total of 108 tornadoes touched down in the vicinity of Claiborne, Warren, and Hinds Counties in Mississippi and Tenasa Parish in Louisiana from 1950 to April 2002. The applicant used these data to calculate a tornado mean recurrence interval of 2860 years. The applicant also noted that a highly destructive tornado struck Vicksburg in

December 1953, and a tornado struck the GGNS site while the plant was under construction in April 1978.

The applicant estimated that, on average, 66 thunderstorm-days occur per year in the site area, resulting in an estimated 33 lightning flashes to earth per square mile per year. Hail often accompanies severe thunderstorms and can be a major weather hazard, causing damage to crops and property. The applicant reported that 279 hailstorms occurred in the region (Claiborne, Warren, and Hinds Counties in Mississippi and Tenasa Parish in Louisiana) from 1955 through April 2002. Property damage occurred infrequently, with only 26 events recorded during this period.

Large-scale episodes of atmospheric stagnation are not common in the site region. The applicant noted that 36 cases of 4 days or more of atmospheric stagnation over southwest Mississippi were reported in the 35-year period from 1936–1970.

The applicant indicated that three ice storms and one heavy snowstorm were reported in the three counties and one parish around the Grand Gulf ESP site for 1993–2001. From these data, the applicant estimated that the frequency of ice storms in the Grand Gulf ESP site area is 4 storms in 8 years or 0.5 per year.

The applicant stated that the occurrence of dust, blowing dust, or blowing sand is a comparatively rare phenomenon in the Grand Gulf ESP site area. Vicksburg did not record any hours of blowing dust or blowing sand in the period 1997–2001. However, Jackson reported 33 hours of blowing dust during the period 1955–1964. Using the Jackson data, the percent frequency of occurrence of dust, blowing dust, or blowing sand is 0.04.

In Revision 0 of the SSAR, the applicant estimated a 100-year return period snowpack of 11 inches based on historic maximum regional snowfall data. Using a conservative estimate of 0.20 inches of water per inch of snowpack, the applicant estimated that the water equivalent of the 100-year return period snowpack of 11 inches is 2.2 inches of water, which equals a weight of 11.44 lbf/ft^2. In its submittal dated June 21, 2005, the applicant revised its estimated weight of the 100-year return period snowpack to 6.1 lbf/ft^2, based on SEI/ASCE 7-02, "Minimum Design Loads for Buildings and Other Structures," issued 2002, and the maximum 24-hour snowfall of 10.6 inches reported for Jackson for a recent 83-year data period. Because snow melts and/or evaporates quickly, usually within 48 hours and before additional snow is added, the applicant believes that the Jackson maximum 24-hour snowfall is indicative of the 100-year return period snowpack.

In Revision 0 of the SSAR, the applicant estimated the weight of the 48-hour probable maximum winter precipitation (PMWP) as 36.4 lbf/ft^2, based on 7.0 inches (water equivalent) of precipitation. The figure of 7.0 inches of precipitation represents a 100-year return period value derived by the applicant using a statistical extrapolation of the maximum 48-hour winter (November–March) precipitation values reported each year at Jackson during the period 1960–1975.

In Open Item 2.3-2, the staff stated that the applicant had not provided an appropriate 48-hour PMWP value that can be used to define the extreme winter precipitation roof loads. As discussed in the staff's branch position on winter precipitation loads (see memorandum from H.R. Denton to R.R. Maccary, dated March 24, 1975), the 48-hour PMWP should be developed

in accordance with the guidance provided in the National Oceanic and Atmospheric Administration (NOAA) hydrometeorological reports (HMRs) (e.g., HMR 53, “Seasonal Variation

of 10-Square Mile Probable Maximum Precipitation Estimates, United States East of the 105th Meridian,” issued April 1980). In its submittal dated June 21, 2005, the applicant responded to Open Item 2.3-2 by identifying a 48-hour PMWP value of 35 inches of rainwater based on HMR 53. However, the applicant contended that because this PMWP is in the form of rainfall, it would not remain on rooftops. Instead, the applicant proposed a 48-hour “frozen” PMWP value of 1.9 inches of frozen precipitation (equivalent to 9.9 lbf/ft^2), based on a 100-year return period frozen precipitation value that was statistically extrapolated by the applicant from four ice storms recorded in nearby counties and parishes during the 11-year period 1993–2003.

In the same June 21, 2005, submittal, the applicant proposed defining the snow load for extreme live loads to be considered for roof structural design purposes as 16 lbf/ft^2, which represents the sum of the 100-year return period snowpack (6.1 lbf/ft^2) and the 48-hour frozen PMWP (9.9 lbf/ft^2).

Table 2.3.1-3 presents the applicant’s proposed snow load site characteristics.

Table 2.3.1-3 Applicant’s Proposed Snow Load Site Characteristics

SITE CHARACTERISTIC	VALUE	DESCRIPTION
48-Hour PMWP (Rainfall)	35 inches of rainfall	The 48-hour 10-square-mile probable maximum winter-month precipitation from HMR 53
48-Hour PMWP (Frozen)	1.9 inches of ice	The 48-hour probable maximum frozen winter precipitation
100-Year Snowpack	6.1 lbf/ft^2	Weight, per unit area, of the 100-year return period snowpack
Extreme Live Winter Precipitation Load	16 lbf/ft^2	The combination of the 48-hour probable maximum frozen winter precipitation and the 100-year snowpack (to be used in determining extreme winter precipitation loads for roofs)

According to the applicant, the wet-bulb temperature and the coincident dry-bulb temperature are the controlling parameters for the type of UHS it selected (e.g., mechanical draft cooling towers with water storage basins). The applicant calculated the worst 1-, 5-, and 30-day daily average wet-bulb temperatures and coincident dry-bulb temperatures as UHS site characteristic values.

Revision 0 of the SSAR presented UHS meteorological site characteristic values for maximum evaporation and minimum water cooling based on wet-bulb and dry-bulb temperatures recorded at Jackson during the period 1948–1975. In RAI 2.3.1-3, the staff noted that the SSAR states that Vicksburg humidity data are considered to be more appropriate for site estimates than the Jackson data because of the proximity and similar location relative of the Mississippi River. Therefore, the staff asked the applicant to use temperature and humidity data from Vicksburg to determine the site characteristics for evaluating UHS performance. In its response to this RAI,

the applicant examined temperature and humidity data from Jackson (1948–1975), Vicksburg (July 1996–December 2000), and the GGNS onsite meteorological monitoring program (2001–2003) to determine bounding meteorological design conditions for the UHS in accordance with RG 1.27, "Ultimate Heat Sink for Nuclear Power Plants," issued January 1976. Table 2.3.1-4 presents these results.

In Open Item 2.3-3, the staff identified the need for an additional UHS meteorological site characteristic for use in evaluating the potential for water freezing in the UHS water storage facility, a phenomenon which would reduce the amount of water available for used by the UHS. In its submittal dated June 21, 2005, the applicant responded to Open Item 2.3-3 by proposing a cumulative degree-day below freezing site characteristic value of 98 EF degree days (i.e., 98 accumulated freezing degree days), based on the worst case freezing spell recorded at Port Gibson for the period 1930–2001.

Table 2.3.1-4 Applicant's Proposed UHS Site Characteristics

SITE CHARACTERISTIC	VALUE
Worst 1-Day Daily Average of Wet-Bulb Temperatures and Coincident Dry-Bulb Temperatures	81.0 EF wet-bulb temperature with coincident 86.3 EF dry-bulb temperature
Worst 5-Day Daily Average of Wet-Bulb Temperatures and Coincident Dry-Bulb Temperatures	80.2 EF wet-bulb temperature with coincident 86.2 EF dry-bulb temperature
Worst 30-Day Daily Average of Wet-Bulb Temperatures and Coincident Dry-Bulb Temperatures	78.5 EF wet-bulb temperature with coincident 83.1 EF dry-bulb temperature
Worst Accumulated Freezing Degree Days	98 EF

Revision 0 of the SSAR presented tornado site characteristics based on the staff's interim position on the design-basis tornado for the region in which the Grand Gulf ESP site is located (see letter from L.S. Rubinstein to E.E. Kintner, dated March 25, 1988). In its submittal dated June 21, 2005, the applicant revised the tornado maximum wind speed site characteristic based on the recently published Revision 1 to NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," issued April 2005. The applicant also revised the remaining tornado site characteristics to be consistent with the staff's interim position on the design-basis tornado for a tornado with a maximum wind speed of 300 mi/h. Table 2.3.1-5 shows the applicant's proposed tornado site characteristics.

Table 2.3.1-5 Applicant's Proposed Tornado Site Characteristics

SITE CHARACTERISTIC	VALUE
Maximum Wind Speed	300 mi/h
Maximum Translational Speed	60 mi/h

SITE CHARACTERISTIC	VALUE
Rotational Speed	240 mi/h
Radius of Maximum Rotational Speed	150 feet
Pressure Drop	2.0 lbf/in.^{2}
Rate of Pressure Drop	1.2 lbf/in.^{2}/s

The applicant reported that the highest “fastest-mile” wind speed recorded at Jackson, corrected to a standard height of 30 feet above ground level, is 64 mi/h. The applicant selected a basic fastest-mile wind speed site characteristic of 83 mi/h, which it considers to represent a “fastest mile of wind” at 30 feet above the ground with a 100-year return period. In Open Item 2.3-4, the staff asked the applicant to also identify a 3-second gust wind speed that represents a 100-year return period for the ESP site. The 3-second gust wind speed site characteristic value potentially represents a typical design parameter input for new reactor designs. In its submittal dated June 21, 2005, the applicant responded to Open Item 2.3-4 by proposing a 100-year return period 3-second gust site characteristic value of 96 mi/h. Table 2.3.1-6 shows the applicant’s selected basic wind speed site characteristics.

Table 2.3.1-6 Applicant’s Proposed Basic Wind Speed Site Characteristic

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Basic Wind Speed (fastest mile)	83 mi/h	Highest “fastest mile of wind” at 30 feet above the ground with a 100-year return period
Basic Wind Speed (3-s gust)	96 mi/h	100-year return period 3-second gust wind speed at 33-ft elevation

2.3.1.2 Regulatory Evaluation

In SSAR Section 3.0, the applicant noted that the NRC regulations that apply to the evaluation of an ESP include 10 CFR 100.20 and 10 CFR 100.21. The staff notes that 10 CFR 100.20(c) and 100.21(d) are the applicable 10 CFR Part 100 regulations with respect to the consideration of the site’s regional meteorological characteristics.

In SSAR Sections 1.0, 1.4, and 2.3.1 and in its response to RAI 2.3.1-3, the applicant identified the following applicable NRC guidance regarding regional climatology:

- RG 1.27, with respect to the meteorological conditions that should be considered in the design of the UHS

- RG 1.70, with respect to the type of general climate and regional meteorological data that should be presented

- RG 1.76, "Design Basis Tornado for Nuclear Power Plants," issued April 1974, with respect to the characteristics of the design-basis tornado[1]

The staff has reviewed this portion of the application in accordance with the guidance identified by the applicant and to determine if the application is in compliance with the applicable regulations.

Section 2.3.1 of RS-002 and Section 2.3.1 of RG 1.70 provide the following guidance on information appropriate for determining regional climatology:

- The description of the general climate of the region should be based on standard climatic summaries compiled by NOAA. Consideration of the relationships between regional synoptic-scale atmospheric processes and local (site) meteorological conditions should be based on appropriate meteorological data.

- Data on severe weather phenomena should be based on standard meteorological records from nearby representative NWS, military, or other stations recognized as standard installations that have long periods of data on record. The ability of these data to represent site conditions during the expected period of reactor operation should be substantiated.

- Tornado site characteristics may be based on RG 1.76 or the staff's interim position on design-basis tornado characteristics. An ESP applicant may specify any tornado wind speed site characteristics that are appropriately justified, provided that a technical evaluation of site-specific data is conducted.

- Basic (straight-line) wind speed site characteristics should be based on appropriate standards, with suitable corrections for local conditions.

- The UHS meteorological site characteristics, as stated in RG 1.27, should be based on long-period regional records which represent site conditions. Suitable information may be found in climatological summaries for the evaluation of wind, temperature, humidity, and other meteorological data used for UHS design.

- Freezing rain estimates should be based on representative NWS station data.

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

- All other meteorological and air quality data identified as climatic site characteristics should be documented and substantiated.

2.3.1.3 Technical Evaluation

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[1] In SSAR Table 1.4-1, the applicant noted that the staff developed an interim position modifying the design-basis tornado criteria presented in RG 1.76.

The staff evaluated regional meteorological conditions using information reported by NWS, NCDC, the National Severe Storms Laboratory (NSSL), the Southern Regional Climate Center (SRCC), ASHRAE, SEI, and ASCE. The staff reviewed statistics for the following climatic stations located in the vicinity of the Grand Gulf ESP site:

- Port Gibson, Mississippi, located approximately 5 miles east-southeast of the ESP site
- St. Joseph, Louisiana, located approximately 11 miles west-southwest of the ESP site
- Vicksburg, Mississippi, located approximately 26 miles north-northeast of the ESP site
- Jackson, Mississippi, located approximately 61 miles east-northeast of the ESP site

The staff concurs with the applicant's description of the general climate of the region, which is consistent with the SRCC narrative, "Climate Synopsis for Mississippi," as well as the NCDC narrative, "Jackson, Mississippi, 2003 Local Climatological Data, Annual Summary with Comparative Data." The NCDC climatic data summary for Jackson shows an annual mean wind speed of 6.8 mi/h, and the annual prevailing wind direction is from the south-southeast.

The applicant based the maximum annual 98 percent and 99.6 percent exceedance dry-bulb and wet-bulb temperatures and the minimum annual 99 percent and 99.6 percent exceedance dry-bulb temperatures on Jackson data that ASHRAE published in its July 2001 handbook.[2] The applicant also evaluated the GGNS site data using these same exceedance criteria and found that the site values generally match the Jackson values, except that the Grand Gulf ESP site is slightly warmer than the Jackson data would indicate at cold temperatures. Therefore, the staff agrees with the annual exceedance temperature and humidity site characteristics presented by the applicant.

In its response to RAI 2.3.1-5, the applicant reported the historic highest and lowest dry-bulb temperatures recorded at Jackson during the 108-year period 1896–2003 as 107 EF and !5 EF, respectively, and proposed using these historic dry-bulb temperatures to represent 100-year return period temperatures for the Grand Gulf ESP site. The staff did not believe that the applicant had conservatively identified the historic extreme dry-bulb temperatures recorded in the Grand Gulf ESP site region for use as the 100-year return period temperatures. The staff found a higher temperature, 110 EF, that was recorded at Vicksburg (August 31, 2000) during the 38-year period 1967–2004 in SRCC, "Vicksburg Military Park, Mississippi Period of Record General Climate Summary—Temperature." The staff also found a lower temperature, !8 EF, that was recorded at St. Joseph (January 27, 1940) during the 72-year period 1930–2001 in NCDC, "Cooperative Summary of the Day TD 3200 POR—2001 Data CDROM, Central United States." This concern resulted in Open Item 2.3-1.

In its response to Open Item 2.3-1, the applicant statistically generated 100-year return period temperatures (108 EF and !6 EF) using data recorded at Port Gibson during the 73-year period 1930–2001 and proposed using these values as the 100-year return period temperature site characteristics. The staff believes that the Port Gibson temperature data, collected at a similar grade elevation approximately 5 miles from the Grand Gulf ESP site, are representative of the Grand Gulf ESP site. The staff performed an equivalent analysis with the same Port Gibson

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[2] The data presented by the applicant as the maximum 98 percent and 99.6 percent temperatures are equivalent to (1) the ASHRAE 2 percent and 0.4 percent exceedance values and (2) the 2 percent and 0.4 percent exceedance values identified by the staff as regional climatic site characteristics in SER Table 2.3.1-7.

data set and obtained similar results. The staff also used the Port Gibson data to generate mean annual highest and lowest temperatures and obtained results similar to the applicant. Therefore, the staff agrees with the 100-year return period temperature site characteristics presented by the applicant.

During the period 1900–2000, 35 hurricanes directly hit either Mississippi or Louisiana or both States at hurricane-storm intensity with maximum sustained winds of 74 mi/h or greater. According to Jarrell, et al. (2003), 18 of these storms were classified as major hurricanes (Category 3 or higher on the Saffir/Simpson hurricane scale) with maximum sustained winds of 111 mi/h or greater. These hurricanes typically weaken as they move inland, so wind damage tends to be confined to the coastal regions while damage inland comes primarily from heavy rain and flooding. During this period, the most intense hurricane to affect the Mississippi and Louisiana coasts was Hurricane Camille in August 1969. Hurricane Camille was classified as a Category 5 hurricane on the Saffir/Simpson hurricane scale with maximum sustained winds exceeding 155 mi/h as it crossed the coastline. However, according to Simpson, et al. (1970), Hurricane Camille only generated gusts of 67 mi/h as it passed 10 miles east of Jackson.

According to NSSL, "Severe Thunderstorm Climatology, Total Threat," dated August 29, 2003, the mean number of days per year with the threat of tornadoes occurring within 25 miles of the Grand Gulf ESP site is approximately 1.0 to 1.2 days per year for any tornado, approximately 0.30 to 0.35 days per year for a significant tornado (F2 or greater; wind speeds in excess of 113 mi/h), and approximately 0.020 to 0.025 days per year for a violent tornado (F4 or greater; wind speeds in excess of 207 mi/h).

At the direction of the NRC, J.V. Ramsdell, Jr., of Pacific Northwest National Laboratory prepared a report titled, "Technical Evaluation Report on Design-Basis Tornadoes for the Grand Gulf ESP Site," dated November 9, 2004, which derived a best-estimate annual tornado strike probability of 7.4×10^{-4}, based on tornado data from January 1950 through August 2003. This probability corresponds to a mean recurrence interval of 1350 years. Using a different methodology and period of record, the applicant calculated a less conservative tornado return period of 2860 years.

A tornado struck the GGNS site shortly after 11:00 p.m. on April 17, 1978. Two units were under construction at the time; GGNS Unit 1 was 50 percent complete and GGNS Unit 2 was 10 percent complete. The tornado initially touched down approximately 9 miles west-southwest of the GGNS site and traveled to the site where the centerline passed just to the right of the cooling tower and crossed the concrete batch plant area and the northeast corner of the switchyard. The damage path at the plant site was approximately 1500–1800 feet wide, and the highest onsite wind speeds were estimated to be in the 125–150 mi/h range (indicative of an F2 tornado). After leaving the plant site, the storm intensified into an F3 tornado for approximately 1.3 miles and continued for approximately 7 miles before dissipating. According to Fujita (1978) and McDonald (1978), the collapse of construction cranes caused major damage to the power plant facility; high winds also extensively damaged the switchyard installation.

The following discussion on thunderstorms, lightning, hail, and ice events provides a general climatic understanding of the severe weather phenomena in the site region but does not result in the generation of site characteristics for use as design- or operating-basis considerations.

The applicant estimated that 66 thunderstorm-days per year occur in the site area. This frequency is compatible with the 68 thunderstorm-days per year reported by NCDC in 2003 for Jackson. The majority of these thunderstorm days occur from May through August. The applicant estimated that approximately 33 flashes to earth per square mile per year occur around the site area. This estimate is conservative compared to the mean annual ground flash density of 23 flashes per square mile presented in NUREG/CR-3759, "Lightning Strike Density for the Contiguous United States from Thunderstorm Duration Records," issued May 1984, for the Grand Gulf ESP site region. Considering a flash frequency of 33 flashes to earth per square mile per year and the 1.3 square mile exclusion area, the applicant estimated the expected frequency of lightning flashes within the Grand Gulf ESP site EAB as 43 flashes per year.

Hail often accompanies severe thunderstorms and can be a major weather hazard, which causes damage to crops and property. The NCDC Storm Event Database, "Storm Events for Mississippi, Query Results, Hail Event(s) Reported in Claiborne County, Mississippi Between 01/01/1950 and 09/30/2004," reports that a total of 20 hail events with hail 0.75 inches or greater occurred in Claiborne County from January 1984 through December 2003. Ten of these events had hail 1.75 inches or greater in diameter. According to NSSL, "Severe Thunderstorm Climatology, Total Threat," the threat of hail occurring within 25 miles of the Grand Gulf ESP site is approximately 3–4 days per year for damaging hail or hail 0.75 inches in diameter or greater and 0.50–0.75 days per year for hail 2 inches or more in diameter.

The NCDC Storm Event Database, "Storm Events for Mississippi, Query Results, Snow & Ice Event(s) Reported in Claiborne County, Mississippi Between 01/01/1950 and 09/30/2004," lists two ice events for Claiborne County for the period January 1993 through December 2003. In Jones, et al. (2002), the NCDC reports a 50-year return period uniform radial ice thickness of 0.5 inches because of freezing rain, with a concurrent 3-second gust wind speed of 30 mi/h for the Grand Gulf ESP site area.

Large-scale episodes of atmospheric stagnation are not common in the site region. During the 40-year period between 1936 and 1975, high-pressure stagnation conditions, lasting for 4 days or more, occurred approximately 40 times, averaging 4.6 stagnation days per case. Korshover (1976) reports that two of these stagnation cases lasted 7 days or longer. The above discussion on atmospheric stagnation provides a general climatic understanding of the air pollution potential in the region. Section 2.3.2 of this SER discusses the ESP air quality conditions for design- and operating-basis considerations. Sections 2.3.4 and 2.3.5 of this SER present the atmospheric dispersion site characteristics used to evaluate short-term postaccident airborne releases and long-term routine airborne releases, respectively.

Both the weight of the 100-year return period snowpack and the weight of the 48-hour PMWP are specified in RG 1.70 to assess the potential snow loads on the roofs of safety-related structures. The staff's branch position on winter precipitation loads provides clarification as to the load combinations to be used in evaluating the roofs of safety-related structures. Consistent with the staff's branch position on winter precipitation loads, the winter precipitation loads to be included in the combination of normal live loads to be considered in the design of a nuclear power plant that might be constructed on a proposed ESP should be based on the weight of the 100-year snowpack or snowfall, whichever is greater, recorded at ground level. Likewise, the winter precipitation loads to be included in the combination of extreme live loads

to be considered in the design of a nuclear power plant that might be constructed on a proposed ESP should be based on the weight of the 100-year snowpack at ground level plus the weight of the 48-hour PMWP at ground level for the month corresponding to the selected snowpack. A COL or CP applicant may choose and justify an alternative method for defining the extreme winter precipitation load by demonstrating that the 48-hour PMWP could neither fall nor remain on the top of the snowpack and/or building roofs.

The applicant has identified a 100-year return period snowpack of 6.1 lbf/ft^2, which it based on the guidance in SEI/ASCE 7-02. The staff agrees with the applicant's comment that the Grand Gulf ESP site is not in a heavy snowload region, in that snow typically melts and/or evaporates within 48 hours before additional snow is added. According to SRCC, "Monthly Total Snowfall, Jackson 4 NW, Mississippi" and "Monthly Total Snowfall, Jackson WSFO Airport, Mississippi," the highest monthly total snowfall reported for Jackson during the period 1930–2000 is 10.6 inches in January 1940. According to the NCDC database "Cooperative Summary of the Day TD 3200 POR—2001 Data CDROM, Eastern United States, Puerto Rico, and Virgin Islands," issued November 2002, this 10.6 inches of snow fell on January 22 and

January 23, 1940, during which time 0.78 inches of equivalent liquid precipitation (equivalent to 4.1 lbf/ft^2) was recorded. Because the applicant performed its analysis in accordance with the appropriate guidance and the results bound the estimated weight of the maximum monthly snowfall for Jackson, the staff concludes that a 100-year return period snowpack site characteristic value of 6.1 lbf/ft^2 is acceptable.

In Open Item 2.3-2, the staff stated that the applicant had not provided an appropriate 48-hour PMWP value that can be used with the 100-year snowpack to define the extreme winter precipitation roof loads. As discussed in the staff's branch position on winter precipitation loads, the 48-hour PMWP should be developed in accordance with the guidance provided in HMR 53. The applicant responded to Open Item 2.3-2 by proposing a 48-hour PMWP value of 35 inches of water based on HMR 53. Because the applicant determined this value in accordance with HMR 53, the staff concludes that a 48-hour PMWP site characteristic value of 35 inches of water is acceptable.

In its submittal dated June 21, 2005, the applicant contended that the HMR 53 48-hour PMWP value of 35 inches is in the form of rainwater that would not remain on rooftops. Instead, the applicant proposed a 48-hour frozen PMWP value of 1.9 inches of frozen precipitation (equivalent to 9.9 lbf/ft^2) for use in defining extreme live loads for roof design purposes. The applicant's 48-hour frozen PMWP value represents a 100-year return period value statistically extrapolated from four ice storms recorded in nearby counties and parishes during the 11-year period 1993–2003. The applicant proposed defining the snow load for extreme live loads to be considered for roof structural design purposes as 16 lbf/ft^2, which represents the sum of the 100-year return period snowpack (6.1 lbf/ft^2) and the 48-hour frozen PMWP (9.9 lbf/ft^2).

The staff believes that the 11-year period of record used to derive the 48-hour frozen PMWP value of 9.9 lbf/ft^2 is too short, resulting in an unacceptably large uncertainty in the resulting value. In addition, the staff contends that the temporary roof load contributed by a heavy rain on top of an existing snowpack can be significant. Its magnitude will depend on the duration and intensity of the design rainstorm, the drainage characteristics of the snow on the roof, the geometry of the roof, and the type of drainage provided. Where adequate slope to drain does not exist, or where drains are blocked by ice, snow meltwater, and rainwater may pond in low

areas on the roof. As rainwater or snow meltwater flows to such low areas, these areas tend to deflect increasingly, allowing a deeper pond to form. If the structure does not possess enough stiffness to resist this progression, failure by localizing overloading can result. This mechanism has been responsible for several roof failures under combined rain and snow loads.

Therefore, the staff contends that, until a roof design has been established, the “default” winter precipitation loads to be included in the combination of extreme live loads to be considered in the design of a nuclear power plant that might be constructed at the Grand Gulf ESP site should be based on the weight of the 100-year snowpack at ground level plus the weight of the 48-hour PMWP. Once the roof design has been established, a COL or CP applicant may then choose and justify an alternative method for defining the extreme winter precipitation load by demonstrating that the 48-hour PMWP could neither fall nor remain on the top of the snowpack and/or building roofs based on the design of the roof and its drains.

To verify the applicant’s UHS meteorological site characteristics for maximum evaporation and minimum water cooling, the staff examined 30 years (1961–1990) of hourly temperature and humidity data from Jackson using NCDC, “Solar and Meteorological Surface Observational Network (SAMSON) for Eastern U.S. CDROM,” issued September 1993. The staff calculated running 1-, 5-, and 30-day average wet-bulb temperatures from the hourly data, and it selected the periods with the highest average wet-bulb temperatures as the worst periods. The resulting maximum 1-, 5-, and 30-day average wet-bulb temperature values are similar to the values presented by the applicant.

In Open Item 2.3-3, the staff identified the need for an additional UHS meteorological site characteristic for use in evaluating the potential for water freezing in the UHS water storage facility, a phenomenon which would reduce the amount of water available for use by the UHS. The applicant responded to Open Item 2.3-3 by proposing a cumulative degree-day below freezing site characteristic value of 98 EF degree days (i.e., 98 accumulated freezing degree days), based on daily minimum and maximum temperatures recorded at Port Gibson for the period 1930–2001. Because the average winter temperature at the Grand Gulf ESP site is well above freezing, the applicant derived this site characteristic value by evaluating the Port Gibson data for the worst case cold spell.

The staff performed a similar analysis using the 1930–2001 Port Gibson daily minimum and maximum temperature data contained in the NCDC database, “Cooperative Summary of the Day TD 3200 POR—2001 Data CDROM, Eastern United States, Puerto Rico, and Virgin Islands.” The staff calculated daily average temperatures by averaging the daily minimum and maximum temperatures and defining a cold spell as one or more consecutive days where the average daily temperature was below freezing. The worst-case cold spell was then determined by identifying the cold spell with the highest accumulated freezing degree days. The staff’s results were similar to those of the applicant.

Based on the discussion presented above, the staff concludes that the UHS meteorological site characteristics proposed by the applicant are acceptable.

The applicant chose the tornado maximum wind speed site characteristic of 300 mi/h based on the recently published Revision 1 to NUREG/CR-4461. The applicant’s remaining tornado site characteristics (e.g., pressure drop and rate of pressure drop) are consistent with staff’s interim

position on design-basis tornado characteristics for a tornado with a maximum wind speed of 300 mi/h. Therefore, the staff concludes that the tornado site characteristic parameters proposed by the applicant are acceptable.

The applicant's proposed site characteristic basic wind speed of 83 mi/h is compatible with the fastest-mile wind speed having a 1-percent annual probability of being exceeded (100-year mean recurrence interval) for the Grand Gulf ESP site area, as derived by the staff from American National Standards Institute (ANSI) A58.1-1982, "Minimum Design Loads for Buildings and Other Structures," dated March 10, 1982. Figure 1 of ANSI A58.1-1982 shows a basic wind speed of approximately 78 mi/h for the Grand Gulf ESP site, which, by definition, has a 2-percent annual probability of being exceeded or a 50-year mean recurrence interval. According to ANSI A58.1-1982, Section A6.5.2, the ratio of the 100-year to 50-year mean recurrence interval values is typically 1.07, which means that the 50-year return period basic wind speed value of 78 mi/h corresponds to a 100-year return period basic wind speed value of 83 mi/h. Therefore, the staff concludes that a site characteristic fastest-mile basic wind speed value of 83 mi/h is acceptable.

In Open Item 2.3-4, the staff asked the applicant to identify a 3-second gust wind speed that represents a 100-year return period for the ESP site. The applicant responded to Open Item 2.3-4 by proposing a 100-year return period 3-second gust site characteristic value of 96 mi/h. The applicant determined this value in accordance with the guidance provided by SEI/ASCE 7-02. Therefore, the staff concludes that a 3-second gust wind speed site characteristic of 96 mi/h is acceptable.

The staff will include the regional climatology site characteristics listed in Table 2.3.1-7 in any ESP that it might issue for the Grand Gulf ESP site.

Table 2.3.1-7 Staff's Proposed Regional Climatology Site Characteristics

SITE CHARACTERISTIC		VALUE	DESCRIPTION
Ambient Air Temperature and Humidity			
Maximum Dry-Bulb Temperature	2% annual exceedance	92 EF	The ambient dry-bulb temperature that will be exceeded 2% of the time annually
	0.4% annual exceedance	95 EF	The ambient dry-bulb temperature that will be exceeded 0.4% of the time annually
	average annual highest	98 EF	The average of the maximum temperatures recorded each year
	100-year return period	108 EF	The ambient dry-bulb temperature that has a 1% annual probability of being exceeded (100-year mean recurrence interval)

SITE CHARACTERISTIC		VALUE	DESCRIPTION
Minimum Dry-Bulb Temperature	99% annual exceedance	25 EF	The ambient dry-bulb temperature below which dry-bulb temperatures will fall 1% of the time annually
	99.6% annual exceedance	21 EF	The ambient dry-bulb temperature below which dry-bulb temperature will fall 0.4% of the time annually
	average annual lowest	14 EF	The average of the minimum temperatures recorded each year
	100-year return period	! 6 EF	The ambient dry-bulb temperature for which a 1% annual probability of a lower dry-bulb temperature exists (100-year mean recurrence interval)
Maximum Wet-Bulb Temperature	2% annual exceedance	78 EF	The ambient wet-bulb temperature that will be exceeded 2% of the time annually
	0.4% annual exceedance	80 EF	The ambient wet-bulb temperature that will be exceeded 0.4% of the time annually
Basic Wind Speed			
Fastest-mile		83 mi/h	The fastest-mile wind speed to be used in determining wind loads, defined as the fastest-mile wind speed at 33 feet above the ground that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
3-Second Gust		96 mi/h	The 3-second gust wind speed to be used in determining wind loads, defined as the 3-second gust wind speed at 33 feet above the ground that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Tornado			
Maximum Wind Speed		300 mi/h	Maximum wind speed resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year
Translational Speed		60 mi/h	Translation component of the maximum tornado wind speed
Maximum Rotational Speed		240 mi/h	Rotation component of the maximum tornado wind speed
Radius of Maximum Rotational Speed		150 feet	Distance from the center of the tornado at which the maximum rotational wind speed occurs
Pressure Drop		2.0 $lbf/in.^2$	Decrease in ambient pressure from normal atmospheric pressure resulting from passage of the tornado
Rate of Pressure Drop		1.2 $lbf/in.^2/s$	Rate of pressure drop resulting from the passage of the tornado
Winter Precipitation			
100-Year Snowpack		6.1 lbf/ft^2	Weight of the 100-year return period snowpack (to be used in determining normal precipitation loads for roofs)

SITE CHARACTERISTIC	VALUE	DESCRIPTION
48-Hour Probable Maximum Winter Precipitation	35 inches of water	Probable maximum precipitation during the winter months (to be used in conjunction with the 100-year snowpack in determining extreme winter precipitation loads for roofs)
Ultimate Heat Sink		
Meteorological Conditions Resulting in the Minimum Water Cooling during Any 1 Day	81.0 EF wet-bulb temperature with coincident 86.3 EF dry-bulb temperature	Historic worst 1-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures
Meteorological Conditions Resulting in the Minimum Water Cooling during Any Consecutive 5 Days	80.2 EF wet-bulb temperature with coincident 86.2 EF dry-bulb temperature	Historic worst 5-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures
Meteorological Conditions Resulting in the Maximum Evaporation and Drift Loss during Any Consecutive 30 Days	78.5 EF wet-bulb temperature with coincident 83.1 EF dry-bulb temperature	Historic worst 30-day daily average of wet-bulb temperatures and coincident dry-bulb temperatures
Meteorological Conditions Resulting in Maximum Water Freezing in the UHS Water Storage Facility	98 EF degree days below freezing	Historic maximum cumulative degree days below freezing

The staff acknowledges that long-term climatic change resulting from human or natural causes may introduce changes into the most severe natural phenomena reported for the site. However, no conclusive evidence or consensus of opinion is available on the rapidity or nature of such changes. If in the future the ESP site is no longer in compliance with the terms and conditions of the ESP (e.g., if new information shows that the climate has changed and that the climatic site characteristics no longer represent extreme weather conditions), the staff may seek to modify the ESP or impose requirements on the site in accordance with the provisions of 10 CFR 52.39, “Finality of Early Site Permit Determinations,” if necessary, to bring the site into compliance with Commission requirements to assure adequate protection of the public health and safety.

2.3.1.4 Conclusions

As set forth above, the applicant has presented and substantiated information relative to the regional meteorological conditions important to the safe design and siting of a nuclear power plant or plants falling within the applicant’s PPE that might be constructed on the proposed site. The staff has reviewed the available information provided and, for the reasons given above, concludes that the identification and consideration of the regional and site meteorological characteristics set forth above meet the requirements of 10 CFR 100.20(c) and 10 CFR 100.21(d).

The staff finds that the applicant has considered the most severe regional weather phenomena in establishing the above site characteristics. The staff has generally accepted the methodologies used to determine the severity of the weather phenomena reflected in these site characteristics as documented in SERs for previous licensing actions. Accordingly, the staff concludes that the use of these methodologies results in site characteristics containing margin

sufficient for the limited accuracy, quantity, and period of time in which the data have been accumulated. In view of the above, the site characteristics previously identified are acceptable for use as part of the design bases for SSCs important to safety, as may be proposed in a COL or CP application.

The applicant has conformed with a technical assessment of tornado wind speed data and, in part, with the staff's interim position on design-basis tornado characteristics. Therefore, the staff concludes that the identification and consideration of tornadoes are acceptable and that the resulting tornado site characteristics are acceptable for the tornado used for the generation of missiles.

The staff reviewed the applicant's proposed site characteristics related to climatology for inclusion in an ESP for the applicant's site, should one be issued, and finds these characteristics to be acceptable. The staff has also reviewed the applicant's proposed design parameters (PPE values) for inclusion in such an ESP (SSAR Section 1.3) and finds them to be reasonable. The staff did not perform a detailed review of these parameters.

2.3.2 Local Meteorology

2.3.2.1 Technical Information in the Application

In Section 2.3.2 of the SSAR, the applicant presented local (site) meteorological information. This SSAR section also addresses the potential influence of construction and operation of a nuclear power plant or plants falling within the applicant's PPE on local meteorological conditions that might in turn adversely impact such a plant or plants or the associated facilities. Finally, the applicant provided a topographical description of the site and its environs. Specifically, the applicant provided the following information:

- a description of the local (site) meteorology in terms of airflow, temperature, atmospheric water vapor, precipitation, fog, atmospheric stability, and air quality

- an assessment of the influence on the local meteorology of construction and operation of a nuclear power plant or plants falling within the applicant's PPE that might be constructed on the proposed site and its facilities, including the effects of plant structures, terrain modification, and heat and moisture sources resulting from plant operation

- a topographical description of the site and its environs, as modified by the structures of a nuclear power plant or plants falling within the applicant's PPE that might be constructed on the proposed site

The applicant used data from the GGNS onsite meteorological monitoring system, as well as data from Vicksburg and Jackson, Mississippi, and St. Joseph, Louisiana, to characterize local meteorological conditions. The applicant considered the data from the GGNS monitoring station to be the most representative of the Grand Gulf ESP site because of the station's proximity to the site.

The applicant presented wind data from Vicksburg for the period 1997–2001. The Vicksburg wind data indicate that the predominant wind directions are from the north and south (about 14 percent of the time for each sector). The mean wind speed is 7.4 mi/h.

