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), the applicant presents information concerning the location and area of the early site permit (ESP) site 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 states that the Exelon ESP site will be located approximately 700 feet south of the existing Clinton Power Station (CPS), which lies within Zone 16 of the Universal Transverse Mercator (UTM) coordinates. The applicant further states that the exact UTM coordinates for a new unit(s) constructed on the proposed ESP site will be finalized at the time of a combined license (COL) application. The applicant provides the following information on site location and area:

- the site boundary for a new unit(s) on the proposed ESP site with respect to the location of CPS
- the site location with respect to political subdivisions and prominent natural and manmade features of the area within the low population zone (LPZ) and the 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 ESP site from 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

In request for additional information (RAI) 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to RAI 1.5-1, the applicant stated that NRC Review Standard (RS)-002, "Processing Applications for Early Site Permits," Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, identifies the applicable U.S. Nuclear Regulatory Commission (NRC) regulations regarding site location and description as Title 10, Section 52.17, "Contents of Applications," of the *Code of Federal Regulations* (10 CFR 52.17) and Subpart B to 10 CFR Part 100, "Reactor Site Criteria." The staff finds that the applicant has correctly identified the applicable regulations.

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

(1) 10 CFR Part 100, which requires the consideration of factors relating to the size and location of proposed sites

(2) 10 CFR 52.17, which requires the applicant to submit information needed to evaluate factors involving the characteristics of the site environs

According to Section 2.1.1 of RS-002, Attachment 2, 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 the applicant's PPE that might be constructed on the proposed site, is described in sufficient detail to determine whether 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 which traverse the exclusion area are sufficiently distant from the planned or likely locations of any structures of a nuclear power plant(s) of specified type falling within the applicant's PPE that might be constructed on the proposed site so that routine use of these routes is not likely to interfere with normal plant operation.

2.1.1.3 Technical Evaluation

The proposed Exelon ESP site is located approximately 700 feet south of the existing CPS facility. The CPS lies within Zone 16 of the UTM coordinates. Figure 2.1-8 of the SSAR depicts the EAB and the LPZ for the proposed ESP site. The applicant stated that the exact UTM coordinates for a new unit(s) constructed on the proposed ESP site will depend upon the specific reactor technology selected for deployment. This decision will be finalized at the time of a COL application. The staff will review the exact UTM coordinates of the new unit(s) at the time of a COL application. This is **COL Action Item 2.1-1**, "Latitude and longitude and Universal Transverse Mercator coordinates for new unit(s) on the EGC ESP site."

The applicant has elected to define the EAB envelope as a circular radius of 3,362 feet (0.64 miles) and the LPZ as a circular radius of 13,182 feet (2.5 miles) from the center of the proposed ESP facility footprint. The EAB for the proposed ESP site overlaps the existing EAB for CPS; however, the two are not concentric. Also, the EAB for the existing CPS is slightly smaller, with a circular radius of 3199 feet (0.6 miles) and both CPS and the proposed ESP site have the same LPZ. 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 persons live within either the CPS EAB or the proposed ESP site EAB. The staff verified that the exclusion area distance is consistent with the distance used in the radiological consequence analyses the applicant performed and which Section 3.3 of the SSAR describes, as well as the analysis the staff performed and which Section 3.3 of this SER describes.

The proposed ESP site, located in east-central Illinois, falls within Harp Township in DeWitt County. Specifically, the site is about 6 miles east of the City of Clinton, and lies between the cities of Bloomington and Decatur, 22 miles to the north and 22 miles to the south, respectively. Regionally, the proposed site is located between the cities of Lincoln and Champaign-Urbana, 28 miles to the west and 30 miles to the east, respectively. The nearest major highways are Illinois State Routes 54, 10, and 48, all of which cross the CPS facility property. Other major highways within the region include Interstate 155 in the west, Interstate 72 in the southeast, Interstate 55 in the northwest, Interstate 74 in the northeast, Interstate 39 in the north, and Interstate 57 in the east. The closest of these highways (State Route 54) approaches to within 1 mile north of the proposed ESP Facility footprint. Routine use of State Route 54 is not likely to interfere with normal plant operation.

The gaseous effluent release limits for the new unit(s) would apply at the proposed ESP exclusion area site boundary, and the liquid effluent release limits for the new unit(s) would apply at the end of the discharge canal into Clinton Lake, the outfall of which joins the Sangamon River approximately 56 miles downstream. The staff finds that these release points are acceptable for determining the radiation exposures to the public to meet the criterion, “as low as 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 Section 5.4 of the staff’s environmental impact statement for the Exelon ESP application for a further discussion of this subject.)

In addition, for the reasons set forth in Section 13.3 of this SER, the staff finds that no physical characteristics unique to the proposed ESP site have been identified 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 the site location and area that could affect the design of SSCs important to the 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 has 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 Section 2.1.2 of the SSAR, the applicant presents information concerning the applicant's plan to ensure the legal authority necessary to determine all activities within the designated EAB, if the applicant decides to proceed with the development of a new reactor unit(s) at the proposed ESP site. The regulations in 10 CFR 100.3, "Definitions," require that a reactor licensee have the authority to determine all activities within the designated exclusion area, including the exclusion or removal of personnel and property. With respect to this requirement, the applicant states the following:

> EGC [Exelon Generation Company] will ensure that it has or will be granted the necessary authority, rights, and control of the EGC ESP Site, including the exclusion area prior to commencing actions allowed pursuant to any ESP granted from the Application.

In RAI 2.1.2-1, the staff asked the applicant for additional information regarding its approach to obtaining a grant from the appropriate regulatory agencies and other private parties for the necessary authority, rights, and control of the EGC ESP site. In its response, the applicant stated the following:

> EGC plans to enter into an agreement with AmerGen prior to construction that will grant EGC an exclusive and irrevocable option to purchase, enter a long-term lease for, and/or procure other legal right in the land required for the EGC ESP Facility. Additionally, EGC will enter into an Exclusion Area Agreement with AmerGen. This agreement will provide EGC with authority to determine the activities within the EGC ESP exclusion area, including the exclusion of personnel and property, to the extent necessary to comply with applicable NRC guidance. EGC anticipates that this Agreement and the lease will extend for 99 years.

2.1.2.2 Regulatory Evaluation

In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, identifies the applicable NRC regulations regarding exclusion area authority and control, as 10 CFR 52.17, 10 CFR Part 100, and 10 CFR 50.34(a)(1). The staff finds that the applicant has correctly identified the applicable regulations and guidance.

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 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.

To meet the requirements of 10 CFR Part 100, the applicant must demonstrate, before the issuance of an ESP, that it has an exclusion area and an LPZ, as defined in 10 CFR 100.3, and that it has the required authority within the exclusion area, also defined by 10 CFR 100.3. If not, the applicant must provide reasonable assurance that it will have such authority before construction of a new unit(s) commences.

2.1.2.3 Technical Evaluation

As noted in Section 2.1.2.1 of this SER, the applicant plans to enter into an agreement with AmerGen, before any construction, that will grant Exelon an exclusive and irrevocable option to purchase, enter into a long-term lease for, and/or procure other legal right in the land required for the EGC ESP facility. The applicant has therefore not attempted to demonstrate that it currently has the authority to determine all activities, including exclusion or removal of personnel and property from the area, as required by 10 CFR 100.3. To meet the exclusion area control requirements of 10 CFR 100.21(a), “Non-Seismic Site Criteria,” and 10 CFR 100.3, the applicant does not need to demonstrate total control of the property before issuance of the ESP. However, the applicant must provide reasonable assurance that it can acquire the land (i.e., that it has the legal right to obtain control of the exclusion area). The applicant should demonstrate that it has the legal right to control the exclusion area or has irrevocable right to obtain such control. Specifically, the applicant should provide a detailed explanation of the corporate relationship between Exelon (the parent company) and AmerGen (the subsidiary). This is **Open Item 2.1-1**.

The applicant stated that the CPS operator, AmerGen, owns the property associated with the proposed ESP site, with the exception of a right-of-way for the township road that traverses the exclusion area. This road provides access to privately owned property which lies outside the proposed ESP exclusion area. The applicant further stated that in an emergency, Exelon, together with the local law enforcement agency, will control access to the exclusion area via this road. Furthermore, the property ownership and mineral rights provide AmerGen the authority to control activities, including exclusion and removal of personnel and property, within the exclusion area. There are no residents within the EAB.

Should the NRC grant the ESP and the ESP holder decide to perform the activities authorized by 10 CFR 52.25, the ESP holder will need to obtain the authority to undertake those activities on the ESP site. In obtaining such a right, the ESP holder will also need to obtain the corresponding right to implement the site redress plan described in the staff’s final environmental impact statement in the event no plant is built on the ESP site. This issue might be resolved through the applicant’s actions to obtain control over the exclusion area or the legal right to obtain such control in addressing Open Item 2.1-1. If this issue is not resolved by the time the staff completes the FSER, the staff will include this item in any ESP that might be issued for the proposed site as Permit Condition 2.1.2.

A small area of Clinton Lake lies within the proposed ESP exclusion area boundary and is used for public recreation lake activities. Should the NRC grant the ESP and the ESP holder decide to apply for a COL [or for a construction permit (CP) and operating license (OL)], the ESP holder will need to make arrangements with the appropriate Federal, State, local, or other public agencies to provide for control of the portion of Clinton Lake that lies within the exclusion area. These public agencies, together with the ESP holder, will need authority over these bodies of water sufficient to allow for the exclusion and ready removal, in an emergency, of any persons present on them. This is **COL Action Item 2.1-2**.

2.1.2.4 Conclusions

As set forth above, the applicant has provided and substantiated 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 evaluate 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.

Based on the above, the staff concludes that the applicant's exclusion area is acceptable and meets the requirements of 10 CFR Part 100. However, the applicant should demonstrate that it has or will have the authority to control all activities within the exclusion area, as described in the discussion of Open Item 2.1-1 above. Further, the ESP holder will need to demonstrate that it will have authority to perform the activities authorized by 10 CFR 52.25, should it choose to do so, and the corresponding right to implement the site redress plan, as described in the discussion of Permit Condition 2.1-1 above.

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 within a 50-mile radius of the proposed ESP site, based on the most recent U.S. census data and the projected population estimates up to 2060, including transient populations. The applicant also provided the population distribution within the LPZ, facilities and institutions within the vicinity of the LPZ, the nearest population center, population densities within a 50-mile radius of the proposed ESP site for 2000, and estimated population data for 2060.

The population distribution provided by the applicant encompasses nine concentric rings at various distances out to 50 miles from the proposed ESP site and 16 directional sectors. The applicant also estimated and provided transient population data out to 50 miles for 2000 and projected estimates to 2060 based on the recreational use of Clinton Lake State Recreational Area, seasonal residents, and business and migrant workers that normally do not live in the area.

2.1.3.2 Regulatory Evaluation

In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, identifies the applicable NRC regulations regarding population distribution as 10 CFR 52.17, 10 CFR Part 100, and Regulatory Guide (RG) 4.7, "General Site Suitability Criteria for Nuclear Power Stations," issued April 1998. The staff finds that the applicant has correctly identified the applicable regulations.

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

- 10 CFR 52.17, which requires each applicant to provide a description and safety assessment of the site and which requires site characteristics to comply with the criteria of 10 CFR Part 100

- 10 CFR Part 100, which establishes requirements with respect to population center distance and the LPZ

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 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, Attachment 2, 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 (as defined in 10 CFR Part 100) is at least one and one-third times the distance from the reactor to the outer boundary of the LPZ.

- The population center distance is acceptable if there are no likely concentrations of greater than 25,000 people over the lifetime of a nuclear power plant or plants of specified type or falling within a PPE that might be constructed on the proposed site (plus the term of the ESP) closer than the distance designated by the applicant as the population center distance. The boundary of the population center shall 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 or plants of specified type (or falling within a PPE) that might be constructed on the proposed site (such date(s) 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 Reference 3, (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 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 population data 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 alternate 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 planning 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. The staff reviewed (see Section 13.3 of this SER) the projected population data provided by the applicant, including transient populations for 2010, 2020, 2030, 2040, 2050, and 2060. If the ESP were approved and issued in 2006, assuming a COL application is submitted around the middle of the ESP term, with a projected startup of a new unit(s) in about 2020 and an operational period of 40 years, the projected year for end of plant life is about 2060. Accordingly, the staff finds that the applicant's projected population data cover an appropriate number of years and are therefore reasonable.

The staff reviewed the transient population data provided by the applicant. The transient population up to a 50-mile radius is based on recreational use of Clinton Lake Recreational Area, seasonal residents, special population (e.g., schools, hospitals, nursing homes, and correctional facilities), and business and migrant workers that do not normally live in the area. The applicant stated that it collected the transient population estimates for the larger business transient population, recreation areas, and special population using surveys performed during August and September 2002; the DeWitt County Emergency Services and Disaster Agency Coordinator verified the data. The applicant further stated that it obtained the data on the recreation area population from the Department of Illinois Natural Resources. The applicant obtained data on migrant workers from the Bureau of Economic Analysis, U.S. Department of Commerce. Based on this information, the staff finds that the applicant's estimate of the transient population is reasonable.

The staff notes that no member of the public lives within the exclusion area.

Section 3.3 of the SSAR describes the applicant's evaluation of design-basis accidents; Section 3.3 of this SER describes the staff's independent verification of the applicant's evaluation. These analyses demonstrate that the radiological consequences of design-basis reactor accidents at the proposed EAB and LPZ would be within the dose consequence evaluation factors set forth in 10 CFR 50.34(a)(1).

The applicant stated that the nearest population center greater than 25,000 people likely to exist over the lifetime of the proposed ESP site is Decatur, Illinois, with a population of 81,860, located approximately 22 miles south-southwest of the proposed ESP site. The distance to Decatur is well in excess of the minimum population center distance of 3.3 miles (one and one-third times the distance of 2.5 miles from the reactor to the outer boundary of the LPZ). The proposed LPZ is the area immediately surrounding the exclusion area encompassed by a circle, centered on the proposed ESP facility footprint, with a radius of 2.5 miles.

Therefore, the staff concludes that the proposed ESP site meets the population center distance requirement, as defined in 10 CFR Part 100. The staff determined that it is unlikely that a population center with 25,000 people or more will exist within the 3.3-mile minimum population center distance during the lifetime of any new unit(s) that might be constructed on the site. This conclusion is based on projected cumulative resident and transient populations within 10 miles of the site during the lifetime of any new unit(s) (i.e., to 2060).

The staff evaluated the site against the criterion in Regulatory Position C.4 of RG 4.7 regarding the need to consider alternative sites with lower population densities. This criterion requires that if the population densities in the vicinity of the proposed site, including transient population, projected at the time of initial site approval and within about 5 years thereafter, were to 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), then alternative sites should be considered. The staff has determined that population densities for the proposed ESP site would be well below 500 persons per square mile. Therefore, the staff concludes that the site conforms to Regulatory Position C.4 in RG 4.7, Revision 2. Assuming construction of a new nuclear reactor(s) at the proposed site would begin near the middle of the term of the ESP, and based on its review of the applicant's population density data and projections, the staff finds that the site also meets the guidance of RS-002, Attachment 2, regarding population densities over the lifetime of any facility that might be constructed at the site. Specifically, the population density over that period would be expected to remain below 500 persons per square mile averaged out to a radial distance of 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 permanent and transient residents in the LPZ in the event of a serious accident. The applicant stated that the LPZ was selected to provide reasonable probability that appropriate protective measures could be taken in such an event. The staff finds that the applicant's statement 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 review provided 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 (assuming a new unit(s) is 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 Section 3.3 of this SER, the staff documents that the radiological consequences of bounding design-basis accidents at the EAB and the outer boundary of the LPZ also 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 an ESP application, the NRC staff reviews the site and its vicinity in terms of their relative location and separation distance from industrial, military, and transportation facilities and routes. Facilities and routes of potential concern include air, ground, and water traffic; pipelines; and fixed manufacturing, processing, and storage facilities. The staff's review focuses 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 prepared Sections 2.2.1 through 2.2.2 of this SER in accordance with the review procedures described in RS-002, Attachment 2, using information presented in Section 2.2 of the applicant's SSAR, responses to staff RAIs, and generally available reference materials, as described in the appropriate sections of RS-002, Attachment 2.

2.2.1.1–2.2.2.1 Technical Information in the Application

Section 2.2 of the SSAR presents information concerning the industrial, transportation, and military facilities in the vicinity of the proposed ESP site.

Specifically, in Section 2.2.2.1, the applicant states that the proposed site is in DeWitt County, Illinois, which is a rural and agricultural area. According to the applicant, the 461-acre ESP site controlled by the applicant is zoned for industrial uses. The applicant identifies three small industrial facilities within 5 miles of the proposed ESP site, in addition to the existing CPS. These facilities include two agricultural chemical and fertilizer production and storage facilities, and a propane storage facility. Figure 2.2.1-1 below illustrates the locations of nearby industrial facilities. Exelon Generation Company's wholly owned subsidiary, AmerGen, owns the surrounding areas within the exclusion area boundary. No industrial facilities, pipelines, or other developments are located in the proposed exclusion area other than the existing CPS, operated by AmerGen.

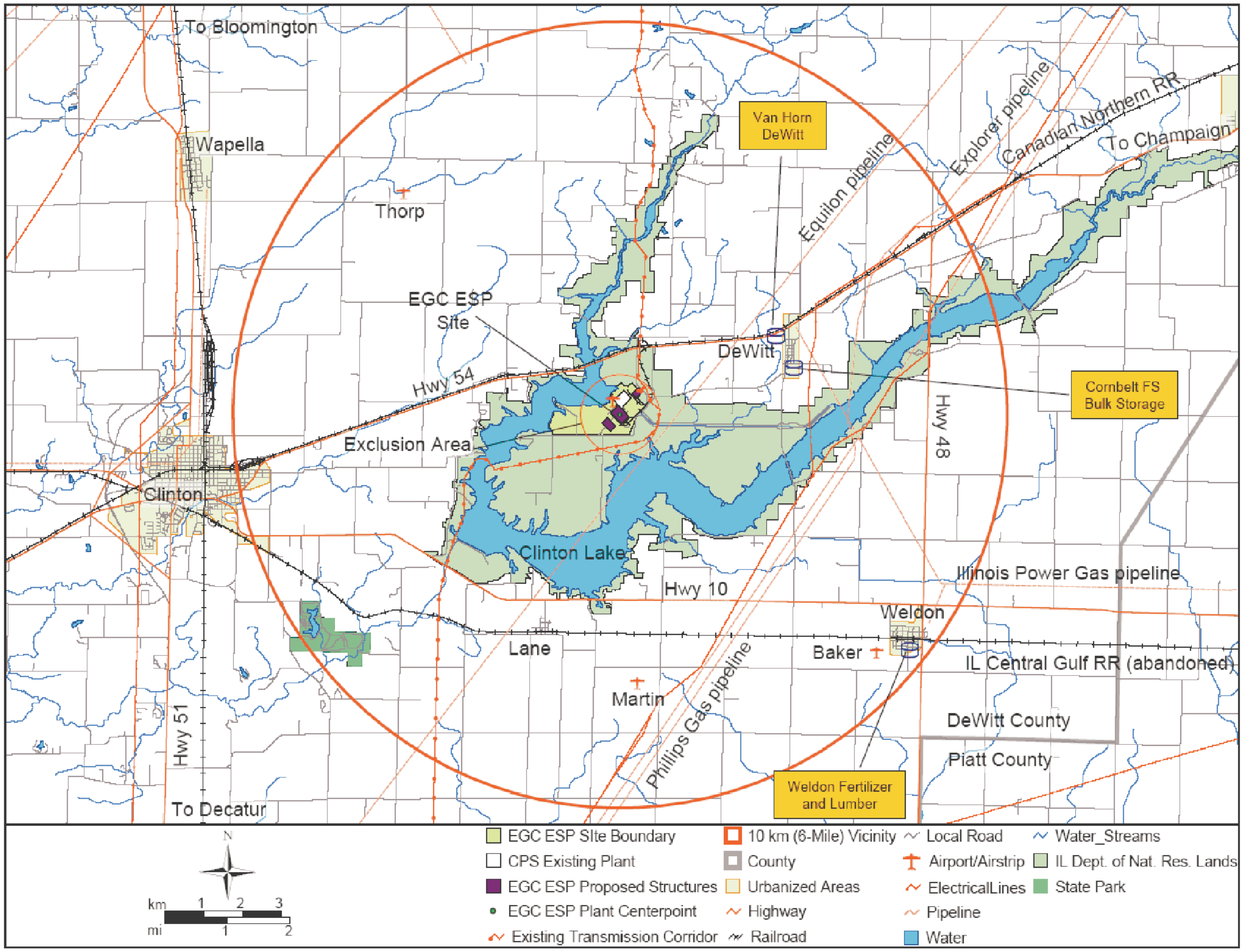

Figure 2.2.1-1 Industrial Facilities in the Vicinity of the ESP Site.

Section 2.2.1 of the SSAR describes the roads within 5 miles of the proposed ESP site. Several Illinois State routes (Routes 54, 48, and 10) pass no closer than 1 mile of the proposed site, and U.S. Route 51 passes within about 6 miles west of the proposed site. The applicant states that the Gilman Line of the Canadian National Railroad parallels State Route 54 and passes about 1 mile to the north of the proposed site.

In SSAR Section 2.2.2.3, the applicant states that five pipelines cross the CPS property; one of these pipelines passes within 1 mile of the ESP site. The Shell/Equilon 14-inch pipeline currently transports gasoline and diesel, but is configured so it could transport higher volatility products like propane. The SSAR states that the pipeline owner has agreed to notification protocols in the event that propane or other high-volatility substances are moved through the pipeline. However, the SSAR states that recent discussions with the pipeline owner indicate that the use of the pipeline is not likely to change. Table 2.2-4 of the SSAR indicates that three other pipelines carrying refined petroleum products pass no closer than 12,000 feet from the ESP site.

In SSAR Section 2.2.2.5, the applicant describes aircraft activities (nearby airports and airways) in the vicinity of the proposed ESP site. SSAR Figure 2.2-1 identifies four small private airstrips within 6 miles of the ESP site. The SSAR indicates that these small private strips have turf runways of 1500-2000 feet and can only accommodate small single- or twin-engine propeller craft. The airstrip closest to the ESP site (Spencer), owned by AmerGen, is not operational. A heliport is also located at CPS for the exclusive use of CPS staff. The applicant committed to revise SSAR Section 2.2.2.5.1 in response to RAI 2.2.2-1 to include flight traffic estimates for these airstrips.

The aircraft activities associated with the three operational airstrips in the vicinity of the ESP site involve light aircraft. These airstrips handle an estimated 800 operations per year in total aircraft traffic. In SSAR Figure 2.2-3, Exelon indicates that four low-altitude Federal airways cross near the ESP site. Airway V313 passes 2 miles east of the ESP site. Airway V233 passes 3 miles northwest. Airway V72 passes 5 miles to the northeast, and Airway V434 passes 6 miles north-northeast of the ESP site.

The SSAR states that Clinton Lake is the only navigable waterway in the vicinity of the ESP site. Recreational boating is the only water navigation occurring on the lake. Seven public boat launch ramps and one marina provide boat access to the lake.

2.2.1.2–2.2.2.2 Regulatory Evaluation

In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. The staff considered the following regulatory requirements identified in RS-002, Attachment 2, 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 plant parameter envelope (PPE) that might be constructed at the proposed site:

- Title 10, Section 52.17(a)(1)(vii), of the *Code of Federal Regulations* (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 man-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

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

- Regulatory Guide (RG) 1.91, "Evaluation 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 Hazardous Chemical Release," issued December 2001

- RG 1.70, Revision 3, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," issued November 1978

- NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," issued in 1981

- RS-002, Attachment 2

The staff used the regulatory positions and specific criteria in RG 1.91 and RG 1.78, Revision 1, which describe acceptable methods for hazard evaluation, to determine the applicant's compliance with the NRC regulations listed above.

Sections 2.2.1–2.2.2, 2.2.3, and 3.5.1.6 of RS-002, Attachment 2, as well as RG 1.70, Revision 3, provide guidance on the information appropriate for identifying, describing, and evaluating potential manmade hazards. The staff finds that the applicant has correctly identified the applicable regulations and guidance.

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 the applicant provided in SSAR Sections 2.2.1–2.2.2, (2) the applicant's responses to the staff's RAIs, (3) information obtained during the staff's visit to the proposed ESP site and its vicinity, and (4) other publicly available reference material published by the U.S. Geological Survey (USGS) (see the Clinton, Heyworth, Maroa, Farmer City North, Farmer City South, LeRoy, Weldon East, Weldon West, and DeWitt, Illinois, 7.5-minute quadrangle maps) and other topographic maps (see *Illinois Atlas and Gazetteer*, issued 2000), aerial imagery (Terraserver-usa.com, 2004), and geographic information system (GIS) 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 information provided by the applicant regarding nearby industrial facilities. Because the ESP facility would be located adjacent to the existing CPS facility, the applicant relied on the CPS updated safety analysis report (USAR) which has already identified and evaluated the potential hazards from nearby industrial facilities. The applicant provided a listing of the chemical and potentially hazardous material storage volumes at the CPS site. Within 5 miles of the ESP site, Van Horn-DeWitt stores herbicides, insecticides, and fertilizers. Cornbelt FS maintains a large propane tank at its facility in DeWitt. The staff's review did not identify any relevant facilities not previously noted by the applicant.

The applicant neither identified nor evaluated any hazards that the existing CPS may pose to a new facility that might be constructed and operated on the proposed ESP site. Design-specific interactions between the existing unit and any new units would need to be evaluated and addressed in a COL application that references an ESP for the EGC ESP site. This is **COL Action Item 2.2-1**.