Revision 0 of the SSAR presents wind data from the 33-foot level on the GGNS meteorological tower for the period 1996–2001. The staff noted a lack of easterly winds for the period 1996–2000, as compared to the August 1972 through July 1974 GGNS data presented in the GGNS UFSAR and the 2001 GGNS data presented in the SSAR. The staff subsequently reviewed the GGNS onsite meteorological monitoring program during a site visit and identified that the use of a wide (4-foot by 6-foot) scaffolding tower to collect the 1996–2000 data probably contributed to this phenomenon. In early 2001, a narrower triaxial tower replaced the rectangular scaffolding tower. Consequently, in RAI 2.3.2-5, the staff asked the applicant to provide wind data summaries for the data collected with the newer, narrower tower. In its response to this RAI, the applicant provided a copy of the 1996–2003 GGNS hourly meteorological database.

The newer GGNS 2001–2003 wind data set indicates that the predominant wind directions are from the northeast (about 10 percent of the time) and southeast (about 8–9 percent of the time). The average wind speed is 4.3 mi/h. The longest single-sector wind direction persistences tend to be from the northeast sector. Seasonal variations are also evident from the data, with higher wind speeds during the winter and lower wind speeds during the summer. The prevailing wind direction is from the north during the winter, from the south during the spring, and from the northeast during the summer and autumn.

The SSAR presents dry-bulb temperature data from Vicksburg for the period 1997–2001 and from the GGNS onsite monitoring program for the period 2000–2001. The average dry-bulb temperature recorded at Vicksburg is 65.6 EF, ranging from a low monthly mean value of 47.2 EF in December to a high monthly mean value of 82.5 EF in July. The average dry-bulb temperature recorded at GGNS is 65.1 EF, ranging from a low monthly mean value of 46.2 EF in December to a high monthly mean value of 81.4 EF in July. Temperature extremes at Vicksburg range from 16 EF to 107 EF, whereas temperature extremes at GGNS range from 17.3 EF to 104.2 EF. Other observed temperature extremes include 110 EF for the Vicksburg Military Park 1967–2004 database, 107 EF and !5 EF for the Jackson 1896–2003 database, and !8 EF for the St. Joseph 1930–2001 database. The applicant statistically extrapolated 100-year return period extreme temperatures of 108 EF and !6 EF from the Port Gibson 1930–2001 database.

According to the applicant, all of Mississippi experiences high humidity during much of the year. The average relative humidity recorded at Vicksburg during the period 1997–2001 is 75 percent, with relative humidity values of 90 percent or higher occurring at any hour of the day.

The SSAR presents precipitation data recorded on site during the period 2000–2001 and at Vicksburg during the period 1997–2001. The annual average precipitation recorded on site is 44.85 inches, with monthly mean totals ranging from 8.58 inches in March to 1.65 inches in October. The annual average precipitation recorded at Vicksburg is 49.56 inches, with monthly mean totals ranging from 6.89 inches in March to 1.98 inches in August. The applicant also presented maximum short period precipitation estimates ranging from 30-minute to 10-day durations. In RAI 2.3.2-1, the staff asked the applicant to update the 30-minute and 1-hour

precipitation estimates using the latest data generated by NWS, and the applicant complied with this request. The resulting 100-year recurrence interval 1-hour and 24-hour maximum precipitation estimates are 4.3 inches and 9.9 inches, respectively.

The applicant estimated the annual average snowfall in the Grand Gulf ESP site area as 1–2 inches. The applicant reported that the highest monthly amount of snowfall recorded at Jackson is 10.6 inches, which fell in a 24-hour period. The highest seasonal amount of snowfall recorded at Jackson is 11.6 inches.

The SSAR presents a precipitation wind rose for Jackson, which shows that precipitation occurs most often with winds from the southeast through south and north-northwest through northeast. A precipitation wind rose for GGNS site shows a similar pattern.

The applicant stated that Vicksburg recorded an average of 93 hours of fog per year during the period 1997–2001, with the greatest frequency of fog occurring between October and March. The applicant considered the Vicksburg fog data to be representative of the Grand Gulf ESP site because of its proximity and similar location relative to the Mississippi River. During this same period, Vicksburg reported an average of 194 hours of haze but had no reports of heavy fog, smoke, duststorms, or sandstorms.

The SSAR presents atmospheric stability data based on wind data observations from the GGNS tower and sky cover data from Vicksburg. These data show that neutral (Pasquill type “D”) conditions predominated, occurring about 23 percent of the time. Moderately stable (Pasquill type “F”) and extremely stable (Pasquill type “G”) conditions occurred about 17 percent and 19 percent of the time, respectively, most often during the summer.

The applicant presented inversion height statistics based on twice daily weather balloon data at Jackson during the period 1992–2000. These data show that inversions (defined as three weather balloon elevation readings below 3000 meters showing consecutive increases in temperature with height) occurred during approximately 60 percent of the mornings and 25 percent of the afternoons. The average morning and afternoon inversion heights are 685 meters and 1490 meters, respectively. A separate study of mixing height data from Jackson for the period 1992–2001 shows that monthly mixing heights range from an average low of 320–330 meters during August and October mornings to an average high of 1820 meters during August afternoons. Ground-based inversion statistics using Jackson hourly surface observations show that ground-based inversions occurred approximately 39 percent of the time, with the longest durations lasting 16 hours.

The SSAR also presents inversion data based on GGNS onsite delta-temperature measurements taken during the periods August 1972 through July 1974 and January 1976 through December 1976. These data show inversions occurring approximately 47 percent of the time, most frequently during August (approximately 58 percent of the time) and least frequently during January (approximately 35 percent of the time). The longest durations last 14 hours.

In RAI 2.3.2-3, the staff asked the applicant to identify the air quality characteristics of the site that it would include in the design and operating bases for a nuclear power plant or plants that might be constructed on the Grand Gulf ESP site. The applicant responded that no air quality

parameters exist that require consideration for the proposed ESP facility's design and operating bases.

The applicant stated that the only aspects of the Grand Gulf ESP site that could be categorized as a unique microclimate result from the site's proximity to the Mississippi River. The proximity of the river increases local humidity a small amount and creates a slight tendency for lower level winds to be channeled along the river.

In RAI 2.3.2-4, the staff asked the applicant to describe potential modifications to local meteorological conditions as the result of the presence and operation of a nuclear power plant or plants falling within the PPE specified in the SSAR. The applicant responded that it does not expect new construction at the site to significantly impact the local climate. Although some ground leveling will occur, it will not change any of the significant climate-shaping topographic features. Some trees will be removed, but the trees within the construction footprint are few in number compared to the surrounding forested land. The site already contains numerous buildings, large parking areas, and traffic; the impact of more structures, facilities, and activities is not expected to be noticeable in terms of local meteorology.

In its response to RAI 2.3.2-4, the applicant also stated that operation of a new facility at the Grand Gulf ESP site could affect local climate by increasing particulate emissions to the atmosphere, producing thermal discharges to the Mississippi River, and adding heat and moisture to the atmosphere through the use of cooling towers. The increase in particulate emissions during plant operation would result from a modest increase in automobile traffic and infrequent operation of diesel generators. The applicant noted that the net increase in particulate emissions would be negligible and would not cause any noticeable climatic effects.

Likewise, in its response, the applicant stated that the amount of heat rejected to the high volumetric flow of the Mississippi River would be relatively small, causing an incidentally small impact on local meteorology. The applicant's evaluation of the surface thermal plumes resulting from the discharge of blowdown water into the Mississippi River predicts a steam fog occurrence probability of only a few percent higher than over ambient river water.

The SSAR evaluates the atmospheric impact for two different options for providing normal heat sink cooling capability to the proposed facility—(1) four natural draft cooling towers and (2) four 20-cell linear mechanical draft cooling towers. These cooling systems would create visible plumes under certain atmospheric conditions, which can cause shadowing of nearby lands, salt deposition, fogging, and icing. The predicted seasonal average plume lengths for the natural draft cooling towers range from 0.93 miles in the summer to 2.32 miles in the winter. The predicted plume lengths for the mechanical draft cooling towers are generally 40 percent less, but the plumes would be closer to the ground, resulting in increased salt deposition and the possibility of fog. The applicant's plume study shows that no fogging would occur for the natural draft cooling tower option, whereas the study predicts that the mechanical draft cooling towers would cause minimal fogging (on the order of 15 hours per year). The applicant considered ground-level icing insignificant because of the low probabilities of ground-level plumes from either type of tower and freezing conditions. Except for the limited potential for fogging, the applicant determined that the use of either cooling system option would have no significant impact on meteorological conditions outside the site boundary.

In the SSAR, the applicant noted that the proposed location for the new facility site lies about 6300 feet east of the Mississippi River at an elevation of approximately 132.5 feet above mean sea level (MSL). The applicant described the surrounding terrain as generally hilly and wooded to the south and east, with several hilltops more than 350 feet above MSL to the south. To the north and west, the terrain is generally flat and wooded, lying less than 100 feet above MSL. Numerous lakes of various sizes and isolated marshes dot the landscape. A rather abrupt (irregular) 100- to 200-foot rise in terrain occurs approximately 1 mile east of the riverbank.

2.3.2.2 Regulatory Evaluation

In SSAR Section 3.0, the applicant stated that the NRC regulations that apply to evaluating an ESP include 10 CFR 100.20 and 10 CFR 100.21. The staff notes that 10 CFR 100.20(c) and 10 CFR 100.21(d) are the applicable 10 CFR Part 100 regulations with respect to the consideration that has been given to the regional meteorological characteristics of the site.

In SSAR Sections 1.0 and 1.4, the applicant identified the following applicable NRC guidance regarding local meteorology:

- RG 1.3, Revision 2, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors," issued June 1974, with respect to acceptable methods for modeling radiological releases

- RG 1.23, "Onsite Meteorological Programs," issued February 1972, with respect to providing the criteria for an acceptable onsite meteorological measurements program

- RG 1.70, with respect to the type of local meteorological data that should be presented

The staff has reviewed this portion of the application in accordance with the guidance identified by the applicant and to determine if the application is in compliance with the applicable regulations.

Section 2.3.2 of RS-002 and Section 2.3.2 of RG 1.70 provide the following guidance on information appropriate for a presentation on local meteorology:

- Local meteorological data based on onsite measurements and data from nearby NWS stations or other standard installations should be presented in the format specified in Section 2.3.2 of RG 1.70. RG 1.23 provides guidance related to onsite meteorological measurements.

- A topographical description of the site and environs should be provided. Section 2.3.2.2 of RG 1.70 provides guidance on the topographical description.

- A discussion and evaluation of the influence of a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed on the proposed site and its facilities on local meteorological and air quality conditions should be provided. Potential changes in the normal and extreme values resulting from plant construction and operation should be discussed.

2.3.2.3 Technical Evaluation

The staff evaluated local meteorological conditions using data from the GGNS onsite meteorological monitoring system, as well as climatic data reported by NWS, NCDC, and SRCC. The staff reviewed statistics for the following climatic stations located in the vicinity of the Grand Gulf ESP site:

- Port Gibson, Mississippi, located approximately 5 miles east-southeast of the ESP site
- St. Joseph, Louisiana, located approximately 11 miles west-southwest of the ESP site
- Vicksburg, Mississippi, located approximately 26 miles north-northeast of the ESP site
- Jackson, Mississippi, located approximately 61 miles east-northeast of the ESP site

As discussed in Section 2.3.2.1 of this SER, the GGNS 33-foot level wind data presented in Revision 0 of the SSAR for the period 1996–2000 lack easterly winds as compared to the August 1972 through July 1974 GGNS data presented in the GGNS UFSAR and the 2001 GGNS data given in the SSAR. In response to RAI 2.3.2-5, the applicant provided a copy of the 1996–2003 GGNS hourly meteorological database.

The staff's review of the applicant's 33-foot wind data from August 1972 through July 1974 and January 2002 through December 2003 shows that the data from these two periods are compatible. The predominant wind directions for the 1972–1974 data are from the east-northeast clockwise to south-southeast (43 percent of the time), as compared to the predominant northeast clockwise to southeast (42 percent of the time) wind directions for the 2001–2003 time period. The wind speed frequency distributions between the two time periods are similar as well, with average wind speeds of 4.4 mi/h and 4.3 mi/h for the 1972–1974 and 2001–2003 time periods, respectively.

According to NCDC, "Southeast Mississippi Divisional Normals—Temperature, Period 1971–2000," dated June 15, 2002, the 1971–2000 normal climatic data for the southwest climatic division of Mississippi indicate an annual mean temperature of 64.6 EF, ranging from a low monthly mean value of 46.6 EF in January to a high monthly mean value of 80.8 EF in July. These climatic division mean temperature values are compatible with the mean temperature values recorded on site during the period 2000–2001 (e.g., annual mean temperature of 65.1 EF with a low monthly mean value of 46.2 EF in December and a high monthly mean value of 81.4 EF in July).

The staff presents an evaluation of the applicant's 100-year return period extreme temperatures in Section 2.3.1.3 of this SER.

The annual mean wet-bulb temperature at Jackson is 58.6 EF and ranges from a high monthly mean value of 74.3 EF in July to a low monthly mean value of 41.5 EF in January. As reported in NCDC, "Jackson, Mississippi, 2003 Local Climatological Data, Annual Summary with Comparative Data," the annual mean relative humidity is 75 percent.

As stated in NCDC, "Southeast Mississippi Divisional Normals—Precipitation, Period 1971–2000," dated June 15, 2002, precipitation for the southwest Mississippi climatic division averages 61.37 inches per year, with monthly climate division normals ranging from a minimum of 3.62 inches in October to a maximum of 6.51 inches in March. The annual average precipitation recorded at Port Gibson during 2000–2001 is 54.57 inches, compared to 44.85 inches noted at the GGNS site during the same period, as reported in SRCC, "Monthly Precipitation, Port Gibson 1 NW, Mississippi." According to NWS, "NWS Jackson,

MS—St. Joseph 3N Climate," maximum and minimum monthly amounts of precipitation observed in the area are 21.80 inches in April 1940 and 0 inches in October 1952 at St. Joseph. One of the highest 24-hour precipitation totals recorded for the site region is 9.85 inches at St. Joseph on April 4, 1940, according to NCDC, "Cooperative Summary of the Day TD 3200 POR–2001 Data CDROM, Central United States." Precipitation wind roses provided by the applicant for Jackson and the GGNS site show that rain occurs most often with wind from the southeast through south and north-northwest through northeast.

The average seasonal snowfall at Port Gibson for the period 1929–1930 through 2003–2004 is 1.1 inches. Measurable snowfall was reported during 23 seasons out of this 75-season period, with measurable snowfall recorded during November through March. According to SRCC, "Monthly Total Snowfall, Port Gibson 1 NW, Mississippi," the highest monthly and seasonal total snowfalls reported for Port Gibson are 9.0 inches for January 1940 and 10.0 inches for the 1967–1968 season.

The SSAR presents atmospheric stability data based on delta-temperature measurements between the 162-foot and 33-foot levels on the GGNS meteorological tower for the period 2001–2002. Neutral (Pasquill type "D") and slightly stable (Pasquill type "E") conditions were predominant, occurring about 35 percent and 26 percent of the time, respectively. Moderately stable (Pasquill type "F") and extremely stable (Pasquill type "G") conditions occurred about 10 and 11 percent of the time, respectively. The onsite data presented in the GGNS UFSAR for the period 1972–1976 show similar stability frequencies. Neutral and slightly stable conditions were predominant in the 1972–1976 data set, occurring about 29 and 22 percent of the time, respectively. Moderately stable and extremely stable conditions occurred about 10 and 14 percent of the time, respectively.

In summary, the staff reviewed the applicant's description of the local meteorology and determined that it represents the conditions at and near the site. The applicant based the wind, temperature, precipitation, and atmospheric stability data on onsite data recorded by the GGNS meteorological monitoring system. Section 2.3.3 of this SER discusses the representativeness of the GGNS onsite data. Additional meteorological summaries are based on data from nearby stations with long periods of record. The staff's review of the recorded extreme values shows that the site characteristics presented in SSAR Section 2.3.1 reflect these values.

The staff reviewed the topographic information provided in the SSAR and concluded that it can readily extract the information needed.

Because of the limited and localized nature of the expected terrain modifications associated with the development of the ESP facility, the staff finds that these terrain modifications, along with the resulting plant structures and associated improved surfaces, will not have enough of an impact on local meteorological conditions to affect plant design and operation. The use of natural draft cooling towers, mechanical draft cooling towers, or both, would create visible plumes under certain atmospheric conditions, which can cause shadowing of nearby lands, salt deposition, and fogging. Ground-level icing would be insignificant because of the low probabilities of both ground-level plumes from either type of tower and freezing conditions. The staff finds that these atmospheric impacts will not have enough of an impact on local meteorological conditions to affect plant design and operation.

The Grand Gulf ESP Environmental Report (ER) states that the air quality in the vicinity of the ESP site is generally good, reflecting the predominantly rural character of the region. The Grand Gulf ESP site region has been designated as in attainment of the national ambient air quality standards. Therefore, the staff finds that the Grand Gulf ESP site air quality conditions should not be a significant factor in the design and operating bases for the ESP facility.

2.3.2.4 Conclusions

As set forth above, the applicant has presented and substantiated information on local meteorological, air quality, and topographic characteristics of importance to the safe design and operation of a nuclear power plant or plants falling within the applicant's PPE that might be constructed on the proposed site. The staff has reviewed the available information provided and, for the reasons given, concludes that the applicant's identification and consideration of the meteorological, air quality, and topographical characteristics of the site and the surrounding area meet the requirements of 10 CFR Part 100, 10 CFR 100.20(c), and 10 CFR 100.21(d) and are sufficient to determine the acceptability of the site.

The staff also reviewed available information relative to severe local weather phenomena at the site and in the surrounding area. As set forth above, the staff concludes that the applicant has identified the most severe local weather phenomena at the site and surrounding area.

2.3.3 Onsite Meteorological Measurements Program

2.3.3.1 Technical Information in the Application

In Section 2.3.3 of the SSAR, the applicant presented information concerning its onsite meteorological measurements program, including instrumentation and measured data. Specifically, the applicant provided the following information:

- a description of meteorological instrumentation, including siting of sensors, sensor performance specifications, methods and equipment for recording sensor output, the quality assurance program for sensors and recorders, and data acquisition and reduction procedures

- meteorological data, including consideration of the period of record and amenability of the data for use in characterizing atmospheric dispersion conditions

The applicant used the existing onsite meteorological measurements program for the GGNS facility to collect data for the Grand Gulf ESP site. According to the applicant, data collection (except for the humidity data) has been compliant with the applicable requirements of RG 1.23 since the startup of the GGNS onsite monitoring system in 1972.

The GGNS meteorological monitoring program has evolved over the years. A 162-foot tower was first installed before plant construction in August 1972. The tower was located approximately 5300 feet north-northwest of the center of the GGNS Unit 1 reactor and approximately 3600 feet north of the center of the proposed Grand Gulf ESP powerblock area. The tower structure consisted of approximately 4-foot-wide by 6-foot-long scaffolding with a set of climbing stairs running up the center. The instrumentation on this tower was upgraded and a

33-foot backup tower was installed approximately 300 feet south-southwest of the primary tower in 1983 as part of the initial licensing conditions for GGNS Unit 1.

Wind speed and direction were measured at the 33-foot and 162-foot elevations. Ambient temperature and dew point were measured at the 33-foot elevation, and vertical temperature difference (delta-temperature) was measured between the 162-foot and 33-foot elevations. Precipitation was monitored at the ground level.

Because of concerns that the width of the primary tower would affect the wind speed and direction measurements, the wind sensors on the primary tower had redundant/duplicate sensors located on the opposite face of the tower. Strip chart recorders located in the instrument shed near the base of the tower recorded data; in addition, data from one set of instruments were sent to the plant data system (PDS) for data display and recording.

The primary and backup tower structures were replaced in March 2001. A 162-foot guyed, triaxial, open lattice (18-inch-wide) tower was installed at the location of the 33-foot backup tower, and a 33-foot open lattice backup tower was installed at the location of the 162-foot scaffolding tower. Instrumentation on both towers was also replaced as part of the 2001 system upgrade. The new primary tower sensors are located at the same heights as on the previous tower (i.e., at the 33-foot and 162-foot levels). However, unlike the previous primary tower, the new primary tower has only one set of wind sensors. Redundant wind instrumentation is no longer necessary since the new tower's structure should have little to no effect on the wind measurements (because of the new tower structure's narrower face). The 33-foot dew point sensor was also replaced with a relative humidity sensor as part of the instrumentation upgrade.

The wind sensors on the new tower are mounted on 6-foot booms and are oriented towards the west. The temperature and relative humidity sensors are housed in motor-aspirated shields to insulate them from the effects of precipitation and thermal radiation.

Before 2001, the meteorological data were recorded in both digital and analog form. Digital data averages were calculated each hour from 1-second readings. The analog traces recorded on strip charts served as a backup and verification for the digital data. Beginning in 2001, the meteorological data are recorded digitally from readings taken at least once every 10 seconds. Data averages are calculated every 15 minutes and every hour. The applicant used the resulting 2002–2003 hourly digital database to perform the atmospheric dispersion analyses presented in Sections 2.3.4 and 2.3.5 of the SSAR.

The meteorological monitoring system is calibrated at least semiannually. The data recovery for the 2002–2003 period of record used to evaluate atmospheric dispersion is more than 90 percent.

In RAI 2.3.2-2, the staff asked the applicant to specify the proposed locations of the two different options under consideration for normal heat sink cooling (i.e., the four natural draft cooling towers and the four mechanical draft cooling towers) and identify their potential influence on the onsite meteorological measurement system. In its response to this RAI, the applicant stated that the closest natural draft cooling tower at its proposed location would be approximately 1400 feet from the current meteorological tower location. The applicant also stated that wake effects and potential plume interaction could affect the meteorological tower if

the natural draft cooling towers were to be constructed at their proposed locations and the existing meteorological tower were to remain at its current location. The natural draft cooling tower option would be the only option with potential for wake effects.

In RAI 2.3.2-5, the staff asked the applicant to provide an hourly listing of the onsite meteorological database used to generate the SSAR Section 2.3.4 short-term diffusion estimates and the SSAR Section 2.3.5 long-term diffusion estimates. In its response to this RAI, the applicant provided a copy of the hourly database for 1996–2003.

2.3.3.2 Regulatory Evaluation

In SSAR Section 3.0, the applicant stated that the NRC regulations that apply to evaluation of an ESP include Appendix I to 10 CFR Part 50, 10 CFR 100.20, and 10 CFR 100.21. The staff notes that 10 CFR 100.20(c), 10 CFR 100.21(c), and 10 CFR 100.21(d) are the applicable 10 CFR Part 100 regulations as they relate to meteorological data collected for use in characterizing the site's meteorological characteristics. The staff also notes that Appendix I to 10 CFR Part 50 pertains to the meteorological data used to determine compliance with the numerical guides for doses in meeting the criterion of "as low as is reasonable achievable" (ALARA).

In SSAR Sections 1.0, 1.4, and 2.3.3, the applicant identified the following applicable NRC guidance regarding onsite meteorological measurements programs:

- RG 1.23, with respect to criteria for an acceptable onsite meteorological measurements program

- RG 1.70, with respect to describing the meteorological measurements at the site and providing joint frequency distributions of wind speed and direction by atmospheric stability class

The staff has reviewed this portion of the application in accordance with the guidance identified by the applicant and to determine if the application is in compliance with the applicable regulations.

Both RG 1.23 and RS-002, Section 2.3.3, document the criteria for an acceptable onsite meteorological measurements program. The onsite meteorological measurements program should produce data that describe the meteorological characteristics of the site and its vicinity for the purpose of making atmospheric dispersion estimates for both postulated accidental and expected routine airborne releases of effluents, and for comparison with offsite sources to determine the appropriateness of climatological data used for design considerations.

Section 2.3.3 of RS-002 and Section 2.3.3 of RG 1.70 provide guidance on information appropriate for presentation on an onsite meteorological measurements program. As set forth in this guidance, at least one annual cycle of onsite meteorological data should be provided. These data should be presented in the form of joint frequency distributions of wind speed and wind direction by atmospheric stability class in the format described in RG 1.23. If a site has a high occurrence of low wind speeds, a finer category breakdown should be used for the lower speeds so data are not clustered in a few categories. A listing of each hour of the hourly averaged data should also be provided on electronic media in the format described in

Appendix A to Section 2.3.3 of RS-002. Evidence of how well these data represent long-term conditions at the site should be discussed.

2.3.3.3 Technical Evaluation

The staff evaluated the onsite meteorological measurements program by reviewing the description presented in the SSAR and conducting a site visit. During the site visit, the staff reviewed the meteorological monitoring system location and exposure, sensor type and performance specifications, data transmission and recording, data acquisition and reduction, and instrumentation maintenance and calibration procedures. In addition, the staff reviewed hourly listings of the 2002–2003 meteorological database provided by the applicant in its response to RAI 2.3.2-5. The applicant used the 2002–2003 database to generate the SSAR Section 2.3.4 short-term diffusion estimates and the SSAR Section 2.3.5 long-term diffusion estimates.

The Grand Gulf ESP site is within the existing GGNS site, and the proposed ESP facility is intended to be in close proximity to the existing GGNS facility. The GGNS primary tower is located far enough away from existing plant structures to preclude any adverse impact on measurements. Since the 2001 system upgrade, the wind sensors are mounted on 6-foot booms to preclude tower influence on the wind measurements. The temperature and relative humidity sensors are housed in motor-aspirated shields to insulate them from the effects of precipitation and thermal radiation. The ground cover at the base of the tower consists primarily

of native grasses. Trees 50 feet tall are located approximately 362 feet to the west of the primary tower, and 50-foot to 60-foot trees are located approximately 396 feet to the east and 489 feet to the south of the primary tower. RS-002, Section 2.3.3, states that wind sensors should be at least 10 obstruction heights away from any obstructions (such as trees) to avoid potential influence on wind measurements. Although these trees are located within 10 times their height from the primary tower, their influence is not considered to be significant in that they are at least 6 times their height from the tower. According to the applicant, all trees within a 900-foot radius of the primary tower are scheduled to be trimmed back in the near future.

The staff evaluated the types and heights of the meteorological variables measured and found them to be compatible with the criteria of RG 1.23. During the site visit, the staff reviewed the sensor types and performance specifications, data transmission, and recording methods, as well as the inspection, maintenance, and calibration procedures and frequencies, and found them to be consistent with the guidance in RG 1.23.

The applicant based the short-term and long-term diffusion estimates presented in Revision 0 of SSAR Sections 2.3.4 and 2.3.5 on onsite meteorological data recorded from January 1996 through December 2000. However, a review of this meteorological data set by the staff revealed that wind data collected during this period show an apparent lack of easterly winds as compared to the August 1972 through July 1974 GGNS onsite meteorological data set presented in the GGNS UFSAR.

This apparent lack of easterly winds in the 1996–2000 data set may be the result of tower “shadowing” from the wide scaffolding tower used during this period. Although redundant/duplicate wind sensors were located on the opposite face of the tower, the PDS

recorded only one set of these data during this period. The data recorded by the PDS were a function of an A/B switch located in the instrument shed at the base of the tower, and its setting was probably never changed during the 1996–2000 recording period. It appears that data from both sets of wind instruments were appropriately used to compile the 1972–1974 wind data presented in the GGNS UFSAR. These earlier data probably predate the use of the PDS and were most likely compiled from the strip charts.

Therefore, since the narrower triaxial tower replaced the wide scaffolding tower in March 2001, the staff asked the applicant in RAI 2.3.2-5 to recalculate the short-term and long-term diffusion factors presented in SSAR Sections 2.3.4 and 2.3.5 using meteorological data collected by the GGNS monitoring program since the 2001 system upgrade. In its response to RAI 2.3.2-5, the applicant revised the requested atmospheric diffusion factors using GGNS site meteorological data for 2002–2003.

The staff performed a quality review of the 2002–2003 hourly meteorological database provided by the applicant using the methodology described in NUREG-0917, "Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data," issued July 1982. The staff performed further review using computer spreadsheets. As expected, its examination of the data revealed generally stable and neutral atmospheric conditions at night and unstable and neutral conditions during the day. Wind speed, wind direction, and stability class frequency distributions for each measurement channel were reasonably similar from year to year and generally consistent with the 1972–1976 data presented in the GGNS UFSAR. A comparison between the joint frequency distribution used by the applicant as input to the PAVAN and XOQDOQ atmospheric dispersion computer codes and a staff-generated joint frequency distribution from the hourly database provided by the applicant showed that they were similar.

For the reasons cited above, the staff considers the meteorological data collected by the GGNS monitoring program since the 2001 system upgrade to be representative of the dispersion conditions at the Grand Gulf ESP site.

In its response to RAI 2.3.2-2, the applicant stated that, should natural draft cooling towers be constructed in the proposed location and the existing meteorological tower remain in its current location, the meteorological tower could experience wake effects, potential plume interactions, and other impacts. Therefore, the issue of interaction between the existing meteorological tower and the proposed facility's cooling towers should be evaluated following the finalization of the cooling tower design and placement. This is **COL Action Item 2.3-1.**

2.3.3.4 Conclusions

As set forth above, the applicant has provided and substantiated information regarding the onsite meteorological measurements program. The staff has reviewed the available information relative to the meteorological measurements program and the data collected by the program. On the basis of this review and as set forth above, the staff concludes that the system provides data adequate to represent onsite meteorological conditions, as required by 10 CFR 100.20. The onsite data collected from 2002–2003 provide an acceptable basis for (1) making estimates of atmospheric dispersion for DBA and routine releases from a nuclear

power plant or plants falling within the applicant's PPE that might be constructed on the proposed site and (2) meeting the requirements of 10 CFR Part 100 and Appendix I to 10 CFR Part 50.

2.3.4 Short-Term Diffusion Estimates

2.3.4.1 Technical Information in the Application

In Section 2.3.4 of the SSAR, the applicant presented information on atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and LPZ. Specifically, the applicant provided the following information:

- atmospheric transport and diffusion models to calculate dispersion estimates (atmospheric dispersion factors or χ/Q values) for postulated accidental radioactive releases
- meteorological data summaries used as input to dispersion models
- specification of diffusion parameters
- probability distributions of χ/Q values
- determination of χ/Q values used for assessment of consequences of postulated radioactive atmospheric releases from design-basis and other accidents

The applicant used the computer code PAVAN (NUREG/CR-2858, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design-Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations," issued November 1982) to estimate χ/Q values at the EAB and LPZ for potential accidental releases of radioactive material. The PAVAN model implements the methodology outlined in RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," issued November 1982.

The PAVAN code estimates χ/Q values for various time-averaging periods ranging from 2 hours to 30 days. The meteorological input to PAVAN consists of a joint frequency distribution of wind speed, wind direction, and atmospheric stability data. The PAVAN code computes χ/Q values at the EAB and LPZ for each combination of wind speed and atmospheric stability for each of the 16 downwind direction sectors. The code then ranks χ/Q values for each sector in descending order, and it derives an associated cumulative frequency distribution based on the frequency distribution of wind speed and stabilities for that sector. The χ/Q value that is equaled or exceeded 0.5 percent of the total time is determined for each sector, and the highest 0.5 percentile χ/Q value among the 16 sectors becomes the maximum sector-dependent χ/Q value. The code also ranks χ/Q values independent of wind direction into a cumulative frequency distribution for the entire site. The PAVAN program then selects the χ/Q value that is equaled or exceeded 5 percent of the total time. The larger of the two values, the maximum sector-dependent 0.5-percent χ/Q value or the overall site 5-percent χ/Q value, is used to represent the χ/Q value for a 0–2-hour time period.

To determine χ/Q values for longer time periods, PAVAN calculates annual average χ/Q values. Logarithmic interpolation is then used between the 0–2-hour χ/Q values and the annual average χ/Q values to calculate the values for intermediate time periods (i.e., 8 hours, 16 hours, 72 hours, and 624 hours).

In RAI 2.3.4-2, the staff asked the applicant to provide a copy of the PAVAN computer code input and output files used to generate the EAB and LPZ χ/Q values presented in SSAR Section 2.3.4. The applicant complied with this request in its response to this RAI.

The applicant used the following input data and assumptions in applying the PAVAN model to the Grand Gulf ESP site:

- Revision 0 to the SSAR presents PAVAN results using a joint frequency distribution of wind speed, wind direction, and atmospheric stability data based on onsite meteorological data from January 1996 through December 2000. The wind data were obtained from the 33-foot level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 162-foot and 33-foot levels of the GGNS onsite meteorological tower. As discussed in Section 2.3.3.3 of this SER, a review of this data set by the staff revealed that wind data collected during this period show an apparent lack of easterly winds as compared to the August 1972 through July 1974 GGNS onsite meteorological data set presented in the GGNS UFSAR. In RAI 2.3.2-5, the staff asked the applicant to recalculate the short-term dispersion estimates presented in SSAR Section 2.3.4 using meteorological data collected by the GGNS monitoring program since the 2001 system upgrade. In its response to this RAI, the applicant revised the requested short-term atmospheric dispersion estimates using GGNS site meteorological data for 2002–2003.

- The applicant modeled one ground-level release point and did not take credit for building wake effects.

- SSAR Section 2.1.2 states that the EAB for the new facility consists of a circle of approximately 0.52-mile (841-meter) radial distance from the circumference of a 630-foot (192-meter) radius circle encompassing the proposed powerblock location for the new facility. Thus, the minimum distance to the EAB from any individual new reactor sited within the 630-foot circle would be 0.52 miles (841 meters). Therefore, the applicant used an EAB distance of 841 meters as input to the PAVAN computer code.

- Likewise, SSAR Section 2.1.3.4 states that the LPZ for the new facility consists of a circle of approximately 2-mile (3219-meter) radial distance from the circumference of a 630-foot (192-meter) radius circle encompassing the proposed powerblock location for the new facility. Thus, the minimum distance to the LPZ from any individual new reactor sited within the 630-foot (192-meter) circle would be 2 miles (3219 meters). Therefore, the applicant used an LPZ distance of 3219 meters as input to the PAVAN computer code.

Based on the PAVAN modeling results, the applicant proposed the short-term atmospheric dispersion site characteristics presented in Table 2.3.4-1 for inclusion in an ESP, should one be issued for the applicant's proposed Grand Gulf ESP site.

Table 2.3.4-1 Applicant's Proposed Short-Term (Accident Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2-H χ/Q Value @ EAB (5%)	5.95×10^{-4} s/m^3	The atmospheric dispersion factors used in the safety analysis to estimate dose consequences of accidental airborne releases
0–8-H χ/Q Value @ LPZ (5%)	8.83×10^{-5} s/m^3	
8–24-H χ/Q Value @ LPZ (5%)	6.16×10^{-5} s/m^3	
1–4-Day χ/Q Value @ LPZ (5%)	2.82×10^{-5} s/m^3	
4–30-Day χ/Q Value @ LPZ (5%)	9.15×10^{-6} s/m^3	

2.3.4.2 Regulatory Evaluation

In SSAR Section 3.0, the applicant stated that the NRC regulations that apply to the evaluation of an ESP include 10 CFR 100.21. The staff notes that 10 CFR 100.21 is the applicable NRC regulation regarding short-term (accident release) dispersion estimates with respect to the meteorological considerations used in the evaluation to determine an acceptable exclusion area and LPZ.

In SSAR Sections 1.0, 1.4, and 2.3.4, the applicant identified the following applicable NRC guidance regarding short-term dispersion estimates:

- RG 1.23, with respect to criteria for an acceptable onsite meteorological measurements program
- RG 1.70, with respect to providing conservative estimates of atmospheric dispersion at the EAB and LPZ, based on the most representative meteorological data and impacts caused by local topography
- RG 1.145, with respect to acceptable methods for choosing χ/Q values for evaluating the consequences of potential accidents

The staff has reviewed this portion of the application in accordance with the guidance identified by the applicant and to determine if the application is in compliance with the applicable regulations.

In SSAR Sections 1.4 and 2.3.4, the applicant identified RG 1.145 as describing methods acceptable to the staff for characterizing atmospheric transport and diffusion conditions for evaluating the consequences of DBA releases. Use of the PAVAN model described in NUREG/CR-2858 is acceptable.

Section 2.3.4 of RS-002 and Section 2.3.4 of RG 1.70 provide guidance on information appropriate for a presentation on short-term (accident release) dispersion estimates. According to this guidance, the application should present the following:

- conservative estimates of atmospheric transport and diffusion conditions at appropriate distances from the source for postulated accidental releases of radioactive materials to the atmosphere

- a description of the atmospheric dispersion models used to calculate χ/Q values in air resulting from accidental releases of radioactive material to the atmosphere, with models documented in detail and substantiated within the limits of the model so that the staff can evaluate their appropriateness to site characteristics, plant characteristics (to the extent known), and release characteristics

- the meteorological data used for the evaluation (as input to the dispersion models) that represent annual cycles of hourly values of wind direction, wind speed, and atmospheric stability for each mode of accidental release

- an explanation of the variation of atmospheric diffusion parameters used to characterize lateral and vertical plume spread (σ_y and σ_z) as a function of distance, topography, and atmospheric conditions, as related to measured meteorological parameters, and a description of a methodology for establishing these relationships that is appropriate for estimating the consequences of accidents within the range of distances that are of interest with respect to site characteristics and established regulatory criteria

- cumulative probability distributions of χ/Q values and the probabilities of exceeding these χ/Q values, presented for appropriate distances (e.g., the EAB and LPZ) and time periods as specified in Section 2.3.4.2 of RG 1.70, as well as an adequate description of the methods used for generating these distributions

- the χ/Q values used for assessing the consequences of atmospheric radioactive releases from design-basis and other accidents

2.3.4.3 Technical Evaluation

The applicant generated its atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and LPZ using the staff-endorsed computer code PAVAN. The staff evaluated the applicability of the PAVAN model and concluded that no unique topographic features preclude the use of PAVAN for the Grand Gulf ESP site. The staff also reviewed the applicant's input to the PAVAN computer code, including the assumptions used concerning plant configuration and release characteristics, and the appropriateness of the meteorological data input. The staff found that the applicant made conservative assumptions by ignoring building wake effects and treating all releases as ground-level releases. The staff independently evaluated the resulting atmospheric dispersion estimates by running the PAVAN computer model and obtained similar results.

From this review, the staff concludes that the applicant has used an adequately conservative atmospheric dispersion model and appropriate meteorological data to calculate χ/Q values for appropriate offsite (EAB and LPZ) distances and directions from postulated release points for accidental airborne releases of radioactive materials.

In order to evaluate atmospheric dispersion characteristics with respect to radiological releases to the control room, detailed design information (e.g., vent heights, intake heights, distance and direction from release vents to the room) is necessary. Because little detailed design information is available for the nuclear power plant or plants that might be constructed on the proposed site, the COL or CP applicant should assess the dispersion of airborne radioactive materials to the control room at the COL or CP stage. This is **COL Action Item 2.3-2.**

The staff intends to include the short-term (accident release) atmospheric dispersion estimates listed in Table 2.3.4-2 as site characteristics in any ESP permit that might be issued for the site.

Table 2.3.4-2 Staff's Proposed Short-Term (Accident Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2-H χ/Q Value @ EAB	5.95×10^{-4} s/m^3	The 0–2-hour atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the EAB
0–8-H χ/Q Value @ LPZ	8.83×10^{-5} s/m^3	The 0–8-hour atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ
8–24-H χ/Q Value @ LPZ	6.16×10^{-5} s/m^3	The 8–24-hour atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ
1–4-Day χ/Q Value @ LPZ	2.82×10^{-5} s/m^3	The 1–4 day-atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ
4–30-Day χ/Q Value @ LPZ	9.15×10^{-6} s/m^3	The 4–30-day atmospheric dispersion factor to be used to estimate dose consequences of accidental airborne releases at the LPZ

2.3.4.4 Conclusions

As set forth above, the applicant has made conservative assessments of post-accident atmospheric dispersion conditions using its meteorological data and appropriate dispersion models. The applicant has calculated representative atmospheric transport and diffusion conditions for the EAB and the LPZ. The staff has reviewed the applicant's proposed short-term atmospheric dispersion site characteristics for inclusion in an ESP for the applicant's site, should one be issued, and, as discussed above, finds these characteristics to be acceptable. Therefore, the staff concludes that the applicant's atmospheric dispersion estimates are appropriate for the assessment of consequences from radioactive releases for postulated (i.e., design-basis) accidents, in accordance with 10 CFR 100.21.

Based on these considerations, the staff concludes that the applicant's short-term atmospheric dispersion estimates are acceptable and meet the relevant requirements of 10 CFR Part 100. The staff will address atmospheric dispersion estimates used to evaluate radiological doses for the control room in its review of any COL or CP application that references this information.

2.3.5 Long-Term Diffusion Estimates

2.3.5.1 Technical Information in the Application

In Section 2.3.5 of the SSAR, the applicant presented its atmospheric dispersion estimates for routine releases of effluents to the atmosphere. Specifically, the applicant provided the following information:

- the atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material to the atmosphere

- the meteorological data used as input to diffusion models

- diffusion parameters

- relative concentration (χ/Q) and relative deposition (D/Q) values used to assess the consequences of routine airborne radioactive releases

- points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations

The applicant used the NRC-sponsored computer code XOQDOQ (NUREG/CR-2919, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," issued September 1977) to estimate χ/Q and D/Q values resulting from routine releases. The XOQDOQ model implements the methodology outlined in RG 1.111, Revision 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," issued July 1977.

In RAI 2.3.5-1, the staff asked the applicant to provide a copy of the XOQDOQ computer code input and output files used to generate the χ/Q values presented in SSAR Section 2.3.5. The applicant complied with this request.

The applicant used the following input data and assumptions in applying the XOQDOQ model for the Grand Gulf ESP site:

- Revision 0 to the SSAR presents XOQDOQ results using a joint frequency distribution of wind speed, wind direction, and atmospheric stability data based on onsite meteorological data from January 1996 through December 2000. The wind data were obtained from the 33-foot level of the onsite meteorological tower, and the stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 162-foot and 33-foot levels of the GGNS onsite meteorological tower. As discussed in Section 2.3.3.3 of this SER, a review of this data set by the staff revealed that wind data collected during this period show an apparent lack of easterly winds as compared to the August 1972 through July 1974 GGNS onsite meteorological data set presented in the GGNS UFSAR. In RAI 2.3.2-5, the staff asked the applicant to recalculate the long-term dispersion estimates presented in SSAR Section 2.3.5 using meteorological data collected by the GGNS monitoring program since the 2001 system upgrade. In its response to this RAI, the applicant revised the

requested long-term atmospheric dispersion estimates using GGNS site meteorological data for 2002–2003.

- The applicant modeled one ground-level release point and took no credit for building wake effects.

In Revision 0 to the SSAR, the applicant presented annual average undepleted/no decay and depleted/no decay χ/Q values and D/Q values for the site boundary and special receptors of interest (e.g., nearest home and garden within 5 miles in each downwind sector), as determined from the locations given in the GGNS 2001 Land Use Census. In Open Item 2.3-5, the staff noted that the receptor locations listed in SSAR Table 3.2-3A include the nearest milk cow and the nearest meat cow and requested that the applicant provide the χ/Q and D/Q values for these receptor locations. The applicant provided the requested information in its response to Open Item 2.3-5.

Table 2.3.5-1 lists the long-term atmospheric dispersion estimates that the applicant derived based on the XOQDOQ modeling results.

Table 2.3.5-1 Applicant's Long-Term (Routine Release) Dispersion Estimates

	X/Q VALUE (s/m^3)		
TYPE OF LOCATION	NO DECAY UNDEPLETED	NO DECAY DEPLETED	D/Q VALUE ($1/m^2$)
Site Boundary	8.8×10^{-6} (0.85 mi WSW)	7.8×10^{-6} (0.85 mi WSW)	1.2×10^{-8} (0.58 mi N)
Nearest Home	2.2×10^{-6} (0.81 mi N)	1.9×10^{-6} (0.81 mi N)	7.0×10^{-9} (0.64 mi NNE)
Nearest Garden	2.0×10^{-6} (1.05 mi SSW)	1.7×10^{-6} (1.05 mi SSW)	5.4×10^{-9} (0.63 mi ENE)
Nearest Milk Cow	7.0×10^{-8} (10 mi SSW)	4.7×10^{-8} (10 mi SSW)	8.7×10^{-11} (10 mi SSW)
Nearest Meat Cow	1.4×10^{-7} (4 mi S)	1.1×10^{-7} (4 mi S)	4.0×10^{-10} (4 mi S)

2.3.5.2 Regulatory Evaluation

In SSAR Section 3.0, the applicant stated that the NRC regulations that apply to the evaluation of an ESP include Appendix I to 10 CFR Part 50 and 10 CFR 100.21. The staff notes that Appendix I to 10 CFR Part 50 is the applicable NRC regulation regarding the demonstration of compliance with the numerical guides for doses contained in this appendix by characterizing atmospheric transport and diffusion conditions in order to estimate the radiological consequences of routine releases of materials to the atmosphere. The staff also notes that 10 CFR 100.21 requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters be established such that radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located off site.

In SSAR Sections 1.0, 1.4, and 2.3.5, the applicant identified the following applicable NRC guidance regarding long-term dispersion estimates:

- RG 1.70 relates to providing realistic estimates of annual average atmospheric transport and diffusion characteristics to a distance of 50 miles from the plant, including a detailed description of the model used and a calculation of the maximum annual average χ/Q values at or beyond the site boundary for each venting location.

- RG 1.109, Revision 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," issued October 1977, presents identification criteria to be used for specific receptors of interest (applicable at the ESP stage to the extent the applicant provides receptors of interest).

- RG 1.111 describes acceptable methods for characterizing atmospheric transport and diffusion conditions for evaluating the consequences of routine releases. Use of the XOQDOQ model described in NUREG/CR-2919 is acceptable.

The staff finds that the applicant should have also identified RG 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," issued May 1977, with respect to the criteria to be used to identify release points and release characteristics (applicable to the extent the applicant provides release points and release characteristics at the ESP stage).

The staff has reviewed this portion of the application in accordance with the guidance identified by the applicant and to determine if the application is in compliance with the applicable regulations.

Section 2.3.5 of RS-002 and Section 2.3.5 of RG 1.70 provide the following guidance on information appropriate for a presentation on long-term (routine release) atmospheric dispersion estimates:

- The applicant should provide a description of the atmospheric dispersion models used to calculate concentrations in air and the amount of material deposited as a result of routine releases of radioactive material to the atmosphere. The models should be sufficiently documented and substantiated to allow a review of their appropriateness for site characteristics, plant characteristics (to the extent known), and release characteristics.

- The applicant should discuss the relationship between atmospheric diffusion parameters, such as vertical plume spread (σ_z), and measured meteorological parameters. The applicant should substantiate the use of these parameters in terms of the appropriateness of their use in estimating the consequences of routine releases from the site boundary to a radius of 50 miles from the plant site.

- The applicant should provide the meteorological data used as input to the dispersion models. Data used for this evaluation should represent hourly average values of wind speed, wind direction, and atmospheric stability, which are appropriate for each mode of

release. The data should reflect atmospheric transport and diffusion conditions in the vicinity of the site throughout the course of a year.

- The applicant should provide the χ/Q and D/Q values used for assessing the consequences of routine radioactive gas releases, as described in Section 2.3.5.2 of RG 1.70.

- The applicant should identify points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations (if available at the ESP stage). Bounding values for these parameters may be provided at the ESP stage. In such a case, the applicant will need to confirm, at the COL or CP stage, that the parameters provided at the ESP stage bound the actual values provided at the COL or CP stage, and that the calculational methodology used for the confirmation is consistent with that employed at the ESP stage.

2.3.5.3 Technical Evaluation

The applicant generated its atmospheric diffusion estimates for routine airborne releases of radioactive effluents to the site boundary and special receptors of interest using the staff-endorsed computer code XOQDOQ. The staff evaluated the applicability of the XOQDOQ model and concluded that no unique topographic features preclude the use of the XOQDOQ model for the Grand Gulf ESP site. The staff also reviewed the applicant's input to the XOQDOQ computer code, including the assumptions it used concerning plant configuration and release characteristics and the appropriateness of the meteorological data input. The staff found that the applicant made conservative assumptions by treating all releases as ground-level releases and ignoring building wake effects. The staff made an independent evaluation of the resulting atmospheric diffusion estimates by running the XOQDOQ computer model and obtaining similar results.

From this review, the staff concludes that the applicant used an appropriate atmospheric dispersion model and adequate meteorological data to calculate χ/Q and D/Q values at appropriate distances from postulated release points for the evaluation of routine airborne releases of radioactive material. Any COL or CP applicant referencing this information should verify that the specific release point characteristics (e.g., release height and building wake dimensions) and specific locations of receptors of interest (e.g., distance and direction to nearest home, garden, meat animal, and milk animal) used to generate the ESP long-term (routine release) atmospheric dispersion site characteristics bound the actual values provided at the COL or CP stage. This is **COL Action Item 2.3-3.**

The staff intends to include the long-term (routine release) atmospheric dispersion and deposition factors listed in Table 2.3.5-2 as site characteristics in any ESP that the NRC might issue for the Grand Gulf ESP site.

Table 2.3.5-2 Staff's Proposed Long-Term (Routine Release) Atmospheric Dispersion Site Characteristics

SITE CHARACTERISTIC	VALUE	DEFINITION
Annual Average Undepleted/No Decay χ/Q Value @ Site Boundary	8.8×10^{-6} s/m^3	The maximum annual average site boundary undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/No Decay χ/Q Value @ Site Boundary	7.8×10^{-6} s/m^3	The maximum annual average site boundary depleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Site Boundary	1.2×10^{-8} 1/m^2	The maximum annual average site boundary D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Home	2.2×10^{-6} s/m^3	The maximum annual average home undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/No Decay χ/Q Value @ Nearest Home	1.9×10^{-6} s/m^3	The maximum annual average home depleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Home	7.0×10^{-9} 1/m^2	The maximum annual average home D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Garden	2.0×10^{-6} s/m^3	The maximum annual average garden undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/No Decay χ/Q Value @ Nearest Garden	1.7×10^{-6} s/m^3	The maximum annual average garden depleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Garden	5.4×10^{-9} 1/m^2	The maximum annual average garden D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Milk Cow	7.0×10^{-8} s/m^3	The maximum annual average milk cow undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/No Decay χ/Q Value @ Nearest Milk Cow	4.7×10^{-8} s/m^3	The maximum annual average milk cow depleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Milk Cow	8.7×10^{-11} 1/m^2	The maximum annual average milk cow D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Meat Cow	1.4×10^{-7} s/m^3	The maximum annual average meat cow undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/No Decay χ/Q Value @ Nearest Meat Cow	1.1×10^{-7} s/m^3	The maximum annual average meat cow depleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Meat Cow	4.0×10^{-10} 1/m^2	The maximum annual average meat cow D/Q value for use in determining gaseous pathway doses to the maximally exposed individual

2.3.5.4 Conclusions

As set forth above, the applicant has provided meteorological data and an atmospheric dispersion model that are appropriate for the characteristics of the site and release points. The applicant has calculated representative atmospheric transport and diffusion conditions for 16 radial sectors from the site boundary to a distance of 50 miles, as well as for specific receptor locations. The staff has reviewed the long-term atmospheric dispersion estimates that the applicant proposed for inclusion as site characteristics in an ESP for its site (should one be issued) and, for the reasons set forth above, finds these estimates to be acceptable. Therefore, the staff concludes that the applicant has provided the information needed to address the requirements of 10 CFR 100.21(c)(1).

Based on these considerations, the staff concludes that the applicant's characterization of long-term atmospheric transport and diffusion conditions is appropriate for use in demonstrating compliance with the numerical guides for doses contained in Appendix I to 10 CFR Part 50.

The applicant provided bounding values for points of routine release of radioactive material to the atmosphere, the characteristics of each release mode, and the location of potential receptors for dose computations. Any COL or CP applicant must confirm that the parameters provided at the ESP stage bound the actual values provided at the COL or CP stage, and that the calculational methodology used for the confirmation is consistent with that employed at the ESP stage.

2.4 Hydrology

The ESP site is located on the east bank of the Mississippi River near river mile 406, approximately 25 miles south of Vicksburg, Mississippi, and 6 miles northwest of Port Gibson, Mississippi. The ESP site is bounded on the east by loessial bluffs and on the west by the Mississippi River. The floodplain of the Mississippi River near the ESP site ranges in elevation from 55 feet to 75 feet above MSL. The existing GGNS Unit 1 site has a grade elevation of 132.5 feet above MSL.

The Mississippi River would supply makeup and normal service water for the ESP facility or facilities. A series of existing radial collector wells that draw water from the alluvial aquifer supply plant makeup and service water to the existing GGNS Unit 1. Based on the estimation by the applicant of the total plant and service water requirement for the ESP facility or facilities and the characteristics of the alluvial aquifer, the capacity of existing radial collector wells would not be sufficient to meet combined demands of the ESP facility or facilities and the existing GGNS Unit 1. A new intake structure will be located on the east bank of the river and north of the barge slip used during construction of the existing GGNS Unit 1. The effluent from both the ESP facility or facilities and GGNS Unit 1 would be discharged into the Mississippi River. The UHS for the ESP facility or facilities will use a closed cooling system, possibly mechanical draft cooling towers. The ESP facility UHS will not rely on water intake from the Mississippi River.

2.4.1 Hydrologic Description

2.4.1.1 Technical Information in the Application

In Section 2.4.1.1 of the SSAR, SERI stated that the ESP site is located on the east bank of the Mississippi River near river mile 406, approximately 25 miles south of Vicksburg, Mississippi, and 6 miles northwest of Port Gibson, Mississippi. The ESP site is bounded on the east by loessial bluffs and on the west by the Mississippi River. The floodplain of the Mississippi River near the ESP site ranges in elevation from 55 feet to 75 feet above MSL. The GGNS Unit 1 nuclear unit site has a grade elevation of 132.5 feet above MSL.

The applicant stated that the powerblock of the ESP facility or facilities would be located approximately at UTM coordinates N3,542,873 meters and E684,021 meters. The plant grade for the ESP facility or facilities would be established in consideration of the requirements to provide flood protection for associated safety-related SSCs.

The applicant also stated that effluent from the ESP facility or facilities will be combined with effluent from the existing GGNS Unit 1, and then the combined effluent will be discharged into the Mississippi River. The outfall will be located downstream of the intake so as to preclude recirculation of the effluent to the embayment area and intake pipes.

Two small streams flow around the GGNS plant site into Hamilton Lake, located in the floodplain of the Mississippi River. Stream B is located south of the GGNS plant site and was rerouted during construction of the existing unit. A 15-foot culvert was placed at its outlet to safely carry local floods. The drainage area of Stream B is approximately 0.6 square miles (mi^2). Stream A is located to the north of the GGNS plant site and was not rerouted. A 12-foot culvert placed under the access road connects its drainage to the floodplain. The drainage area of Stream A is approximately 2.8 mi^2. Several lakes lie in the floodplain of the Mississippi River, but they do not influence the GGNS plant site.

According to SERI, the natural floodplain of the Mississippi River is about 60 miles wide near the GGNS plant site. The flow of the river is restricted to a width of about 2 to 4 miles by high bluffs on the east bank and manmade levees with crest elevation between 101 and 103 feet above MSL. During the dry season, the approximate river width is 0.5 to 1 mile and increases to about 4 miles during floods.

The applicant stated that the U.S. Army Corps of Engineers (USACE) has finished revetments on the east bank of the river near the GGNS site to maintain the river channel. The design project flood (DPF) elevation at the GGNS site is 102.1 feet above MSL, as given in USACE, "1994 Flood Control and Navigation Maps—Mississippi River," issued 1994.

In RAI 2.4.1-1, the NRC staff asked SERI to provide survey coordinates, including elevations, for the bounding areas of all ESP facility safety-related structures. The staff also requested that the applicant provide the coordinates of existing aquifers in the bounding areas, particularly perched aquifers. In response to RAI 2.4.1-1, the applicant stated that the UTM grid coordinates for the center of the location of the powerblock area for a new nuclear unit are approximately N3,542,873 meters and E684,021 meters in UTM Zone 15. These UTM coordinates correspond approximately to 32E N latitude and 91E3' W longitude. SERI also stated that all safety-related structures will be contained within the proposed powerblock area (PPBA) indicated on SSAR Figure 2.1-1, included below as Figure 2.4-1.

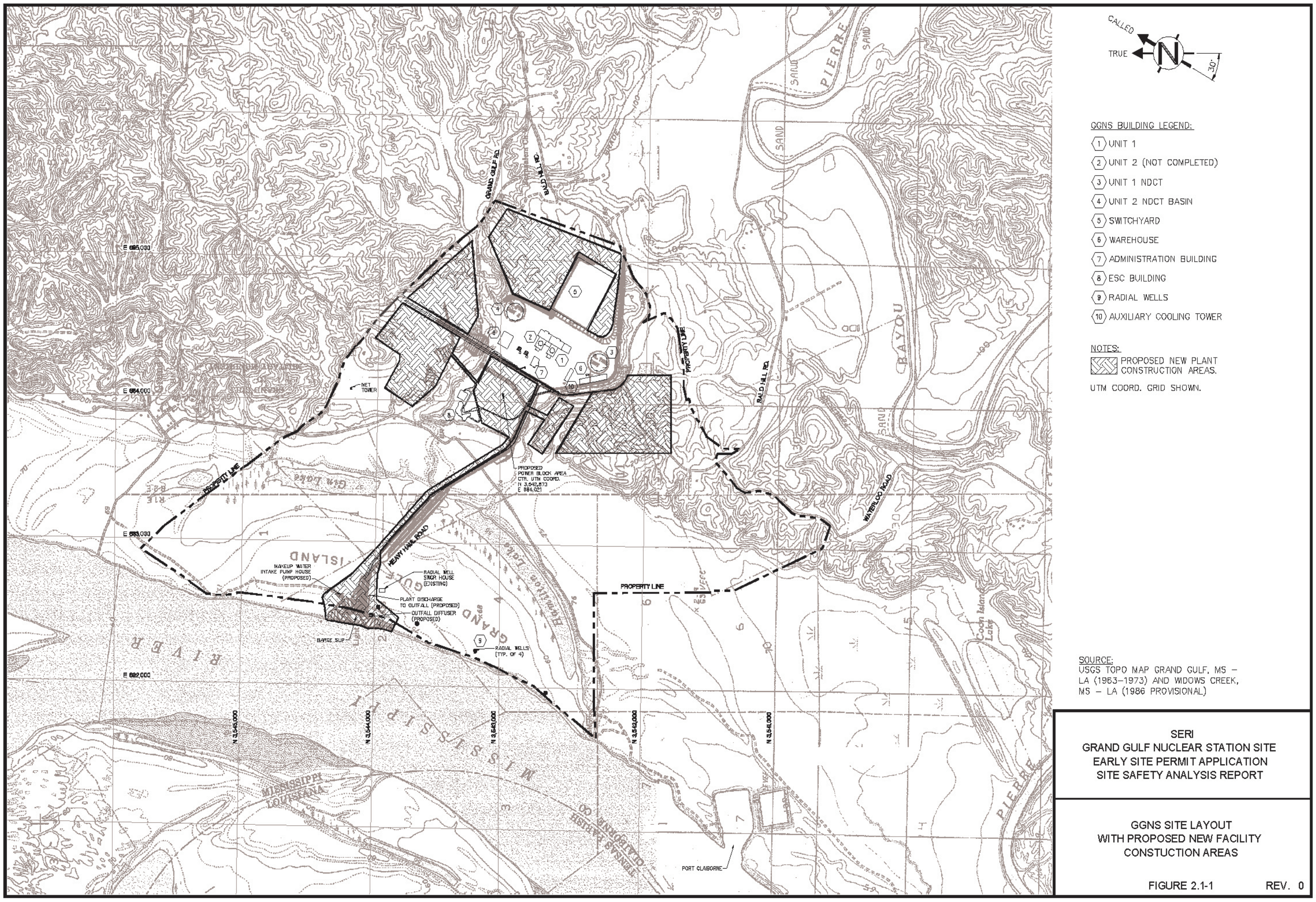

Figure 2.4-1 SSAR Figure 2.1-1 showing location and extent of PPBA

According to the applicant, SSAR Figure 2.4-37 provides a cross-section of the ESP site subsurface, including the portion that is designated as the PPBA. This figure indicates the regional ground water table for the area and the perched water table for the existing GGNS Unit 1 plant area. Section 2.4 of the GGNS Unit 1 UFSAR discusses previous site investigations, including extensive subsurface data obtained from borings. SSAR Section 2.4 summarizes these pieces of data. In addition, four borings were drilled as part of the ESP site geotechnical investigation. SSAR Section 2.5.4 describes the results of this investigation. SERI stated that the conditions encountered during the ESP geotechnical investigation were consistent with those found during the initial site investigations documented in the GGNS UFSAR. The applicant did not obtain direct ground water measurements during the ESP geotechnical investigation. Instead, it used borehole seismic compression and shear wave velocity surveys to estimate the location of the ground water table. According to the applicant, the estimated location of the ground water table ranged from 70 to 100 feet below the ground surface, which itself is located between 55 and 63 feet above MSL.

The cross-sections in SSAR Figures 2.5-75 through 2.5-77 show the ground water levels and gradients. The applicant stated that, as mentioned in SSAR Section 2.5.4.2, it is possible for a shallow perched water table to form in parts of the loess during periods of high rainfall, especially over fine-grained zones. However, the applicant stated that these perched zones are likely to dissipate rapidly after the heavy rainfall stops. Additional assessment to define the location and extent of perched aquifers would be conducted at the COL stage.

In RAI 2.4.1-2, the staff asked SERI to describe the potential use of dewatering systems in the design of a future reactor(s). In response to this RAI, the applicant stated that, during excavation of the existing GGNS Unit 1 powerblock, the use of tie-back walls effectively restricted dewatering to a localized area. The applicant anticipated that dewatering will be required for construction of a new nuclear unit on the ESP site and stated that dewatering wells will be installed to support plant construction and operation, if required. Specific well locations and well design details will be provided at the COL stage when the plant design and layout are finalized.

In RAI 2.4.1-3, the staff asked the applicant to explain how flooding from localized intense precipitation will be handled without interfering with safety-related structures of the new reactor(s). In response to this RAI, the applicant stated that the GGNS Unit 1 site has a plant grade elevation of 132.5 feet above MSL. The proposed site for a new nuclear unit is adjacent to the existing GGNS Unit 1. The design flood considerations for the site areas were based on local drainage areas shown in SSAR Figure 2.4-10. Because a specific plant design for a new nuclear unit has not yet been selected, SERI has not determined the final plant grade.

SERI reiterated that the estimated maximum floodwater elevations resulting from local intense precipitation do not exceed 133.25 feet above MSL. This is the maximum floodwater elevation from the probable maximum precipitation (PMP) at the existing GGNS Unit 1 site. The applicant considers this maximum floodwater level to be valid for the new nuclear facility on the proposed ESP site. According to the applicant, all safety-related SSCs for the new nuclear facility will be placed above the maximum flood elevation, or flood protection such as drainage provisions, grading, culverts, dams, and water-tight doors will be provided.

In RAI 2.4.1-4, the staff asked SERI to explain its estimation of the service and makeup water requirement of 85,000 gpm. In response to this RAI, the applicant stated that the normal makeup flow rate to the proposed ESP facility is approximately 50,320 gpm, and the maximum expected makeup flow rate is 85,000 gpm. SSAR Table 1.3-1 shows specific system uses of this makeup water and the estimated maximum and normal or expected amounts required. According to the applicant, the SSAR provides this value of 85,000 gpm for the proposed facility's maximum makeup water requirement primarily to demonstrate site suitability and to offer a comparison with the historical low river flow to show that adequate water will be available. As previously noted in SSAR Section 2.4.11.2, this maximum makeup water quantity is approximately 0.2 percent of the minimum historical river discharge and thus has an insignificant impact on the river's capability as a cooling water source for the ESP facility. SERI also stated that it did not use this parameter, maximum makeup water demand, in the SSAR for the analysis of safety-related features.

The applicant noted that, as discussed with NRC staff during a site visit on June 30, 2004, it did not intend for this makeup water requirement of 85,000 gpm to be a limiting parameter included as a basis for the ESP. The applicant stated that it would revise the SSAR text and Table 1.3-1 to ensure that they clearly identify the parameters and their corresponding values that were actually used in the analysis of safety-related features and treat them as bases for the SSAR.

SERI stated that it also used the river water makeup flow rate in the evaluation of environmental impacts to the site. It based the value of 85,000 gpm, developed by the PPE process, on a review of a range of plant technologies to establish the bounding makeup water requirement, as described in ESP ER Section 3.4.2.1. The applicant also referred to ESP ER Figure 2.3-29, which provides details regarding estimated plant water needs. The applicant revised the SSAR text and Table 1.3-1 to ensure that they clearly identify the parameters and their corresponding values that were actually used in the analysis of safety-related features and treat them as bases for the SSAR. The revised (Revision 2, SSAR Table 1.3-1) maximum makeup water requirement is 78,000 gpm.

2.4.1.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that SERI correctly identified the applicable regulatory guidance. Section 2.4.1 of RS-002 provides the review guidance used by the staff to evaluate this SSAR section.

The SSAR should address 10 CFR Part 52 and 10 CFR Part 100 as they relate to identifying and evaluating hydrologic features of the site. The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the review take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability to host a nuclear unit(s). In addition, 10 CFR 100.20(c) addresses the hydrologic characteristics of a proposed site that may affect the consequences of an escape of radioactive material from the facility. Applicants should determine factors important to hydrologic radionuclide transport, described in 10 CFR 100.20(c)(3), by using onsite measurements. The staff evaluated SSAR Section 2.4.1 in light of these requirements.

To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's SSAR should describe the surface and subsurface hydrologic characteristics of the site and

region. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of the SSCs of a nuclear unit(s) (or a facility falling within a PPE) that might be constructed on the proposed site.

Meeting this guidance provides reasonable assurance that the hydrologic characteristics of the site and potential hydrologic phenomena will pose no undue risk to the type of facility (or facility falling within a PPE) proposed for the site. Further, it provides reasonable assurance that such a facility will pose no undue risk of radioactive contamination to surface or subsurface water from either normal operations or as the result of a reactor accident.

To meet the requirements of the hydrologic aspects of 10 CFR Part 52 and 10 CFR Part 100, SSAR Section 2.4.1 should form the basis for the hydrologic engineering analysis with respect to subsequent sections of the application for an ESP. Therefore, completeness and clarity are of paramount importance. Maps should be legible and adequate in their coverage to substantiate applicable data. Site topographic maps should be of good quality and of sufficient scale to allow independent analysis of preconstruction drainage patterns. Data on surface water users, location with respect to the site, type of use, and quantity of surface water used are necessary. Inventories of surface water users should be consistent with regional hydrologic inventories reported by applicable Federal and State agencies. The description of the hydrologic characteristics of streams, lakes, and shore regions should correspond to those of the U.S. Geological Survey (USGS), NOAA, Soil Conservation Service (SCS), USACE, or appropriate State and river basin agencies. Applicants should describe all existing or proposed reservoirs and dams (both upstream and downstream) that could influence conditions at the site. Descriptions may be obtained from reports of USGS, U.S. Bureau of Reclamation (USBR), USACE, and others. Generally, reservoir descriptions of a quality similar to those contained in pertinent datasheets of a standard USACE hydrology design memorandum are adequate. Tabulations of drainage areas, types of structures, appurtenances, ownership, seismic and spillway design criteria, elevation-storage relationships, and short- and long-term storage allocations should be provided.

2.4.1.3 Technical Evaluation

The staff conducted a site visit in accordance with the guidance provided in Section 2.4.1 of RS-002. The staff used information from the site visit, digital maps, and streamflow data from USGS to independently verify the hydrologic description provided in SSAR Section 2.4.1. SERI provided data, including maps, charts, and information from Federal, State, and regulatory bodies, describing hydrologic characteristics and water use in the vicinity of ESP site.

The staff independently verified the applicant’s description of the ESP site location using maps of the GGNS ESP site and its vicinity (Figures 2.4-2 and 2.4-3). The staff created these maps using publicly available data sources (e.g., State boundaries, city locations, and digital raster graphs (DRGs) of topographic maps). The GGNS site is located on the east bank of the Mississippi River. Cities located near GGNS include Port Gibson, about 5 miles to the southeast; Vicksburg, about 26.3 miles to the north-northeast; and Natchez, about 37.2 miles to the southwest. The staff estimated that the GGNS site is located at approximately river mile 407, based on river mile markings on the Mississippi River near the GGNS site.

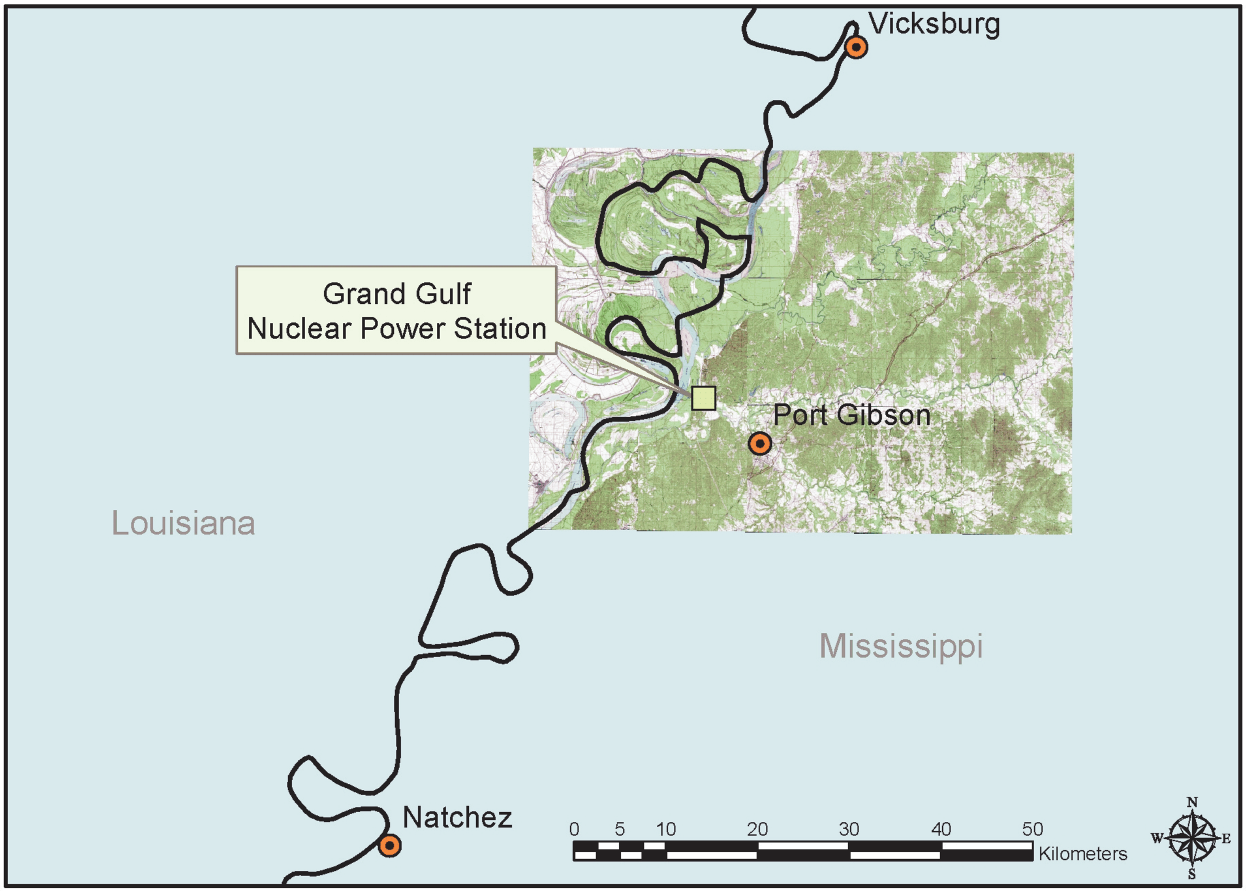

Figure 2.4-2 Location map of the GGNS site. The site is located on the east bank of the Mississippi River in Mississippi about 8 kilometers northwest of Port Gibson, Mississippi. Vicksburg, Mississippi, is about 41 kilometers north-northeast, and Natchez, Mississippi, is about 60 kilometers southwest of the GGNS site.

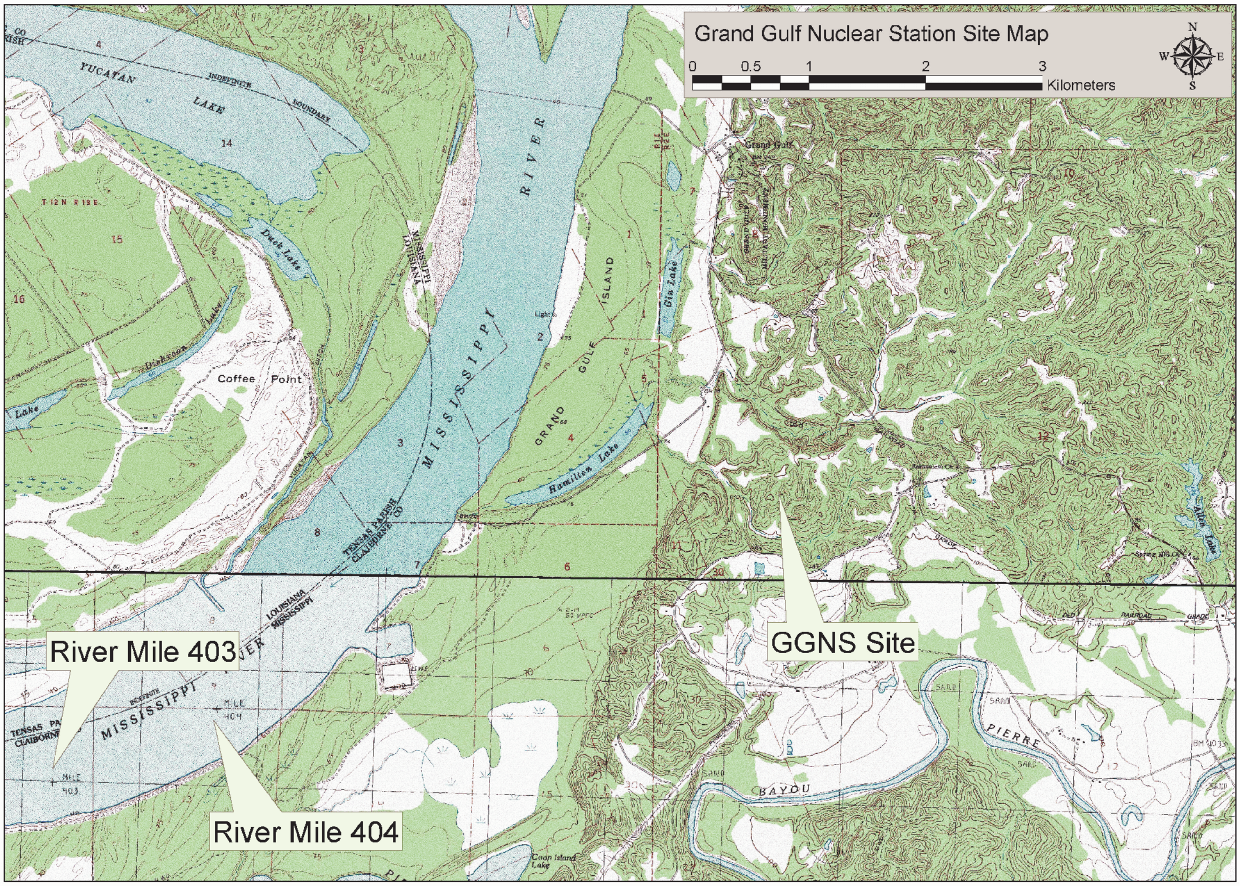

Figure 2.4-3 The GGNS site and Mississippi River miles. This map also shows Gin and Hamilton Lakes, located on the floodplain of the Mississippi River.