2.2.1.4–2.2.2.4 Conclusions

As set forth above, the applicant has 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, Revision 3, such that the staff can evaluate the applicant's compliance with the requirements of 10 CFR 100.20 and 10 CFR 100.21. 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 undue risk to the type of facility proposed under this ESP application. Figure 2.2.1-1 illustrates the locations of such facilities in reference to the ESP site. On the basis of its evaluation of the SSAR, review of information given in responses to RAIs, as well as information obtained independently, the staff concludes that the applicant identified all potentially hazardous activities on and in the vicinity of the site. SSAR and SER Sections 2.2.3 and 3.5.1.6 discuss the evaluation of such hazards.

2.2.3 Evaluation of Potential Accidents

In SSAR Section 2.2.3, the applicant identifies 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 facility falling within the applicant's PPE that might be constructed on the proposed ESP site (see SER Section 2.2.1–2.2.2).

The applicant elected to use a PPE as a surrogate for plant design in analyzing potential accidents. As such, it has not determined the precise design of the facility control room. Some potential accidents on or in the vicinity of the ESP site may affect control room habitability (e.g., toxic gases, asphyxiants). 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 within the review conducted using Section 2.2.3 of RS-002, Attachment 2). The staff will review these potential accidents at the combined operating license (COL) or construction permit (CP) stage using the guidance in SRP Section 6.4.

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

2.2.3.1 Technical Information in the Application

Section 2.2.3 of the SSAR presents information concerning potential accidents. Accident pathways considered include flammable vapor clouds, aircraft crashes, and toxic chemicals.

The SSAR states that potential accidents involving transportation routes or flammable, explosive, chemical, or toxic storage at the CPS site were dismissed as design concerns in the CPS Updated Safety Analysis Report (USAR). It further states that, because the precise design of the ESP control room habitability systems will not be known until the COL stage, certain toxic chemical hazards cannot be evaluated until that time.

Section 2.2.2.5.3 of the SSAR describes the potential for accidents originating from airports or airways. SER Section 2.2.1–2.2.2 discusses the locations of airports and airways, as provided by the applicant. The applicant relied on the CPS USAR and the SRP for guidance on determining the accident probabilities associated with airways crossing within 5 miles of the ESP site. The applicant determined the probability of accidents from plane crashes from the civil and military airways in the vicinity to be less than the SRP guideline of $1x10^{-7}$ per year. The SSAR also states that none of the airports within 10 miles of the ESP site support operations in excess of the threshold criteria in RG 1.70, Revision 3.

Section 2.2.3.1.3 of the SSAR describes the applicant's analysis of potential accidents involving toxic chemicals. The Van Horn-DeWitt facility stores and distributes agricultural products such as pesticides, herbicides, and fertilizers. This facility is located next to State Route 54, about 2.6 miles from the ESP site. The applicant used the guidance in RG 1.78 to demonstrate that a potential spill of anhydrous ammonia is not a concern because of the small number of shipments made to the Van Horn-DeWitt facility.

The applicant also found that the CPS USAR used the guidance in RG 1.78 to determine that the likelihood of potential accidents on the Gilman Line of the Canadian National Railroad, which runs parallel to State Route 54, is acceptably low. However, CPS has committed to survey the rail line every 3 years to keep abreast of changes in hazardous material shipments. The SSAR indicates that once a control room design has been determined at the COL stage, the potential for accidents involving the rail line must be revisited. SSAR Section 2.2.3.1.2 also states that the probability of a flammable vapor cloud and its subsequent explosion overpressure exceeding the RG 1.91 acceptance criteria is less than $1x10^{-6}$ per year.

2.2.3.2 Regulatory Evaluation

In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. The staff considered the following regulatory requirements identified in RS-002, Attachment 2, in reviewing 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:

(1) 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

(2) 10 CFR 100.20(b), with respect to information on the nature and proximity of man-related hazards

(3) 10 CFR 100.21(e), with respect to the evaluation of potential hazards associated with nearby transportation routes and industrial and military facilities.

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

- RG 1.91
- RG 1.78, Revision 1
- RG 1.70, Revision 3
- NUREG-0800 (SRP)
- RS-002, Attachment 2

The staff used the regulatory positions and specific criteria in Revision 3 of RG 1.70 to determine the applicant's compliance with the regulations listed above. Sections 2.2.1–2.2.2, 2.2.3, and 3.5.1.6 of RS-002, Attachment 2, as well as RG 1.70, Revision 3, provide guidance on the information appropriate for identifying, describing, and evaluating potential accidents. The staff finds that the applicant has correctly identified the applicable regulations and guidance.

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 RAIs, (3) information obtained during a visit to the proposed ESP site and its vicinity, and (4) other publicly available reference material published by the USGS (see the Clinton, Heyworth, Maroa, Farmer City North, Farmer City South, LeRoy, Weldon East, Weldon West, and DeWitt, Illinois, 7.5-minute quadrangle maps) and other topographic maps (see the *Illinois Atlas and Gazetteer*), aerial imagery (see Terraserver-usa.com, 2004), and GIS coverage files (see the Platts POWERmap GIS spatial data).

Section 2.2.1–2.2.2 of this SER describes potential hazards affecting the ESP site. These hazards include the existence of commercial airways and airport facilities in or near the vicinity of the ESP site, the onsite storage of chemicals and other materials at the CPS site, three additional industrial plant sites in the vicinity, and the Gilman Line of the Canadian National Railroad. The staff notes that the CPS USAR did not find that the potential hazards from flammable, chemical, explosive, and toxic material storage at CPS constitute design concerns. Therefore, the staff believes it is unlikely that these hazards would be significant with respect to the ESP site. However, the staff will review these hazards at the COL stage to verify that no design-specific vulnerabilities exist. Section 3.5.1.6 of this SER provides the staff's evaluation of aircraft hazards.

The staff reviewed the applicant's analysis of the effects of potential explosions and the formation of flammable vapor clouds. The staff finds that, because of the distance from the potential ESP facility and the worst-case train tank explosion accident (according to RG 1.91), no significant damage would be expected with respect to the typical nuclear power plant safety-related structures, systems, and components that might be located on the ESP site. The staff relied on an analysis provided in the CPS USAR of a single year of rail shipment data during the 1981–1982 period. Updated shipment data for the Gilman Rail Line will be required at the COL stage to account for current shipment characteristics and the actual design of the control room systems of the new nuclear unit(s). To ensure that the USAR conclusions remain valid, the applicant has committed to update the rail shipment data for hazardous material every 3 years.

The staff reviewed the applicant's analysis of potential toxic chemical accidents. These accidents include train and truck tanker spills of anhydrous ammonia, chemical materials stored and used on site at CPS and that could be used and stored at future facilities that might be constructed on the ESP site, and anhydrous ammonia storage tank failure at the Van Horn-DeWitt facility. Given that the PPE does not specify a control room design, no specific determination can be made with respect to control room habitability in the event of a toxic chemical accident at the site or in the vicinity. Although the applicant cited the USAR's inventory of toxic chemicals, such quantities cannot be determined at the ESP stage without a precise set of plant-design parameters. Therefore, the staff cannot evaluate the potential effects of accidents on control room habitability at this time. The staff will evaluate such effects at the COL stage.

2.2.3.4 Conclusions

As set forth above, the applicant has identified potential accidents related to the presence of hazardous materials or activities onsite and in the site vicinity that could affect a nuclear power plant(s) represented by the chosen PPE. The applicant also identified those that, in accordance with the relevant requirements of 10 CFR Part 100, "Reactor Site Criteria," should be considered as design-basis events at the COL or CP stage. Therefore, the staff concludes that the site location is acceptable with regard to potential accidents that could affect a nuclear power plant(s) based on the applicant's PPE that might be constructed on the site, and that the site location 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(s) can be designed, constructed, and operated on an applicant's proposed early site permit (ESP) site in compliance with the U.S. Nuclear Regulatory Commission's (NRC) 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 prepared Sections 2.3.1 through 2.3.5 of this safety evaluation report (SER) in accordance with the review procedures described in Review Standard (RS)-002, "Processing Applications for Early Site Permits," Attachment 2, using information presented in Section 2.3 of the site safety analysis report (SSAR), responses to staff requests for additional information (RAIs), and generally available reference materials, as described in the applicable sections of RS-002, Attachment 2.

2.3.1 Regional Climatology

2.3.1.1 Technical Information in the Application

In this section of the SSAR, the applicant (Exelon) 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(s) that falls within the applicant's plant parameter envelope (PPE) and that might be constructed on the proposed site. 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, waterspouts, thunderstorms, lightning, hail (including probable maximum size), and high air pollution potential

- meteorological conditions used as 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

  — the probable maximum frequency of occurrence and time duration of freezing rain (ice storms) and, where applicable, dust (sand) storms

  — other meteorological conditions used for design- and operating-basis considerations

The applicant characterized the regional climatology pertinent to the Clinton ESP site using data reported by the National Weather Service (NWS) at the Peoria, Illinois, and Springfield, Illinois, first-order weather stations, as well as nearby cooperative observer stations, such as Decatur, Illinois. The applicant considered the Peoria and Springfield weather stations to be representative of the climate at the Clinton ESP site, because of their relatively close proximity to the site and similarities in terrain and vegetation features. The applicant obtained information on severe weather, including extreme design-basis conditions, from a variety of sources, such as publications by the National Climatic Data Center (NCDC), the American Society of Civil Engineers (ASCE), the Illinois State Climatologist Office (ISCO), and the Illinois State Water Survey (ISWS).

The Clinton ESP site is located in the central climatic division of Illinois. The applicant described the climate as continental, with cold winters, warm summers, and frequent, short-period fluctuations in temperature, humidity, cloudiness, and wind direction. The great variability in central Illinois climate is because of its location in a confluence zone, particularly during the cooler months, between different air masses. The air masses that affect central Illinois typically include maritime tropical air, which originates in the Gulf of Mexico; continental tropical air, which originates in Mexico and the southern Rockies; Pacific air, which originates in Mexico and the eastern North Pacific Ocean; and continental polar and continental arctic air, which originates in Canada.

The applicant noted that, for the most part, the general synoptic conditions dominate the climactic characteristics of the site region. However, during periods of extreme temperatures or light wind conditions, the local conditions influence the site's meteorology. Nearby Clinton Lake can have a moderating effect with respect to extreme temperatures in the immediate vicinity of the site.

The applicant reported that Peoria and Springfield average approximately 2.2 hail days per year, with about 55 percent of all hail days occurring in the spring. There is considerable year-to-year variation in the number of days with hail, with some years reporting as many as 8 hail days. During the 13-year period from 1955 to 1967, the 1-degree latitude by longitude square containing the Clinton ESP site (approximately 9400 square kilometers (km^2)) had 15 hailstorms producing hail 0.75 inch in diameter or greater.

According to the applicant, about 48 thunderstorm days can be expected yearly, most frequently during June and July. The applicant has conservatively estimated that there are approximately 9.4 lightning flashes to earth per year per square kilometer around the site area. Considering the frequency of thunderstorms and the size of the Clinton ESP site [14,000 acres or 56.7 km^2 (the EGC ESP site boundary is the same as the CPS property lines)], the applicant estimated the expected frequency of lightning flashes at the site at 533 per year. The expected frequency of lightning flashes within the 3.3 km^2 exclusion area is 31 flashes per year.

The applicant originally reported 11 tornadoes for DeWitt County during the period 1950–2002. Since there were numerous tornadoes reported in Illinois during 2003, the staff requested in RAI 2.3.1-1 that the applicant update the tornado data presented in its SSAR to include tornado occurrences recorded during 2003. In its response to RAI 2.3.1-1, the applicant revised its tornado statistics for DeWitt County, stating that 18 tornadoes were reported during the period 1950–2003. Using various sets of tornado data statistics for the Clinton ESP site region, the applicant calculated an annual tornado probability for a tornado of any intensity in the Clinton ESP site region as ranging from 1.5×10^{-3} to 3.1×10^{-3}, which corresponds to a tornado return period ranging from 325 to 670 years. For violent tornadoes (F4 or greater; wind speeds in excess of 207 miles per hour (mi/h)), the applicant calculated an annual tornado probability ranging from 3.8×10^{-5} to 7.8×10^{-5}, which corresponds to a return period ranging from 12,800 to 26,300 years.

The applicant chose a design-basis tornado site characteristics wind speed of 300 mi/h based on the maximum tornado wind speed recommended in SECY-93-087, “Policy, Technical, Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” for use in the design of evolutionary and passive advanced light water reactors (ALWRs). Since it does not believe that citing SECY-93-087 (or any other document related to design certification) is an adequate justification for selecting a site characteristic tornado wind speed, the staff requested in RAI 2.3.1-9 that the applicant provide a safety justification for choosing 300 mi/h as the site characteristic tornado wind speed. In its response to RAI 2.3.1-9, the applicant cited a tornado study covering much of the United States east of the Rocky Mountains which showed that the maximum tornado wind speed expected in central Illinois (where the Clinton ESP site is located), at a probability level of 10^{-7} per year, is between 250 and 300 mi/h. The applicant chose the other design-basis tornado site characteristics (e.g., maximum pressure drop, rate of pressure drop) based on the characteristics associated with a tornado wind speed of 300 mi/h, as identified in the staff’s interim position on the design-basis tornado (NRC, “ALWR Design-Basis Tornado”). Table 2.3.1-1 lists the applicant’s proposed design-basis tornado site characteristics.