Sections 2.4.2 and 2.4.3 of the DSER described staff's independent estimate of the flood elevation caused by local intense precipitation on the ESP site. The NRC will require the COL applicant to design the ESP plant grade such that flooding caused by local intense precipitation will be discharged to Streams A and B without reliance on any active drainage systems that may become blocked during the local intense precipitation event. The staff intended to specify this requirement as DSER Permit Condition 2.4-1. However, DSER Permit Condition 2.4-4 in Section 2.4.2.3 of the SER also stated a similar requirement. Therefore, Section 2.4.2.3 of this SER describes the resolution of DSER Permit Conditions 2.4-1 and 2.4-4, and these DSER permit conditions are replaced by COL Action Item 2.4-5.

GGNS Unit 1 and the ESP facility or facilities will discharge their combined effluents into the Mississippi River downstream of the new ESP intake. The NRC will require the COL applicant to demonstrate that sufficient separation between the new ESP intake and the combined effluent outfall is provided so that the effluent recirculating back to the new ESP intake will not adversely affect the intake. The staff intended to specify this requirement as DSER Permit Condition 2.4-2. However, based on applicant's response to open items, the staff determined that detailed design of the ESP facility intake and outfall has not been completed at the ESP stage and will only be undertaken at the COL stage after a reactor design for the ESP facility is

chosen. The staff also determined that the NRC will review the detailed design of ESP facility intake and outfall at the COL stage according to existing regulations and regulatory guidance. Therefore, the staff determined that specification of DSER Permit Condition 2.4-2 is not required. Instead, the COL or CP applicant should demonstrate that sufficient separation between the new ESP intake and the combined effluent outfall is provided so that the effluent recirculating back to the new ESP intake will not adversely affect the intake. This is **COL Action Item 2.4-1.**

The staff independently verified the applicant's description of the two small, steep streams that flow around the GGNS site. The staff manually delineated the watersheds for these two streams using USGS topographic maps (Figure 2.4-4). Stream A, located to the north of the GGNS site, drains Basin A. The staff estimated that the contributing area of Basin A at its outlet into Hamilton Lake is approximately 2.94 mi^2. Stream B, located to the south of the GGNS site, drains Basin B. The staff estimated that the contributing area of Basin B at its outlet into Hamilton Lake is approximately 0.68 mi^2.

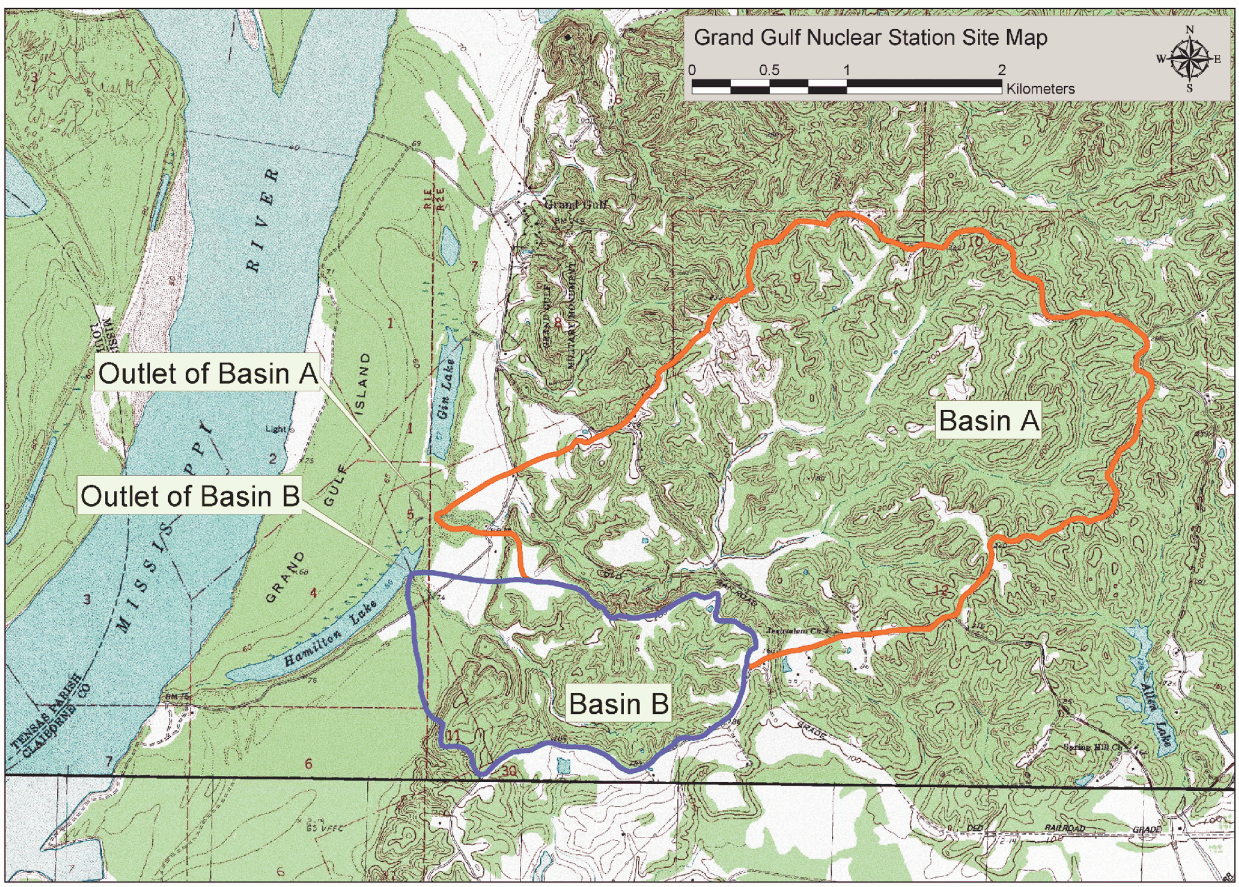

Figure 2.4-4 Small drainage basins (Basins A and B) that are drained by small, steep streams to the north and south of the GGNS site

In RAI 2.4.1-1, the staff asked SERI to provide survey coordinates, including elevations, for the bounding areas of all ESP safety-related structures. The staff also requested that the applicant provide the coordinates of existing aquifers in the bounding areas, particularly perched aquifers. In response to RAI 2.4.1-1, the applicant stated that the UTM grid coordinates for the center of the location of the powerblock area for a new facility are approximately N3,542,873 meters and E684,021 meters in UTM Zone 15. According to the applicant, these UTM coordinates correspond to approximately 32E N latitude and 91E3' W longitude. SERI also stated that all safety-related structures will be contained within the PPBA indicated on SSAR Figure 2.1-1.

The staff's review of SSAR Figures 2.1-1 and 2.1-2 revealed that, although the coordinates inscribed on these figures for the center of the proposed powerblock are the same as those mentioned in applicant's response to RAI 2.4.1-1, the coordinates do not agree accurately with the position of the center of the proposed powerblock as drawn on these figures. The staff independently created a map to more accurately locate the center of the proposed powerblock. Figure 2.4-5 shows this map.

The staff downloaded USGS DRGs and orthorectified and georeferenced aerial photographs from the Mississippi Automated Resource Information System. The staff used ArcMap™ Version 8.3 to create a map of the GGNS site, including the ESP site and its immediate vicinity. The staff used the topographic contours on the USGS DRGs to manually delineate the basins draining through local Streams A and B. The staff also used topographic contours to determine the approximate location of the bluff line that separates the GGNS site from the Mississippi River floodplain to the west. It used USGS bluelines that indicate stream channels on DRGs to locate Streams A and B, as shown on the map. Since the USGS DRGs predate GGNS construction, Stream B was located in its original configuration on the topographic maps. The staff determined the post-GGNS construction location of Stream B using the aerial photos. Aerial photos were also used to determine the location of Sedimentation Basins A and B and locations of proposed intake and discharge for the ESP facility.

The map shown in Figure 2.4-5 uses the UTM Zone 15N North American Datum (NAD) 1983 geographic projection. As shown on SSAR Figures 2.1-1 and 2.1-2, the applicant's PPBA is located north of the heavy haul road, east of the bluffs, and southeast of the ESC building. The staff created the polygon labeled "Proposed Powerblock Area" on Figure 2.4-5 closely following the location of applicant's PPBA shown on SSAR Figures 2.1-1 and 2.1-2. The staff overlaid the largest circle that could fit inside the PPBA as shown in Figure 2.4-5. The staff assumed that the center of this circle represents the location of the center of the proposed powerblock. The UTM coordinates determined by the staff for the center of the proposed powerblock are N3,543,266.06 meters and E684,017.28 meters, with reference to the UTM Zone 15N NAD 1983 geographic projection.

The staff also overlaid the applicant-stated coordinates of the center of the proposed powerblock on the map and found that these coordinates place the proposed powerblock approximately 302 feet southwest of the staff-estimated coordinates mentioned above and closer to Stream B. Because of this discrepancy between the coordinates provided by the applicant and the plotted location of the powerblock on Figures 2.1-1 and 2.1-2, the staff cannot determine the actual location of the powerblock on the ESP site. Therefore, the staff required additional information on the true coordinates of the center of the powerblock. This was

Open Item 2.4-1. The staff intended to specify the coordinates of the center of the proposed powerblock as a permit condition subsequent to the satisfactory resolution of Open Item 2.4-1.

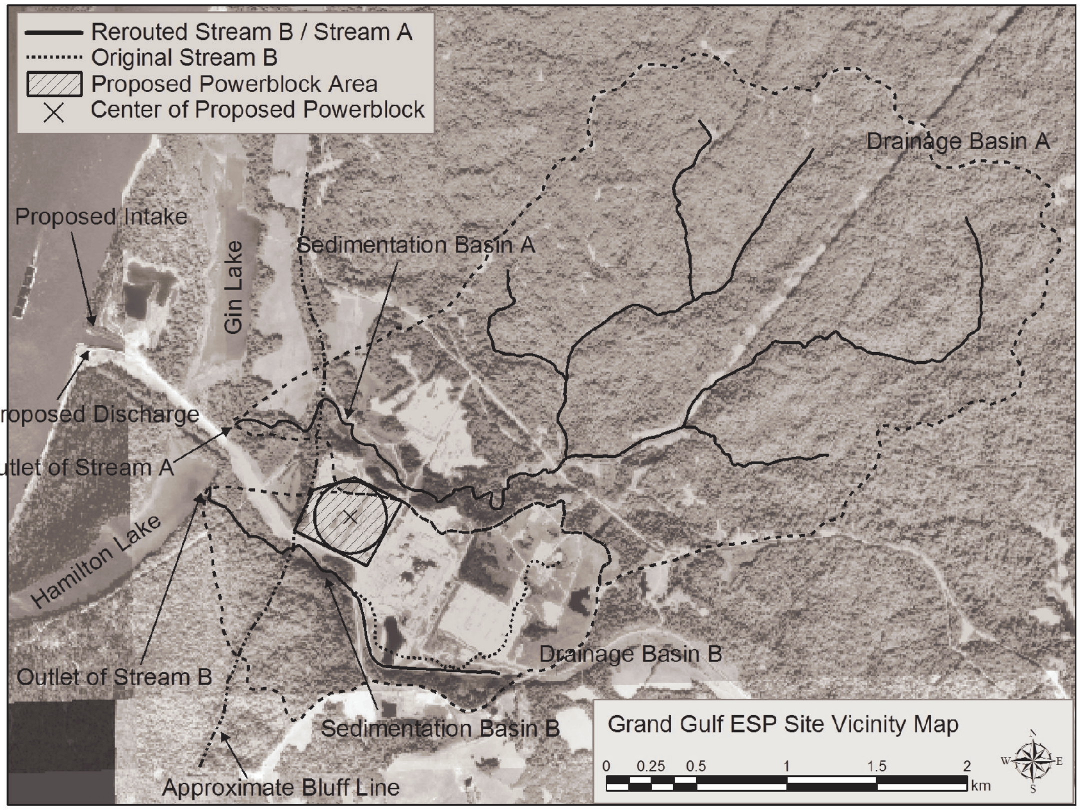

Figure 2.4-5 Grand Gulf ESP site vicinity map

In response to Open Item 2.4-1 (Response to Request for Additional Information to Resolve the Grand Gulf Early Site Permit draft Safety Evaluation Report Open Items, System Energy Resources, Inc., June 21, 2005), the applicant stated that the UTM coordinates indicated in the SSAR, ER, and Environmental Policy Institute documents were inaccurate because of an error in a spreadsheet which was used to calculate UTM coordinates corresponding to Mississippi West grid coordinates. The applicant converted the coordinates of the center of the ESP powerblock, N550,099 feet and E277,346 feet in the Mississippi West grid coordinate system, to N3,543,261 meters and E684,018 meters in the UTM Zone 18 NAD 83 projection system using USACE software Corpscon Version 6.0. The applicant revised Figures 2.1-1, 2.1-2, 2.2-4, 2.4-1, 2.4-10, and 2.4-33 of the SSAR. The applicant also revised SSAR Sections 1.2, 2.1.1.1, and 2.4.1.1; Part 1, “Administrative Information,” in Section 1.1; Part 4, “Emergency Planning Information,” and Figures 2-1 and 2-3; and Section 2.1.1, ER Figures 2.1-1, 2.2-1, 2.3-1, 2.3-7, 2.3-12, and 2.3-20; and ER Sections 1.1, 2.1, 2.3, and 4.5.1 to include corrected UTM coordinates.

The staff reviewed the applicant’s response to Open Item 2.4-1 and concluded that the corrected UTM coordinates of the center of the proposed ESP powerblock are approximately 16.8 feet away from the coordinates estimated by the staff in its independent review. Since this

separation is small compared to the overall dimensions of the ESP footprint, the staff concluded that the applicant's corrected UTM coordinates for the proposed ESP powerblock are acceptable. Based on the above review, the staff considers Open Item 2.4-1 resolved.

The applicant did not provide information on the elevation (depth) of the zone that the construction of the new facility could disturb. Excavation and fill activities will alter the local subsurface environment and its alignment with the existing hydrogeological environment. Therefore, the staff needed information on the elevation (depth) of the zone that the construction of the new nuclear facility could disturb. This was Open Item 2.4-2.

In response to Open Item 2.4-2, the applicant stated that SSAR Section 2.5 discusses various depths of foundation and excavation in relation to required foundation bearing capacity, minimum shear wave velocity at foundation mat, and depth of the same stratigraphic layer that forms the foundation of the existing GGNS unit. The applicant stated that these three criteria resulted in different embedment depths for the proposed ESP facility. The applicant noted that the foundation depth requirement based on the first two criteria may also depend on plant design and may also vary within the ESP footprint because of irregularities in elevations of contact between different geologic strata that underlie the ESP site. For these reasons, the applicant could not identify a single maximum excavation depth, and the statements made in the SSAR were an attempt to bracket the likely foundation depths based on each criterion.

The applicant stated that specific foundation design, site grading, and ground improvements can be used in some cases to decrease the required foundation depths based on the first two of the three criteria mentioned above, but not for the last. The applicant, as an example, stated that deep soil densification or grouting could be used to strengthen the soil to reduce the embedment depth required for adequate bearing capacity and may also be effective to marginally increase the shear wave velocity. However, the last criterion, the requirement to found the ESP facility structures in strata equivalent to those for the existing GGNS unit, requires a specific foundation depth that cannot be adjusted by engineering approaches.

The applicant stated that the parameters which define the range of required foundation depths are 35 to 140 feet, as reported in SSAR Section 2.5.4.6, and were developed based on a PPE worksheet. However, the PPE table (Table 1.3-1 of the SSAR) did not include the depth of the foundation.

The applicant stated that it is likely that additional excavation below the required foundation depth specified for a particular plant design will be required. The applicant also stated that soils underlying the selected plant foundation that have shear wave velocities below the design requirement will either require replacement or in situ improvements to meet seismic design criteria.

The applicant stated that the overall ground water regional gradient for the GGNS site including the ESP site points westward to the Mississippi River controlled by the prevailing river stage. The applicant stated that excavation and other construction activities related to installation of the ESP facility will alter the subsurface environment and its alignment with the existing hydrogeological environment. The applicant argued that these alterations during construction of the ESP facility are expected to be localized and temporary. The presence of the ESP facility itself will alter the subsurface environment and its alignment with the existing hydrogeological

environment, but the applicant argued that these effects are also expected to be localized. The presence of the ESP facility is not expected to substantially alter the overall and controlling regional ground water table gradient or its direction. The applicant stated that any postulated liquid effluent release would be expected to eventually enter the regional ground water table beneath the GGNS site property and then move laterally towards the Mississippi River. This expectation is based on an understanding of the characteristics of the GGNS site, including site and ground water table elevations, measured gradients toward the river, and evidence of the influence of the river stage on monitored ground water levels, as summarized in SSAR Section 2.4.12.2.3.

The applicant stated that as part of standard construction measures, ground water levels will be monitored during various phases of the ESP site development and facility construction. A detailed ground water monitoring program will be developed at the COL stage.

The staff reviewed the applicant's response to Open Item 2.4-2 and concluded that because of construction activities at the ESP site, the subsurface environment will be disturbed to a depth ranging from 35 to 140 feet plus some additional excavation required to place the foundation based on three criteria—bearing capacity, minimum shear wave velocity at the foundation mat, and depth of the same stratigraphic layer that forms the foundation of the existing GGNS unit. Based on the applicant's response, the staff determined that the actual excavation depth will also depend on the foundation requirements of the chosen plant design for the ESP facility, which has not been finalized at the ESP stage. The staff had intended to use the information on the extent of ground disruption as it might affect liquid pathway and overall site drainage. At the ESP stage, the detailed design information is not available; therefore, the staff included COL Action Item 2.4-2 on ESP site dewatering related to the Open Item 2.4-3 below, and Permit Condition 2.4-1 related to preclusion of accidental release from waste treatment storage facilities in Section 2.4.13.3. Based on the above review, staff concluded that the applicant has provided sufficient information and Open Item 2.4-2 is resolved.

In response to RAI 2.4.1-2, the applicant stated that it anticipates that dewatering will be required during construction of the ESP facility, and dewatering wells may be installed to support plant operation, if required. The applicant also stated that specific locations and design details of these wells will be provided at the COL stage. The staff determined that dewatering wells, if required to support plant operation, are safety-related ESP structures. Based on the applicant's response, the staff concluded that it needed more details at the ESP stage regarding dewatering wells to determine whether ground surface subsidence could affect safety-related structures and piping. In particular, the staff needed information related to the location of dewatering wells in relation to safety-related structures and associated monitoring of the ground water table. This was Open Item 2.4-3.

In response to Open Item 2.4-3, the applicant stated that the existing site ground water levels and gradients are only expected to undergo slight modifications because of installation of the ESP facility. The applicant stated that this expectation is based upon ground water monitoring conducted for the installation of GGNS Unit 1, which showed only localized, short-term effects to ground water levels from dewatering during construction. The applicant concluded that the effect of dewatering at the ESP site will be similar and will not result in any ground water flow reversal. Dewatering is a likely necessity during construction of the ESP facility and is a possibility for ESP facility operation. The applicant also stated that any such alteration to

ground water levels would be included in design considerations for safety-related structures for the ESP facility.

The applicant stated that the potential for subsidence resulting from alterations to ground water levels will be one such design consideration. Several factors that may affect the potential for subsidence, including stability of soils and other subsurface material, will be evaluated. The applicant stated that this analysis will be used to define where over-excavation may be required to reach proper soil characteristics for foundation embedment, or where other stability control measures such as the use of engineered backfill may be required. The applicant stated that any backfill around safety-related structures would have strict gradation requirements that will ensure lateral confinement and appropriate soil-structure interaction along sidewalls of buried structures to prevent any possible liquefaction or dynamic strength loss under seismic loadings. The applicant stated that backfill criteria would be developed to minimize potential settlement of shallow structures that may be placed over filled areas adjacent to the ESP facility powerblock.

The applicant stated that geotechnical analyses would determine temporary excavation stabilization requirements. For example, tie-back walls could be used to provide support to temporary foundation excavation walls and also to assist in control of ground water inflow into the excavation pit during construction. The applicant noted that during construction of GGNS Unit 1, no unstable conditions or materials were discovered and standard shoring techniques were successfully used to stabilize deep foundations in loess and alluvial soils below the ground water table.

The applicant stated that the specific location of dewatering wells in relation to safety-related structures of the ESP facility is a design feature and will be addressed at the COL stage. After the selection of location and plant design of the ESP facility, a program to monitor ground water levels will be developed, which would start preconstruction monitoring with additional exploratory borings throughout the planned excavation area and ESP facility footprint. This monitoring plan is expected to provide detailed information on ground water levels, including the location of perched water, and to assist in assessment of dewatering requirements, determination of location and design of dewatering wells, and in measuring dewatering effects.

The applicant stated that inspection and monitoring procedures will be developed for the construction phase of the ESP facility. Observation wells would be installed and monitored periodically throughout the construction of the ESP facility to measure ground water levels and to verify that ground water drawdown and radius of influence evolve as predicted. The design of dewatering wells will be modified if necessary.

Information obtained during the preconstruction and construction ground water monitoring will be used to determine the location of permanent dewatering wells, if required by the selected plant design and ground water conditions at the ESP site. The applicant stated that localized reversal of the ground water gradient may occur, but engineering and design controls will be used to minimize the need for dewatering and subsequent impact on the gradient and the area of influence.

The applicant stated that the pumping rate of 3570 gpm given in the SSAR is the maximum expected consumption of water during operation of the ESP facility, which is a short-term or temporary flow rate with an expected average usage of approximately one-third of the stated

maximum. Since the maximum withdrawal rate is short-term, it is not relevant for the consideration of ground subsidence because any impact on the subsurface ground water table would also be temporary. The applicant also stated that this water supply (3570 gpm) will likely come from a variety of sources, including, but not necessarily limited to, ground water and/or surface water.

Any newly required water supply wells would be designed and located at a suitable distance from the ESP facility to prevent significant drawdown of the water table and impacts to the ground water gradient. The operational ground water monitoring program would be used to ensure that effects from any new water supply wells are within expected ranges.

The staff reviewed the applicant's response to Open Item 2.4-3 and concluded that dewatering will be necessary during construction of the ESP facility. The staff also determined that local impacts to ground water levels and the ground water gradient may occur because of the dewatering activities. Since a specific plant design for the ESP facility has not been chosen at the ESP stage, the design and location of dewatering wells, which partially depend on the foundation type of the selected plant design, are also not known. The COL applicant will design the dewatering wells and establish their locations, and the NRC will review them at the COL stage according to appropriate regulations and regulatory guidance. However, if dewatering is necessary for the operation of the ESP facility, it will be considered a safety-related facility and must be designed, operated, and maintained as such. This is **COL Action Item 2.4-2.** Based on the above review, the staff considers Open Item 2.4-3 resolved.

In response to RAI 2.4.1-3, SERI stated that it has not yet determined the final plant grade since it has not finalized a specific plant design for the ESP facility. The estimated maximum floodwater elevation caused by local intense precipitation does not exceed 133.25 feet above MSL. However, the staff's independent assessment of flooding caused by local intense precipitation could not verify the same floodwater elevation. Therefore, the staff determined that the applicant must provide more details regarding its floodwater level estimation, including the data and methods used during this analysis. This was Open Item 2.4-4.

In response to Open Item 2.4-4, the applicant stated that SSAR Revision 0 contained the current GGNS Unit 1 design basis for local flooding based on a PMP determined using HMR 33, "Seasonal Variation of the Probable Maximum Precipitation East of 105th Meridian for Areas from 10 to 100 Square Miles and Durations of 6, 12, 24, and 48 hours," issued April 1956, and USACE EM-1110-2-1411, "Standard Project Flood Determinations," issued 1965. According to the applicant, SSAR Revision 0 indicated that the GGNS Unit 1 design basis was reviewed and that the flooding level for GGNS Unit 1 was also considered valid for the ESP site flooding from local intense precipitation because the 6-hour-duration PMP from HMR 53 was within 2 percent of that derived from HMR 33.

In response to the staff's Open Item 2.4-5, SERI agreed that local intense precipitation should be estimated using the guidelines of HMR 52, "Application of Probable Maximum Precipitation Estimates—United States East of the 105th Meridian," issued August 1982, which is the current relevant guidance for this site characteristic. The applicant provided newly estimated PMP values for various durations in response to Open Item 2.4-5. It noted that PMP values for 30-minute and 1-hour durations are about 40 percent greater than those based on HMR 33 and reported previously in the SSAR.

The applicant stated that the higher local intense precipitation will have an impact on the ESP site flooding calculations because of increased runoff from Basins A and B. It still considers the method used to determine flow in Streams A and B during a PMP event valid, although the maximum flow in these streams would increase. The applicant described differences in relative positions of the existing GGNS Unit 1 site and the proposed ESP facility site to provide a qualitative evaluation of the effect of increased flow on the estimated floodwater levels at the ESP site.

SSAR Figures 2.4-13 (Sheet 1) and 2.4-18, which show site drainage characteristics, indicate that the proposed ESP site powerblock area is located west of the existing GGNS Unit 1 across the site access road. The topography from the ESP site drops off to the north to Sedimentation Basin A, located at the downstream end of Stream A, which flows west from GGNS Unit 1 through Culvert 9, and to the south to Sedimentation Basin B, located at the downstream end of Stream B, which flows west from GGNS Unit 1 through Culvert 1. Although the ESP site grade has not been established at the ESP stage, the applicant estimated that it will approximately be 132.5 feet above MSL. ESP site grading will take full advantage of its topography to provide adequate runoff to the north and south to Streams A and B, respectively.

Culverts 1 and 9, on Streams B and A, respectively, and the site access road act as restrictions to flow in these streams that drain Basins B and A, respectively. The applicant noted that downstream of the culverts and the access road, the primary restrictions to flow in the streams are sedimentation basin dams shown in SSAR Figure 2.4-13 (Sheet 1), with the top elevation of these dams at approximately 89 feet above MSL. Design-basis PMP flooding calculations for the GGNS UFSAR showed that water levels in the two streams to the west of the access road and downstream of the two culverts were significantly less than the water levels upstream. Runoff from the ESP site would drain into Streams A and B downstream of the two culverts. Therefore, the applicant argued, during a local PMP event, storm water runoff from the ESP site would discharge directly into receiving channels where significantly more discharge capacity would be available than for discharge point receiving runoff from the GGNS Unit 1 site.

Given the physical site topography and the proposed location of the ESP facility powerblock to the west of the site access road and downstream of existing Culverts 1 and 9, it is reasonable to expect that the flood water elevation in the two streams at locations adjacent to the ESP facility powerblock would be substantially less than that of the proposed ESP site grade. The applicant noted that since local PMP rainfall intensities have been revised according to the guidelines of HMR 52, GGNS Unit 1 flood calculations are no longer applicable to the ESP site. Since Streams A and B are expected to be capable of carrying PMP-event flows from the ESP site without flooding, the potential and extent of flooding from a local PMP event on the ESP site will depend on the facility design, the final grade, and the drainage system design. The applicant also stated that the final ESP site drainage systems may use several techniques, including grading slopes and providing additional drainage channels, to efficiently move runoff water. Given the topographic location of the ESP site in relation to Streams A and B, an effective drainage system can be designed at the COL stage. The COL applicant will establish the final ESP site characteristic for local intense precipitation flood water elevation and design flooding protection requirements, such as placement of safety-related equipment above the estimated PMP flood elevation, provision of water-tight doors, elevated structure access openings and floors, and provision of penetration seals.

The applicant revised SSAR Section 2.4.2 to indicate that the flooding analysis discussed is specific to the GGNS Unit 1 site area and that a local intense precipitation flooding analysis for the ESP site will be carried out at the COL stage. The applicant removed the references to a maximum GGNS Unit 1 PMP flood water elevation of 133.25 feet above MSL from the SSAR and annotated tables and figures in the SSAR that refer to the PMP flooding analysis to clearly indicate their limited applicability to the GGNS Unit 1 site.

The staff reviewed the applicant's response to Open Item 2.4-4 and concluded that the applicant provided a qualitative comparison of the topographic layout of the flooding mechanism for the ESP site with that of the GGNS Unit 1 site. The applicant stated, and the staff agrees, that the flood water elevation estimation performed for the GGNS Unit 1 site is not appropriate for the ESP site because the local intense precipitation at the ESP site is different and greater than that at the GGNS Unit 1 site and because the drainage pattern at the ESP site is expected to be much different than that at the GGNS Unit 1 site. The staff also concluded that the site grade for the ESP facility powerblock footprint has not been determined at the ESP stage. For these reasons, a comprehensive flood water elevation analysis for the ESP site cannot be carried out at this time. However, the COL applicant will have to design the site grading to provide flooding protection to safety-related structures at the ESP site based on a comprehensive flood water routing analysis for a local PMP event on the ESP site. This is **COL Action Item 2.4-3.** Based on the above review, the staff considers Open Item 2.4-4 resolved.

In response to RAI 2.4.1-4, the applicant stated, "As discussed with the NRC Staff in the site visit of June 30, 2004, it was not intended that this makeup value of 85,000 gpm be understood as a limiting parameter to be included as bases for the early site permit." However, the staff determined that this statement contradicts the concept of enveloped parameter (PPE). In response to RAI 2.4.1-4, the applicant also stated that it would revise the SSAR text and Table 1.3-1 to ensure that they clearly identify the parameters and their corresponding values that were actually used in the analysis of safety-related features and treat them as bases for the SSAR. The staff determined that the applicant has not amended PPE Section 2.4 of SSAR Table 1.3-1 as of SSAR Revision 2. According to the latest available revision of the SSAR, the staff assumed that all parameters included in PPE Section 2.4 of SSAR Table 1.3-1 are important and bounding PPE parameters. Therefore, the NRC will limit the COL applicant to a maximum service and makeup water withdrawal of 85,000 gpm (SSAR Revision 2, Section 2.4.1.1, page 2.4-2). The staff intended to specify this limit as DSER Permit Condition 2.4-3. However, based on the applicant's response to open items, the staff determined that the detailed design of the ESP facility including its makeup water requirements will not be available until the COL stage. At that time, the NRC will review the detailed facility design according to existing regulations and regulatory guidance. The staff determined, therefore, that specification of DSER Permit Condition 2.4-3 is not necessary. The COL applicant should design the ESP facility with a maximum withdrawal of 85,000 gpm from the Mississippi River to meet the makeup water requirement for the ESP facility. This is **COL Action Item 2.4-4.**

2.4.1.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to the general hydrologic characteristics of the site, including descriptions of rivers, streams, lakes, water-

control structures, and users of the waters discussed. Therefore, the staff concludes that the applicant has met the requirements for general hydrologic descriptions with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c).

2.4.2 Floods

The ESP site is adjacent to the existing GGNS Unit 1 site, located on the bluffs to the east of the Mississippi River floodplain. Runoff resulting from precipitation and snow melt on major tributaries (i.e., the Ohio, Missouri, Arkansas, and Red Rivers) is primarily responsible for flooding in the Mississippi River.

Two small, steep streams, called Stream A and Stream B, flow around the GGNS site. Stream A is located to the north of the GGNS site, and Stream B is located to the south. The greatest floods in these small streams are expected to result from local intense precipitation. These streams and their drainage basins are of interest because they will carry runoff from local precipitation on the ESP site itself. Stream B was rerouted during construction of GGNS Unit 1.

2.4.2.1 Technical Information in the Application

SERI stated that runoff resulting from precipitation and snow melt on major tributaries (i.e., the Ohio, Missouri, Arkansas, and Red Rivers) is primarily responsible for flooding in the Mississippi River. The Ohio River contributes 66 to 76 percent of mean flow in the Mississippi from January to March, and the Missouri River contributes 47 to 52 percent of this flow from June to September. The applicant stated that major floods on the Ohio River occur between mid-January and mid-April, and those on the Missouri and Upper Mississippi Rivers occur between mid-April and the end of July. The Arkansas and White Rivers flood from April through June. The applicant stated that, because the timing of floods varies within the tributaries, flooding on the Lower Mississippi River extends from mid-December to July, and the magnitude, duration, and number of flood peaks during a year vary greatly.

SSAR Table 2.4-4 shows the flood discharges for the Mississippi River measured at Vicksburg, Mississippi, during the six highest historical floods. SSAR Figure 2.4-6 provides a water surface profile for the Mississippi River between river miles 360 and 480 corresponding to the 1937 flood. Based on this water surface profile, SERI estimated that the highest recorded water level near the GGNS site is 92.5 feet above MSL. The applicant stated that the 1927 flood is the highest on record, with a peak discharge equal to 2,278,000 cubic feet per second (cfs) at Vicksburg, Mississippi. Updated records show that no flood since the construction of GGNS has exceeded the discharge of the 1973 flood. The applicant also included graphs of maximum, minimum, and average water surface elevation at Vicksburg, Mississippi, based on data from 1932 to 2000, and those at Natchez, Mississippi, based on data from 1940 to 2000. The SSAR also provided the annual instantaneous peak discharge at Vicksburg, Mississippi, from 1858 to 1999.

According to the applicant, no historical data exist for the two streams (A and B) that flow around the GGNS site. Based on U.S. Weather Bureau (now NOAA) Technical Paper 16, “Maximum 24-Hour Precipitation in the United States,” issued January 1952, the maximum observed 24-hour rainfall in the region varies from about 7.9 to 21.4 inches. Based on USGS

Water Supply Paper 1870-D, “Summary of Floods in the United States during 1966,” issued 1971, and USGS Water Supply Paper 2030, “Summary of Floods in the United States during 1969,” issued 1975, the applicant estimated the maximum observed streamflow values for drainage basins located in the region, ranging in area from 0.18 to 182 mi^2. These flood values range from 147 to 1581 cfs per mi^2.

The applicant considered several flooding events that safety-related structures must withstand, including (1) the Mississippi River probable maximum flood (PMF) coincident with wind-generated waves, (2) seismic failures of upstream dams coincident with the USACE DPF, (3) ice flooding, and (4) PMF events on Streams A and B. The applicant provided details on its estimation of these flooding events in SSAR Section 2.4.3. The applicant stated that the plant-grade elevation of the ESP facility or facilities will be well above the Mississippi River DPF; thus, the design flood for safety-related SSCs will be the PMF caused by local intense precipitation on the ESP site.

SERI stated that all safety-related SSCs for the ESP facility or facilities would be located above the maximum flood elevation, or that flood protection would be provided such that the requirements of 10 CFR Part 100 and General Design Criterion (GDC) 2, “Design Bases for Protection Against Natural Phenomena,” in Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50 will be met.

According to the applicant, the GGNS UFSAR evaluated the effects of local intense precipitation at the GGNS site, and its review determined that this evaluation is valid for the ESP site. The local intense precipitation at the GGNS site was based on the PMP estimated using NOAA HMR 33. The all-season PMP of 48-hour duration for a 10-mi^2 area was determined using HMR 33. However, since the original UFSAR analysis, HMR 53 has superceded HMR 33 and shows a 2-percent increase in the hourly rate of rainfall. The applicant concluded that this increase is relatively small and will not significantly affect the previous analysis. Thus, according to the applicant, the PMF analysis for GGNS Unit 1 also applies to the ESP facility or facilities.

The applicant stated that, because of the small drainage areas of Basins A and B, the duration of the PMP is too long for determination of the PMF. The applicant used the guidelines of USACE EM-1110-2-1411 to distribute the first 6-hour PMP depth within the first 6-hour time period (SSAR Table 2.4-7).

SERI estimated the peak discharges from Basins A and B in response to the 6-hour PMP event using a synthetic unit hydrograph. This approach consisted of the estimation of basin lag times based on the length and slope of the draining channel for Basins A and B using the curves given by Chow in University of Illinois Experimental Station, Bulletin 462, “Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins,” issued 1962. Hudlow (1966) and Feddes (1970) developed a set of curves for small basins varying in size from 0.5–75 mi^2 for the estimation of dimensionless hydrographs. From these studies, the applicant used dimensionless hydrographs for two basins called Basin J and Hudson Creek, which have characteristics similar to Basins A and B, to derive an average hydrograph for use in Basins A and B.

The applicant used estimated basin lag times for Basins A and B to develop a 0.5-hour unit hydrograph for Basin A and a 0.25-hour unit hydrograph for Basin B. These unit hydrographs were used along with a runoff coefficient equal to 1.0 to compute the PMF for Streams A and B.

The applicant stated that the time of concentration for a drainage basin is defined as the time required for precipitation falling at the most remote point of the drainage basin to reach the outlet of the drainage basin. The time of concentration includes overland flow time and channel flow time. The applicant estimated the overland flow time using a formula given by Chow in Bulletin 462. It estimated the channel flow time based on the average velocity of flow in the channel and the length of channel to the outlet of the drainage basin.