Table 2.3.1-1 Applicant’s Proposed Design-Basis Tornado Site Characteristics

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Maximum Wind Speed	300 mi/h	The design assumption for the sum of maximum rotational and maximum translational wind speed components
Maximum Translational Speed	60 mi/h	The design assumption for the component of tornado wind speed resulting from the movement of the tornado over the ground
Maximum Rotational Speed	240 mi/h	The design assumption for the component of tornado wind speed caused by the rotation within the tornado
Radius of Maximum Rotational Speed	150 feet	The design assumption for distance from the center of the tornado at which the maximum rotational wind speed occurs
Maximum Pressure Drop	2.0 pounds-force per square inch (lbf/in.^{2})	The design assumption for the decrease in ambient pressure from normal atmospheric pressure resulting from the passage of the tornado
Rate of Pressure Drop	1.2 lbf/in.^{2}/ second	The assumed design rate at which the pressure drops resulting from the passage of the tornado

The applicant stated that the highest “fastest mile” wind speeds observed at Peoria and Springfield were 75 mi/h. In RAI 2.3.1-3, the staff requested that the applicant clarify the fastest mile and peak wind speed data that it presented in the SSAR. As part of its response to RAI 2.3.1-3, the applicant reported that the Peoria and Springfield data represent the 67-year period between 1930 and 1996. As reported in Table 2.3.1-2, the applicant selected this wind speed value as the basic wind speed site characteristic. In RAI 2.3.1-2, the staff asked the applicant to also provide a 3-second gust wind speed that represents a 100-year return. In its response to RAI 2.3.1-2, the applicant provided a 3-second gust wind speed value of 96 mi/h, but did not propose this value as a site characteristic. Instead, the applicant stated that the 3-second gust wind speed site characteristic will be determined at the combined license (COL) or construction permit (CP) stage, based on the applicable design standard at the time.

Table 2.3.1-2 Applicant's Proposed Basic Wind Speed Site Characteristic

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Basic Wind Speed	75 mi/h	The design wind, or fastest mile of wind with a 100-year return period, for which the facility is designed

In the SSAR, the applicant reports that severe winter storms, which usually produce snowfall in excess of 6 inches and are often accompanied by damaging glaze ice, produce more damage than any other form of short-term severe weather, including hail, tornadoes, and lightning. Central Illinois had 107 occurrences of a 6-inch snow or glaze damage area during the years from 1900 through 1960, and about 42 of those storms deposited more than 6 inches of snowfall in DeWitt County. During this same 61-year period, there were 92 severe glaze storms in Illinois, defined as damaging, widespread, or both. The Clinton ESP site region averaged slightly more than 5 days of glaze per year during the period 1901–1962, and 11 localized areas within the central third of Illinois can expect to receive damaging glaze during a typical 10-year period. An average of one storm every 3 years will produce glaze ice 0.75 inch or thicker on wires.

According to the applicant, the estimated 2-day and 7-day maximum snowfalls for the Clinton ESP site region associated with a 50-year recurrence interval are 15.2 inches and 22.0 inches, respectively. The staff requested clarification on the regional snowfall and snowpack data, as well as the winter probable maximum precipitation (PMP) value in RAIs 2.3.1-4, 2.3.1-5, 2.3.1-6, and 2.3.1-10. In its response to RAI 2.3.1-4, the applicant stated that the maximum monthly and 24-hour snowfalls recorded in the Springfield area are 24.4 inches and 15.0 inches, respectively. In its response to RAI 2.3.1-10, the applicant noted that the maximum recorded monthly snowfall in the Clinton ESP site region is 30.5 inches, which was recorded in Decatur.

The applicant initially provided a 100-year return period ground-level snowpack estimate of 22 pounds-force per square foot (lbf/ft^2), which it later revised to 24.4 lbf/ft^2 in response to RAI 2.3.1-5. The applicant also provided a 48-hour winter PMP value of 15.2 inches of water, which it subsequently revised to 16.6 inches of water in response to RAI 2.3.1-6. The 48-hour winter PMP value of 16.6 inches corresponds to approximately 86 lbf/ft^2. The combined 100-year return snowpack and the estimated winter PMP is 110.4 lbf/ft^2, which the applicant contends is an extremely conservative and highly unlikely snow/ice roof loading for a structure in Illinois. In its response to RAI 2.3.1-6, the applicant proposed defining the site-characteristic ground snow load as 40 lbf/ft^2, which represents a combination of the 100-year return snowpack (24.4 lbf/ft^2) and the maximum recorded monthly snowfall in the region (30.5 inches of snow, which is approximately equivalent to 3 inches of water or 15.6 lbf/ft^2). Table 2.3.1-3 cites the applicant's proposed design-basis snow load site characteristics.

Table 2.3.1-3 Applicant's Proposed Design-Basis Snow Load Site Characteristics

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Snow Load	40 lbf/ft^2	The maximum load on structure roofs resulting from the accumulation of snow that can be accommodated by a plant design

In the SSAR, the applicant indicates that the controlling meteorological parameters for the type of UHS that it selected (i.e., mechanical draft cooling towers with makeup water from Clinton Lake) is the wet-bulb temperature. In RAI 2.3.1-7, the NRC staff requested that the applicant clarify the meteorological data that it would use to evaluate the performance of the UHS mechanical draft cooling towers with respect to maximum evaporation, drift loss, and minimum water cooling, as discussed in Regulatory Guide (RG) 1.27, "Ultimate Heat Sink for Nuclear Power Plants." In its response to RAI 2.3.1-7, the applicant reiterated that it calculated a maximum evaporation rate of 700 gallons per minute (Item 3.3.7 in SSAR Table 1.4-1) based on the maximum system heat load and the amount of water that would need to be evaporated to dissipate that heat load. The applicant considers this a highly conservative value because the actual amount of evaporative cooling that would be necessary would be less for any time period, including the worst 30-day period discussed in RG 1.27. The applicant stated that the final design of the cooling towers would account for the bounding ambient air temperature and humidity site characteristic conditions presented in Table 2.3.1-4, which include a design wet-bulb temperature that is exceeded less than 1 percent of the time and a maximum wet-bulb temperature of 86 EF. The applicant indicated that it did not expect drift loss to be a critical design parameter since the drift in a modern cooling tower is typically very low (on the order of 0.1 percent or less).

The applicant stated that central Illinois is in a relatively favorable dispersion regime that has a relatively low frequency of extended periods of high air pollution potential. Inversions based below 500 feet occur in the general area of the Clinton ESP site during approximately 33 percent of the total hours throughout the year and occur most frequently in the fall (39 percent of the total time) and least frequently in the winter and spring (29 percent of the total time for each season). Seasonal morning average mixing layer heights in the Clinton ESP site region range from a low of 330 meters during the summer to a high of 490 meters in the spring, and seasonal afternoon average mixing layer heights range from a low of 690 meters in the winter to a high of 1600 meters in the summer.

In RAI 2.3.1-8, the staff requested that the applicant provide ambient air temperature and humidity site characteristics. In its response to RAI 2.3.1-8, the applicant provided dry-bulb and wet-bulb temperature site characteristics based on temperature and humidity data recorded at Peoria and Springfield. Table 2.3.1-4 presents the applicant's proposed ambient air temperature and humidity site characteristics.

Table 2.3.1-4 Applicant's Proposed Design-Basis Ambient Air Temperature and Humidity Site Characteristics

SITE CHARACTERISTIC		VALUE	DESCRIPTION
Maximum Dry-Bulb Temperature	2% annual exceedance	88 EF with 74 EF concurrent wet-bulb	Wet-bulb and dry-bulb temperatures associated with the listed exceedance values and the 100-year return period
	1% annual exceedance	91 EF	
	0.4% annual exceedance	94 EF with 77 EF concurrent wet-bulb	
	0% annual exceedance	117 EF	
	100-year return period	117 EF with 86 EF concurrent wet-bulb	
Minimum Dry-Bulb Temperature	1% annual exceedance	0 EF	
	0.4% annual exceedance	!6 EF	
	0% annual exceedance	!36 EF	
	100-year return period	!36 EF	
Maximum Wet-Bulb Temperature	1% annual exceedance	78 EF	
	0.4% annual exceedance	80 EF	
	0% annual exceedance	86 EF	
	100-year return period	86 EF	

2.3.1.2 Regulatory Evaluation

In response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the regulations applicable to the ESP SSAR. RS-002, Attachment 2, identifies the following applicable NRC regulations regarding regional climatology:

- Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50 of the *Code of Federal Regulations* (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities," General Design Criterion (GDC) 2, "Design Bases for Protection Against Natural Phenomena," with respect to information on severe regional weather phenomena that have historically been reported for the region and that are reflected in the design bases for structures, systems, and components (SSCs) important to safety

- Appendix A to 10 CFR Part 50, GDC 4, “Environmental and Dynamic Effects Design Bases,” with respect to information on tornadoes that could generate missiles

- 10 CFR 100.20(c), “Reactor Site Criteria,” and 10 CFR 100.21(d), “Non-Seismic Siting Criteria,” with respect to the consideration of the regional meteorological characteristics of the site

In SSAR Sections 1.1.1, 1.5, and 2.3.1, the applicant identifies the following applicable NRC guidance regarding regional climatology:

- RG 1.27 issued January 1976, with respect to the meteorological conditions that should be considered in the design of the UHS

- Section 2.3.1 of RG 1.70, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants—LWR Edition,” issued November 1978, 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

The staff finds that the applicant has correctly identified the applicable regulations and guidance, with the exception that an ESP applicant need not demonstrate compliance with the GDC.

Sections 2.3.1 of RS-002, Attachment 2, and 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 that the National Oceanic and Atmospheric Administration compiled. 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 applicability of these data to represent site conditions during the expected period of reactor operation should be substantiated.

- Design-basis tornado parameters may be based on RG 1.76 or the staff’s interim position on design-basis tornado characteristics (NRC, “ALWR Design-Basis Tornado”). An ESP applicant may use any design-basis tornado wind speeds that are appropriately justified, provided that it conducts a technical evaluation of site-specific data.

- Design-basis straight-line wind velocity should be based on appropriate standards, with suitable corrections for local conditions.

- The UHS meteorological data, as stated in RG 1.27, should be based on long-period regional records that 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 (EPA) studies.

- All other meteorological and air quality data used for safety-related plant design and operating bases should be documented and substantiated.

2.3.1.3 Technical Evaluation

The staff evaluated regional meteorological conditions using information that the NCDC, National Severe Storms Laboratory (NSSL), ISCO, and ASCE reported. The staff reviewed statistics for the following climatic stations located in the vicinity of the Clinton ESP site:

- Clinton, Illinois, located approximately 7 miles west-southwest of the ESP site
- Decatur, Illinois, located approximately 24 miles south-southwest of the ESP site
- Lincoln, Illinois, located approximately 26 miles west of the ESP site
- Springfield, Illinois, located approximately 50 miles west-southwest of the ESP site
- Peoria, Illinois, located approximately 56 miles west-northwest of the ESP site

The staff concurs with the applicant's description of the general climate of the region, which is consistent with a narrative of the climate of Illinois published by ISCO (ISCO, "Climate of Illinois"). The staff also finds the applicant's estimates of thunderstorm day frequency to be consistent with regional data and its estimates of expected frequency of lightning flashes to be consistent with accepted methodology.

Hail often accompanies severe thunderstorms and can be a major weather hazard, causing damage to crops and property. According to NSSL, the threat of hail occurring within 25 miles of the Clinton ESP site is approximately 2–3 days per year for damaging hail, or hail 0.75 inch in diameter or greater, and 0.50 to 0.75 days per year for hail 2 inches or more in diameter (NSSL, "Severe Thunderstorm Climatology").

The above discussion on lightning and hail 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 bases.

According to NSSL, the mean number of days per year with the threat of tornados occurring within 25 miles of the Clinton ESP site is approximately 1.0 to 1.2 days per year for any tornado, approximately 0.20 to 0.25 days per year for a significant tornado (F2 or greater; wind speeds in excess of 113 mi/h), and approximately 0.015 to 0.020 days per year for a violent tornado (F4 or greater; wind speeds in excess of 207 mi/h) (NSSL, "Severe Thunderstorm Climatology").

At the staff's direction, Pacific Northwest National Laboratories (PNNL) prepared a technical evaluation report evaluating the design-basis tornado for the Clinton ESP site (Ramsdell, "Technical Evaluation Report on Design Basis Tornadoes for the Clinton ESP Site"). This report derived a best estimate annual tornado strike probability of 1.2×10^{-3}, based on tornado data from the period January 1950 through August 2003. This corresponds to a mean recurrence interval of 833 years, which is slightly less conservative than the applicant's calculated tornado return period (i.e., 325 to 670 years). The PNNL report also derived a best estimate 10^{-7} per year occurrence design-basis tornado wind speed of 300 mi/h, which is equal to the applicant's design-basis tornado wind speed. The applicant chose the other design-basis tornado characteristics associated with a tornado wind speed of 300 mi/h as identified in the staff's interim position (NRC, "ALWR Design Basis Tornado"). Therefore, the staff concludes that the applicant's design-basis tornado site characteristics are acceptable.

The applicant's proposed site characteristic basic wind speed of 75 mi/h is compatible with the fastest mile wind speeds having a 1 percent annual probability of being exceeded (100-year mean recurrence interval) of 75 mi/h and 74 mi/h for Peoria and Springfield, respectively, as reported in Table A7 of American National Standards Institute (ANSI) A58.1-1982, "Minimum Design Loads for Buildings and Other Structures." Therefore, the staff concludes that a site characteristic fastest mile basic wind speed value of 75 mi/h is acceptable.

The applicant has also defined a 3-second gust wind speed site value of 96 mi/h, based on a 100-year return period at 10 meters above the ground. The applicant determined this value in accordance with the guidance provided by Structural Engineering Institute (SEI)/ASCE 7-02, "Minimum Design Loads for Buildings and Other Structures." However, the applicant has indicated that the 3-second gust wind speed will be determined at the COL or CP stage based on the applicable design standard at that time. This is **COL Action Item 2.3-1**.

The NCDC reports a 50-year period return period uniform radial ice thickness of 1 inch because of freezing rain, with a concurrent 3-second gust wind speed of 40 mi/h for the Clinton ESP site area (Jones et al., "The Development of a U.S. Climatology of Extreme Ice Loads").

Snowfall in the site vicinity averages approximately 21.9 inches per year, based on historical data collected during the period 1971–2000 at the Decatur cooperative weather station. The highest monthly and seasonal total snowfalls recorded at Decatur during the period of record 1893–2001 were 30.5 inches and 49.7 inches, respectively (ISCO, "Historical Climate Summary—112193 Decatur, IL"). One of the highest reported 24-hour snowfall observations in the site region was 17.0 inches in December 1972 at Springfield (ISCO, "Historical Climate Summary—118179 Springfield WSO AP, IL").

The applicant has identified a 100-year return period snowpack of 24.4 lbf/ft^2 for the Clinton ESP site, determining this value in accordance with the guidance of ASCE 7-98, "Minimum Design Loads for Buildings and Other Structures." Because the applicant performed its analysis in accordance with the appropriate guidance and the results bound the observations described above, the staff concludes that a 100-year return period snowpack site characteristic value of 24.4 lbf/ft^2 is acceptable.

The applicant has identified a 48-hour winter PMP value of 16.6 inches for the Clinton ESP site. The winter PMP value is specified in RG 1.70 to assess the potential snow loads on the roofs of safety-related structures. However, the applicant proposed an alternative approach (as discussed in the following paragraph) for defining the site characteristic snow load that does not rely on the winter PMP value. Consequently, the staff did not evaluate or accept the applicant's winter PMP value.

The applicant has proposed a site characteristic ground snow load value of 40 lbf/ft^2, which represents a combination of the 100-year return snowpack (24.4 lbf/ft^2) and the maximum-recorded monthly snowfall in the region (30.5 inches of snow, which is approximately equivalent to 15.6 lbf/ft^2). Section 2.3.1.2 of RG 1.70 states that the weight of snow and ice on the roof of each safety-related structure should be a function of the weight of the 100-year return period snowpack and the weight of the 48-hour winter PMP for the site vicinity. The combined loading resulting from the 100-year return snowpack (30.5 lbf/ft^2) and the applicant's estimated winter PMP (86 lbf/ft^2) is 110.4 lbf/ft^2, which the applicant believes is an unreasonable snow/ice roof loading for a structure at the Clinton ESP site. As an alternative, the applicant proposed defining the site characteristic ground snow load as a combination of the 100-year return snowpack and the historic worst-case winter storm event represented by the maximum monthly snowfall observed in the area. The staff agrees that this represents a more realistic and yet still conservative ground snow load site characteristic for the Clinton ESP site.

The staff believes that the applicant did not adequately identify the meteorological data to use in evaluating the performance of a mechanical draft cooling tower UHS with respect to maximum evaporation and minimum water cooling, as discussed in RG 1.27. The controlling meteorological variables used to evaluate cooling tower performance are the wet-bulb temperature and the coincident dry-bulb temperature. The historical maximum 30-day average wet-bulb temperature and coincident dry-bulb temperature are widely used to represent meteorological conditions resulting in maximum evaporation and drift loss. Likewise, the historical maximum 1-day and 5-day average wet-bulb temperatures and the coincident dry-bulb temperatures are widely used to represent the worst combination of meteorological conditions resulting in minimal water cooling. This item is unresolved and is **Open Item 2.3-1**.

The staff also believes that the applicant needs to identify an additional UHS design-basis site characteristic for use in evaluating the potential for water freezing in the UHS water storage facility (e.g., Clinton Lake), a phenomenon that would reduce the amount of water available for use by the UHS. The lowest 7-day average air temperature recorded in the site region may be a reasonably conservative site characteristic for evaluating the potential for water freezing in the UHS water storage facility. This item is unresolved and is **Open Item 2.3-2**.

Large-scale episodes of atmospheric stagnation are not common in the site region. During the 40-year period from 1936 to 1975, high-pressure stagnation conditions lasting for 4 days or more occurred about 15 times with an average of 5.4 stagnation days per case. Only two of these stagnation cases lasted 7 days or longer (Korshover, "Climatology of Stagnating Anticyclones East of the Rocky Mountains, 1936–1975"). This discussion of 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 considered for design and operating bases. 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.

Normal climatic data for the period 1971–2000 that the NCDC reported for the central climatic division of Illinois indicate that the annual mean temperature in the area is about 50.9 EF and ranges from a low monthly mean value of 22.9 EF in January to a high monthly mean value of 74.9 EF in July (NCDC, “Central Illinois Divisional Normals—Temperature, Period 1971–2000”). One of the highest temperatures recorded in the site region was 113 EF at Decatur on July 14, 1954 (ISCO, “Historical Climate Summary—112193 Decatur, IL”), Lincoln on July 15, 1936 (ISCO, “Historical Climate Summary—115079 Lincoln, IL”), and Peoria on July 15, 1936 (ISCO, “Historical Climate Summary—116711 Peoria WSO Airport, IL”). One of the lowest temperatures recorded in the site region was !29 EF at Lincoln on December 26, 1914 (ISCO, “Historical Climate Summary—115079 Lincoln, IL”).

The annual mean wet-bulb temperatures at Peoria and Springfield are 47.0 EF and 47.5 EF, respectively. The Peoria wet-bulb temperatures range from a high monthly mean value of 69.2 EF in July to a low monthly mean value of 23.4 EF in January, while the Springfield wet-bulb temperatures range from a high monthly mean value of 68.4 EF in July to a low monthly mean value of 25.5 EF in January. The annual mean relative humidity is 70 percent at both Peoria and Springfield (NCDC, “Peoria, Illinois, 2003 Local Climatological Data, Annual Summary with Comparative Data,” and NCDC, “Springfield, Illinois, 2003 Local Climatological Data, Annual Summary with Comparative Data”).

For the following reasons, the staff concurs with the applicant’s design-basis temperature and humidity site characteristics. The applicant’s 2 percent, 1 percent, and 0.4 percent annual exceedance maximum dry-bulb (and, where applicable, concurrent wet-bulb) temperatures; the 1 percent and 0.4 percent annual exceedance minimum dry-bulb temperatures; and the 1 percent and 0.4 percent exceedance maximum wet-bulb temperatures are based on the Peoria and Springfield data published by the NCDC (NCDC, “Engineering Weather Data CDROM”). The staff believes that the applicant used the record highest temperature for Illinois, as reported by both NCDC (NCDC, “Temperature Extremes”) and ISCO (ISCO, “Illinois Records”), to represent the 0 percent annual exceedance and 100-year return period maximum dry-bulb temperature values. Likewise, the applicant apparently used the record lowest temperature for Illinois, as reported by both NCDC (NCDC, “Temperature Extremes”) and ISCO (ISCO, “Illinois Records”), to represent the 0 percent annual exceedance and 100-year return period minimum dry-bulb temperature values. The applicant estimated the 100-year return period maximum wet-bulb temperature from the 2 percent occurrence and median annual extreme high wet-bulb temperatures reported for Peoria, Springfield, and Decatur (NCDC, “Engineering Weather Data CDROM”).

To verify the applicant’s 100-year return period data, the staff also calculated 100-year return period maximum and minimum dry-bulb temperatures and maximum wet-bulb temperatures using NCDC data for Peoria and Springfield during the period 1961–1990 (NCDC, “Solar and Meteorological Surface Observational Network (SAMSON) for Central U.S. CDROM”) and algorithms based on the Gumbel Type 1 extreme value distribution defined in Chapter 27, “Climatic Design Information,” of the 2001 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook, *Fundamentals*. The staff found that the 100-year return period maximum and minimum dry-bulb temperatures and maximum wet-bulb temperature values presented by the applicant bound the corresponding values that the staff calculated.

The staff will include the regional climatology site characteristics listed in Table 2.3.1-5 in any ESP permit that the NRC might issue for the Clinton ESP site.

Table 2.3.1-5 Staff's Proposed Regional Climatology Site Characteristics

SITE CHARACTERISTIC		VALUE	DESCRIPTION
Ambient Air Temperature and Humidity			
Maximum Dry-Bulb Temperature	2% annual exceedance	88 EF with 74 EF concurrent wet-bulb	The ambient dry-bulb temperature (and coincident wet-bulb temperature) that will be exceeded 2% of the time annually
	1% annual exceedance	91 EF	The ambient dry-bulb temperature that will be exceeded 1% of the time annually
	0.4% annual exceedance	94 EF with 77 EF concurrent wet-bulb	The ambient dry-bulb temperature (and coincident wet-bulb temperature) that will be exceeded 0.4% of the time annually
	100-year return period	117 EF	The ambient dry-bulb temperature that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Minimum Dry-Bulb Temperature	99% annual exceedance	0 EF	The ambient dry-bulb temperature below which dry-bulb temperatures will fall 1% of the time annually
	99.6% annual exceedance	!6 EF	The ambient dry-bulb temperature below which dry-bulb temperatures will fall 0.4% of the time annually
	100-year return period	!36 EF	The ambient dry-bulb temperature for which there is a 1% annual probability of a lower dry-bulb temperature (100-year mean recurrence interval)
Maximum Wet-Bulb Temperature	1% annual exceedance	78 EF	The ambient wet-bulb temperature that will be exceeded 1% 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
	100-year return period	86 EF	The ambient wet-bulb temperature that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Wind Speed			
Basic Wind Speed (fastest mile)		75 mi/h	The fastest-mile wind speed to be used in determining wind loads, defined as the fastest-mile wind speed at 33 feet (10 meters) above the ground that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Basic Wind Speed (3-second gust)		**(COL Action Item 2.3-1)**	The 3-second gust wind speed to be used in determining wind loads, defined as the 3-second gust wind speed at 33 feet (10 meters) above the ground that has a 1% annual probability of being exceeded (100-year mean recurrence interval)
Design-Basis Tornado			
Maximum Wind Speed		300 mi/h	Maximum wind speed for the design-basis tornado resulting from passage of a tornado having a probability of occurrence of 10^{-7} per year

SITE CHARACTERISTIC	VALUE	DESCRIPTION
Translational Speed	60 mi/h	Translation component of the maximum design-basis tornado wind speed
Rotational Speed	240 mi/h	Rotation component of the maximum design-basis tornado wind speed
Radius of Maximum Rotational Speed	150 feet	Distance from the center of the design-basis tornado at which the maximum rotational wind speed occurs
Maximum Pressure Drop	2.0 lbf/in.^{2}	Decrease in ambient pressure from normal atmospheric pressure resulting from passage of the design-basis tornado
Maximum Rate of Pressure Drop	1.2 lbf/in.^{2}/s	Rate of pressure drop resulting from the passage of the design-basis tornado
Precipitation		
Ground Snow Load	40 lbf/ft^2	The ground snow load to be used in determining snow loads for roofs, defined as the ground snow load that has a 1% annual probability of being exceeded (100-year mean recurrence interval) plus the maximum recorded monthly snowfall
Ultimate Heat Sink Ambient Air Characteristics		
Meteorological Conditions Resulting in the Minimum Water Cooling	**(Open Item 2.3-1)**	Worst combination of meteorological variables resulting in minimum water cooling
Meteorological Conditions Resulting in the Maximum Evaporation and Drift Loss	**(Open Item 2.3-1)**	Worst combination of meteorological variables resulting in maximum evaporation and drift loss
Meteorological Conditions Resulting in Maximum Water Freezing in the UHS Water Storage Facility	**(Open Item 2.3-2)**	Worst combination of meteorological variables resulting in maximum water freezing in the UHS water storage facility

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(s) falling within its PPE that might be constructed on the proposed site. The staff 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), with the exception of the open items identified.

The staff finds that the applicant has considered the most severe regional weather phenomena in establishing the site characteristics identified above. The methodologies used by the applicant to determine the severity of the weather phenomena reflected in these site characteristics have generally been accepted by the staff, as documented in safety evaluation reports for previous licensing actions. Accordingly, it is the staff’s engineering judgment that the use of these methodologies results in site characteristics that contain margin sufficient for the limited accuracy, quantity, and period of time in which the data were accumulated. In view of the above, the site characteristics identified above are acceptable for use as part of the design bases for SSCs important to safety, as may be proposed in a COL application.