SERI estimated that the times of concentration for different subareas of Basins A and B range from about 24 to 48 minutes. The applicant argued that, during the PMP event, the detention of water from ponding in different subareas will result in a longer time of concentration. Therefore, the applicant decided to use an average time of concentration of 30 minutes for local site basins.

The applicant stated that the PMP rainfall intensity corresponding to a time of concentration of 30 minutes is 16.4 inches per hour (in./h), based on a probable maximum half-hour precipitation of 8.2 inches determined from HMR 33 and USACE EM-1110-2-1411. SERI estimated the peak discharges for Basins A and B using flood hydrographs determined from unit hydrographs developed previously.

The applicant's estimate of maximum floodwater elevation is 133.25 feet above MSL.

The applicant stated that snowfall at the GGNS site occurs about once a year with an average depth of 2 inches. The site is not subject to heavy snow accumulations. The maximum depth of winter PMP is smaller than that for the all-season PMP. Therefore, the applicant concluded that flooding resulting from winter PMP will not be a design issue for the ESP facility or facilities.

In RAI 2.4.2-1, the staff asked SERI to provide the road height above Culvert 9 on Stream A and the survey coordinates, including elevation, of Culvert 1 on Stream B. In response to this RAI, the applicant stated that SSAR Figure 2.4-21 shows the road height above Culvert 9, which is 125 feet above MSL. SSAR Figures 2.4-18, 2.4-20 (Sheet 2), 2.4-23, and 2.4-24 and SSAR Table 2.4-12 provide details regarding Culvert 1. The survey coordinates for the center of Culvert 1 are N548,692.44 meters and E277,342.18 meters. The inlet elevation of Culvert 1 is 107.50 feet above MSL, and the outlet elevation is 103.17 feet above MSL. The length of Culvert 1 is 230 feet, and its diameter is 180 inches.

In RAI 2.4.2-2, the staff asked the applicant to explain its use of a DPF to PMF ratio of 0.5. The SSAR estimated the PMF for the Mississippi River based upon the DPF defined by USACE. According to a reference cited in the SSAR, the ratio of DPF to PMF ranges from 0.4 to 0.6. Use of the former (DPF/PMF = 0.4) will result in a more conservative estimate of the PMF, given the DPF. In response to RAI 2.4.2-2, the applicant stated that it included the text in question in SSAR Section 2.4.3.4.1 from the GGNS Unit 1 UFSAR. The applicant noted that the UFSAR stated that the standard project flood (SPF) is generally 40 to 60 percent of the PMF. The DPF is approximately equivalent to the SPF but probably higher. The applicant

considered it conservative to use a midpoint of 50 percent for the DPF to PMF ratio. This ratio results in an estimated Mississippi River PMF of 6.6 million cfs.

According to SERI, SSAR Section 2.4.3.5 indicates that a flood with a peak discharge of 6.6 million cfs in the Mississippi River near the GGNS site will overtop the levee with a maximum elevation of 103 feet above MSL, which can contain a peak discharge of about 3 million cfs, and inundate the wide alluvial floodplain west of the levee. The applicant conservatively estimated a discharge capacity of the floodplain west of the levee at a water surface elevation slightly in excess of 103 feet above MSL of about 11 million cfs using Manning's roughness coefficient of 0.1, floodplain slope of 0.2 ft/mi, and floodplain width of 60 miles. The applicant stated that, based on the total river and floodplain discharge capacity of 11 million cfs, which is much larger than the estimated PMF of 6.6 million cfs, use of a DPF to PMF ratio of 0.4 instead of 0.6 will not change the conclusions of the analysis for the ESP site.

In RAI 2.4.2-3, the staff asked SERI to explain which parts of the new facility might need flood protection during local intense precipitation since the plant grade level is above the PMF level. In response to this RAI, the applicant noted that the statement referenced by the staff in this RAI came out of SSAR Section 2.4.2.2. The applicant stated that this section of the SSAR addresses flooding in broad terms and includes consideration of both Mississippi River floods and the impact of PMP on the ESP site.

The applicant stated that, as noted in SSAR Section 2.4.3, the levee elevation of 103 feet above MSL on the west bank of the Mississippi River controls the maximum water surface elevation caused by a PMF in the river. Thus, the maximum PMF water surface elevation is about 29 feet below the proposed ESP facility grade of approximately 132.5 feet above MSL. Since the ESP site is located on the bluffs on the east side of the river, the maximum PMF water surface elevation in the Mississippi River would not affect any safety-related structures of the ESP facility or facilities. The applicant stated that this evaluation is separate from that conducted with regard to PMP.

SSAR Section 2.4.2.3 discusses the potential flooding of the ESP site from PMP. According to the applicant, the estimated maximum floodwater elevation for the ESP site in its existing configuration does not exceed 133.25 feet above MSL. The applicant anticipated that the construction of the ESP facility or facilities in the proposed powerblock locations would approximately maintain the existing plant grade elevation of 132.5 feet above MSL. The plant yard for the ESP facility would be graded such that runoff is directed away from existing and ESP facility buildings. Assuming that the final ESP site grade in relation to the location of safety-related equipment is such that flooding of the safety-related equipment during a PMP event is precluded, the applicant stated that flooding protection would not be needed. However, as noted in SSAR Sections 2.4.2.2 and 2.4.10, once the final ESP plant grade is established at the COL stage, the need for flood protection of safety-related equipment will be reevaluated.

In RAI 2.4.2-4, the staff asked SERI to provide details to support the estimation of a maximum flood elevation of 133.25 feet above MSL. In response to this RAI, the applicant stated that Section 2.4.3.5, particularly Section 2.4.3.5.3, of the GGNS Unit 1 UFSAR provided a detailed discussion of flooding caused by the local PMP on the GGNS site.

2.4.2.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The applicant identified the applicable RGs. Section 2.4.2 of RS-002 provides the review guidance that the staff used to evaluate this SSAR section.

The acceptance criteria for this section address 10 CFR Part 52 and 10 CFR Part 100 as they relate to identifying and evaluating hydrologic features of the site. The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the review take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the surface and subsurface hydrologic characteristics of the site and region and an analysis of the PMF. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of plant SSCs important to safety. Meeting this guidance provides reasonable assurance that the hydrologic characteristics of the site and potential hydrologic phenomena will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the relevant limiting parameters.

To judge whether the applicant has met the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the NRC uses the following criteria:

- For SSAR Section 2.4.2.1, the staff compares the potential flood sources and flood response characteristics of the region and site identified in its review (as described in the review procedures) to those identified by the applicant. If similar, the staff accepts the applicant's conclusions. If, in the staff's opinion, significant discrepancies exist, the applicant must provide additional data, reestimate the effects on a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site, or revise the applicable flood design bases, as appropriate.

- For SSAR Section 2.4.2.2, the applicant's estimate of controlling flood levels is acceptable if it is no more than 5 percent less conservative than the staff's independently determined (or verified) estimate. If the applicant's SSAR estimate is more than 5 percent less conservative, the applicant should fully document and justify its estimate of the controlling level. Alternatively, the applicant may accept the staff's estimate.

- For SSAR Section 2.4.2.3, the applicant's estimates of the local PMP and the capacity of site drainage facilities (including drainage from the roofs of buildings and site ponding) are acceptable if the estimates are no more than 5 percent less conservative than the corresponding staff assessment. Similarly, conclusions relating to the potential for any adverse effects of blockage of site drainage facilities by debris, ice, or snow

should be based upon conservative assumptions of the storm and vegetation conditions likely to exist during storm periods. If a potential hazard does exist (e.g., the elevation of ponding exceeds the elevation of plant access openings), the applicant should document and justify the local PMP basis.

The staff used the appropriate sections of several documents to determine the acceptability of the applicant's data and analyses in meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100. RG 1.59, Revision 2, "Design Basis Floods for Nuclear Power Plants," issued August 1977, provides guidance for estimating the design-basis flooding considering the worst single phenomenon, as well as combinations of less severe phenomena. The staff used the publications of USGS, NOAA, SCS, USACE, applicable State and river basin authorities, and other similar agencies to verify the applicant's data relating to the hydrologic characteristics and extreme events in the region.

2.4.2.3 Technical Evaluation

The staff obtained peak flow data for the Mississippi River from the USGS "Peak Streamflow for the Nation" Web site for the streamflow gauge located at Vicksburg, Mississippi (USGS Gauge No. 07289000), and used them to create the plot shown in Figure 2.4-6. The staff selected the six highest historical peak flows from the record. These observations are shown by red circles on the plot and are also labeled by their corresponding water years. Table 2.4-1 shows the streamflow values corresponding to these observations. Gauge heights corresponding to these six highest flows were not available.

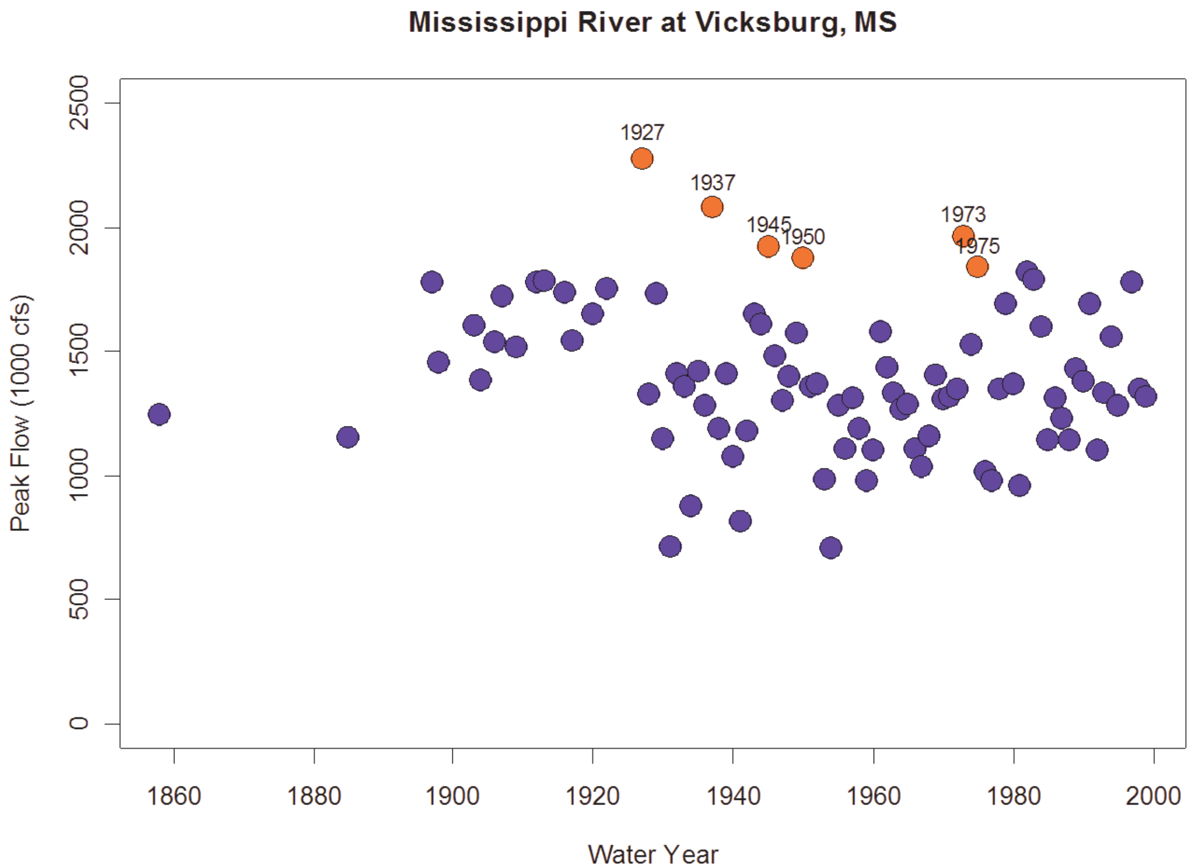

Figure 2.4-6 Peak flow in the Mississippi River observed at Vicksburg, Mississippi. The six highest peak flows are shown by red circles and are labeled by their corresponding water years.

Table 2.4-1 Peak Streamflow during Six Highest Floods at Vicksburg, Mississippi

Water Year	Peak Streamflow in cfs
1927	2278000
1937	2080000
1973	1962000
1945	1922000
1950	1876000
1975	1839000

Based on the peak flow data obtained by the staff, five of the six highest peak flows are identical to those reported by SERI in SSAR Table 2.4-4. However, the peak flow reported by the applicant, that of 1,783,000 cfs in 1913, was exceeded in 1975. The peak flow in 1975 was 1,839,000 cfs. The staff accepted the applicant's statement that no flood in the Mississippi River has exceeded the magnitude of the 1973 flood since the construction of GGNS.

The staff did not find any historical data for the two local streams, Streams A and B. The staff estimated the PMP for the drainages of Streams A and B using HMR 53 and estimated the PMF for these drainages assuming no precipitation losses and an instantaneous time of concentration. These assumptions result in more conservative PMF values. The staff analyzed the resulting flood hydrographs assuming that the culverts on Streams A and B are completely blocked to obtain flood elevations under these conservative PMF events. Section 2.4.3 of this SER provides details of this analysis.

Section 2.4.3 of this SER also provides more detail on the staff's evaluation of floods in the Mississippi River and their impact on the ESP site. The staff estimates that the highest water surface elevation in the Mississippi River as a result of the DPF, wind setup, and wave runup will not impact the ESP site since the maximum water surface elevation is significantly below the ESP site grade.

Section 2.4.4 of this SER describes the staff's evaluation of floods caused by the seismically induced failure of upstream dams. The staff concluded that any upstream dam failure and resulting flood wave would not impact the ESP site.

Section 2.4.7 of this SER describes the staff's evaluation of ice-jam-induced flooding. The staff concluded that ice jams are not likely to form sufficiently close to the GGNS site on the Mississippi River to adversely impact the operations or safety of the ESP facility or facilities.

According to HMR 52, local intense precipitation at the ESP site is equivalent to a short-duration, 1-mi^2 PMP. The staff used HMR 52 guidelines to estimate the 1-hour, 1-mi^2 PMP depth for the ESP site. Column 2 of Table 2.4-2 lists the HMR 52-recommended multiplication

factors that are applied to the 1-hour, 1-mi^2 PMP depth to estimate the PMP depths for other durations. Column 3 shows the staff's estimated PMP depths corresponding to these durations.

Table 2.4-2 Local Intense Precipitation (1 mi^2 PMP) at the ESP Site

Duration	Multiplier to 1-Hour PMP Depth	PMP Depth (in.)
5 min	0.331	6.08
15 min	0.522	9.58
30 min	0.748	13.73
1 h	1	18.36
6 h	1.527	28.04

SSAR Table 2.4-7 shows the applicant's estimate of the local intense precipitation. SERI estimated a 1-hour PMP depth at the plant site of 11.6 inches (see SSAR Table 2.4-7) and a 30-minute PMP depth of 8.2 inches using HMR 33. The applicant's estimates are 37 and 40 percent less than the corresponding staff estimates, respectively. Therefore, the staff determined that the applicant's assertion that the hourly PMP values contained in the newer HMR 53 are only 2 percent higher than those recommended by HMR 33 is not valid. HMR 53 applies to 10-mi^2 areas. However, local intense precipitation should be based on a 1-mi^2 area as recommended in HMR 52. Therefore, the staff concluded that the applicant must estimate the local intense precipitation using the guidelines of HMR 52. This was Open Item 2.4-5.

In response to Open Item 2.4-5, the applicant stated that it estimated the local intense precipitation using the guidelines of HMR 52. Table 2.4-2a provides the applicant's revised PMP values for the ESP site.

Table 2.4-2a Applicant's Revised Local Intense Precipitation (1 mi^2 PMP) at the ESP Site

Duration	Area	Multiplier to 1-h, 1-mi^2 PMP	Source in HMR 52	PMP Depth (in.)	Comments
5 min	1 mi^2	0.325	Fig. 36	6.2	multiplier*1 h, 1 mi^2
15 min	1 mi^2	0.505	Fig. 37	9.7	multiplier*1 h, 1 mi^2
30 min	1 mi^2	0.735	Fig. 38	14.1	multiplier*1 h, 1 mi^2
1 h	1 mi^2	1		19.2	HMR 52, Fig. 24
1 h	10 mi^2	0.825	Fig. 28	15.8	HMR 52, Fig. 29
6 h	10 mi^2	1/0.615	Fig. 23	31.2	multiplier*1 h, 1 mi^2

The applicant revised SSAR Section 2.4.2.3 to include the above HMR 52 PMP values and annotated SSAR Table 2.4-7 to indicate its applicability to the GGNS Unit 1 analysis only.

The staff reviewed the applicant's response to Open Item 2.4-5 and concluded that it is sufficient to resolve the open item because the applicant's revised estimates closely match those of the staff and conforms to the latest HMR-52 criteria. The staff also determined that newly provided PMP values for local intense precipitation at the ESP site will be specified as site characteristics in this ESP.

In response to RAI 2.4.2-1, the applicant provided the road heights above Culverts 1 and 9 and the survey coordinates of Culvert 1. The staff determined that the applicant provided sufficient information for it to locate these culverts on the map in relation to the drainage characteristics of Basins A and B. Therefore, the applicant's response is satisfactory.

In response to RAI 2.4.2-2, SERI stated that a flood with a peak discharge of about 3 million cfs can be carried by the levees on the west bank of the river near the GGNS site. The peak PMF discharge of 6.6 million cfs estimated by the applicant will overtop the levees on the west bank. However, the applicant estimated a discharge capacity of the floodplain west of the levees of about 11 million cfs. If a DPF to PMF ratio equal to 0.4 were used for estimation of the PMF, the peak PMF discharge would be 8.25 million cfs. Therefore, the applicant concluded that, since this more conservative estimate of peak PMF discharge is still less than the discharge capacity of the floodplain west of the levee, the conclusion of the applicant's previous analysis will not change. The staff determined that the applicant satisfactorily addressed the concern regarding its use of a less conservative DPF to PMF ratio in the previous analysis presented in the SSAR. The staff also agreed that, even with the more conservative estimate of peak PMF discharge in the Mississippi River, the water surface elevation at peak PMF discharge will not be appreciably higher than 103 feet above MSL, the top surface elevation of the levee on the west bank.

In response to RAI 2.4.2-3, SERI stated that it established the maximum water surface elevation at the ESP site based on local intense precipitation at the site. The applicant's estimate of maximum water surface elevation at the ESP site is 133.25 feet above MSL. The applicant proposed to use the existing site grade of 132.5 feet above MSL as the ESP site grade. The applicant also suggested that the plant yard for the ESP facility or facilities would be graded to direct the runoff away from the ESP facility and buildings. Finally, the applicant proposed to reevaluate the need for flooding protection requirements once the ESP plant grade is established at the COL stage.

The NRC will require the COL applicant to demonstrate that the ESP plant grade is safe from the flooding effects of maximum water surface elevation during local intense precipitation without relying on any active surface drainage systems that may be blocked during this event. Section 2.4.1.3 of this SER stated a similar requirement as DSER Permit Condition 2.4-1:

> The NRC will require the COL applicant to design the ESP plant grade such that flooding caused by local intense precipitation will be discharged to Streams A and B without reliance on any active drainage systems that may become blocked during the local intense precipitation event.

The staff intended to propose that the Commission include this requirement in the ESP, should it be granted. However, based on the applicant's response to open items, the staff determined that the ESP site grade will not be designed until the COL stage when a reactor design is chosen and the locations of safety-related structures are established. The NRC will review the ESP site grade design according to existing regulations and regulatory guidance at that time. The staff determined, therefore, that specification of DSER Permit Conditions 2.4-1 and 2.4-4 is not required. The COL applicant should demonstrate that the ESP plant grade is safe from the flooding effects of maximum water surface elevation during local intense precipitation without

relying on any active surface drainage systems that may be blocked during this event. This is **COL Action Item 2.4-5.**

In response to RAI 2.4.2-4, the applicant provided the reference to GGNS Unit 1 UFSAR Section 2.4.3.5. This section contained details of the PMF backwater analysis during local intense precipitation. The staff reviewed this section of the GGNS Unit 1 UFSAR and is satisfied that the applicant's response to RAI 2.4.2-4 is adequate.

2.4.2.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to floods. Therefore, the staff concludes that the applicant has met the requirements for floods with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3).

2.4.3 Probable Maximum Flood on Streams and Rivers

The ESP site is located at approximately 32E N latitude and 91E3' W longitude. It is located at approximately river mile 406 on the east bank of the Mississippi River, about 25 miles south of Vicksburg, Mississippi.

Two small, steep streams flow around the ESP site, draining a combined area of less than 4 mi^2, and into Lake Hamilton, located in the floodplain of the Mississippi River. The ESP site itself partially drains to both streams.

The ESP site is subject to flooding from the Mississippi River, because of flooding in the two small streams that flow around the site, and to local flooding in response to intense precipitation.

2.4.3.1 Technical Information in the Application

According to SERI, it based the PMF for the Mississippi River on the DPF for the Lower Mississippi Basin, as estimated by USACE in Annex C, "Project Design Flood Study, 'Comprehensive Review of the Mississippi River and Tributaries Project,' " issued 1969. According to the applicant, using the DPF to estimate the PMF for the Mississippi River meets the requirements of RG 1.59 and is consistent with the GGNS UFSAR position on RG 1.59.

The USACE determined the DPF for the Mississippi River, as described in its comprehensive review cited above. Several logical storm combinations within the Mississippi River Basin were studied to compute floods on tributaries. These storm combinations were then analyzed in meteorologically feasible sequences that would result in the peak flows of individual tributaries coinciding with each other as far as practicable at key discharge locations on the Mississippi River. These hypothetical floods were used to select four storm combinations. These storms were rearranged to maximize flood flows at key locations. Based on regulation data, modified hydrographs were estimated for three groups of reservoirs—(1) existing, (2) existing and near future, and (3) existing, near future, and distant future. The modified and unregulated flows were routed down the Mississippi River to determine daily flows at St. Louis, Missouri; Cairo, Illinois; Memphis, Tennessee; Helena and Arkansas City, Arkansas; and Vicksburg and Natchez, Mississippi.

The applicant developed the DPF hydrograph for the GGNS site from the USACE DPF hydrograph for Arkansas City, Arkansas, located at approximately river mile 547. The Arkansas City DPF hydrograph was lagged by 36 hours, assuming an approximate average flood velocity of 100 miles per day, and augmented to account for inflow from the Yazoo and Big Black River tributaries. Figure 2.4-15 of the ESP application shows the resulting DPF at the GGNS site. The applicant stated that peak discharge of the unregulated DPF at the GGNS site is 3.3 million cfs.

According to Chow in "Open Channel Hydraulics," issued 1959, the SPF is generally between 40 and 60 percent of the PMF. According to the applicant, the DPF is approximately equivalent to the SPF but is probably somewhat greater. Based on these statements, SERI used a value of 0.5 for the ratio of DPF to PMF. The applicant estimated the PMF on the Mississippi River near the GGNS site by doubling the DPF previously estimated for the GGNS site. The applicant estimated a peak discharge in the Mississippi River near the GGNS site during a PMF event of 6.6 million cfs.

The applicant determined water surface elevations corresponding to the peak discharges during the PMF in the Mississippi River. For the Mississippi River near the GGNS site, it developed a rating curve using the one at Vicksburg. In developing the rating curve for the GGNS site, the applicant assumed that the two locations (GGNS site and Vicksburg) have the same discharge, since no major tributaries exist between Vicksburg and the GGNS site except the Big Black River. The Big Black River contributes less than 1 percent to the discharge in the Mississippi River at its confluence, as compared to the discharge in the Mississippi River at Vicksburg. Figure 2.4-6 in the ESP application shows this rating curve.

The applicant stated that the peak flow during the PMF in the Mississippi River will overtop the west bank levee, which has a maximum elevation of 103 feet. At a flood elevation of 103 feet, the discharge in the Mississippi River is about 3 million cfs, resulting in inundation of the floodplain on the west bank. The applicant estimated that the discharge capacity of the floodplain at a water surface elevation slightly above 103 feet, assuming a width of 60 miles, a Manning's roughness coefficient of 0.1, and a channel slope of 0.2 ft/mi, is approximately 11 million cfs. The applicant concluded that the peak discharge of 6.6 million cfs during the PMF is not expected to raise the water surface elevation much above 103 feet within the Mississippi River. This peak water surface elevation is about 29 feet below the plant grade.

The applicant estimated the PMF for Streams A and B using the local PMP. Section 2.4.2 of this SER discusses the applicant's description of the estimation of the PMP for drainages of local Streams A and B. The applicant used a unit hydrograph approach to determine peak discharge on these drainages during the PMP event, as described above in SER Section 2.4.2.1. The applicant's estimates of peak discharges during the PMF event for Basins A and B are 13,900 cfs and 4,630 cfs, respectively.

SERI estimated the water surface elevation in Stream A at the culvert assuming that the culvert would be completely blocked and the top of the access road would act as a broad-crested weir 580 feet wide, with a weir bottom surface elevation of 125 feet above MSL. The applicant carried out a backwater analysis of Stream A during the PMF event using the HEC-2 program for water surface profiles. The resulting maximum water surface elevation is 128.93 feet above MSL.

According to the applicant, Stream B was rerouted around the GGNS Unit 1 cooling tower. This rerouted channel was lined with concrete and has a bottom width of 6.67 feet. The sides were lined with concrete to a height of 5 feet above the bottom, and riprap was provided above the concrete to the plant grade. The applicant stated that the channel is hydraulically steep because of its slope of 0.4 percent in the downstream reach and 1 percent upstream of Culvert 15. The culvert is located at the downstream end of this channel, and an access road passes over it. The natural drainage area of Basin B to Culvert 1 is about 0.5 mi^2. Because of site grading, about 0.15 mi^2 of this area now drains to Basin A, and the remaining 0.35 mi^2 drains to Culvert 1.

The applicant estimated the water surface elevation in Stream B during the PMF event using a standard step backwater method. The analysis used a prorated peak discharge of 2775 cfs at Culvert 1, corresponding to a drainage area of 0.35 mi^2. The applicant conservatively assumed concurrent peak discharges at all culverts draining into the channel. The water depth in the channel exceeded the normal depth, resulting in a hydraulic jump about 1200 feet upstream of the entrance to Culvert 1. The applicant stated that the Froude number based on the upstream and downstream depth of flow is 1.1, classifying the hydraulic jump as a low-energy jump, dissipating less than 1 percent energy.

According to the applicant, the possibility of substantial blockage of Culvert 1 is highly unlikely because the channel is lined up to the 100-year flood level and riprap is provided above this level. The watershed draining to the channel upstream of Culvert 2, including the plant yard, contains no source of debris that may cause blockage. Therefore, the applicant concluded that, in the event of a 45-percent blockage of the culvert entrance area, part of the PMF discharge would be passed through the culvert, and the remaining volume could be impounded in the channel and the yard area around the GGNS Unit 1 cooling tower below an elevation of 132.8 feet above MSL.

In RAI 2.4.3-1, the staff asked SERI to explain how it bounded the wave runup estimation through the examination of the combined event criteria indicated in ANSI/American Nuclear Society (ANS)-2.8-1992, “Determining Design Basis Flooding at Power Reactor Sites,” issued 1992. The staff also asked the applicant to discuss the coincident wave estimation and its basis for using a 40-miles per hour (mph) wind speed. In response to this RAI, the applicant stated that SSAR Section 2.4.3.6 discusses wind-wave estimation in detail. The applicant stated that it performed wave height estimation in accordance with the procedures described in the USACE "Shore Protection Manual," issued 1973. According to the applicant, this estimation used an overland windspeed of 40 mph and assumed a wind velocity over water that was 1.3 times higher than the overland wind speed. The resulting over-water wind speed is 52 mph. The applicant estimated the resulting water surface elevation caused by wind-wave activity coincident with the PMF in the Mississippi River to be 108.8 feet above MSL. Based on this estimation, the maximum water surface elevation during the PMF event in the Mississippi River is about 23.7 feet below the proposed ESP plant grade elevation of 132.5 feet above MSL.

According to the applicant, ANSI/ANS-2.8-1992 indicates that the 2-year annual extreme mile wind speed may be used as a starting point. According to Figure 1 of the ANSI/ANS standard, the wind speed for GGNS is between 40 and 50 mph. The fastest hourly averaged wind speeds at GGNS and Vicksburg are 31 and 33 mph, respectively, in 1999, based on data from

1997–2001. The wind speed value used in the original estimation of coincident wave activity is more conservative than the measured values at GGNS.

SERI argued that, even if the wind speed were increased to 65 mph, using the most conservative range from Figure 1 of ANSI/ANS-2.8-1992, the new estimate of wave height would be 6.9 feet (4.4 feet x $(65/52)^2$ = 6.9 feet). The difference in elevation between the new maximum water surface elevation and the proposed ESP site grade would still be 21.2 feet. The new estimation will not result in a significant change from the original analysis and will not pose a safety hazard to the ESP site from flooding in the Mississippi River.

In RAI 2.4.3-2, the staff asked the applicant to provide survey coordinates for points A and B on SSAR Figure 2.4-10. In response to this RAI, the applicant stated that points A and B only represent approximate locations of the discharge locations of drainage Basins A and B, respectively. The approximate UTM coordinates in NAD 83 are N3,543,936 meters and E683,868 meters for point A and N3,543,108 meters and E683,868 meters for point B.

2.4.3.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that SERI correctly identified the applicable regulatory guidance. Section 2.4.3 of RS-002 provides the review guidance used by the staff to evaluate this SSAR section.

The acceptance criteria for this section address 10 CFR Part 52 and 10 CFR Part 100, as they relate to identifying and evaluating the hydrologic features of the site. The regulations at 10 CFR Part 52 and 10 CFR Part 100 require that the review take into account a site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the hydrologic characteristics of the site and region and an analysis of the PMF. This description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of SSCs important to safety for a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site. Meeting this guidance provides reasonable assurance that any hydrologic phenomena of severity up to and including the PMF will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters.

To judge whether the applicant has met the requirements of the hydrologic aspects of 10 CFR Part 52 and 10 CFR Part 100, the NRC uses specific criteria.

The PMF, as defined in RG 1.59, has been adopted as one of the conditions to be evaluated in establishing the applicable stream and river flooding design basis referenced in GDC 2. PMF

estimates are needed for all adjacent streams or rivers and site drainage (including the consideration of PMP on the roofs of safety-related structures). The criteria for accepting the applicant's PMF-related design basis depend on one of the following three conditions:

(1) The elevation attained by the PMF (with coincident wind waves) establishes a necessary protection level to be used in the design of the facility.

(2) The elevation attained by the PMF (with coincident wind waves) is not controlling; the design-basis flood protection level is established by another flood phenomenon (e.g., the probable maximum hurricane (PMH)).

(3) The site is "dry"; that is, the site is well above the elevation attained by a PMF (with coincident wind waves).

When condition (1) is applicable, the staff will assess the flood level. The staff may perform this assessment independently from basic data, by detailed review and checking of the applicant's analyses, or by comparison with estimates made by others that have been reviewed in detail. The applicant's estimates of the PMF level and the coincident wave action are acceptable if the estimates are no more than 5 percent less conservative than the staff estimates. If the applicant's estimates of discharge are more than 5 percent less conservative than the staff's, the applicant should fully document and justify its estimates or accept the staff estimates.

When condition (2) or (3) applies, the staff analyses may be less rigorous. For condition (2), acceptance is based on the protection level estimated for another flood-producing phenomenon exceeding the staff estimate of PMF water levels. For condition (3), the site grade should be well above the staff assessment of PMF water levels. The evaluation of the adequacy of the margin (difference in flood and site elevations) is generally a matter of engineering judgment. Such judgment is based on the confidence in the flood-level estimate and the degree of conservatism in each parameter used in the estimate.

The staff used the appropriate sections of several documents to determine the acceptability of the applicant's data and analyses. RG 1.59 provides guidance for estimating the PMF design basis. Publications by NOAA and USACE may be used to estimate PMF discharge and water level conditions at the site, as well as coincident wind-generated wave activity.

2.4.3.3 Technical Evaluation

The staff evaluation consisted of an independent analysis to verify the applicant's PMF analysis.

The current HMR publications from NOAA are applicable for the estimation of the PMP that is subsequently used to develop the PMF in a given drainage basin. These reports, accessible through the NWS Hydrometeorological Design Studies Center Web site, deal with specific regions within the continental United States (Figure 2.4-7). Procedures outlined in HMR publications are recommended for drainage areas up to 20,000 mi^2. The drainage area of the Mississippi River Basin upstream of the USGS streamflow gauge at Vicksburg is 1,144,500 mi^2, approximately 57 times larger than the largest areas of applicability recommended by the HMRs. The extent of the Mississippi River Basin implies that at least four of these regions, with five different HMRs, may apply in different portions of the Mississippi River Basin (Figure 2.4-7).

There are no recommendations on combining estimates from different HMRs for a PMP estimation over a large basin that straddles multiple HMR regions.

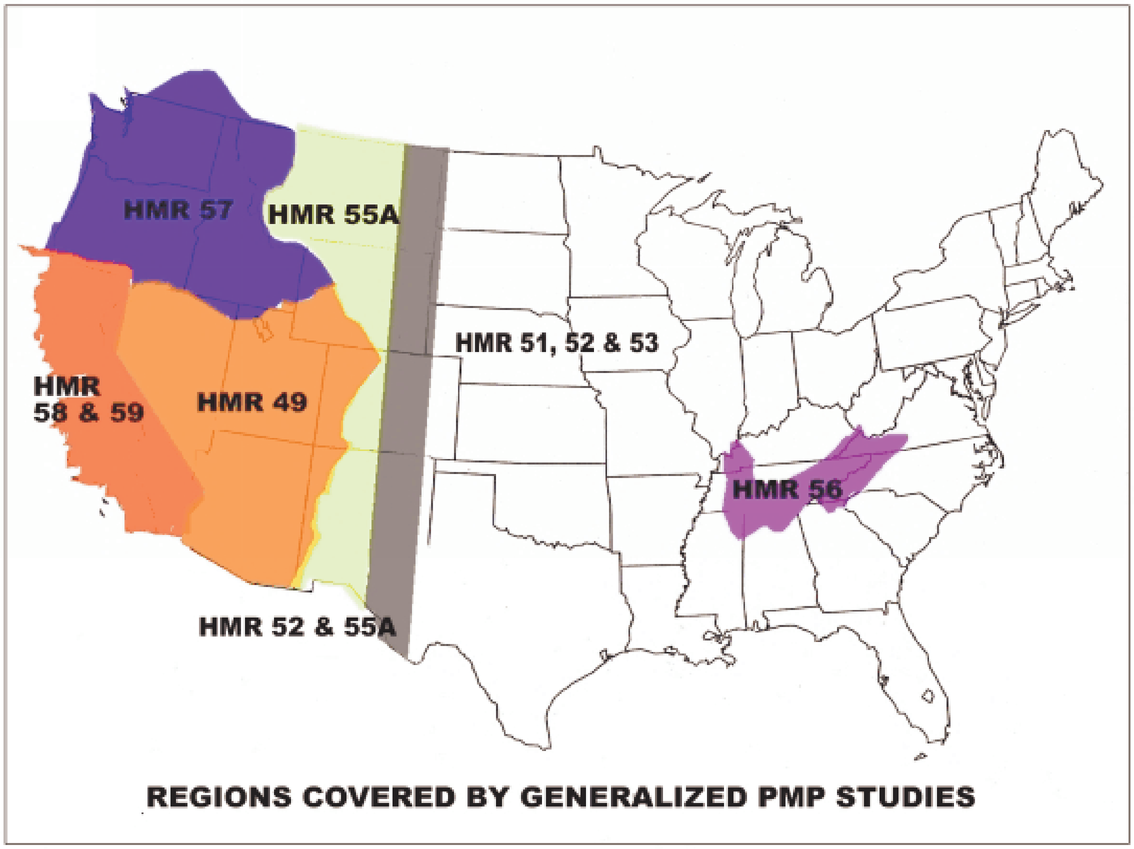

Figure 2.4-7 Regions of applicability of HMRs within the continental United States for estimation of the PMP. Figure from the Hydrometeorological Design Studies Center <http://www.nws.noaa.gov/oh/hdsc/max_precip/pmp.html>

The staff consulted USACE, Vicksburg District, for independent verification of the DPF in the Mississippi River near the GGNS site. In a letter to Mr. G. Bagchi of the NRC, dated July 9, 2004, USACE stated that major storms that occurred in the central United States were examined for their flood-producing potentialities in the Lower Mississippi River. Selected storms from this set were transposed or shifted in timing within the season in which they occurred and arranged in critical sequence on the drainage area to produce maximum flows in the lower Mississippi River. The USACE used observed hydrographs and hydrographs computed from unit graphs to determine flows from major tributaries. The resulting flows were routed to key stations along the river as unregulated or regulated by tributary reservoirs. The DPF was selected from these routed flows.

According to USACE, it used four combinations of the selected storms for detailed study on the basis of the large floods produced and the variation in season of occurrence. It selected the

combination designated 58A as the DPF for the Lower Mississippi River. Combination 58A consists of the storm that occurred January 6–24, 1937, over all areas with rainfall excess increased by 10 percent, followed in 4 days by the storm of January 3–16, 1950, over all areas above Cairo, Illinois, and followed in 3 days by the storm of February 4–18, 1938, transposed 90 miles and rotated 20 degrees for all areas below Cairo, Illinois.

The USACE stated that the levee on the west bank of the Mississippi River opposite the current GGNS plant (approximate levee station 5300+00) varies in elevation from 105 feet above MSL to 102 feet above MSL. The levee is proposed to be raised 3 to 4 feet within the next 7 to 10 years at this location.

The USACE also stated that the DPF elevation at river mile 406, the location of the current GGNS plant, is 102.2 feet above MSL, based on the Refined 1973 Mississippi Rivers and Tributaries Project Flood Flowline.

In RAI 2.4.3-1, the staff asked SERI to provide additional information on the bounding of its wave runup calculations through the examination of the combined events criteria indicated in ANSI/ANS-2.8-1992. In addition, the staff asked the applicant to discuss the basis for applying a 40-mph design wind.

In its response to RAI 2.4.3-1, the applicant estimated wave heights using a more conservative value based upon a 65-mph wind. With this higher wind speed, the revised wave heights were 6.9 feet, and the margin to the proposed ESP facility grade elevation was more than 20 feet.

The staff examined wave heights generated by winds at 100 mph. This more conservative value was thought plausible because the site is located near the Gulf of Mexico, where hurricanes are known to develop. The staff estimated wave heights using wave height nomographs (see USACE EM-1110-2-1100, Revision 1, "Coastal Engineering Manual," issued July 2003). These nomographs estimate wave height based upon fetch length and wind speed. The staff used a fetch length of 22,704 feet; the resulting 1-percent wave height was 10.9 feet. When this conservative wave height value was added to the PMF water surface elevation, an adequate margin existed to determine that the ESP site will not be affected. Therefore, the staff determined that the applicant's response is satisfactory.

In response to RAI 2.4.3-2, SERI provided the coordinates of points A and B shown on SSAR Figure 2.4-10. The applicant also clarified that these coordinates are only approximate locations of the discharge points for Basins A and B, respectively. The staff determined that the applicant's response is satisfactory.

2.4.3.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to the PMF on streams and rivers. Therefore, staff concludes that the applicant has met the requirements for the PMF on streams and rivers with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c).

2.4.4 Potential Dam Failures, Seismically Induced

The ESP site is adjacent to the existing GGNS Unit 1 site, located on the bluffs to the east of the Mississippi River floodplain. Runoff resulting from precipitation and snow melt on major tributaries (i.e., the Ohio, Missouri, Arkansas, and Red Rivers) is primarily responsible for flooding in the Mississippi River.

2.4.4.1 Technical Information in the Application

SERI analyzed the effect of dam failures on the water surface elevation of the Mississippi River at the GGNS site, assuming that the Mississippi River would be carrying a flood of DPF magnitude with the water surface elevation at 96.2 feet above MSL when an upstream dam breaks. Since no dams exist on the Mississippi River upstream of the site, the applicant considered dam failure of the largest upstream dam closest to the ESPs on a tributary to the Mississippi River.

The applicant divided the Mississippi River Basin into six major drainage areas (Figure 2.4-27 of the ESP application):

(1) Upper Mississippi
(2) Missouri
(3) Tennessee-Ohio
(4) Red-Ouachita
(5) Arkansas-White
(6) Lower Mississippi

The total number of dams in the Mississippi River Basin exceeds 300; 61 of these dams have storage capacities greater than 1 million acre-feet (acre-ft). Figure 2.4-28 of the ESP application shows the seismic risk map of the United States which divides the United States into four zones of seismic risk. Zone 0 represents minimum risk, while Zone 3 represents maximum risk. The applicant took the information on dams listed in Table 2.4-15 of the SSAR from the report of the International Commission on Large Dams. The table was arranged on the basis of the major drainage areas in which the dams are located. Table 2.4-15 of the SSAR only lists dams with reservoir capacities greater than 1 million acre-ft.

According to SERI, the Upper Mississippi Basin has a total estimated storage capacity of 10.0 million acre-ft. Only three dams within the Upper Mississippi Basin have capacities greater than 1 million acre-ft. All dams in the Upper Mississippi Basin are in seismic Zone 1.

The total storage of the dams in the Missouri subbasin is estimated to be 140 million acre-ft. This subbasin includes 21 dams with a capacity of 1 million acre-ft or more. The dams in this subbasin belong to seismic Zones 1 and 2.

The Tennessee-Ohio subbasin has a total estimated storage capacity of approximately 45 million acre-ft. This subbasin includes 14 dams with reservoir capacities greater than 1 million acre-ft. Nine of these are in seismic Zone 2 and the other five are in seismic Zone 3.

The Red River subbasin joins the Mississippi River downstream from the site. Hence, consideration of the dams and storage in this subbasin was not required.

The Arkansas-White subbasin has a total estimated storage capacity of 45 million acre-ft, with 20 dams having capacities greater than 1 million acre-ft. Two of these dams are in seismic Zone 3, four in seismic Zone 2, and the rest of the dams are in seismic Zone 1.

The Lower Mississippi Basin has an extensive river-control system consisting of levees, revetments, cutoffs, and floodways extending from Cairo, Illinois, to the Gulf of Mexico. Two dams are in seismic Zone 2.

The largest dam that is nearest to the GGNS site is the Kentucky Dam on the Tennessee River, located in the Tennessee-Ohio subbasin about 450 river miles upstream, with a storage capacity of 6.13 million acre-ft. The Fort Randall Reservoir and Dam on the Missouri River, located in the Missouri subbasin, exceeds the capacity of the Kentucky Dam by 0.17 million acre-ft, but this dam is located 1300 river miles from the GGNS site, almost three times as far as the Kentucky Dam. Because of the relative proximity of the Kentucky Dam to the GGNS site, the applicant chose it as the dam to use in its hypothetical seismically induced failure analysis.

The applicant estimated that the initial discharge from the Kentucky Dam in the event of its complete failure will be about 3 million cfs. Conservatively neglecting the attenuation caused by the travel of the flood wave 450 miles down the river from the Kentucky Dam to the GGNS site, the applicant estimated a peak flow of about 5.7 million cfs at the GGNS site.

SERI estimated a PMF of 6.6 million cfs, which exceeds the peak flood caused by the effect of Kentucky Dam failure combined with a DPF at the GGNS site. Therefore, the applicant concluded that the failure of the nearest largest dam from seismic causes when the Mississippi River is carrying a flood of (regulated) DPF magnitude at the GGNS site is not a safety issue.

2.4.4.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance and cites RGs 1.29, "Seismic Design Classification"; 1.59; 1.70; and 1.102, Revision 1, "Flood Protection for Nuclear Power Plants," issued September 1976. The staff finds that SERI correctly identified the applicable RGs. The applicable regulations are 10 CFR 52.17(a)(1)(vi), 10 CFR 100.20(c), and 10 CFR 100.23(c). Section 2.4.4 of RS-002 provides the review guidance used by the staff to evaluate this SSAR section.

The acceptance criteria for this section are based on meeting the requirements of the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100, as they relate to evaluating the hydrologic features of the site

- 10 CFR 100.23, "Geologic and Seismic Siting Criteria," as it relates to establishing the design-basis flood resulting from seismic dam failure

The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the review take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

The regulations at 10 CFR Part 52 and 10 CFR Part 100 apply to SSAR Section 2.4.4 because it addresses the site's physical characteristics, including hydrology, considered by the Commission when determining its acceptability to host a nuclear unit(s). To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the hydrologic characteristics of the region and an analysis of potential dam failures. The description should be sufficient to assess the acceptability of the site and the potential for those characteristics to influence the design of SSCs important to safety. Meeting this criterion provides reasonable assurance that the effects of high water levels resulting from the failure of upstream dams, as well as those of low water levels resulting from the failure of a downstream dam, will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters.

The regulation at 10 CFR 100.23 requires consideration of geologic and seismic factors in determining site suitability. Specifically, 10 CFR 100.23(c) requires an investigation of the geologic and seismic site characteristics to permit evaluation of seismic effects on the site. Such an evaluation must consider seismically induced floods, including failure of an upstream dam during an earthquake.

The regulation at 10 CFR 100.23 applies to SSAR Section 2.4.4 because it requires investigation of seismic effects on the site. Such effects include seismically induced floods or low water levels, which constitute one element in the Commission's consideration of the suitability of proposed sites for nuclear power plants. RG 1.70 provides more detailed guidance on the investigation of seismically induced floods, including results for seismically induced dam failures and antecedent flood flows coincident with the flood peak. Meeting this guidance provides reasonable assurance that, given the geologic and seismic characteristics of the proposed site, a nuclear unit(s) of a specified type (or falling within a PPE) could be constructed and operated on the proposed site without undue risk to the health and safety of the public, with respect to those characteristics.

To judge whether the applicant has met the requirements of 10 CFR Part 52, 10 CFR Part 100, and 10 CFR 100.23 as they relate to dam failures, the NRC uses the following criteria:

- The staff will review the applicant's analyses and independently assess the coincident river flows at the site and at the dams being analyzed. ANSI/ANS-2.8-1992 provides guidance on acceptable river flow conditions to be assumed coincident with the dam failure event. To be acceptable, the applicant's estimates of the flood discharge resulting from the coincident events (which may include landslide-induced failures) should be no more than 5 percent less conservative than the staff estimates. If the applicant's estimates differ by more than 5 percent, the applicant should fully document and justify its estimates or accept the staff estimates.

- The applicant should identify the location of dams and potentially likely or severe modes of failure, as well as dams or embankments built to impound water for a nuclear unit(s) that might be constructed on the proposed site. The applicant should discuss the

potential for multiple, seismically induced dam failures and the domino failure of a series of dams. Approved USACE and Tennessee Valley Authority models should be used to predict the downstream water levels resulting from a dam breach. First-time use of other models will necessitate complete model description and documentation. The staff will review the model theory, available verification, and application to determine the acceptability of the model and subsequent analyses. For cases that assume something other than instantaneous failure, the conservatism of the rate of failure and shape of the breach should be well documented. The applicant should present a determination of the peak flow rate and water level at the site for the worst possible combination of dam failures, a summary analysis that substantiates the condition as the critical permutation, and a description of and the bases for all coefficients and methods used. In addition, the effects of other concurrent events on plant safety, such as blockage of the river and waterborne missiles, should be considered.

- The effects of coincident and antecedent flood flows (or low flows for downstream structures) on initial pool levels should be considered. Depending upon estimated failure modes and the elevation difference between plant grade and normal river levels, it may be acceptable to use conservative, simplified procedures to estimate flood levels at the site. For cases in which calculated flood levels employing simplified methods are at or above plant grade and use assumptions which cannot be demonstrated as conservative, it will be necessary to use unsteady flow methods to develop flood levels at the site. The methods described in RS-002 "Processing Applications for Early Site Permits," (ML040700094), are acceptable to the staff; however, other programs could be acceptable with proper documentation and justification. Applications should summarize the computations, coefficients, and methods used to establish the water level at the site for the most critical dam failures. Coincident wind-generated wave activity should be considered in a manner similar to that discussed in Section 2.4.3 of RS-002.

RG 1.59 provides guidance for estimating the design basis for flooding, considering the worst single phenomenon and a combination of less severe phenomena.

2.4.4.3 Technical Evaluation

The staff carried out a simplified bracketing estimation of the discharge needed to raise the water surface elevation near the GGNS site above the existing GGNS Unit 1 plant grade of 132.5 feet above MSL. The staff assumed a simplified cross-section for the Mississippi River near the GGNS site, as shown in Figure 2.4-8. The staff conservatively assumed that the width of the floodplain is 60 miles, even at a water surface elevation of 132.5 feet above MSL. The cross-sectional area of discharge is estimated as 11.5 million square feet (ft^2). The wetted perimeter was estimated as 317,065 feet.

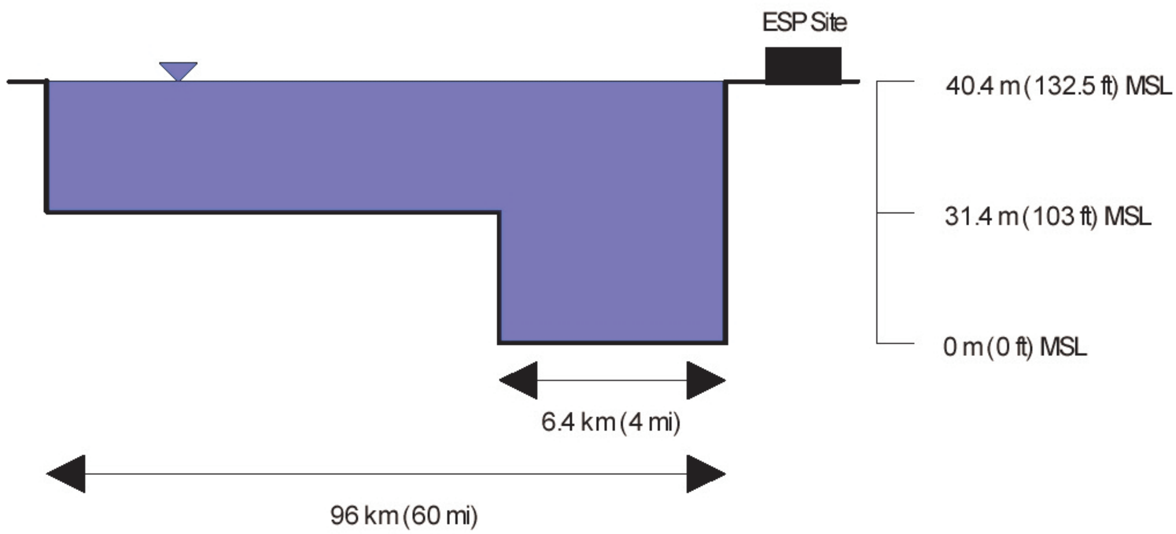

Figure 2.4-8 Simplified cross-section of the Mississippi River near the ESP site (not drawn to scale)

Based on a staff-assumed Manning's roughness coefficient of 0.025 for natural channels and a bed slope of 0.2 feet per mile (ft/mi), the staff estimated the discharge in the Mississippi River corresponding to a water surface elevation of 132.5 feet above MSL as 46.3 million cfs. This estimate is more than four times larger than the discharge capacity of the river at a water surface elevation of 103 feet above MSL, and about seven times larger than the applicant-estimated PMF. Therefore, the staff concluded that the ESP site is safe from flooding caused by a seismically induced dam failure upstream of the GGNS site.

2.4.4.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to dam failures. Therefore, the staff concludes that the applicant has met the requirements for dam failures with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). The staff finds that the application is in partial compliance with GDC 2 with respect to the assumption of upstream dam failure caused by a seismic event.

2.4.5 Probable Maximum Surge and Seiche Flooding

The ESP site is adjacent to the existing GGNS Unit 1 site, located on the bluffs to the east of the Mississippi River floodplain at approximately river mile 406. The existing power plant site has a grade elevation of 132.5 feet above MSL.

2.4.5.1 Technical Information in the Application

SERI stated in SSAR Section 2.4.5 that the ESP site is not located in a coastal region or on a lake. Therefore, the applicant concluded that consideration of surge and seiche flooding was not warranted.

2.4.5.2 Regulatory Evaluation

Section 1.4 of the application discusses conformance to NRC regulatory guidance. The applicant identified the applicable regulations as 10 CFR 52.17(a) and 10 CFR 100.20. The staff finds that the applicant correctly identified the applicable regulatory guidance as RG 1.70. Section 2.4.5 of RS-002 provides the review guidance used by the staff to evaluate this SSAR section.

The acceptance criteria for this section are based on meeting the requirements of the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100, as they relate to evaluating the hydrologic characteristics of the site

The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the review take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's safety assessment should contain a description of the surface and subsurface hydrologic characteristics of the region and an analysis of the potential for flooding caused by surges or seiches. This description should be sufficient to assess the acceptability of the site and the potential for a surge or seiche to influence the design of SSCs important to safety for a nuclear unit(s) of a specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the most severe flooding likely to occur as a result of storm surges or seiches will not pose an undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters. Important PPE parameters for SSAR Section 2.4 include, but are not limited to, precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

If it has been determined that surge and seiche flooding estimates are necessary to identify flood design bases, the NRC will consider the applicant's analysis to be complete and acceptable if it addresses the following areas and if the staff can independently and comparably evaluate them based on the applicant's submission:

- All reasonable combinations of PMH, moving squall line, or other cyclonic windstorm parameters are investigated, and the most critical combination is selected for use in estimating a water level.

- Models used in the evaluation are verified or have been previously approved by the staff.

- Detailed descriptions of bottom profiles are provided (or are readily obtainable) to enable an independent staff estimate of surge levels.

- Detailed descriptions of shoreline protection and safety-related facilities are provided to enable an independent staff estimate of wind-generated waves, runup, and potential erosion and sedimentation.

- Ambient water levels, including tides and sea level anomalies, are estimated using NOAA and USACE publications, as described below.

- Combinations of surge levels and waves that may be critical to the design of a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site are considered, and adequate information is supplied to allow a determination that no adverse combinations have been omitted.

- At the COL stage, if the applicant elects RG 1.59, Position 2, the adequacy of the design basis for flood protection of all safety-related facilities identified in RG 1.29 should be shown in terms of the time necessary for the implementation of any emergency procedures. The applicant should also demonstrate that the less severe design basis selected provides for all potential flood situations that could negate the time and capability to initiate flood emergency procedures.

This section of the SSAR may also state with justification that surge and seiche flooding estimates are not necessary to identify the flood design basis (e.g., the site is not near a large body of water).

Hydrometeorological estimates and criteria for the development of PMHs for East and Gulf Coast sites, squall lines for the Great Lakes, and severe cyclonic windstorms for all lake sites by USACE, NOAA, and the staff are used for evaluating the conservatism of the applicant's estimates of severe windstorm conditions, as discussed in RG 1.59. USACE and NOAA criteria call for variation of the basic meteorological parameters within given limits to determine the most severe combination that could result. The applicant's hydrometeorological analysis should be based on the most critical combination of these parameters.

Data from publications by NOAA, USACE, and other sources (such as tide tables, tide records, and historical lake level records) are used to substantiate antecedent water levels. These antecedent water levels should be as high as the 10-percent exceedance monthly spring high tide, plus a sea-level anomaly based on (1) the maximum difference between recorded and predicted average water levels for durations of 2 weeks or longer for coastal locations or (2) the 100-year recurrence interval high water for the Great Lakes. In a similar manner, the staff independently analyzes the storm track, wind fields, effective fetch lengths, direction of

approach, timing, and frictional surface and bottom effects to ensure that the applicant selected the most critical values. Models used to estimate surge hydrographs that the staff has not previously reviewed and approved are verified by reproducing historical events, with any discrepancies in the model being on the conservative (i.e., high) side.

The staff uses USACE criteria and methods, as generally summarized in RS-002, as a standard to evaluate the applicant's estimate of coincident wind-generated wave action and runup.

The staff uses USACE criteria and methods and other standard techniques to evaluate the potential for oscillation of waves at natural periodicity.

At the COL stage, the staff uses USACE criteria and methods to evaluate the adequacy of protection from flooding, including the static and dynamic effects of broken, breaking, and nonbreaking waves. RG 1.102 provides further guidance on flood protection, and RG 1.125, Revision 1, "Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants," issued October 1978, provides guidance for using physical models in assessing flood protection.

2.4.5.3 Technical Evaluation

The staff conducted its review in accordance with RS-002, Section 2.4.5, and RG 1.59.

Because the ESP site is located on a flowing river, an increase in water surface elevation on one bank of the river because of wind blowing across the water's surface would be minor and negligible during nonflood conditions. This conclusion follows because the ESP site is located at an elevation of 132.5 feet above MSL and the normal surface elevation of the Mississippi River is between 55 and 75 feet above MSL. Section 2.4.3 of this report examined wind waves on the water surface during the DPF, which were found not to impact the ESP facility or facilities because of the grade elevation of the ESP site.

Storm surge flooding is unlikely to have a measurable impact at the ESP site because of the distance (406 river miles), elevation change of the water surface (typically between 55 and 75 feet above MSL) between the site and the mouth of the Mississippi River, and the elevation of the ESP site (132.5 feet above MSL) during nonflood river conditions. During a large storm event, a surge in the Gulf of Mexico would hinder flow from exiting the Mississippi River because the difference of elevation between the two water bodies would be less, causing backwater effects. The applicant took backwater effects into account during the estimation of the DPF, discussed in Section 2.3.4 of this report, which was also the worst-case scenario for storm surge.

2.4.5.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to surge and seiche. Therefore, the staff concludes that the applicant has met the requirements for surge and seiche with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c).

2.4.6 Probable Maximum Tsunami Flooding

The ESP site is adjacent to the existing GGNS Unit 1 site, located on the bluffs to the east of the Mississippi River floodplain at approximately river mile 406. The existing GGNS Unit 1 power plant site has a grade elevation of 132.5 feet above MSL.

2.4.6.1 Technical Information in the Application

The applicant stated that the ESP site is located near river mile 406 above Head of Passes and is not in a coastal region. Therefore, SERI did not expect any effects on water level in the Mississippi River resulting from geoseismic activity to occur at the ESP site.

In RAI 2.4.6-1, the staff asked the applicant to document any seismically induced tsunami-like waves near the ESP site. The staff also requested that the applicant include in its review the ability of a tsunami-like wave to impact the ESP site. In response to this RAI, SERI stated that no historical indication exists of landslides in the GGNS area caused by seismic activity, according to the Center for Earthquake Research and Information in Memphis, Tennessee. The applicant also stated that USACE did not have any records of bluff failures or collapses in the GGNS site area.

SERI noted that according to USACE, the Mississippi coast is located in Tsunami Zone 1, with a predicted wave height of 5 feet. Conservatively assuming a coastal tsunami wave reached the GGNS site without attenuation and was coincident with the DPF on the Mississippi River, the maximum combined wave height would be 107.1 feet above MSL (102.1 feet from DPF + 5 feet from tsunami). The applicant concluded that the tsunami wave would not affect the ESP facility or facilities located at an elevation of 132.5 feet above MSL.

2.4.6.2 Regulatory Evaluation

Section 1.4 of the application discusses the applicant's conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulations and guidance as 10 CFR 52.17(a), 10 CFR 100.20(c), and RG 1.70.

Section 2.4.6 of RS-002 provides the following review guidance used by the staff to evaluate this SSAR section. The acceptance criteria for this section are based on meeting the requirements of the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100, as they relate to identifying and evaluating hydrologic features of the site

- 10 CFR 100.23, as it relates to investigating the tsunami potential at the site

The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the NRC take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s). The regulations at 10 CFR Part 52 and 10 CFR Part 100 apply to RS-002, Section 2.4.6, because they address the physical characteristics, including hydrology, considered by the Commission when

determining the acceptability of the proposed site. To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of the hydrologic characteristics of the coastal region in which the proposed site is located and an analysis of severe seismically induced waves. The applicant's description should be sufficient to assess the site's acceptability and the potential for a tsunami to influence the design of SSCs important to safety for a nuclear unit(s) of specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the most severe flooding likely to occur as a result of a tsunami will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of parameters. Important PPE parameters for SSAR Section 2.4 include, but are not limited to, precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

The regulation at 10 CFR 100.23(c) requires that the NRC consider the geologic and seismic factors when determining suitability of the site. Pursuant to 10 CFR 100.23(c), an investigation must be completed to obtain geologic and seismic data necessary for evaluating seismically induced floods and water waves. This regulation also applies to RS-002, Section 2.4.6, because it requires the investigation of distantly and locally generated waves or tsunamis that have affected or could affect a proposed site, including available evidence regarding the runup or drawdown associated with an historic tsunami in the same coastal region and local features of coastal topography that might modify runup or drawdown. RG 1.70 provides more detailed guidance on the investigation of seismically induced flooding.

Though not required at the ESP stage, the applicant for a COL must demonstrate compliance with GDC 2 as it relates to designing SSCs important to safety to withstand the effects of a tsunami.

To judge whether the applicant has met the requirements of 10 CFR Part 52, 10 CFR Part 100, and 10 CFR 100.23 with respect to tsunamis and the analysis thereof, the NRC uses the following criteria:

- If it has been determined that tsunami estimates are necessary to identify flood or low-water design bases, the NRC will consider the applicant's analysis to be complete if it addresses the following areas and if the staff can independently and comparably evaluate them based on the applicant's submission:

    — All potential distant and local tsunami generators, including volcanoes and areas of potential landslides, are investigated, and the most critical ones are selected.

    — Conservative values of seismic characteristics (source dimensions, fault orientation, and vertical displacement) for the tsunami generators selected are used in the analysis.

— The staff previously approved or verified all models used in the analysis. RG 1.125 provides guidance in the use of physical models of wave protection structures.

— Bathymetric data are provided (or are readily obtainable).

— Detailed descriptions of shoreline protection and safety-related facilities are provided for wave runup and drawdown estimates. RG 1.102 provides guidance on flood protection for nuclear power plants.

— Ambient water levels, including tides, sea level anomalies, and wind waves, are estimated using NOAA and USACE publications, as described below.

— If the applicant adopts RG 1.59, Position 2, the design basis for tsunami protection of all safety-related facilities identified in RG 1.29 should be shown at the COL stage to be adequate in terms of the time necessary for implementation of any emergency procedures.

- The applicant's estimates of tsunami runup and drawdown levels are acceptable if the estimates are no more than 5 percent less conservative than the staff's estimates. If the applicant's estimates are more than 5 percent less conservative (based on the difference between normal water levels and the maximum runup or drawdown levels) than the staff's, the applicant should fully document and justify its estimates or accept the staff's estimates.

- This section of the SSAR will also be acceptable if it states that the criteria used to determine that tsunami flooding estimates are not necessary to identify the flood design basis (e.g., the site is not near a large body of water).

2.4.6.3 Technical Evaluation

The staff investigated two potential failure mechanisms that have the potential to cause flooding and that other sections do not cover, including hill slope failure and an inland tsunami generated by an earthquake.

The area surrounding the ESP site is relatively flat, except for the bluffs upon which the ESP facility or facilities would be constructed. Hill slopes on the bank opposite the ESP site do not have the potential to fail in such a manner that a wave could be produced of sufficient height to flood the ESP site. In addition, the integrity of the bank in the vicinity of the plant was evaluated for the construction of GGNS Unit 1. As SERI stated in SSAR Section 2.4.3.6, the new facility would be closer to the bluffs than the existing reactor containment, and the potential impact of a new facility to bank stability will be evaluated before the final design construction.

Earthquakes have the potential to create tsunami-like waves and have occurred on the Mississippi. According to Lockridge, et al. (2002), three earthquakes near New Madrid, Missouri, occurred during the winter of 1811–1812 (December 6, January 16, and February 7) that generated large tsunami-like waves. Observers of the New Madrid earthquake reported walls of water that were 15 to 20 feet high. Because these events are rare, one is unlikely to

occur during the time of the PMF. Therefore, assuming a normal mean annual flood elevation of approximately 75 feet above MSL, a tsunami-like wave would have to reach a height greater than 50 feet to inundate the ESP site, which is not credible.

According to NOAA, since 1990, the 10 most destructive tsunamis in the Pacific produced maximum wave heights of 9.8 to 49.2 feet. Effects of even the largest ocean tsunamis occurring during an annual flood event (water surface elevation 75 feet above MSL) would not be of sufficient height to exceed the elevation of the ESP site (grade elevation 132.5 feet above MSL).

The staff also examined the possibility of a severe landslide, concluding that bank slopes on the opposite side of the river from the site are not of sufficient height to generate a wave that could flood the ESP site.

2.4.6.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to probable maximum tsunami flooding. Therefore, the staff concludes that the applicant has met the requirements for probable maximum tsunami flooding with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3). The staff concludes that the ESP site is safe from tsunami flooding, and this application is in partial conformance with GDC 2.

2.4.7 Ice Effects

The ESP site, with coordinates of approximately 32E N latitude and 91E3' W longitude, is adjacent to the existing GGNS Unit 1 site, located on the bluffs to the east of the Mississippi River floodplain at approximately river mile 406. The existing GGNS Unit 1 power plant site has a grade elevation of 132.5 feet above MSL. Runoff resulting from precipitation and snow melt on major tributaries, including the Ohio, Missouri, Arkansas, and Red Rivers, is primarily responsible for flooding in the Mississippi River.

2.4.7.1 Technical Information in the Application

In SSAR Table 2.4-16, the applicant summarized water temperatures at the USGS gauging station on the Mississippi River at Vicksburg for the period 1973–1999. The applicant reported that the lowest temperature recorded at the USGS gauging station was 34.7 EF. In SSAR Table 2.4-16a, SERI also summarized water temperatures recorded by USACE in the Mississippi River at Vicksburg for the period 1962–1979. As shown in Table 2.4-16a, USACE reported the lowest water temperature as ranging from 30 to 40 EF in January 1970. From these two data sources, the applicant concluded that water temperatures in the Mississippi River near the GGNS site are expected to be above the freezing point most of the time.

SERI searched the USACE historical database of ice jams on the Mississippi River in September 2002. The applicant noted that this database did not list any ice jams on the Mississippi River in Mississippi or Louisiana. One ice jam was reported for the Mississippi River in Arkansas on February 1, 1940. SERI concluded that the possibility of a flood resulting from an ice jam occurring downstream of the site was remote, especially because of the continued

development of river control works for navigation, irrigation, and flood control on the Mississippi River and its principal tributaries.

The applicant argued that, in the event of ice-jam-induced high flows, a rise in water level above 103 feet above MSL at the site would result in the overtopping of the levees and the diversion of water into the floodplain on the west bank of the Mississippi River. SERI stated that, since the proposed site for a new facility is located on the property's upland area and is significantly above 103 feet above MSL, ice-jam-induced high flows in the Mississippi River would not affect it.

According to the applicant, in Section 2.4.8 of the NRC SER for GGNS Unit 1 (NUREG-0831), the NRC reported the occurrence of an ice jam at Vicksburg, Mississippi, on February 3, 1940. However, the NRC concluded that the occurrence of a major ice jam on the Mississippi River was very unlikely. SERI stated that the NRC concurred that ice flooding was not a design-basis consideration for the GGNS Unit 1 site.

2.4.7.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance.

Section 2.4.7 of RS-002 provides the review guidance used by the staff to evaluate this SSAR section. The acceptance criteria for this section are based on meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100, as they relate to identifying and evaluating the hydrologic features of the site.

The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the NRC take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability for hosting a nuclear power reactor(s). To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the SSAR should contain a description of any icing phenomena with the potential to result in adverse effects to the intake structure or other safety-related facilities for a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site. Applicants should describe ice-related characteristics historically associated with the site and region, and they should perform an analysis to determine the potential for flooding, low water, or ice damage to safety-related SSCs. The analysis should be sufficient to evaluate the site's acceptability and to assess the potential for those characteristics to influence the design of SSCs important to safety for a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site. Meeting this guidance provides reasonable assurance that the effects of potentially severe icing conditions will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters.

RG 1.59 provides guidance for developing the hydrometeorologic design basis.

To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to ice effects, the NRC uses the following criteria:

- Publications by NOAA, USGS, USACE, and other sources are used to identify the history and potential for ice formation in the region. The historical maximum depths of icing should be noted, as well as mass and velocity of any large, floating ice bodies. The phrase, "historical low water ice affected," or similar phrases in streamflow records (USGS and State publications) will alert the reviewer to the potential for ice effects. The following items should be considered and evaluated, if necessary:

  — The regional ice and ice jam formation history should be described to enable an independent determination of the need for including ice effects in the design basis.

  — If the potential for icing is severe, based on regional icing history, it should be shown that water supplies capable of meeting safety-related needs are available from under the ice formations postulated and that safety-related equipment could be protected from icing. If this cannot be shown, it should be demonstrated that alternate sources of water are available that could be protected from freezing and that the alternate source would be capable of meeting safety-related requirements in such situations.

  — If floating ice is prevalent, based on regional icing history, potential impact forces on safety-related intakes should be considered. The structural design basis should include dynamic loading caused by floating ice. (This item will be addressed at the COL or CP stage.)

  — If ice blockage of the river or estuary is possible, it should be demonstrated that the resulting water level in the vicinity of the site has been considered. If this water level would adversely affect the intake structure or other safety-related facilities of a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site, it should be demonstrated that it would not also adversely affect an alternate safety-related water supply.

- The applicant's estimates of potential ice flooding or low flows are acceptable if the estimates are no more than 5 percent less conservative than the staff estimates. If the applicant's estimates are more than 5 percent less conservative than the staff's, the applicant should fully document and justify its estimates or accept the staff estimates.

2.4.7.3 Technical Evaluation

The staff verified the water temperatures at the USGS gauging station on the Mississippi River at Vicksburg for the period 1973–1999 on June 23, 2004. The staff downloaded daily water quality data, including water temperature, from USGS. The staff found that the lowest water temperature recorded at this USGS station was 34.7 EF, which occurred on January 4, 1977; February 8, 1977; and February 3, 1978. The staff also obtained water temperature data from the USACE Mississippi River Office in Vicksburg for the period 1991–2003. The USACE measured these temperatures near the water surface. The USACE reported the lowest water

temperature as 33 °F, which occurred on January 5, 2001. From these data, the staff concluded that water temperatures are expected to be above the freezing point most of the time in the Mississippi River near the GGNS site.

The staff reviewed air temperature records from the National Climate Data Center spanning January 1930 through December 2001 for the Port Gibson weather station. The average minimum daily temperature was 34.4 °F for the month of January and 37.5 °F for the month of February. The average minimum daily temperature ranged from 33 to 39 °F in December, 32 to 37 °F in January, and 34 to 41 °F in February. The lowest daily minimum air temperature at this station was −5 °F, which occurred on January 27, 1940.

The staff reviewed concurrently available data to look at the differences between water and air temperatures during the winter months (December through March) at Vicksburg. The staff found that the water temperatures in the Mississippi River were consistently higher than the air temperatures during these months. Therefore, the staff concluded that it is highly unlikely that, even when air temperatures fall near historical lows, the water in the Mississippi River will not freeze.

On December 28, 2004, the staff searched the USACE historical database of ice jams on the Mississippi River. This database does not list any ice jams on the Mississippi River in Mississippi or Louisiana. Figure 2.4-9 shows several ice jams reported on the Mississippi River. One ice jam was reported on the Mississippi River at Helena, Arkansas, located at approximately river mile 663, on February 1, 1940. This ice jam was the closest to the GGNS site and persisted for 3 days. The database does not list any ice jams downstream of Helena, Arkansas, on the Mississippi River.

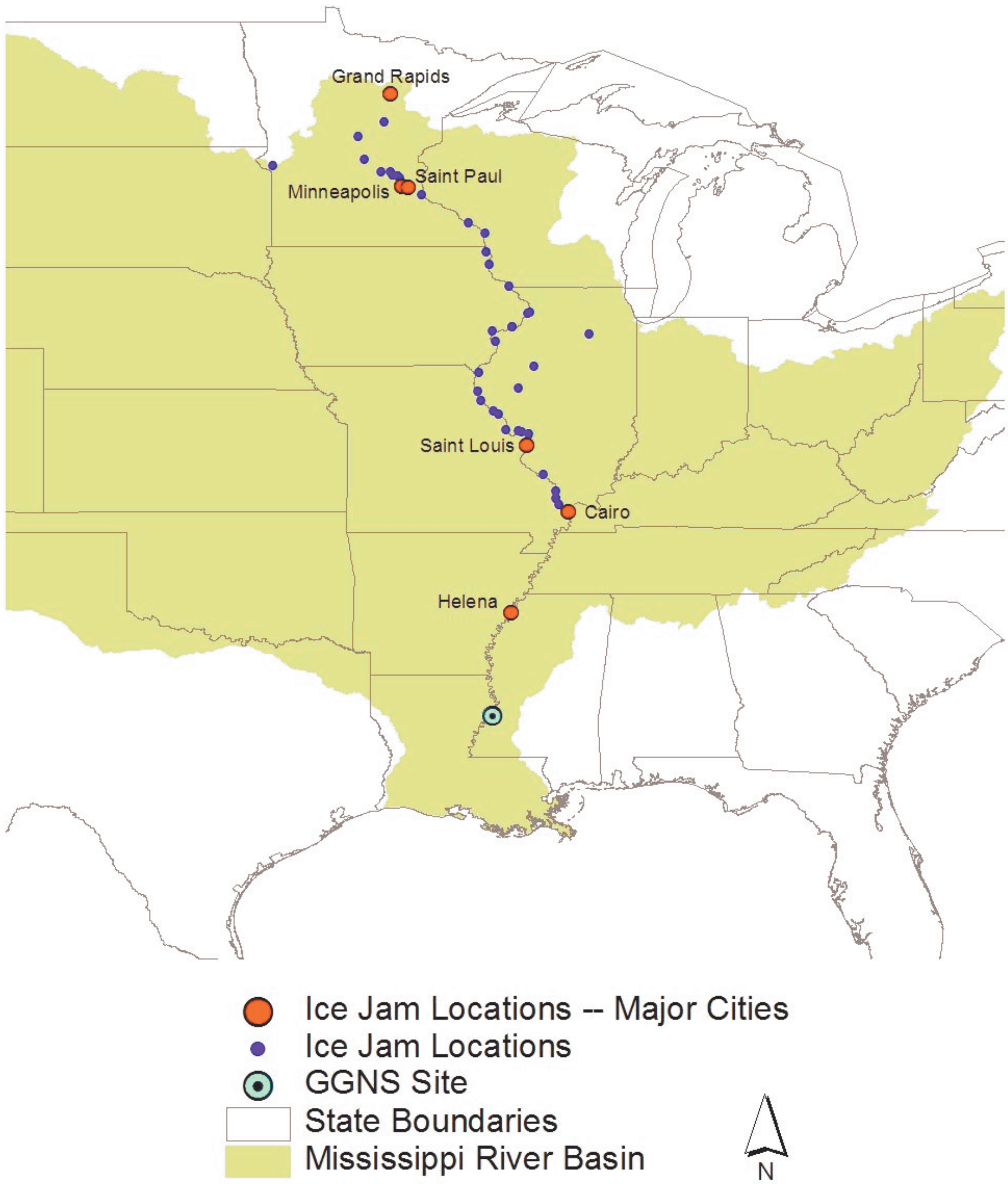

Figure 2.4-9 Locations of reported ice jams on the Mississippi River

The closest location of sustained ice jam on the Mississippi River is more than 250 river miles upstream of the GGNS site. Based on the staff review of the ice jam database, the likelihood of flooding resulting from an ice jam downstream of the GGNS site is considered remote. In addition, continued development of river control works for navigation, irrigation, and flood control on the Mississippi River and its principal tributaries would reduce the possibility of a sustained ice jam.