With regard to tornado wind speed, the applicant cited a tornado study covering much of the United States east of the Rocky Mountains, including central Illinois where the Clinton ESP site is located. The staff conducted its own evaluation of site-specific tornado data and concluded that the results justify the applicant's proposed site tornado characteristics. In addition, the staff finds that these tornado site characteristics are acceptable for the design-basis 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 site, if one is issued, and (with the exception of the open items identified above) finds these characteristics acceptable. The staff also reviewed the applicant's proposed design parameters (PPE values) for inclusion in such an ESP (SSAR Section 1.3) and finds them 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 this section of the SSAR, the applicant presents local (site) meteorological information. This SSAR section also addresses the potential influence of construction and operation of a nuclear power plant(s) falling within the applicant's PPE on local meteorological conditions that might in turn adversely impact such plant(s) or the associated facilities. Finally, the applicant provides a topographical description of the site and its environs and presents 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 the construction and operation of a nuclear power plant(s) and its facilities falling within the applicant's PPE that might be built on the proposed site, 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(s) falling within the applicant's PPE that might be constructed on the proposed site

The applicant characterizes local meteorological conditions using data collected from the meteorological monitoring program at the existing Clinton Power Station (CPS). According to the applicant, the meteorological variables collected by the CPS monitoring program are appropriate for use in describing local meteorological conditions because of the proximity of the CPS meteorological tower to the ESP site. The applicant uses two periods of record to characterize local meteorological conditions: April 1972 through April 1977 (pre-CPS construction), and January 2000 through August 2002 (post-CPS construction).

The applicant presents wind data from the 10-m (33-ft) level of the CPS onsite meteorological tower for both the pre-CPS construction period (1972–1977) and the post-CPS construction period (2000–2002). The 1972–1977 wind direction data indicate that the predominant wind directions were from the south and south-southwest (about 10 percent of the time for each sector). The 2000–2002 wind data indicate that the predominant wind directions were from the south (about 11 percent of the time) and south-southwest (about 10 percent of the time). The 1972–1977 median wind speed was about 3.8 meters per second (m/s) as compared to the 2000–2002 median wind speed of approximately 2.8 m/s. Seasonal variations are also evident from the data, with winter months showing generally higher wind speeds, fewer calms, and more west-northwest wind in comparison to the summer months.

The average ambient dry-bulb temperature recorded onsite during the period of record 1972–1977 was 10.5 EC (50.9 EF), ranging from a low monthly mean value of !5.1 EC (22.8 EF) in January to a high monthly mean value of 23.6 EC (74.5 EF) in July. The annual average relative humidity during the same period of record was 68.3 percent. The annual average dewpoint temperature was 4.7 EC (40.5 EF), ranging from a low monthly mean value of !7.8 EC (18.0 EF) in January to a high monthly mean value of 16.5 EC (61.7 EF) in July. Table 2.3-13 of the SSAR also contains a summary of CPS wet-bulb temperature measurements.

In RAI 2.3.2-6, the staff inquired about the CPS wet-bulb temperature statistics, given that nearly all of the CPS wet-bulb temperature values presented in SSAR Table 2.3-13 exceeded the corresponding CPS dry-bulb temperature values presented in SSAR Table 2.3-9. In its response to RAI 2.3.2-6, the applicant agreed that the wet-bulb temperatures presented in SSAR Table 2.3-13 were inconsistent with what would be expected when compared to the dry-bulb temperatures in SSAR Table 2.3-9. Since it did not use the wet-bulb temperatures presented in Table 2.3-13 to define any site characteristics, the applicant committed to deleting the SSAR Table 2.3-13 wet-bulb temperature data from the SSAR.

Since the temperature and humidity data presented in the SSAR were collected during the period 1972–1977 (before the installation of Clinton Lake and the operation of the CPS once-through cooling system), the staff asked the applicant in RAI 2.3.2-2 whether these data remain representative of the Clinton ESP site, given that the site is now adjacent to a heated lake. The applicant responded that, since the meteorological tower is located approximately 0.5 miles from the nearest shoreline and the nearest shoreline is more than 4 miles downstream of the CPS thermal plume discharge location, it expected that the heating effects attributable to elevated water temperatures in the lake are minimal, if even measurable, at the location of the meteorological tower. The applicant made qualitative comparisons of the 1972–1977 and 2000–2002 temperature and humidity data sets, concluding that the two data sets were compatible, given the kinds of variations that would be expected for the two periods of record.

The average yearly precipitation recorded onsite during the period of record 1972–1977 was 25.47 inches, with monthly averages ranging from 1.15 inches in February to 4.16 inches in June.

According to the applicant, the closest locations to the Clinton ESP site that have a fog data set are Peoria and Springfield. Peoria averages 20 days per year of heavy fog, whereas Springfield averages 18.5 days of heavy fog per year. The highest occurrence of fog is in the winter months for both locations. The applicant noted that the Peoria and Springfield fog statistics should be considered regional estimates because they do not account for any local fog occurrences resulting from the once-through cooling system (Clinton Lake) used by the existing CPS. The applicant used an analytical model to estimate the impacts of fog associated with the presence of Clinton Lake and the once-through cooling system as part of the license application for CPS. This model predicted that 316 hours of heavy fog would occur at the CPS reactor building complex. The applicant predicted the maximum horizontal extent of steam fog from Clinton Lake as 1 mile or less, with the extent of extremely dense steam fog being limited to an area immediately adjacent to Clinton Lake.

The SSAR presents atmospheric stability data for the periods 1972–1977 and 2000–2002, based on delta-temperature measurements between the 60-m and 10-m levels on the CPS meteorological tower and the variation of horizontal wind direction. Data for the later time period (which were used to derive the atmospheric dispersion estimates presented in SSAR Sections 2.3.4 and 2.3.5) show that neutral (Pasquill type "D") and slightly stable (Pasquill type "E") conditions predominate, occurring about 35 percent and 25 percent of the time, respectively. Moderately stable (Pasquill type "F") and extremely stable (Pasquill type "G") conditions occur about 9 percent and 4 percent of the time, respectively.

In RAI 2.3.2-5, the staff asked the applicant to identify the air quality characteristics that would be included in the design and operating bases for a nuclear plant(s) that might be constructed on the ESP site. The applicant responded that the ESP site is located within the east-central Illinois Interstate Air Quality Control Region, which has been designated as in attainment of the national ambient air quality standards. Before construction, the ESP facility will be required to obtain air permits from the Illinois EPA demonstrating that the ambient air quality standards will not be threatened or exceeded as a result of the facility's operation.

The applicant stated that the construction and operation of the ESP facility may influence the local meteorology of the area in the immediate vicinity of the ESP facility, primarily because of minor changes to the topography resulting from the construction of additional buildings and supporting infrastructure and the use of cooling towers for system heat rejection to the atmosphere. The applicant expects that the minor changes in local topography will not have a significant impact on diffusion characteristics except in the immediate vicinity of the buildings themselves.

The use of natural draft cooling towers or mechanical draft cooling towers or both for system heat rejection will result in visible moisture plumes from the cooling towers, primarily during winter months when ambient air temperatures are cool and the air is moist. Icing caused by the freezing of condensed water vapor from the cooling tower plumes could affect vertical surfaces (such as buildings and equipment) and horizontal surfaces (such as roadways) in the immediate vicinity of the cooling towers. The applicant expects that these impacts will occur only at onsite locations. In the SSAR, the applicant states that the quantification of these ambient impacts will require a more in-depth assessment once it determines the facility's cooling system configuration and design parameters.

The applicant states that the ESP site region is characterized by relatively flat terrain ranging from 95 feet below to 25 feet above the site elevation within 5 miles of the site. A large portion of the topographic relief in the immediate site area is filled by Clinton Lake, which is approximately 45 feet below plant grade. Because of the lake's complex configuration, over-water trajectories would generally be less than 1.1 miles. The applicant expects that the low hills and shallow river valleys that exist in the site region could exert a small effect upon nocturnal wind drainage patterns and fog frequency under certain atmospheric conditions.

2.3.2.2 Regulatory Evaluation

In response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the regulations applicable to the ESP SSAR. RS-002, Attachment 2, identifies the following applicable NRC regulations regarding local meteorology:

- Appendix A to 10 CFR Part 50, GDC 2, with respect to information on severe regional weather phenomena that has historically been reported for the region and that is reflected in the design bases for SSCs important to safety

- 10 CFR 100.20(c) and 10 CFR 100.21(d), with respect to the consideration that has been given to the regional meteorological characteristics of the site

In SSAR Sections 1.1.1 and 1.5, and in response to RAI 2.3.3-2, the applicant identified the following applicable NRC guidance regarding local meteorology:

- RG 1.23, Second Proposed Revision 1, “Meteorological Measurement Programs for Nuclear Power Plants,” issued April 1986, with respect to the criteria for an acceptable onsite meteorological measurements program

- Section 2.3.2 of RG 1.70, with respect to the type of local meteorological information that should be presented, including the potential impact of the plant on local meteorology and the local meteorological and air quality conditions used for design- and operating-basis considerations

The staff finds that the applicant correctly identified the applicable regulations and guidance, with the exception that an ESP applicant need not demonstrate compliance with the GDC.

Section 2.3.2 of RS-002, Attachment 2, and 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. Guidance related to onsite meteorological measurements is in RG 1.23.

- 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(s) and its facilities of specified type (or falling within a PPE) that might be constructed on the proposed site 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 CPS onsite meteorological monitoring system, as well as climatic data that NCDC and ISCO reported. Section 2.3.3 of this SER provides a discussion of the representativeness of the CPS onsite data.

The staff’s review of the applicant’s wind data from April 1972 through April 1977 and January 2000 through August 2002 shows that the data from these two periods compare well, with a general shift toward lower wind speeds in the more recent data. A comparison of the atmospheric stability distributions for these two measurement periods indicates that there may have been a shift in the distribution toward unstable conditions between the earlier period and the later period. This shift may be because of the heated cooling water in Clinton Lake from CPS affecting the lower level of the delta-temperature measurements. Clinton Lake was created and heated for the first time after the applicant completed the first data collection period and before it began the second data collection period.

The NCDC-reported normal climatic data for the period 1971–2000 for the central climatic division of Illinois indicate an annual mean temperature in the area of 50.9 EF, ranging from a low monthly mean value of about 22.9 EF in January to a high monthly mean value of about 74.9 EF in July (**NCDC, “Central Illinois Divisional Normals—Temperature, Period 1971–2000”**). These climatic division mean temperature values compare well with the mean temperature values recorded onsite during the period of record 1972–1977 (e.g., annual mean temperature of 10.5 EC (50.9 EF) with a low monthly mean value of !5.1 EC (22.8 EF) in January and a high monthly mean value of 23.6 EC (74.5 EF) in July). One of the highest temperatures recorded in the site region was 113 EF at Decatur on July 14, 1954 (ISCO, “Historical Climate Summary—112193 Decatur, IL”), and one of the lowest temperatures recorded in the site region was !29 EF at Lincoln on December 26, 1914 (ISCO, “Historical Climate Summary—115079 Lincoln, IL”). These values bound the highest and lowest temperatures recorded on site, 35.2 EC (95.4 EF) and !28.8 EC (!19.8 EF), respectively, during the relatively short onsite period of record 1972–1977.

The annual mean wet-bulb temperature at Peoria is 47.0 EF and ranges from a high monthly mean value of 69.2 EF in July to a low monthly mean value of 23.5 EF in January. The normal relative humidity at Peoria (71 percent) is similar to the onsite annual relative humidity (68.3 percent). Likewise, the mean dewpoint temperature at Peoria (42.2 EF) is compatible with the onsite annual dewpoint temperature of 4.7 EC (40.5 EF) (NCDC, “Peoria, Illinois, 2003 Local Climatological Data, Annual Summary with Comparative Data”).

Precipitation for the central Illinois climatic division averages 37.39 inches per year, with monthly climate division normals ranging from a minimum of about 1.70 inches in January and February to a maximum of about 4.29 inches in May (**NCDC, “Central Illinois Divisional Normals—Precipitation, Period 1971-2000”**). Onsite precipitation data recorded during the period 1972–1977 show slightly lower precipitation totals. Maximum and minimum monthly amounts of precipitation observed in the area are 16.96 inches in May 1961 at Clinton (ISCO, “Historical Climate Summary—111743 Clinton, IL”) and 0 inches in September 1979 at Springfield (ISCO, “Historical Climate Summary—118179 Springfield WSO AP, IL”). One of the highest 1-day precipitation totals recorded for the site region was 14.25 inches at Clinton on May 8, 1961 (ISCO, “Historical Climate Summary—111743 Clinton, IL”).

The staff reviewed the applicant's description of the local meteorology and determined that it represents the conditions at and near the site. The wind, temperature, precipitation, and atmospheric stability data are based on onsite data recorded by the CPS meteorological monitoring system. Section 2.3.3 of this SER provides a discussion of the representativeness of the CPS onsite data. The other meteorological summaries are based on data from nearby stations with long periods of record. A review of the recorded extreme values shows that they are reflected in the design-basis site characteristics presented in SSAR Section 2.3.1.