If an ice jam were to occur, and if ice-jam-induced high flows raise the water level to 103 feet above MSL at the GGNS site, it would result in the overtopping of the levees and diversion of water into the floodplain on the west bank of the Mississippi River. The staff determined that the ESP site, located on the upland area of the GGNS property at a plant grade of 132.5 feet above MSL, will be safe from any potential flooding resulting from ice jams.

In the event of low flow from ice blockage, safety-related facilities would not be adversely affected, as the UHS would provide a source of cooling and service water to maintain the plant in a safe mode.

Ice can produce forces on, or can create blockage of, safety-related equipment. Frazil and anchor ice can also form on components. In ER Section 3.4.1.3, SERI stated that the UHS for the ESP facility or facilities would include a dedicated water storage basin. Since the UHS for the ESP facility or facilities would have a dedicated water storage basin(s), the staff considered the effect of sustained low temperatures at the ESP site to evaluate the potential for freezing of the UHS water storage basin(s). DSER Permit Condition 2.4-5 is eliminated in Section 2.4.8.3 of this SER, which would have required that the COL applicant demonstrate that sufficient water will be available for a 30-day UHS supply, accounting for any losses resulting from ice formation in the dedicated water storage basin. However, based on the applicant's response to open items, the staff determined that the detailed design of the ESP facility, including its UHS and dedicated water storage basin(s), will not be available until the COL stage. At that time, the NRC will review the complete design of the ESP facility UHS using existing regulations and regulatory guidance. The staff determined, therefore, that specification of DSER Permit Condition 2.4-5 is not necessary. The COL applicant should show that sufficient liquid water will be available for a 30-day ESP facility UHS supply, accounting for any losses resulting from ice formation in the dedicated water storage basin. This is COL Action Item 2.4-6 stated in Section 2.4.8.3 of this SER. In Section 2.3.1.1 of this SER, the staff discusses the resolution of the cooling parameter at the ESP site. The staff has identified a characteristic value of 98 EF degree days (i.e., 98 accumulated freezing degree days), based on daily minimum and maximum temperatures recorded at Port Gibson for the period 1930–2001.

2.4.7.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to ice effects. Therefore, the staff concludes that the applicant has met the requirements for ice effects with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), and the application is in partial conformance with GDC 2 and 44, "Cooling Water."

2.4.8 Cooling Water Canals and Reservoirs

The ESP site is located on the east bank of the Mississippi River near river mile 406. The applicant proposed the use of a mechanical draft cooling tower and a dedicated makeup water storage basin for the UHS for the ESP facility or facilities.

2.4.8.1 Technical Information in the Application

On page 2.4-18 of the SSAR, the applicant stated, “there are no current or proposed cooling water canals or reservoirs at the Grand Gulf Nuclear Station site.” This quotation is the applicant’s complete submission on this topic in SSAR Section 2.4.8. The staff gleaned the following additional information from the ER.

In ER Section 3.3, SERI stated, “the majority of raw water would be withdrawn from the Mississippi River via an intake structure on the river shoreline and other wells would be used.” In the same section, the applicant also stated that raw water might be used for makeup water for a UHS cooling system.

In Section 3.3.1.3, SERI noted that it anticipated the UHS to be a closed-loop system with a water reservoir and mechanical draft cooling tower(s), and makeup water should replenish water losses because of evaporation, drift, and blowdown.

In ER Section 3.4.1.3, the applicant indicated that the UHS could be used for nonemergency operations. In this section, SERI also stated, “A closed-loop UHS for the new facility would be comprised of pumps, heat exchangers, a dedicated water basin, and cooling tower(s).”

2.4.8.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant’s conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance.

The acceptance criteria for this section are based on meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to identifying and evaluating the hydrologic features of the site.

Compliance with 10 CFR 52.17(a) and 10 CFR 100.20(c) requires that the NRC take into account the site’s physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear power reactor(s). To satisfy the hydrologic requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant’s SSAR should describe the cooling water canals and reservoirs for a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. The analysis related to cooling water canals and reservoirs should be sufficient to evaluate the site’s acceptability and to assess the potential for those characteristics to influence the design of SSCs important to safety for a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the capacities of cooling water canals and reservoirs are adequate.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of parameters. Important PPE parameters for SSAR Section 2.4 include, but are not limited to, cooling needs (e.g., adverse local meteorological conditions, high ambient temperature).

Though not required at the ESP stage, the applicant for a COL must demonstrate compliance with GDC 2 as it relates to designing SSCs important to safety to withstand the effects of natural phenomena.

2.4.8.3 Technical Evaluation

The staff visually inspected the ESP site during the site safety analysis visit on June 29–30, 2004. No cooling water canals exist or are planned at the ESP site.

SERI proposed that the UHS for the ESP facility or facilities consist of a mechanical draft cooling tower(s) supplied by a dedicated water storage basin(s).

RG 1.27 specifies a UHS capable of providing sufficient cooling for 30 days to permit simultaneous safe shutdown and cooldown of all nuclear reactor units that it serves and to maintain them in a safe-shutdown condition. In addition, procedures for ensuring continued capability after 30 days should be available. In ER Section 3.4.1.3, the applicant stated that the UHS may be used for nonemergency operations, but it did not specify the frequency of such nonemergency UHS usage. The UHS storage basin could lose water because of leakage, evaporation, or ice formation.

The COL applicant must demonstrate the availability of a 30-day cooling water supply for the UHS, accounting for any losses including, but not limited to, those resulting from evaporation, seepage, icing, and a margin of safety. The staff intended to propose that the Commission include this requirement in the ESP, should it be granted. However, based on the applicant's response to open items, the staff determined that the detailed design of the ESP facility, including its UHS and dedicated water storage basin(s), will not be available until the COL stage. At that time, the NRC will review the complete design of the ESP facility UHS using existing regulations and regulatory guidance. The staff determined, therefore, that specification of DSER Permit Condition 2.4-5 is not necessary. The COL applicant should demonstrate that a 30-day cooling water supply for the ESP facility UHS will be available as liquid water in any dedicated water storage basin(s), accounting for any losses including, but not limited to, those resulting from evaporation, seepage, icing, and a margin of safety. This is **COL Action Item 2.4-6.**

The COL applicant must demonstrate that the UHS is not used frequently for nonemergency use. The staff intended to specify this requirement as DSER Permit Condition 2.4-6. However, based on the applicant's response to open items, the staff determined that the detailed design of the ESP facility, including its UHS and dedicated water storage basin(s), will not be available until the COL stage. At that time, the NRC will review the complete design of the ESP facility UHS and its performance, including the frequency of reliance of the ESP facility on its UHS, according to existing regulations and regulatory guidance. The staff determined, therefore, that

specification of DSER Permit Condition 2.4-6 is not necessary. The COL applicant should demonstrate that the ESP facility UHS will not be used frequently for nonemergency operation of the ESP facility. This is **COL Action Item 2.4-7.**

2.4.8.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to cooling water canals and reservoirs. Therefore, the staff concludes that the applicant has met the requirements for cooling water canals and reservoirs with respect to Appendix A to 10 CFR Part 50, 10 CFR 52.17(a), and 10 CFR 100.20(c)(3).

2.4.9 Channel Diversions

The ESP site is located on the east bank of the Mississippi River near river mile 406, approximately 25 miles south of Vicksburg, Mississippi, and 6 miles northwest of Port Gibson, Mississippi. The ESP site is bounded on the east by loessial bluffs and on the west by the Mississippi River. The floodplain of the Mississippi River near the ESP site ranges in elevation from 55 to 75 feet above MSL. The existing GGNS Unit 1 power plant site has a grade elevation of 132.5 feet above MSL.

2.4.9.1 Technical Information in the Application

In SSAR Section 2.4.9, the applicant stated that USACE protects the banks of the Mississippi River in the Lower Mississippi region. Protection and stabilization methods include placing revetments composed of articulated concrete under water and stone riprap above the waterline. SERI stated that a revetment mattress is composed of 20 individual concrete blocks, each 4 feet long, 14 inches wide, and 3 inches thick, that are assembled into blocks 4 feet wide and 25 feet long. These blocks are fastened together to form mattresses 140 feet wide that are laid on the river bank in a pattern that resembles shingles on a roof. Usually, an entire bend is revetted from the upstream point of river current attack to the point where the channel crosses to the opposite bank.

The applicant stated that the Mississippi River has in the past experienced, and is currently undergoing, lateral shifting near the GGNS site, as indicated by the presence of oxbow lakes, sand bars, and low-lying swamps. The river divides into two branches around Middle Ground Island that rejoin at approximately river mile 408. SERI noted that USACE performed extensive work to stabilize the river, including construction of submerged dikes across the western channel to help divert flow through the eastern channel and construction of Grand Gulf revetments on the east bank from approximately river mile 400.5 to 407.9 and from river mile 408.2 to 410.0. During the 1960s and 1970s, USACE completed Grand Gulf revetments from river mile 400.5 to 405.0 and from river mile 408.5 to 409.6. The USACE left the rest of the bank between river miles 400.5 and 410.0 unprotected to undergo erosion until it attained acceptable alignment. The USACE then completed the revetment on the east bank down to river mile 410.0 during the mid-1970s and early 1980s, with a small gap at the existing GGNS barge slip.

The applicant stated that USACE does not have any plans to carry out additional revetment work near the GGNS site, except for occasional maintenance of existing structures. The

USACE also evaluates the need for additional shoreline work, and SERI expects it to make improvements where appropriate.

In RAI 2.4.9-1, the NRC staff requested that the applicant provide copies of references related to geologic features or other characteristics that might preclude any likelihood of channel diversion upstream of the site. In response to RAI 2.4.9-1, SERI listed several references from the GGNS UFSAR and the GGNS ESP application.

2.4.9.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance.

The staff used the review guidance provided in RS-002, Section 2.4.9, to evaluate this SSAR section. The acceptance criteria for this section relate to 10 CFR Part 52 and 10 CFR Part 100, insofar as they require that the site evaluation consider hydrologic characteristics. The regulations at 10 CFR 52.17(a), 10 CFR 100.20(c), and 10 CFR 100.21(d) require that the NRC take into account the physical characteristics of the site (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

Channel diversion or realignment poses the potential for flooding or for an adverse effect on the supply of cooling water for a nuclear unit(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site. Therefore, it is one physical characteristic that must be evaluated pursuant to 10 CFR 100.21(d). The consideration of the 10 CFR 100.21(d) criteria in this evaluation provides reasonable assurance that the effects of flooding caused by channel diversion resulting from severe natural phenomena will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters.

To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to channel diversion, the NRC uses the following criteria:

- A description of the applicability (potential adverse effects) of stream channel diversions is necessary.

- Historical diversions and realignments should be discussed.

- The topography and geology of the basin and its applicability to natural stream channel diversions should be addressed.

- If applicable, the safety consequences of diversion and the potential for high or low water levels caused by upstream or downstream diversion to adversely affect safety-related facilities, water supply, or the UHS should be addressed. RG 1.27 provides guidance on acceptable UHS criteria.

2.4.9.3 Technical Evaluation

During its independent review, the staff found on the Web site of the USACE, Vicksburg District, River Operations Branch (ROB) that it—

> …is responsible for channel improvement, dredging, and navigation activities on the lower Mississippi, Red, Ouachita/Black, and Pearl rivers. This work is accomplished by utilizing specialized floating plant, dustpan and cutterhead dredges, towboats, survey boats, and various other river-related equipment. The scope of work encompasses four Corps of Engineers districts, seven states, multiple watersheds, and utilizes the latest technology in river engineering and operations.

The ROB defines a revetment as a "facing (such as of stone or concrete) to sustain an embankment." Every autumn, the ROB mat sinking unit, which comprises some 400 employees, begins several months of work on the river for establishing locations that need bank stabilization. Traditionally, the unit carries out this work during the low-water months of August through November.

The staff found that USACE, Vicksburg District, provided the location of the dikes constructed on the Mississippi River, along with their elevations, in Navigation Bulletin No. 1, "Special Notice: Mississippi River," issued 2004. The USACE constructs these pile and stone dikes in reaches where it is difficult to maintain a navigable channel. The USACE expects that the dikes will reduce flow in secondary channels, thus restricting the width of reaches and helping to maintain good navigation conditions.

The staff found that USACE constructed the dikes at frequent intervals on the Mississippi River channel along the Grand Gulf revetment from approximately river mile 410 to river mile 399 (sheets 26 and 27 in Navigation Bulletin No. 1). Three groups of dikes, named Yukatan, Coffee Point, and Below Grand Gulf Dike Fields, extend from river mile 410.4 to 407.4, river mile 405.0 to 401.8, and river mile 400.3 to 399.0, respectively. The Yucatan and Coffee Point dike groups are on the western part of the channel as the river bends right, flowing past the Grand Gulf Revetment on the east bank. The Below Grand Gulf dikes group is located on the eastern part of the channel as the river bends left, flowing past the Hardscrabble Revetment on the west bank.

Based on its independent review, the staff found that SERI adequately described the issues relating to channel diversions near the ESP site. The Lower Mississippi River is heavily navigated, and USACE, Vicksburg District, is responsible for maintaining navigable conditions. As part of this responsibility, USACE actively maintains revetments and dikes that are constructed to minimize risk of channel diversions, bank erosion, and instability.

2.4.9.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to channel diversions. Therefore, the staff concludes that the applicant has met the requirements for channel diversions with respect to Appendix A to 10 CFR Part 50, 10 CFR 52.17(a), and 10 CFR 100.20(c)(3).

2.4.10 Flooding Protection Requirements

The ESP site is located at approximately 32E N latitude and 91E3' W longitude. The ESP site is located at approximately river mile 406 on the east bank of Mississippi River, about 25 miles south of Vicksburg, Mississippi. GGNS Unit 1 is located at a grade elevation of 132.5 feet above MSL.

Two small, steep streams flow around the ESP site, draining a combined area of less than 4 mi^2, and into Lake Hamilton, located in the floodplain of the Mississippi River. The ESP site drains partially to both streams.

The ESP site is subject to flooding in the Mississippi River, flooding in the two small streams that flow around the ESP site, and local flooding in response to intense precipitation.

2.4.10.1 Technical Information in the Application

In Table 2.4-14 of the SSAR, SERI estimated the design-basis flood elevation in the Mississippi River near the GGNS site as 108.8 feet above MSL. This flood elevation includes flooding caused by the PMF, wind setup, and wave runup. In SSAR Section 2.4.10, the applicant stated that, since it has not selected a specific design for the ESP plant, no final plant grade has been determined. In this section, SERI also stated that all safety-related SSCs of the ESP facility or facilities will be located at or above the site grade elevation of 133 feet above MSL or protected from flooding such that the site would meet the requirements of GDC 2 and 10 CFR Part 100.

2.4.10.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant’s conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance. Acceptance criteria for this section relate to 10 CFR Part 52 and 10 CFR Part 100, insofar as they require that the site evaluation consider hydrologic characteristics. Specifically, the regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the NRC take into account the physical characteristics of the site (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

The regulation at 10 CFR 100.20(c) requires estimation of the PMF using historical data. Meeting this requirement provides reasonable assurance that the effects of flooding or a loss of flooding protection resulting from severe natural phenomena will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters.

To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 as they relate to flooding protection, the NRC uses the following criteria:

- The applicability (potential adverse effects) of a loss of flooding protection should be described.
- Historical incidents of shore erosion and flooding damage should be discussed.
- The topography and geology of the basin and its applicability to damage as a result of flooding should be addressed.
- If applicable, the safety consequences of a loss of flooding protection and the potential to adversely affect safety-related facilities, water supply, or the UHS should be addressed. RG 1.27 provides guidance on acceptable UHS criteria.

2.4.10.3 Technical Evaluation

The staff determined that the ESP site is subject to flooding in the Mississippi River as a result of PMP on the river's contributing area and coincident wind activity, flooding in the Mississippi River resulting from seismically induced upstream dam failures, flooding in the Mississippi River resulting from ice-jam-induced high flows, flooding in the local Streams A and B as a result of PMP on their respective contributing areas, and flooding on the ESP site caused by local intense precipitation.

In DSER Section 2.4.3.3, the staff determined that flooding in the Mississippi River because of a PMF and coincident wind activity will not result in inundation of the ESP site. The staff also noted in DSER Section 2.4.4.3 that seismically induced dam failures will not result in flooding of the ESP site. In DSER Section 2.4.7.3, the staff stated that ice jams on the Mississippi River are not likely to form sufficiently close to the GGNS site and that any high flows resulting from the breaking of such ice jams will not impact the safety of the ESP site.

The staff determined that local intense precipitation controls flooding in Streams A and B and on the ESP site. The applicant used HMR 33 and USACE EM-1110-2-1411 to estimate local intense precipitation at the ESP site. The applicant claimed that hourly rainfall rates derived from the more recent HMR 53 show only a 2-percent increase over the values determined using HMR 33. The staff stated that local intense precipitation obtained using the guidelines of HMR 52 shows a 37- and a 40-percent increase to 1-hour and 30-minute precipitation depths, respectively, compared to those reported by the applicant. This was Open Item 2.4-5, stated in Section 2.4.2.3 of this SER. Subsequent response from the applicant resolved Open Item 2.4-5, as documented in Section 2.4.2.3 of this SER.

As stated in Section 2.4.2.3 of this SER, the COL applicant must demonstrate that the ESP plant grade is safe from the flooding effects of maximum water surface elevation during local intense precipitation without relying on any active surface drainage systems that may be blocked during this event. This is COL Action Item 2.4-5, as stated in Section 2.4.2.3 of this SER.

2.4.10.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to flood protection requirements. Therefore, the staff concludes that the applicant has met the requirements for flood protection with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3), subject to the open items. The staff finds that the application is in partial conformance with GDC 2 for flood protection.

2.4.11 Low-Water Considerations

The ESP site is adjacent to the Mississippi River floodplain, from which ground water is withdrawn for cooling the existing GGNS Unit 1, and is located approximately at river mile 406. Water withdrawn directly from the river will supply the proposed ESP facility or facilities for normal heat sink cooling. Events such as low-river stage and intake blockages from sediment or ice may potentially reduce or limit the availability of cooling water at the site. Makeup water from a dedicated basin will supply the proposed ESP facility or facilities for UHS cooling.

2.4.11.1 Technical Information in the Application

In SSAR Section 2.4.2 and SSAR Figure 2.4-4, the applicant stated that the Lower Mississippi derives its water from six major subbasins, including Upper Mississippi, Missouri, Ohio, Arkansas, White, and Red-Ouachita. SERI concluded that low-flow conditions in the Mississippi River are a function of the nature of flow in the individual subbasins. Table 2.4-1 of the SSAR shows the percentage contribution to mean streamflow in the Lower Mississippi from these individual subbasins. The applicant stated that hydrometeorologic conditions in the basin vary greatly, and although it is difficult to predict low streamflow values in the Lower Mississippi, an analysis may be made on the basis of statistical considerations. SERI noted that no dams on the Mississippi River downstream of the site could affect the low streamflow condition near the GGNS site.

The applicant studied low-water conditions near the GGNS site on the basis of streamflow records at the Vicksburg Gauging Station. Table 2.4-17 of the SSAR presents the annual minimum daily streamflow observed at Vicksburg, Mississippi, for water years 1932–1979; this table also includes corresponding river stages. The minimum streamflow observed during the period of record was 99,400 cfs on November 1, 1940. SERI concluded that the corresponding historical low-flow elevation at the site was approximately 28 feet above MSL, and the mean 30-day low flow was 108,000 cfs, also measured in 1940.

The applicant also referred to a USACE data source for low streamflow in the Mississippi River at Vicksburg. SERI stated that, according to this data source, the lowest daily streamflow for the period 1930–2000 was 93,800 cfs, recorded on August 31, 1936.

Table 2.4-19 of the SSAR provides the 1-, 7-, and 30-day low streamflow for different recurrence intervals, based on the historic streamflow data for the period 1933–1979 at the Vicksburg Gauging Station obtained from USGS. Figure 2.4-32 of the SSAR plots the recurrence interval for low flows of the Mississippi River at Vicksburg.

The applicant cited information provided by USACE to establish the low-water reference plane for river mile 406 at 37.5 feet above MSL. SERI stated that the low-water reference plane was

based on the average stage from 1982–1991, representing the discharge equaled or exceeded 97 percent of the time.

The applicant proposed that an intake located on the east bank of the Mississippi River, on the north side of the existing barge slip, supply the makeup and service water for the ESP facility or facilities. The ESP facility or facilities would require a maximum makeup flow rate of approximately 85,000 gpm of water, equivalent to about 190 cfs. SERI estimated that the maximum expected withdrawal for the ESP facility or facilities would be approximately 0.2 percent of the minimum historical streamflow in the Mississippi River near the GGNS site. The applicant noted that design details of the intake would consider the minimum water surface elevation in the river to determine the location of inlet screens.

SERI stated that continued development of upstream reservoirs for such purposes as flood control, navigation, irrigation, low-flow augmentation, and hydroelectric power will alter streamflow characteristics of the Lower Mississippi River, resulting in an increase of low streamflow and a decrease in the periods of high streamflow.

The applicant noted that, in the event of an emergency shutdown of the reactor or reactors of the ESP facility, while the makeup water system was not in service, dedicated basins would provide the emergency service water for the UHS for the ESP facility or facilities. SERI indicated that the UHS dedicated basins for the ESP facility or facilities would not rely on river intake for makeup water during emergency operations. Therefore, the applicant concluded that low-water conditions would not affect the UHS for the ESP facility or facilities.

In RAI 2.4.11-1, the staff requested that the applicant describe the potential effect of ice jams upstream from the site on low-water conditions at the site. In SSAR Section 2.4.11, SERI stated that a minimum stage of 39.2 feet above MSL occurred on February 3, 1940, when ice jams reduced the river discharge. The staff asked the applicant to provide its source of the river stage data. In response to this RAI, SERI stated that ice jams upstream of the GGNS site could result in low-water conditions. The applicant noted that reduction in discharge in the Mississippi River near the GGNS site because of upstream ice jams is expected to be an infrequent occurrence. The low-water plane for the river near the GGNS site is 37.5 feet above MSL, based on the average water surface elevation in the river from 1982–1991, and represents a discharge equaled or exceeded 97 percent of the time. The applicant concluded that the proposed intake structure would not be affected by low-water conditions.

2.4.11.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance.

The acceptance criteria for this section relate to the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100 require that hydrologic characteristics be considered in the site evaluation.

- 10 CFR 100.23 requires that siting factors to be evaluated must include the cooling water supply.

The regulations at 10 CFR Part 52 and 10 CFR Part 100 require that the evaluation of a nuclear power plant site consider the hydrologic characteristics. To satisfy the requirements of 10 CFR Part 52 and 10 CFR Part 100, the applicant's SSAR should describe the surface and subsurface hydrologic characteristics of the site and region. In particular, the UHS for the cooling water system may consist of water sources that could be affected by the site's hydrologic characteristics that may reduce or limit the available supply of cooling water for safety-related SSCs, such as those resulting from river blockage or diversion, tsunami runup and drawdown, and dam failure.

Meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100 provides reasonable assurance that severe hydrologic phenomena, including low-water conditions, will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters.

As required by 10 CFR 100.23, siting factors, including cooling water supply, must be evaluated for a nuclear unit. The evaluation of the emergency cooling water supply for a nuclear power plant(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site should consider river blockages, diversions, or other failures that may inhibit the flow of cooling water, tsunami runup and drawdown, and dam failures.

The regulation at 10 CFR 100.23 applies to this section because the UHS for the cooling water system consists of water sources that are subject to natural events that may reduce or limit the available supply of cooling water (i.e., the heat sink). Natural events such as river blockages, diversions, or other failures that may inhibit the flow of cooling water, tsunami runup and drawdown, and dam failures should be conservatively estimated to assess the potential for these characteristics to influence the design of those SSCs important to safety for a nuclear unit(s) of a type specified by the applicant (or falling within a PPE) that might be constructed on the proposed site. The available water supply should be sufficient to meet the needs of the unit(s) to be located at the site; those needs may fall within a PPE (e.g., the stored water volume of the cooling water ponds), if an applicant uses that approach. Specifically, those needs include the maximum design essential cooling water flow, as well as the maximum design flow for normal plant needs at power and at shutdown.

The specific criteria discussed in the paragraphs below assess the applicant's ability to meet the requirements of the hydrologic aspects of the above regulations. Acceptance is based primarily on the adequacy of the UHS to supply cooling water for normal operation, anticipated operational occurrences, safe shutdown, cooldown (first 30 days), and long-term cooling (periods in excess of 30 days) during adverse natural conditions.

<u>Low Flow in Rivers and Streams</u>

For essential water supplies, the low-flow/low-level design for the primary water supply source is based on the probable minimum low flow and low level resulting from the most severe

drought that can reasonably be considered for the region. The low-flow/low-level site parameters for operation should not allow shutdowns caused by inadequate water supply to trigger the frequent use of emergency systems.

Low Water Resulting from Surges, Seiches, or Tsunami

For coastal sites, the applicant should postulate the appropriate PMH wind fields at the ESP stage to estimate the maximum winds blowing offshore, thus creating a probable minimum surge level. Low-water levels on inland ponds, lakes, and rivers caused by surges should be estimated based on the probable maximum winds oriented away from the plant site. The same general analysis methods discussed in Sections 2.4.3, 2.4.5, and 2.4.6 of RS-002 apply to low-water estimates resulting from the various phenomena discussed. If the site is susceptible to such phenomena, minimum water levels resulting from setdown (sometimes called runout or rundown) from hurricane surges, seiches, and tsunamis should be verified at the COL or CP stage to be higher than the intake design basis for essential water supplies.

Historical Low Water

If historical flows and levels are used to estimate design values by inference from frequency distribution plots, the data used should be presented to allow for an independent determination. The data and methods of NOAA, USGS, SCS, USBR, and USACE are acceptable.

Future Controls

This section is acceptable if water use and discharge limitations (both physical and legal), which are already in effect or under discussion by the responsible Federal, State, regional, or local authorities and which may affect the water supply for a nuclear unit(s) of a type specified by the applicant (or falling within a PPE) that might be constructed on the proposed site, have been considered and are substantiated by reference to reports of the appropriate agencies. The design basis should identify and take into account the most adverse possible effects of these controls to ensure that essential water supplies are not likely to be negatively affected in the future.

2.4.11.3 Technical Evaluation

During its independent review, the staff found that six major subbasins contribute water to the Lower Mississippi, including the Upper Mississippi, Missouri, Ohio, Arkansas, White, and Red-Ouachita. On January 4, 2005, the staff verified drainage areas of these subbasins using the USGS Web site, “National Stream Water Quality Accounting Network.” Low flow conditions in the Lower Mississippi depend on streamflow conditions in these individual subbasins. On January 4, 2005, the staff used the USACE “National Inventory of Dams” database to determine that no dams exist on the Mississippi River downstream of the GGNS site, the failure of which may lead to low-flow conditions at the GGNS site.

The Vicksburg Gauging Station, located at river mile 435.7, is the closest upstream station from the GGNS site. The staff determined that no major tributaries exist (except the relatively small Bayou Pierre and Big Black River) that join with the Mississippi, and no major river withdrawals exist between Vicksburg and the GGNS site. The staff also reviewed streamflow at Natchez,

located at river mile 363.3, the next streamflow station downstream from the GGNS site, confirming that the river flow at Natchez closely correlates to that at Vicksburg. Since the GGNS site is located between these two gauging stations, the staff concluded that the discharge at the GGNS site closely correlates to that at Vicksburg.

Using the USGS "National Water Information System," the staff reviewed low-water conditions based on daily streamflow records at the Vicksburg Gauging Station. Figure 2.4-10 shows the minimum daily streamflow observed at Vicksburg, Mississippi, during water years 1932–1998 as 100,000 cfs on November 1, 1939. Apparently, the applicant mistyped the date for this same streamflow as November 1, 1940, in the ESP application. According to the USACE report, "Stages and Discharges of the Mississippi River and Tributaries in the Vicksburg District, Annual Report of the District Engineers," issued 1990, a streamflow of 93,800 cfs was observed on August 31, 1936.

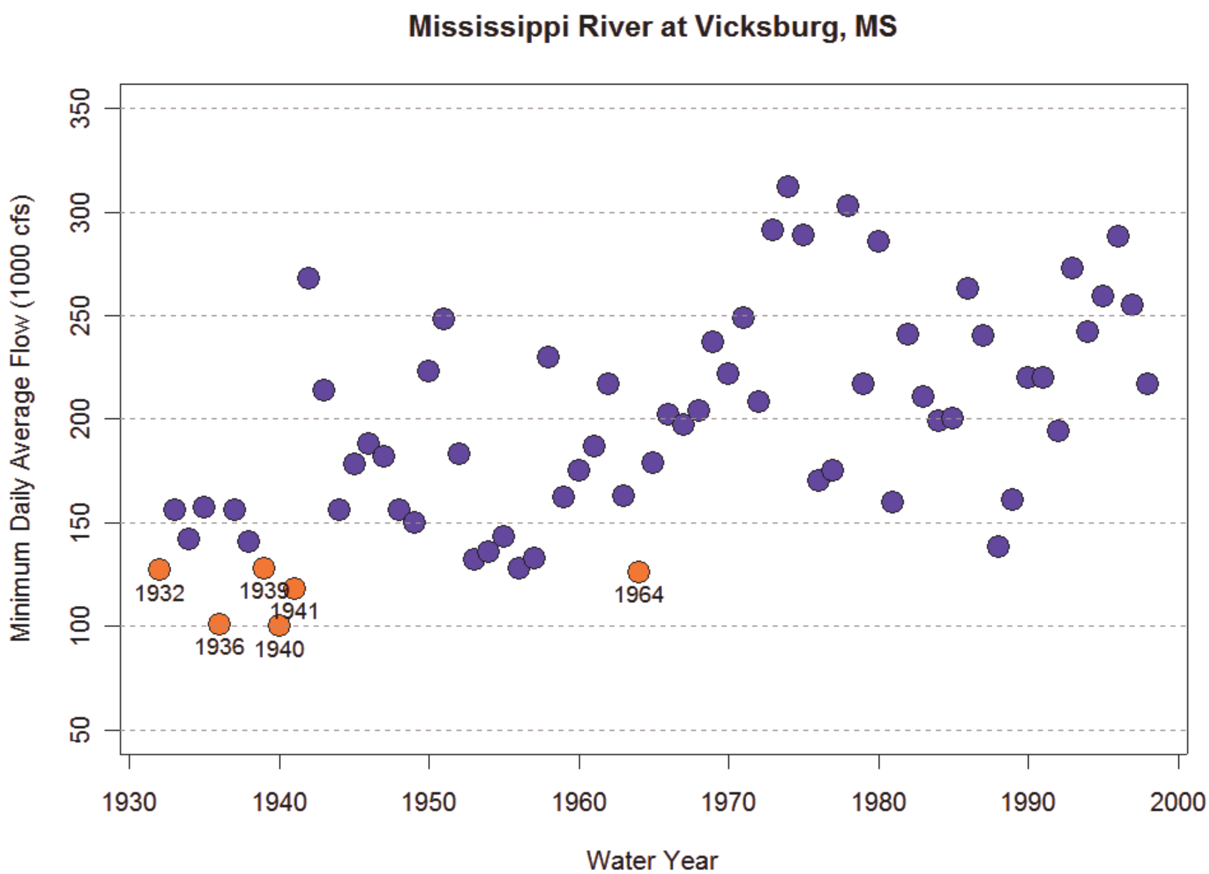

Figure 2.4-10 Minimum daily average streamflow in the USGS record for all water years 1932–1998 at Vicksburg, Mississippi. Red circles with years show six lowest historical values.

The staff obtained a copy of an email communication from SERI, in which USACE stated that the low-water reference plane for river mile 406 is 37.5 feet above MSL.

In SSAR Section 2.4.11.2, SERI stated that the historical low-flow elevation near the GGNS site is approximately 28 feet above MSL, but it did not explain how it estimated the elevation. Using the 1990 USACE report, the staff found that the historical minimum water surface elevation measured at the Vicksburg Gauging Station is 39.23 feet above MSL. The staff estimated the water surface elevation near the GGNS site using measured water surface elevations at Vicksburg and Natchez, which are the closest upstream and downstream gauges from the GGNS site, respectively. The staff used the river stage data provided by USACE to find a period in this record when the water surface elevations at the two gauging stations were fairly steady. The staff assumed that the water surface elevation from Vicksburg to Natchez decreases linearly and estimated the water surface elevation near the GGNS site. The staff-estimated water surface elevation near the GGNS site is 28.4 feet above MSL, corresponding to the historical low-water surface elevation observed at Vicksburg.

In ER Figure 5.3-2, SERI indicated that the ESP intake screens are expected to be located at an elevation of 23.5 feet above MSL, which is 4.9 feet below the staff-estimated minimum water surface elevation near the GGNS site and 14 feet below the USACE low-water reference plane.

Section 2.4.7 of this SER reviewed the USACE historical database of ice jams on the Mississippi River. In the event that ice jams would result in low water elevations in the Mississippi River near the GGNS site, the dedicated ESP UHS basins, which do not rely on the river intake for makeup cooling water, would supply makeup cooling water for emergency shutdown of the ESP reactor(s). The staff concluded that low water elevations resulting from ice jams or other causes would not adversely affect safety of the ESP facility or facilities.

In ER Section 3.4.1.3, SERI noted that the UHS for the ESP facility or facilities would include a dedicated water storage basin. As stated by COL Action Item 2.4-6 in Section 2.4.8.3 of this SER, the COL applicant must demonstrate that sufficient water will be available for a 30-day UHS supply accounting for any losses from the dedicated water storage basin.

2.4.11.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to low-water considerations. Therefore, the staff concludes that the applicant has met the requirements for low-water considerations with respect to 10 CFR 52.17(a), 10 CFR 100.20(c), GDC 2, and GDC 44.

2.4.12 Ground Water

The ESP site is located within the Mississippi Alluvial Plain Section of the Coastal Plain Physiographic Province. Aquifers at the site include the (1) Holocene alluvium in lowlands near the Mississippi River, (2) Pleistocene Upland Complex deposits beneath loess surface strata in the uplands, and (3) Miocene Catahoula Formation that underlies both the upland and lowland aquifers.

2.4.12.1 Technical Information in the Application

In SSAR Section 2.4.12, the applicant described regional and site hydrogeology and ground water conditions. SERI generally used the GGNS UFSAR to derive the information presented

in the SSAR, including the subsurface site characterization performed for the two previously proposed GGNS units, as well as the ongoing monitoring for the constructed GGNS Unit 1. The applicant obtained an additional three borings as part of its pre-ESP application activities; these borings further confirmed the site hydrogeologic conceptual model presented in the UFSAR.

The following summarizes the applicant's description of the principal sources of ground water for both the region and the ESP site, composed of the Holocene Mississippi River alluvium, Pleistocene terrace deposits, and Miocene series, primarily the Catahoula Formation:

- The Mississippi River alluvium occurs in the lowland section of the ESP site to the east of the bluffs and consists of a surficial layer of clay and silt overlying lenses of sand, gravel, silt, and clay. Alluvium thickness at the ESP site ranges from 95 to 182 feet. Recharge to the alluvium occurs from infiltrating precipitation and westward ground water flow from the terrace deposits. Published values of hydraulic conductivity in the alluvium range from 200 to 400 feet/day.
- At the ESP site, the terrace deposits, which occur east of the bluffs, are overlain with 22 to 82 feet of loess. The terrace deposits, which overlay the Catahoula formation, are up to 150 feet thick. The lithology of the terrace deposits is similar to the Holocene alluvium. Recharge to the terrace deposits occurs via percolation through the overlying loess. Hydraulic conductivities for the terrace deposits range from 0.7 to 800 feet/day.
- The Miocene Catahoula Formation is continuous across the entire ESP site and consists of lenticular deposits of sand, clayey silt, and sandy-silty clay. Sand layers are predominately fine grained and range in thickness from a few inches to more than 100 feet. Recharge to the Catahoula Formation occurs from overlying alluvium and terrace deposits. Permeable zones within the Catahoula Formation are the sources of water for the majority of public and private wells in Claiborne County. Published values for five test locations in Claiborne County report hydraulic conductivity values ranging from 13 to 120 feet/day.

The applicant reported that the two routinely used wells operate near full capacity during refueling outages, and additional ground water supply wells would be required for both construction and operational needs of the ESP facility or facilities. The applicant estimated that the maximum consumption of ground water for potable, sanitary, fire protection, demineralized water, and landscape maintenance use would not exceed 3570 gpm. This operational water requirement exceeded the applicant's estimate of water demands during construction.

The GGNS facility obtains makeup and service water from a series of Ranney wells located adjacent to the Mississippi River with laterals extending out under the Mississippi River. While these wells extract a very large volume of ground water, mostly Mississippi River water is induced to flow downward through the riverbed, and therefore the wells have a relatively localized impact on ground water elevation.