The staff reviewed the topographic maps and topographic cross sections included in the SSAR, concluding that the information needed is well labeled and can be readily extracted.

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. However, the use of natural draft cooling towers or mechanical draft cooling towers or both would cause visible moisture plumes and icing on nearby surfaces during the winter months. The applicant noted that the quantification of these ambient impacts will require a more in-depth assessment once the facility's cooling system configuration and design parameters are determined. The applicant will then need to describe how these potential increases in atmospheric moisture and icing would impact plant design and operation. This is **COL Action Item 2.3-2**.

Since the Clinton ESP site is located in an air quality control region that has been designated as being in attainment of the national ambient air quality standards, the staff finds that it is not likely that the ESP site air quality conditions would 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 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(s) falling within its PPE that might be constructed on the proposed site. The staff 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 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 this section of the SSAR, the applicant presents the following information concerning its onsite meteorological measurements program, including instrumentation and measured data:

- 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 uses the existing onsite meteorological measurements program for the CPS facility to collect data for the Clinton ESP site, intending to use it for any additional reactors that might be constructed on the ESP site.

The existing CPS monitoring program began in April 1972. The applicant references and uses two different periods of onsite meteorological data in the SSAR. The first period, April 1972 through April 1977, is representative of the Clinton ESP site before construction of CPS (including the filling of Clinton Lake). The applicant uses data from this first period in the original construction and operating license environmental reports and the updated safety analysis report (USAR) for CPS. The applicant uses data from the second period, January 2000 through August 2002, to characterize current site-specific meteorological conditions. The applicant obtained data from both periods from the same instrumented onsite tower at the same levels above ground. During the course of operation, the applicant replaced various electronic components and sensors with equivalent or upgraded components as a matter of routine maintenance and repair.

In RAI 2.3.3-2, the staff asked the applicant to clarify the Exelon ESP meteorological monitoring program commitments to regulatory guidance documents. In response to RAI 2.3.3-2, the applicant indicated that, since the meteorological monitoring system at CPS began operation, the system has been in compliance with NRC requirements. The CPS meteorological monitoring system currently meets the requirements of ANSI/American Nuclear Society (ANS) 2.5-1984, “Standard for Determining Meteorological Information at Nuclear Power Plants,” proposed as Revision 1 to RG 1.23 with some exceptions.

The CPS meteorological monitoring program consists of a guyed, triaxial, open lattice 199-foot tall tower located approximately 3200 feet south-southeast of the center of the CPS containment structure and approximately 1800 feet south-southeast of the center of the proposed location for a future EGC ESP facility. Wind speed and direction are measured at the 10-meter (33-foot) and 60-meter (198-foot) elevations. Ambient temperature and dewpoint temperature are measured at the 10-meter elevation and vertical temperature difference (delta-temperature) is measured between the 60-meter and 10-meter elevations. Precipitation is monitored at the ground level.

For the 1972–1977 period of operation, meteorological data were recorded on strip charts. The hourly database used for the climatic data summaries and atmospheric dispersion analyses was derived from the strip charts. For the 2000–2002 period of operation, a microprocessor recorded the meteorological data and generated the hourly database used for the climatic data summaries and atmospheric dispersion analyses presented in the SSAR.

The wind sensors are mounted on booms approximately twice the tower face width and are positioned so that the tower does not influence the prevailing south-southwest windflow. The ambient temperature, dewpoint temperature, and delta-temperature sensors are housed in motor-aspirated shields to insulate them from the effects of precipitation and thermal radiation.

The meteorological monitoring system is calibrated at least semiannually. Data recovery for the 2000–2002 period of record used to evaluate atmospheric dispersion exceeded 90 percent.

Measurements are also available from a backup system. The backup monitoring system consists of wind speed and wind direction sensors located at the 10-meter level on the CPS microwave tower. The backup system is intended to function when the primary system is out of service, providing further assurance that basic meteorological information will be available during and immediately following an accidental release of airborne radioactivity.

In RAI 2.3.3-1, the staff asked the applicant to provide an hourly listing of the January 2000–August 2002 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 RAI 2.3.3-1, Exelon provided a copy of the January 2000–December 2002 database.

2.3.3.2 Regulatory Evaluation

In response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies regulations applicable to the ESP SSAR. RS-002, Attachment 2, identifies the following applicable NRC regulations regarding onsite meteorological measurement programs:

- 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, as it relates to meteorological data used to determine compliance with the numerical guides for doses in meeting the criterion of “as low as is reasonably achievable” (ALARA)

- 10 CFR 100.20(c), 10 CFR 100.21(c), and 10 CFR 100.21(d), as they relate to meteorological data collected for use in characterizing the site’s meteorological conditions

In SSAR Sections 1.1.1, 1.5, and 2.3.3, as well as in its response to RAI 2.3.3-2, the applicant identified the following applicable NRC guidance regarding onsite meteorological measurements programs:

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

- Section 2.3.3 of 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 finds that the applicant has correctly identified the applicable regulations and guidance.

Both RG 1.23 and RS-002, Attachment 2, 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, as well as for comparing with offsite sources to determine the appropriateness of climatological data used for design considerations.

Section 2.3.3 of RS-002, Attachment 2, and 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 that 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 RS-002, Attachment 2, Section 2.3.3. 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 program description presented in the SSAR and conducting a site visit. The site visit consisted of reviewing 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 an hourly listing of the 2000–2002 meteorological database that the applicant provided in its response to RAI 2.3.3-1.

The staff considers the meteorological data collected by the existing CPS monitoring program to be representative of the dispersion conditions at the Clinton ESP site. The Clinton ESP site is within the existing CPS site, and the new nuclear unit(s) are intended to be in close proximity to the existing facility. The CPS meteorological tower is located far enough away from existing plant structures to preclude any adverse impact on measurements. The base of the tower is at an elevation similar to plant grade at both CPS and at the proposed location for a future EGC ESP facility. The ground cover at the base of the meteorological tower is primarily native grasses.

The staff reviewed the location of the meteorological tower with respect to nearby ground features and potential obstructions to flow (e.g., trees, buildings), including existing and proposed plant structure layouts, and concluded that there are minimal adverse effects on the measurements taken at the towers. The staff also evaluated the types and heights of the meteorological variables being measured and found them 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 staff performed a quality review of the post-CPS construction January 2000–December 2002 hourly meteorological database that the applicant provided in response to RAI 2.3.3-1 using the methodology described in NUREG-0917, “Nuclear Regulatory Commission Staff Computer Programs for Use with Meteorological Data.” The staff performed further review using computer spreadsheets. Its examination of the data revealed generally stable and neutral atmospheric conditions at night and unstable and neutral conditions during the day, which was expected. Wind speed, wind direction, and stability class frequency distributions for each measurement channel were reasonably similar from year to year. The post-CPS construction 2000–2002 wind speed, wind direction, and stability class frequency distributions were also reasonably consistent with the pre-CPS construction 1972–1977 data, with a general shift toward lower wind speeds and more unstable conditions in the more recent data. The shift toward unstable conditions may have resulted from the heated cooling water in Clinton Lake from CPS affecting the lower level of the delta-temperature measurements or from the more frequent use of the variation of horizontal wind direction to determine atmospheric stability.

The staff compared the joint frequency distribution used by the applicant as input to the NRC-sponsored PAVAN atmospheric dispersion model (NUREG/CR-2858, “PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations”) and a staff-generated January 2000–August 2002 joint frequency distribution from the hourly database and found them to be in good agreement.

2.3.3.4 Conclusions

As set forth above, the applicant provided and substantiated information on the onsite meteorological measurements program. The staff 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 also provide an acceptable basis for (1) making estimates of atmospheric dispersion for design-basis accident and routine releases from a nuclear power plant(s) falling within the applicant’s PPE that might be constructed on the proposed site, and (2) meeting the requirements of 10 CFR Part 100, “Reactor Site Criteria,” 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 this section of the SSAR, the applicant presents the following information on atmospheric dispersion estimates for postulated accidental airborne releases of radioactive effluents to the exclusion area boundary (EAB) and low-population zone (LPZ):

- atmospheric transport and diffusion models to calculate relative concentrations for postulated accidental radioactive releases
- meteorological data summaries used as input to diffusion models
- specification of diffusion parameters

- probability distributions of relative concentrations

- determination of relative concentrations used for assessment of consequences of postulated radioactive atmospheric releases from design-basis and other accidents

Section 2.2 of this SER addresses potential nonradiological accidents on or in the vicinity of the site that could affect control room habitability (such as toxic chemical releases). However, 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(s) that might be constructed on the proposed site, the staff will evaluate the dispersion of airborne radioactive materials to the control room at the COL or CP stage. This is **COL Action Item 2.3-3**.

The applicant used PAVAN to estimate relative concentration (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."

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 code uses 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, 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).

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

- The meteorological input to PAVAN consisted of a joint frequency distribution of wind speed, wind direction, and atmospheric stability data based on January 2000 through August 2002 onsite meteorological data. The wind data were from the 10-meter (33-foot) level of the onsite meteorological tower. The stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 60-meter (198-foot) and 10-meter (33-foot) levels of the onsite meteorological tower, as well as horizontal wind variability. In RAI 2.3.3-4, the staff asked the applicant to explain why it used only 32 months of onsite data (January 2000 through August 2002) to generate the χ/Q values, since potential bias could exist resulting from the underrepresentation of autumn and the early winter months. The applicant responded that the data from the period January 2000 through August 2002 represented the most recent continuous data record available that was obtained and processed using a consistent methodology. While there is a potential for a seasonal bias in the 32-month period of record data, the applicant noted that it performed a variety of comparisons with the original 1972–1977 data analyses and concluded that there were no undue biases in the results.

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

- The proposed EAB is the perimeter of a 1025-meter circle centered on the ESP facility footprint (e.g., the proposed area for locating the ESP site powerblock structures), and the proposed LPZ is the area encompassed by a 4018-meter radius circle centered on the same ESP facility footprint. The applicant placed the release point at the center of the ESP facility footprint for the purposes of determining the downwind distances to the EAB and LPZ (1025 meters and 4018 meters, respectively). In RAI 2.3.4-2, the staff asked the applicant to recalculate the EAB and LPZ χ/Q values using the shortest distances between the ESP plant envelope boundaries and the EAB and LPZ radii for each downwind sector. The applicant responded that, although the major potential release point(s) would be somewhat displaced from the center point, it did not expect the resultant changes in χ/Q values to be significant and did not recalculate the EAB and LPZ χ/Q values.

Based on the PAVAN modeling results, the applicant proposed the short-term (accident release) 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 ESP site.

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

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2 hour χ/Q Value @ EAB (5% value)	1.85×10^{-4} s/m^3	The atmospheric dispersion coefficients used in the SSAR to estimate dose consequences of accidental airborne releases
0–8 hour χ/Q Value @ LPZ (5% value)	2.49×10^{-5} s/m^3	
8–24 hour χ/Q Value @ LPZ (5% value)	1.68×10^{-5} s/m^3	
1–4 day χ/Q Value @ LPZ (5% value)	7.18×10^{-6} s/m^3	
4–30 day χ/Q Value @ LPZ (5% value)	2.11×10^{-6} s/m^3	

2.3.4.2 Regulatory Evaluation

In response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the NRC regulations applicable to the ESP SSAR regarding short-term (accident release) diffusion estimates. RS-002, Attachment 2, identifies the applicable regulation as 10 CFR 100.21, with respect to the meteorological considerations used in the evaluation to determine an acceptable exclusion area and LPZ.

In SSAR Sections 1.5 and 2.3.4, the applicant identifies the following applicable NRC guidance regarding accident release diffusion estimates:

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

- Section 2.3.4 of RG 1.70, with respect to providing conservative and realistic estimates of atmospheric diffusion at the EAB and LPZ, based on the most representative meteorological data and impacts caused by local topography

- RG 1.145, issued November 1982, with respect to acceptable methods for choosing atmospheric dispersion factors (χ/Q values) for evaluating the consequences of potential accidents

The staff finds that the applicant has correctly identified the applicable regulations and guidance.

Section 2.3.4 of RS-002, Attachment 2, and RG 1.70 provide the following guidance on information appropriate for a presentation on short-term (accident release) diffusion estimates. The application should present or describe:

- 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 relative concentrations (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), which 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 relative concentrations (χ/Q values) and the probabilities of these χ/Q values being exceeded 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 relative concentrations 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 diffusion estimates for postulated accidental airborne releases of radioactive effluents to the proposed EAB and LPZ using the staff-endorsed computer code PAVAN. The staff evaluated the applicability of the PAVAN model, concluding that there are no unique topographic features that preclude use of the PAVAN model for the Clinton 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 made an independent evaluation of the resulting atmospheric diffusion estimates by running the PAVAN computer model to review and verify the applicant’s results, finding the following:

- The applicant used 32 months of recent onsite data (January 2000–August 2002) to generate the resulting EAB and LPZ χ/Q values. Potential bias in the results exists because the onsite database underrepresents autumn and the early winter months. The staff made an independent evaluation of the resulting atmospheric diffusion estimates by rerunning the PAVAN computer model using the complete 3-year hourly meteorological database (January 2000–December 2002) provided in the applicant’s response to RAI 2.3.3-1 and concluded that the resulting EAB χ/Q value could increase as much as 10 percent.