Based on population projections, the applicant estimated that the ground water withdrawal within a 2-mile radius of the plant by the year 2070 will be only 2610 gallons per day (gpd). Therefore, the ground water demand for the GGNS and the ESP facility or facilities is projected to dominate the water use in the immediate vicinity of the ESP site for many years.

Ground water at the ESP site generally moves from east to west towards the Mississippi River. Perched aquifers have been identified in the area of the proposed ESP power block. SERI provided data from peizometer measurements.

The SSAR did not provide specific coordinates (including elevation) for the bounding areas of all safety-related structures and aquifers, including perched aquifers. In RAI 2.4.1-1, the staff asked the applicant to provide these locations and elevations. The SSAR did not contain sufficient specific information of the local subsurface environment in the vicinity of the proposed ESP facility or facilities to help the staff understand all the ground water pathways. In RAI 2.4.12-1, the staff requested SERI to further describe the local subsurface environment. The applicant's response to this RAI will help the staff in its independent estimation of ground water flowpaths and water table elevations.

2.4.12.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance. The acceptance criteria for this section relate to the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100 require that hydrologic characteristics be considered in the site evaluation.

- 10 CFR 100.23 sets forth the criteria to determine the suitability of design bases for a nuclear unit(s) of specified type (or falling within a PPE) that might be constructed on the proposed site with respect to its seismic characteristics. This section also requires applicants to ensure the adequacy of the cooling water supply for emergency and long-term shutdown decay heat removal, taking into account information concerning the physical, including hydrological, properties of the materials underlying the site.

As specified in 10 CFR 100.20(c), the NRC must consider the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear unit(s).

The regulation at 10 CFR 100.20(c)(3) requires that the NRC address factors important to hydrologic radionuclide transport using onsite characteristics. To satisfy the hydrologic requirements of 10 CFR Part 100, the NRC review of the applicant's SSAR should verify the description of ground water conditions at the proposed site and of the effect on those conditions of the construction and operation of a nuclear unit(s) of specified type that might be constructed on the site. Meeting this requirement provides reasonable assurance that the release of radioactive effluents from a unit(s) of specified type that might be constructed on the proposed site will not significantly affect the ground water at or near the site.

The regulation at 10 CFR 100.23 requires that the evaluation consider geologic and seismic factors when determining the suitability of the site and the acceptability of the design for each nuclear power plant. In particular, 10 CFR 100.23(d)(4) requires consideration of the physical properties of materials underlying the site when designing a system to supply cooling water for emergency and long-term shutdown decay heat removal. The regulation at 10 CFR 100.23 applies to RS-002, Section 2.4.12, because it addresses requirements for investigating

vibratory ground motion, including the hydrologic conditions at and near the site. Static and dynamic engineering properties of the materials underlying the site should be determined, including the properties (e.g., density, water content, porosity, and strength) needed to determine the behavior of those materials in transmitting earthquake-induced motions to the foundations of a unit(s) of specified type (or falling within a PPE) that might be constructed on the site.

Meeting this requirement provides reasonable assurance that the effects of a safe-shutdown earthquake (SSE) will pose no undue risk to the type of facility proposed for the site.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters. Important PPE parameters for SSAR Section 2.4 include, but are not limited to, precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

Though not required at the ESP stage, the applicant for a COL must demonstrate compliance with GDC 2 as it relates to designing SSCs important to safety to withstand the effects of natural phenomena.

To judge whether the applicant has met the requirements of the hydrologic aspects of 10 CFR Part 52 and 10 CFR Part 100, the NRC uses the following criteria:

- Section 2.4.12.1 of the SSAR must provide a full, documented description of regional and local ground water aquifers, sources, and sinks. In addition, the type of ground water use, wells, pump, storage facilities, and the flow needed for a nuclear unit(s) of specified type (or falling within a PPE) that might be constructed on the site should be described. If ground water is to be used as an essential source of water for safety-related equipment, the design basis for protection from natural and accident phenomena should compare with RG 1.27 guidelines. Bases and sources of data should be adequately described and referenced.

- Section 2.4.12.2 of the SSAR should provide a description of present and projected local and regional ground water use. Existing uses, including amounts, water levels, location, drawdown, and source aquifers, should be discussed and tabulated. Flow directions, gradients, velocities, water levels, and effects of potential future use on these parameters, including any possibility for reversing the direction of ground water flow, should be indicated. Any potential ground water recharge area within the influence of a nuclear unit(s) of specified type (or falling within a PPE) that might be constructed on the site, as well as the effects of construction, including dewatering, should be identified. The influence of existing and potential future wells with respect to ground water beneath the site should also be discussed. Bases and sources of data should be described and referenced. RS-002 discusses certain studies concerning ground water flow problems.

- Section 2.4.12.3 of the SSAR must discuss the need for and extent of procedures and measures, including monitoring programs, to protect present and projected ground water users. These items are site specific and will vary with each application.

To judge whether the applicant has met the requirements of 10 CFR Part 50; 10 CFR 50.55, "Conditions of Construction Permits"; 10 CFR 50.55a; GDC 2; GDC 4, "Environmental and Dynamic Effects Design Bases"; GDC 5, "Sharing of Structures, Systems, and Components"; and 10 CFR Part 100 as they relate to the COL stage, the NRC uses the following criteria:

- SSAR Section 2.4.12.4 should describe the design bases (and development thereof) for ground water-induced loadings on subsurface portions of safety-related SSCs at the COL stage. If a permanent dewatering system is employed to lower design-basis ground water levels, the bases for the design of the system and determination of the design basis for ground water levels should be provided. Information should be provided regarding the following:

  — all structures, components, and features of the system

  — the reliability of the system as related to available performance data for similar systems used at other locations

  — the various soil parameters (such as permeability, porosity, and specific yield) used in the design of the system

  — the bases for determination of ground water flow rates and areas of influence to be expected

  — the bases for determination of time available to mitigate the consequences of system failure where system failure could cause design bases to be exceeded

  — the effects of malfunctions or failures (such as a single failure of a critical active component or failure of circulating water system piping) on system capacity and subsequent ground water levels

  — a description of the proposed ground water level monitoring program and outlet flow monitoring program

  In addition, if wells are proposed for safety-related purposes, the hydrodynamic design bases (and development thereof) for protection against seismically induced pressure waves should be described and should be consistent with site characteristics.

2.4.12.3 Technical Evaluation

Based on a review of the USGS "Ground Water Atlas of the United States," the staff determined that the applicant's description of regional hydrogeologic conditions is adequate. The following summarizes the staff's independent findings:

- The GGNS and ESP sites are both located within the Mississippi Alluvial Plain Section of the Coastal Plain Physiographic Province. Several important aquifer systems are in the vicinity of the proposed site, including the Mississippi River Valley Alluvial Aquifer system, Coastal Lowlands Aquifer system, and the Mississippi Embayment Aquifer system. The proposed ESP site is south of the southern extent of the Mississippi River Valley Alluvial Aquifer system. However, the site is within the very northern extent of the Coastal Lowlands Aquifer system and is located near the center of the Mississippi Embayment Aquifer system.

- The Coastal Lowlands Aquifer System consists of a gulfward-thickening, heterogeneous, unconsolidated to poorly consolidated wedge of discontinuous beds of sand, silt, and clay that range in age from Oligocene to Holocene. The Mississippi Embayment Aquifer system is located beneath the Coastal Lowlands Aquifer system. At the ESP site, the Mississippi Embayment Aquifer system consists of several aquifers ranging in age from Late Cretaceous to Middle Eocene with a combined thickness of over 5000 feet.
- The bluffs at the ESP site delineate a change in the upper stratigraphy. The upland plain, located to the east of the bluffs, is a Pleistocene terrace rising to an elevation of about 150 feet above MSL. The surface layer of the upper plain consists of approximately 75-foot-thick loess overlaying about 40-foot-thick coarse-grained alluvial sand and gravel deposits of the Upland Complex. The lowland, located to the west of the bluffs at an elevation of about 70 feet above MSL, consists of a layer of Holocene alluvium over 100 feet in thickness, including backswamp areas and meander belts of the Mississippi River. The Catahoula Formation underlies both the terrace deposits in the uplands and the alluvium in the lowlands. The proposed ESP plant would be located in the uplands portion of the ESP site.

The staff determined that the SSAR adequately describes onsite and offsite ground water use. The applicant proposed that ground water use will be less than 3570 gpm. The staff determined that, for a ground water well system, the applicant-stated maximum withdrawal capacity of 3570 gpm is large and may require installation of a network of several wells at the ESP site. The COL applicant must demonstrate that an adequately designed well system capable of withdrawing 3570 gpm is provided for the ESP facility or facilities. The staff intended to propose that the Commission include this requirement in the ESP, should it be granted. However, based on the applicant's response to open items, the staff determined that the detailed design of the ESP facility, including the design of a well system to provide ground water for potable, sanitary, fire protection, demineralized water, and landscape maintenance, will not be available until the COL stage. At that time the NRC will review the complete ESP facility design, including the ground water well system, according to existing regulations and regulatory guidance. The staff determined, therefore, that it is not necessary to specify DSER Permit Condition 2.4-7. The COL applicant should demonstrate that an adequately designed ground water well system capable of withdrawing a maximum of 3570 gpm is provided for the ESP facility. This is **COL Action Item 2.4-8.**

Prior construction for the GGNS facility has changed, and future construction for the ESP facility or facilities will further alter, the subsurface environment. The current subsurface environment will be altered with the replacement of existing soils with fill and cement. These changes and any dewatering systems will alter the local ground water flow patterns and water

table elevations. The staff requested in RAI 2.4.1-1 that SERI define the extent of the region (including elevation) of the ESP facility or facilities and the location of any aquifers, including perched aquifers. While the applicant submitted the coordinates of the areal extent of the facility, it did not provide any information regarding the depth of the facility, associated disturbance, or perched aquifers. This was Open Item 2.4-2, as discussed in Section 2.4.1.3 of this report. Subsequent response from the applicant resolved Open Item 2.4-2, as documented in Section 2.4.1.3 of this SER.

To understand the ground water flow paths, adequate characterization of the local subsurface environment is necessary. In RAI 2.4.12-1, the staff requested more information regarding the local subsurface environment. In response to this RAI, SERI stated that it will conduct an additional detailed assessment to define the location and extent of perched aquifers at the COL stage when the plant design and location are finalized. The COL applicant must provide the location and extent of perched aquifers, including their areal and vertical extent. The staff intended to propose that the Commission include this requirement in the ESP, should it be granted. However, based on the applicant's response to Open Item 2.4-3, the staff determined that additional ground water characterization will be carried out by the applicant at the COL stage as part of the design of the dewatering well system. This characterization is expected to provide detailed information on ground water elevation and locations of perched water zones. At that time, in accordance with existing regulations and regulatory guidance, the NRC will review the detailed ESP facility design, including design of dewatering well system, and any potential impact perched water zones may have on construction and operation of the ESP facility. The staff determined, therefore, that specification of DSER Permit Condition 2.4-8 is not necessary. The COL applicant should provide detailed ground water information, including the location and depth of perched aquifers. This is **COL Action Item 2.4-9.**

2.4.12.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to ground water. Therefore, staff concludes that the applicant has met the requirements for ground water with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3).

2.4.13 Accidental Releases of Liquid Effluents to Ground and Surface Waters

The ESP site is located within the Mississippi Alluvial Plain Section of the Coastal Plain Physiographic Province. Aquifers at the site include the (1) Holocene alluvium in lowlands near the Mississippi River, (2) Pleistocene Upland Complex deposits beneath loess surface strata in the uplands, and (3) Miocene Catahoula Formation that underlies both the upland and lowland aquifers.

2.4.13.1 Technical Information in the Application

In SSAR Section 2.4.13, SERI restated the GGNS UFSAR analysis for accidental releases of liquid effluents from GGNS to ground water and surface water. The applicant argued that, since the hydrogeologic characteristics of the site have not changed since the GGNS analysis, the findings from the evaluation of GGNS should extend to the ESP facility even though it is 1200 feet closer to the Mississippi River than GGNS Unit 1.

The applicant identified no surface water intakes within 100 miles downstream of the ESP site that use Mississippi River water as a potable water supply.

The SSAR did not provide specific coordinates (including elevation) for the bounding areas of all safety-related structures and aquifers, including perched aquifers. In RAI 2.4.1-1, the staff requested SERI to provide these locations and elevations. The applicant's response to this RAI will help the staff in its independent estimation of ground water flowpaths and water table elevations.

The SSAR did not contain sufficient specific information of the local subsurface environment in the vicinity of the proposed ESP facility or facilities for the staff to understand all the ground water pathways. In RAI 2.4.12-1, the staff requested SERI to further describe the local subsurface environment. The applicant's response to this RAI will help the staff in its independent estimation of ground water flowpaths and water table elevations.

The SSAR did not provide sufficient rationale as to the selection of strontium- (Sr-) 90 and cesium- (Cs-) 137 as radionuclides to be considered in the analysis. While these are important radionuclides in terms of human health risk, their large distribution coefficients (K_d) significantly retard their migration in the subsurface environment. In RAI 2.4.13-1, the staff requested SERI to further describe the rationale for considering Sr-90 and Cs-137 in its analysis.

2.4.13.2 Regulatory Evaluation

Section 1.4 of the SSAR discusses the applicant's conformance to NRC regulatory guidance. The staff finds that the applicant correctly identified the applicable regulatory guidance. The acceptance criteria for this section relate to the following regulations:

- 10 CFR Part 52 and 10 CFR Part 100, as they require that hydrologic characteristics of the site be evaluated with respect to the consequences of the escape of radioactive material from the facility

Compliance with 10 CFR Part 52 and 10 CFR Part 100 requires that the NRC consider the local geologic and hydrologic characteristics when determining the acceptability of a site to host a nuclear unit(s). The geologic and hydrologic characteristics of the site may have a bearing on the potential consequences of radioactive materials escaping from a nuclear unit(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. Special precautions should be planned if a reactor(s) will be located at a site where a significant quantity of radioactive effluent could accidentally flow into nearby streams or rivers or find ready access to underground water tables.

These criteria apply to RS-002, Section 2.4.13, because the reviewer evaluates site hydrologic characteristics with respect to the potential consequences of radioactive materials escaping from a nuclear unit(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. The review considers the radionuclide transport characteristics of ground water and surface water environments with respect to accidental releases to ensure that current and future users of ground water and surface water are not adversely affected by an accidental release from a nuclear unit(s) of specified type (or falling within a PPE) that might be

constructed on the proposed site. RG 1.113, Revision 1, "Estimating Aquatic Dispersions of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," issued April 1977, and RG 4.4, "Reporting Procedure for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Water Bodies," issued May 1974, provide guidance in the selection and use of surface water models for analyzing the flow field and dispersion of contaminants in surface waters.

Meeting the requirements of 10 CFR Part 52 and 10 CFR Part 100 provides reasonable assurance that accidental releases of liquid effluents to ground water and surface water, and their adverse impact on public health and safety, will be minimized.

For those cases in which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. An ESP applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of relevant parameters. Important PPE parameters for SSAR Section 2.4 include, but are not limited to, precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

To judge whether the applicant has met the requirements of 10 CFR Part 52 and 10 CFR Part 100 with respect to accidental releases of liquid effluents, the NRC uses the following criteria:

- Radionuclide transport characteristics of the ground water environment with respect to existing and future users should be described. Estimates and bases for coefficients of dispersion, adsorption, ground water velocities, travel times, gradients, permeabilities, porosities, and ground water or piezometric levels between the site and existing or known future surface water and ground water users should be described and be consistent with site characteristics. Potential pathways of contamination to ground water users should also be identified. Sources of data should be described and referenced.

- Transport characteristics of the surface water environment with respect to existing and known future users should be described for conditions which reflect worst-case release mechanisms and source terms to postulate the most pessimistic contamination from accidentally released liquid effluents. Estimates of physical parameters necessary to calculate the transport of liquid effluent from the points of release to the site of existing or known future users should be described. Potential pathways of contamination to surface water users should be identified. Sources of information and data should be described and referenced. The staff will base its acceptance on its evaluation of the applicant's computational methods and the apparent completeness of the set of parameters necessary to perform the analysis.

- Mathematical models are acceptable to analyze the flow field and dispersion of contaminants in ground water and surface water, providing that the models have been verified by field data and that conservative site-specific hydrologic parameters are used. Furthermore, conservatism should guide the selection of the proper model to represent a specific physical situation. Radioactive decay and sediment adsorption may be considered, if applicable, providing that the adsorption factors are conservative and site

specific. RG 1.113 guides in the selection and use of surface water models. RS-002 discusses the transport of fluids through porous media.

2.4.13.3 Technical Evaluation

Prior construction for the GGNS facility has changed, and future construction for the ESP facility or facilities will further alter, the subsurface environment. The current subsurface environment will be altered with the replacement of existing soils with fill and cement. These changes and any dewatering systems will alter the local ground water flow patterns and water table elevations. In RAI 2.4.1-1, the staff requested SERI to define the extent of the region (including elevation) of the ESP facility or facilities and the location of any aquifers, including perched aquifers. Although the applicant submitted the coordinates of the areal extent of the facility, it did not provide any information regarding the depth of the facility, associated disturbance, or perched aquifers. This was Open Item 2.4-2, as discussed in Section 2.4.1.3 of this report. Subsequent response from the applicant resolved Open Item 2.4-2, as documented in Section 2.4.1.3 of this SER.

The SSAR did not provide sufficient rationale regarding the selection of Sr-90 and Cs-137 as radionuclides to be considered in the analysis. While these are important radionuclides in terms of human health risk, their large distribution coefficients (K_d) significantly retard their migration in the subsurface environment, thereby increasing their travel time to the receiving waters and making the analysis less conservative. The staff requested SERI to further describe its rationale for considering Sr-90 and Cs-137 in its analysis. In response to RAI 2.4.13-1, the applicant stated that it would need to gather further information, and such issues will be reevaluated at the COL stage. The staff requires this information for its site suitability determination at the ESP stage. Therefore, the applicant must provide the rationale for considering Sr-90 and Cs-137 in the analysis. This was Open Item 2.4-6.

In response to Open Item 2.4-6, the applicant stated that the SSAR assessment was based on the GGNS Unit 1 UFSAR analysis in which Sr-90 and Cs-137 were the primary nuclides of interest and were identified based on transport time while considering retention and retardation from the GGNS Unit 1 site to the Mississippi River. The applicant stated that it has carried out an additional assessment to address Open Item 2.4-6. The applicant’s new assessment primarily consisted of a screening analysis to identify nuclides of interest that should be considered in a more detailed accidental release analysis at the COL stage.

The applicant stated that the screening analysis proposed a hypothetical accidental release from the ESP facility’s radwaste system. The applicant assumed that the ESP facility’s radwaste system is located at the western edge of the proposed ESP facility footprint to minimize the distance to the river and thus making the analysis conservative. The applicant ignored all retention and retardation effects in the subsurface during the transport of an accidental release plume to the river but considered radioactive decay during the transport. The applicant identified all nuclides as nuclides of interest that could be expected to exceed 10 CFR Part 20, “Standards for Protection Against Radiation,” concentration limits.

The applicant stated that the GGNS Unit 1 UFSAR analysis for accidental release had conservatively assumed that effluent would move along fracture paths in the low-permeability silt and clay Catahoula formation at the same flow rate as in the adjacent terrace deposits. The

applicant stated that this assumption was conservative because travel time through the fractures would be faster than that through the surrounding Catahoula formation. The applicant also stated that the hydraulic conductivity of sand and gravel lenses in lower terrace deposits based on site-specific well test data adjacent to the proposed ESP facility footprint is approximately $3x10^5$ feet per year (ft/yr). The applicant stated that the alluvium adjacent to the terrace deposits consists primarily of silt and clay deposits underlain by basal sand and that the hydraulic conductivity of the of the terrace deposits is conservatively assumed to be approximately $5x10^3$ ft/yr, and that of the alluvium between Hamilton Lake and the Mississippi River, as determined from aquifer tests, is approximately $1.3x10^5$ ft/yr. The applicant stated that site-specific data provided in the GGNS Unit 1 UFSAR were used to determine average interstitial ground water velocity, hydraulic conductivity, hydraulic gradient, and effective porosity.

The applicant stated that accidental release at the ESP site would in general follow the same path as that used in the GGNS Unit 1 UFSAR analysis. The presence of the ESP facility may create localized perturbations in ground water flowpaths, but the overall ground water flow to the Mississippi River from the ESP site is expected to remain unchanged. The applicant stated that the exact location of the ESP radwaste facility will not be known until the COL stage, but conservatively assuming it to be located at the western edge of the proposed ESP footprint resulted in a distance approximately 1830 feet closer to the Mississippi River compared to the GGNS Unit 1 release flowpath, which was the only data that were different in applicant’s new analysis for an ESP facility accidental release. The applicant estimated a travel time to the Mississippi River from the ESP radwaste facility of approximately 12.43 years, which is slightly less than that for the GGNS Unit 1 analysis, 12.5 years.

The applicant compiled an expanded list of possible radionuclides for initial screening from two sources, the AP1000 Design Control Document, Tier 2, Table 12.1-9 (Sheet 4), for the effluent holdup tank, liquid phase, and the waste holdup tank, and from the Advanced Boiling Water Reactor Standard Safety Analysis Report, Table 12.1-13a, for the low-conductivity waste collection tank. The applicant used the higher activity level from these two documents for each radionuclide to compile the composite inventory list. The applicant screened radionuclides on the composite inventory list to identify those that had residual activities in excess of their corresponding values in Column 2 of Table 2 in Appendix B, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage,” to 10 CFR Part 20 after transport to the Mississippi River, during which retention and retardation was ignored, but radioactive decay was considered. The applicant identified Cs-134, Cs-137, Sr-90, cobalt- (Co-) 60, iron- (Fe-) 55, and nickel- (Ni-) 63 as the radionuclides of interest.

The staff reviewed the applicant’s response to Open Item 2.4-6 and concluded that the applicant provided more details on its approach for determining radionuclides of interest. Based on the description of the applicant’s screening analysis to identify nuclides of interest, the staff determined that the applicant’s screening analysis may be inappropriate. Section 2.4.13 of RS-002 outlines the review of accidental radioactive liquid effluent releases as they may affect existing and known future uses of ground water and surface water resources. The guidance calls for the evaluation of transport capabilities and potential subsurface contamination pathways under accidental conditions to determine most adverse scenarios for contamination of ground water or of surface waters via subsurface pathways. RS-002 states

that concentrations of radionuclides in the body of water under consideration should be estimated based on dispersion computations with initial concentrations determined for the most critical event. Acceptability of final estimated concentrations in the radioactive effluent at the points of interest must be within acceptable limits as prescribed by Column 2 of Table 2 in Appendix B to 10 CFR Part 20.

According to 10 CFR Part 20, which prescribes standards for protection against radiation, the total ionizing radiation dose to an individual, including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation, must not exceed the standards for protection. The effluent concentration values given in Column 2 of Table 2 of Appendix B to 10 CFR Part 20 are equivalent to the radionuclide concentrations which, if ingested continuously for a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem or 50 millisieverts). The staff concluded that because of the presence of several radionuclides in the potential accidental release, an individual near a contaminated point of interest will receive a cumulative ionizing radiation dose from each radionuclide that constitutes the effluent. The staff determined that the applicant's screening procedure for selecting the radionuclides of importance to subsurface hydrological transport has been explained clearly. On the basis of this determination and the staff's proposed Permit Condition 2 which requires an applicant referencing such an ESP design any new unit's radwaste systems with features to preclude any and all accidental releases of radionuclides into any potential liquid pathway, the staff considers Open Item 2.4.6 resolved.

The regulation at 10 CFR 100.20(c)(3) contains the primary requirement for site suitability determination factors related to accidental releases to the liquid pathway. This regulation outlines factors, such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest body of surface water, important to hydrologic radionuclide transport that must be obtained from onsite measurements. Section 2.4.13 of the SSAR does not provide these required onsite measured values. This was Open Item 2.4-7.

In response to Open Item 2.4-7, the applicant stated that four new borings were drilled at the proposed ESP site to depths between 141.5 and 238 feet to characterize subsurface geological conditions. The applicant stated SSAR Figure 2.5-69 shows the locations of these boreholes, and SSAR Tables 2.5-20 and 2.5-21 summarize the characteristics of these borings.

The applicant stated that extensive geological and geotechnical data are available from investigations completed for the existing GGNS Unit 1. The applicant stated that 275 borings were drilled within the site area to a maximum depth of 447 feet, 10 of which were located within the proposed ESP facility footprint, and some additional borings were drilled in the floodplain of the Mississippi River between the ESP site and the river. In addition to the GGNS database, three new soil borings, four new cone penetrometer tests (CPTs), two downhole geophysical surveys, and geological field observations were completed for the ESP application to evaluate subsurface conditions and to estimate input parameters to assess the dynamic response of subsurface material at the proposed ESP site. Apart from a stratum naming difference, the stratigraphy at the proposed ESP site generally agrees with that shown on the

GGNS UFSAR boring logs, and material descriptions and contacts are generally consistent between the two data sets.

The applicant also stated that 60 samples of loess, Upland Complex alluvium, and Catahoula Formation bedrock from site borings were tested for basic geotechnical properties, as summarized by SSAR Tables 2.5-24 and 2.5-25, and SSAR Figures 2.5-82 and 2.5-83 summarize the results from moisture content and grain size tests, respectively.

The applicant stated that the elevation of the ground water table could not be measured directly in the borings because water was continuously injected during drilling. The applicant noted that the ground water elevation was indirectly estimated using borehole seismic velocity compression and shear (P-S) wave surveys as the elevations where there was a significant increase in compression wave velocity but no corresponding increase in shear wave velocity. The applicant estimated the ground water table elevation to range from 70 to 100 feet deep from the ground surface. The applicant stated that the regional ground water flow near the ESP site is toward the southwest direction to the Mississippi River floodplain, with a hydraulic gradient of approximately 1 foot per 100 to 125 feet of distance. The applicant also noted that it is possible for shallow perched water to form in parts of the loess during high-intensity rainfall events, but the applicant expected that these perched zones would dissipate rapidly after the rainfall ceased.

The applicant stated that SSAR Tables 2.4-34, 2.4-35, and 2.4-37 provide values for hydraulic conductivity, transmissivity, hydraulic gradient, porosity, ground water velocity, and distribution coefficients for Sr and Cs. Six of the borings and well locations listed on the above-mentioned SSAR tables, TW-1, OW29A, OW29B, OW73, P34B, and P34C, were installed within or adjacent to the proposed ESP facility footprint. The applicant argued that since the stratigraphy, as determined from ESP site assessment, generally agrees with the stratigraphy shown on the GGNS Unit 1 UFSAR boring logs and the data in the above-mentioned SSAR tables include information from wells located within the proposed ESP powerblock area, the aquifer characteristics in the above-mentioned SSAR tables are valid and applicable for the ESP site and should be considered as site characteristics for the ESP site.

The applicant included a table, shown below, of K_d values for Cs-137 and Sr-90 that were established for site-specific calculations in the GGNS Unit 1 UFSAR.

	Calculated K_d Values (ml/mg)	
	Cs-137	Sr-90
Terrace Formation	314.85	8.79
Clay-Silt Alluvium	259.29	7.24
Alluvium Aquifer	259.29	7.24

The applicant stated that in the event of accidental liquid release, the contaminants would be expected to follow the same general flowpaths as those described in the GGNS Unit 1 UFSAR. The primary difference between the GGNS Unit 1 location and the proposed ESP site is that the ESP site is closer to the Mississippi River. The west edge of the proposed ESP powerblock area is approximately 5400 feet from the Mississippi River. Based on the above summary, the

applicant stated that the above-mentioned K_d values for Cs-137 and Sr-90 are directly applicable to the ESP site. As described in response to Open Item 2.4-6 above, the applicant's screening analysis selected Cs-134, Co-60, Fe-55, and Ni-63 in addition to Cs-137 and Sr-90 as nuclides of interest. The applicant also argued that since K_d is a chemical property, this site characteristic for Cs-137 and Cs-134 would be the same.

The applicant provided a table of K_d values for Cs and Sr corresponding to different soil types from those published in Table E.3 in Appendix E to RESRAD Version 6, as shown below.

	RESRAD Version 6, Appendix E, Table E.3 K_d Values (ml/gm)			
	Sand	Loam	Clay	Organic
Cs	280	4600	1900	270
Sr	15	20	110	150

The applicant concluded that K_d values corresponding to sand were most representative and appropriate for soil media at the ESP site by comparing RESRAD data with Sr-90 and Cs-137 K_d values used in the GGNS Unit 1 UFSAR analysis. The applicant then obtained K_d values for other nuclides of interest from the user's manual for RESRAD Revision 6, as listed below.

	K_d Value (ml/gm)
Co-60	60
Fe-55	220
Ni-63	400

The applicant considers these K_d values site characteristics for the additional nuclides of interest. The applicant revised SSAR Table 2.4-37 to include the above-stated K_d values as site characteristics for the proposed ESP site.

The staff reviewed the applicant's response to Open Item 2.4-7 and concluded that the applicant provided more details regarding its method for estimating site characteristics important to radionuclide migration in the subsurface at the ESP site. However, the staff determined that several subsurface hydrological properties influence the migration of the radionuclide plume in the ground water. Some of these properties include hydraulic conductivity, hydraulic gradient, and distance to the nearest surface water body that are common to all radionuclides that may constitute the radwaste inventory. Some other properties such as adsorption and retention coefficients may be unique to each radionuclide. In addition, subsurface chemical properties, such as pH, may affect different radionuclides differently (EPA 1999a, 1999b; EPA 2004). Appendix E to the RESRAD Version 6 user manual also states the following:

> Distribution coefficients depend strongly on soil type, the pH and Eh of the soil, and the presence of other ions (see Tables E.3 through E.7). Thus, considerable uncertainty can be introduced by using default values for the distribution coefficients. This uncertainty is a critical matter, particularly in cases in which the water-dependent pathways are the dominant contributors to the total dose/source concentration ratios. Default values for the distribution coefficients are provided only for the purpose of obtaining preliminary estimates; site-specific values should be used for deriving soil guidelines whenever possible.

The radwaste itself may contain certain complexing agents that are frequently used in decontamination processes to remove buildup of radionuclides from cooling systems, such as one or more chelating agents including ethylenedinitrilo tetraacetic acid, picolinic acid, oxalic acid, and citric acid. The presence of these complexing agents can enhance the mobility of some radionuclides, especially transition metals (Davis et al., 2000; Serne et al., 2002). For this reason, EPA (1999b) cautions that its lookup tables do not apply to environments containing organic chelates.

The staff concluded that because of incomplete knowledge of subsurface hydrological and chemical properties and the likely composition of the radwaste effluent itself, significant uncertainty exists in the characterization of radionuclide migration in the subsurface at the ESP site at the time of ESP review. The staff determined that after the reactor design is selected and additional details related to radwaste tank design and its location within the proposed site are known, appropriate subsurface hydrological characterization can be completed. Therefore, at the time of a COL or CP application, more reliable estimation of radionuclide migration to surface waters via subsurface pathways can be made. The staff determined that the COL applicant should be required to perform an updated conservative screening of radionuclides from the radwaste inventory of the chosen reactor design accounting for ESP site soil chemistry, presence of any chelating agents, and any other factor that may affect radionuclide mobility in the subsurface. Based on the above review, and proposed permit condition 2. as discussed below, the staff considers Open Item 2.4-7 resolved.

As reflected, in its ESP application, the applicant has not made a decision as to what specific reactor design might ultimately be built at the ESP site. Therefore, important details are not available for the staff to fully consider the effect of an accidental release of liquid effluents in ground and surface waters, including the exact location of radwaste storage facilities, the location and elevation of likely points of release, and detailed characterization of liquid pathways above and below ground from the point of release to the accessible environment. Although the staff conceptually used siting factors such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water in its site suitability determination, it determined that this issue could be resolved if there were no releases of radionuclides to the ground water. Accordingly, the staff proposes to include a condition in any ESP that might be issued for the Grand Gulf site requiring that an applicant referencing such an ESP design include features in any new unit’s radwaste systems to preclude any and all accidental releases of radionuclides into any potential liquid pathway. This is **Permit Condition 2.**

2.4.13.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to liquid pathways. Therefore, the staff concludes that the applicant has met the requirements for liquid pathways with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3).

2.4.14 Site Characteristics Related to Hydrology

Based on its review of SSAR Section 2.4, the staff has determined that the following site characteristics should be included in any ESP that might be issued for the proposed site.

Table 2.4.14-1 Staff's Proposed Site Characteristics Related to Hydrology

SITE CHARACTERISTIC	VALUE
Proposed Facility Boundaries	SSAR Figure 2.1-1 shows the areal extent of proposed facility boundaries. This figure is reproduced below as Figure 2.4.14-1. The bounding coordinates of the ESP site are a site characteristic. During construction, the ESP site could be disturbed up to a depth ranging from 35 to 140 feet plus some additional excavation.
Site Grade	132.5 feet above MSL
Highest Ground Water Elevation	70 feet below grade; 62.5 feet above MSL; perched water may be present between the site grade at 132.5 feet above MSL and the water table at 62.5 feet above MSL.
Flood Elevation	Flood water elevation at the ESP site caused by local intense precipitation will be established by the COL applicant using local intense precipitation values established in Section 2.4.2.3 of this SER. Local intense precipitation itself is a site characteristic, listed below.
Local Intense Precipitation	19.2 in./h, of which 6.2 in. falls during the first 5 minutes.
Frazil and Anchor Ice	The ESP site does not have the potential for the formation of frazil and anchor ice.
Maximum Cumulative Degree Days Below Freezing	98 EF
Distance to the Closest Surface Water	Stream B is the closest surface water feature, approximately 1017 feet away from center of the powerblock.
Location of Aquifers Used by Large Population for Domestic, Municipal, Industrial, or Irrigation Water Supplies	The nearest public water supply wells are located 2760 feet from the ESP powerblock.

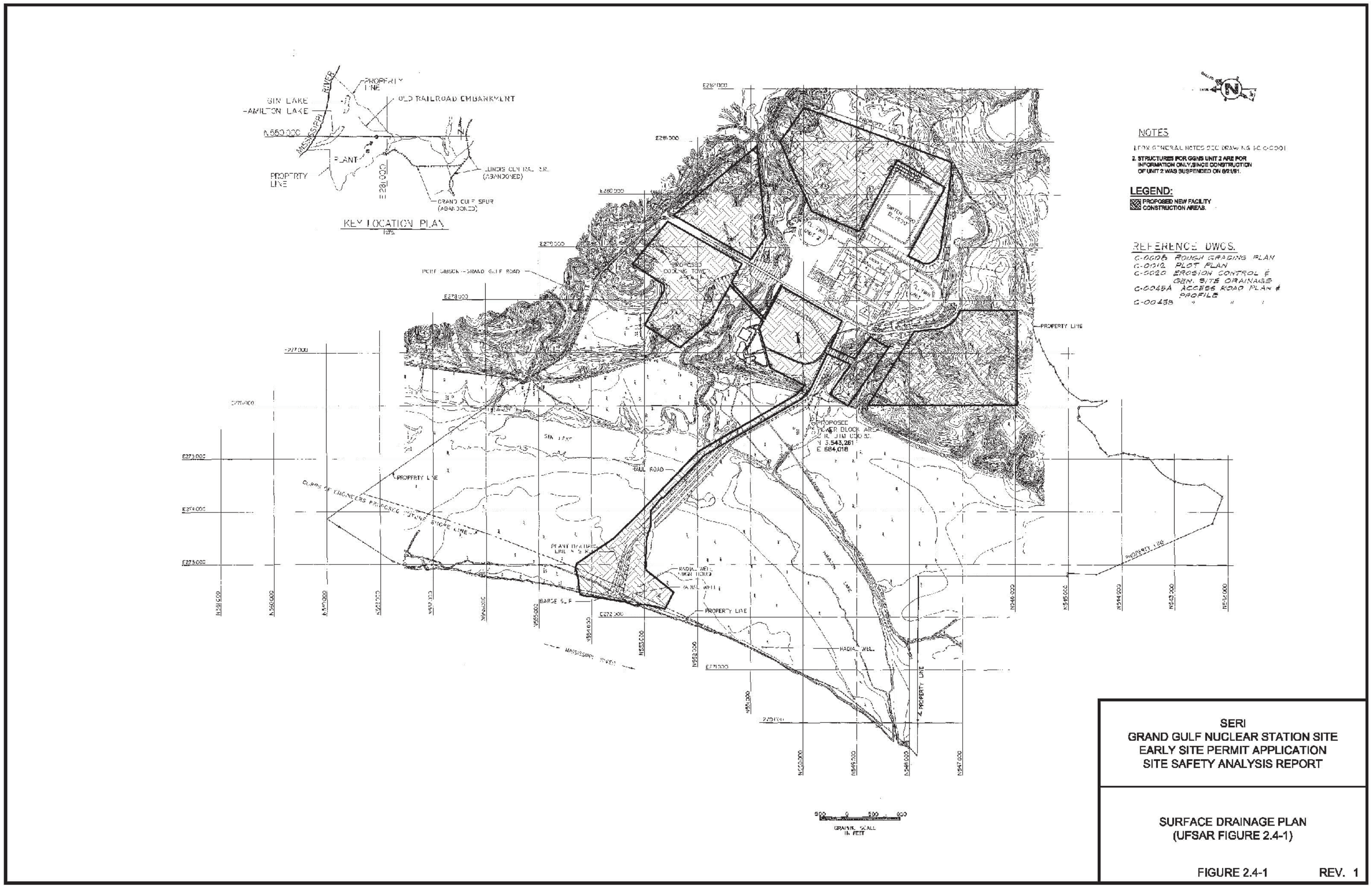

Figure 2.4.14-1 Areal extent of proposed facility boundaries