- The applicant made conservative assumptions by ignoring building wake effects and treating all releases as ground-level releases.

- The applicant selected the center of the proposed area for the ESP site powerblock structures as the basis for determining the downwind distances to the EAB and LPZ (1025 meters and 4018 meters, respectively). Depending upon the ultimate site development (size, number, and type of reactor plant selected), the major release point(s) could be somewhat displaced from this center point. In response to RAI 2.3.4-2, the applicant noted that the minimum distance to the proposed EAB from any point on the envelope of the ESP facility footprint was 805 meters. The staff made an independent evaluation of the resulting atmospheric diffusion estimates by rerunning the PAVAN computer model and concluded that reducing the downwind distance to the EAB from 1025 meters to 805 meters could result in increasing the EAB χ/Q value by as much as 30 percent.

From this review, the staff concludes that the applicant needs to use appropriately conservative meteorological data and appropriately conservative distances from postulated release points to calculate relative concentrations for accidental airborne releases of radioactive materials. This is **Open Item 2.3-3**.

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

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

SITE CHARACTERISTIC	VALUE	DEFINITION
0–2 hour χ/Q Value @ EAB (5% value)	**(Open Item 2.3-3)**	The 0–2 hour atmospheric dispersion factor to be used to estimate dose consequences of design-basis accidents at the EAB
0–8 hour χ/Q Value @ LPZ (5% value)	**(Open Item 2.3-3)**	The 0–8 hour atmospheric dispersion factor to be used to estimate dose consequences of design-basis accidents at the LPZ
8–24 hour χ/Q Value @ LPZ (5% value)	**(Open Item 2.3-3)**	The 8–24 hour atmospheric dispersion factor to be used to estimate dose consequences of design-basis accidents at the LPZ
1–4 day χ/Q Value @ LPZ (5% value)	**(Open Item 2.3-3)**	The 1–4 day atmospheric dispersion factor to be used to estimate dose consequences of design-basis accidents at the LPZ
4–30 day χ/Q Value @ LPZ (5% value)	**(Open Item 2.3-3)**	The 4–30 day atmospheric dispersion factor to be used to estimate dose consequences of design-basis accidents at the LPZ

2.3.4.4 Conclusions

As set forth above, the staff concludes that the applicant did not provide appropriate atmospheric dispersion estimates to meet the relevant requirements of 10 CFR 100.21. The staff will rereview the applicant's proposed short-term atmospheric dispersion site characteristics for inclusion in an ESP for the site, if one is issued, pending the applicant's resolution of the open item identified above.

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 this section of the SSAR, the applicant presents its atmospheric diffusion estimates for routine releases of effluents to the atmosphere, providing 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 subprogram XDCALC from the MIDAS suite of software programs to estimate the χ/Q and D/Q values resulting from routine releases. The applicant indicated that the XDCALC model is consistent with the requirements of RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors." The applicant used the following input data and assumptions in applying the XDCALC model for the Clinton ESP site:

- The meteorological input to XDCALC consisted of hourly CPS onsite wind speed, wind direction, and atmospheric stability data from January 2000 through August 2002. The wind data were from the 10-meter level of the onsite meteorological tower. The stability data were derived from the vertical temperature difference (delta-temperature) measurements taken between the 60-meter and 10-meter levels of the onsite meteorological tower, as well as horizontal wind variability.

- The applicant modeled one ground-level release point, assuming a minimum building cross-sectional area of 2069 m^2 and a containment building height of 76.1 meters. The applicant placed the release point at the center of the ESP facility footprint for the purposes of determining the downwind distances to the EAB and LPZ.

Annual average undepleted/no decay, undepleted/2.26-day decay, and depleted/8.00-day decay χ/Q values and D/Q values were for the site boundary, EAB, LPZ, and special receptors of interest (nearest milk cow, milk goat, garden, meat animal, and residence within 5 miles in each downwind sector), as well as for various radial sectors out to a distance of 50 miles.

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

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

TYPE OF LOCATION	χ/Q VALUE (s/m^3)			D/Q VALUE ($1/m^2$)
	UNDEPLETED NO DECAY	UNDEPLETED 2.26-day DECAY	DEPLETED 8.00-day DECAY	
EAB	2.04×10^{-6} (1025 meters NNE)	2.04×10^{-6} (1025 meters NNE)	1.84×10^{-6} (1025 meters NNE)	1.46×10^{-8} (1025 meters NNE)
Nearest Milk Cow	1.10×10^{-6} (1500 meters N)	1.10×10^{-6} (1500 meters N)	9.63×10^{-7} (1500 meters N)	6.76×10^{-9} (1500 meters N)
Nearest Goat Milk	9.90×10^{-8} (8000 meters NNE)	9.72×10^{-8} (8000 meters NNE)	7.28×10^{-8} (8000 meters NNE)	4.21×10^{-10} (8000 meters NNE)
Nearest Garden	1.10×10^{-6} (1500 meters N)	1.10×10^{-6} (1500 meters N)	9.63×10^{-7} (1500 meters N)	6.76×10^{-9} (1500 meters N)
Nearest Meat Animal	1.10×10^{-6} (1500 meters N)	1.10×10^{-6} (1500 meters N)	9.63×10^{-7} (1500 meters N)	6.76×10^{-9} (1500 meters N)
Nearest Resident	1.50×10^{-6} (1170 meters SW)	1.49×10^{-6} (1170 meters SW)	1.34×10^{-6} (1170 meters SW)	6.76×10^{-9} (1500 meters N)

2.3.5.2 Regulatory Evaluation

In response to RAI 1.5-1, the applicant stated that RS-002, Attachment 2, identifies the NRC regulations applicable to the ESP SSAR regarding long-term (routine release) diffusion estimates. RS-002, Attachment 2, identifies the applicable regulation as 10 CFR 100.21(c)(1), with respect to evaluating site atmospheric dispersion characteristics and establishing dispersion parameters 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 offsite.

The staff finds that the applicant should have also identified Appendix I to 10 CFR Part 50, which requires demonstrating compliance with the numerical guides for doses contained in this appendix by characterizing atmospheric transport and diffusion conditions to estimate the radiological consequences of routine releases of materials to the atmosphere. Nonetheless, the staff finds that the applicant meets these regulatory requirements.

In SSAR Sections 1.8.2 and 2.3.5, the applicant identifies the following applicable NRC guidance regarding routine release diffusion estimates:

- Section 2.3.5 of RG 1.70, with respect 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 atmospheric dispersion factor (χ/Q value) at or beyond the site boundary for each venting location

- RG 1.109, "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," with respect to the criteria for identifying specific receptors of interest (applicable at the ESP stage to the extent the applicant provides receptors of interest)

- RG 1.111, issued July 1977, with respect to the criteria for characterizing atmospheric transport and diffusion conditions for evaluating the consequences of routine releases

The staff finds that the applicant needed to identify 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). Nonetheless, the staff finds that the applicant meets the criteria in all applicable RGs for performing routine release diffusion estimates.

Section 2.3.5 of RS-002, Attachment 2, and RG 1.70 provide the following guidance on information appropriate for a presentation on long-term (routine release) diffusion 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 appropriateness of the use of these parameters 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 submitted 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, EAB, LPZ, and special receptors of interest using the MIDAS software subprogram XDCALC. The applicant stated that the XDCALC code is consistent with the requirements of RG 1.111. The staff reviewed the applicant's input assumptions to the XDCALC computer code concerning plant configuration and release characteristics, as well as the appropriateness of the meteorological data input; the staff found these assumptions to be appropriate. The staff found that the applicant made conservative assumptions by treating all releases as ground-level releases.

The staff made an independent evaluation of the applicant's resulting atmospheric diffusion estimates by executing the staff computer code XOQDOQ (NUREG/CR-2919, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations") using the onsite January 2000–December 2002 meteorological data provided as part of the applicant's response to RAI 2.3.3-1. The XOQDOQ model implements the methodology outlined in RG 1.111. The staff obtained results similar to those obtained by the applicant.

From this review, the staff concluded that the applicant used an appropriate atmospheric dispersion model and adequate meteorological data to calculate relative concentration and relative deposition at appropriate distances from postulated release points for evaluation of routine airborne releases of radioactive material. Any COL or CP application referencing this information will need to confirm that the specific release point characteristics (e.g., building height and cross-sectional area) and the direction and distance to specific locations of receptors of interest (e.g., EAB and the nearest milk cow, goat milk, garden, meat animal, and resident) 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 2.3-4**.

The staff will include the long-term (routine release) atmospheric dispersion factors listed in Table 2.3.5-2 as site characteristics in any ESP that the NRC might issue for the Clinton 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 @ EAB	2.04×10^{-6} s/m^3	The maximum annual average EAB undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26-day Decay χ/Q Value @ EAB	2.04×10^{-6} s/m^3	The maximum annual average EAB undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00-day Decay χ/Q Value @ EAB	1.84×10^{-6} s/m^3	The maximum annual average EAB depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ EAB	1.46×10^{-8} 1/m^2	The maximum annual average EAB 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	1.10×10^{-6} 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 Undepleted/2.26-day Decay χ/Q Value @ Nearest Milk Cow	1.10×10^{-6} s/m^3	The maximum annual average milk cow undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00-day Decay χ/Q Value @ Nearest Milk Cow	9.63×10^{-7} s/m^3	The maximum annual average milk cow depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Milk Cow	6.76×10^{-9} 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 Goat Milk	9.90×10^{-8} s/m^3	The maximum annual average goat milk undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26-day Decay χ/Q Value @ Nearest Goat Milk	9.72×10^{-8} s/m^3	The maximum annual average goat milk undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00-day Decay χ/Q Value @ Nearest Goat Milk	7.28×10^{-8} s/m^3	The maximum annual average goat milk depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Goat Milk	4.21×10^{-10} 1/m^2	The maximum annual average meat animal 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	1.10×10^{-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 Undepleted/2.26-day Decay χ/Q Value @ Nearest Garden	1.10×10^{-6} s/m^3	The maximum annual average garden undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00-day Decay χ/Q Value @ Nearest Garden	9.63×10^{-7} s/m^3	The maximum annual average garden depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual

SITE CHARACTERISTIC	VALUE	DEFINITION
Annual Average D/Q Value @ Nearest Garden	6.76×10^{-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 Meat Animal	1.10×10^{-6} s/m^3	The maximum annual average meat animal undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26-day Decay χ/Q Value @ Nearest Meat Animal	1.10×10^{-6} s/m^3	The maximum annual average meat animal undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00-day Decay χ/Q Value @ Nearest Meat Animal	9.63×10^{-7} s/m^3	The maximum annual average meat animal depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Meat Animal	6.76×10^{-9} 1/m^2	The maximum annual average meat animal D/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/No Decay χ/Q Value @ Nearest Resident	1.50×10^{-6} s/m^3	The maximum annual average resident undepleted/no decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Undepleted/2.26-day Decay χ/Q Value @ Nearest Resident	1.49×10^{-6} s/m^3	The maximum annual average resident undepleted/2.26-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average Depleted/8.00-day Decay χ/Q Value @ Nearest Resident	1.34×10^{-6} s/m^3	The maximum annual average resident depleted/8.00-day decay χ/Q value for use in determining gaseous pathway doses to the maximally exposed individual
Annual Average D/Q Value @ Nearest Resident	6.76×10^{-9} 1/m^2	The maximum annual average resident 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 appropriate for the characteristics of the site and release points. The applicant 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 reviewed the long-term atmospheric dispersion estimates that the applicant proposed for inclusion as site characteristics in an ESP for the site (if one is 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 required 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 will need to confirm that the parameters submitted 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 <u>Hydrologic Engineering</u>

The Exelon Generation Company (Exelon or EGC) early site permit (ESP) site is located 6 mi east of Clinton, DeWitt County, in central Illinois, and is adjacent to the currently operating Clinton Power Station (CPS) Unit 1. Clinton Lake, an impoundment on Salt Creek, currently serves as the principal water source for the existing unit, which uses a once-through cooling system to dissipate heat from the turbine condenser. Water held behind a submerged dam constructed within the North Fork of Salt Creek in Clinton Lake provides the 30-day shutdown cooling water supply for the CPS Unit 1 ultimate heat sink (UHS). The applicant refers to this water source as the submerged UHS pond.

The ESP facility would also use Clinton Lake as the source of cooling water. The applicant proposed that the ESP facility use closed-cycle cooling with wet cooling towers as the plant's normal heat sink (NHS). Clinton Lake would supply makeup water for the NHS. The UHS for the ESP facility would consist of mechanical draft cooling tower(s) with no water storage. The submerged UHS pond would use new intake structures to supply the makeup water required for the UHS for a period of 30 days. The new UHS intake would be an integral part of the UHS and, therefore, a safety-related structure.

2.4.1 Hydrologic Description

2.4.1.1 Technical Information in the Application

The construction of an earthen dam, 1200 ft downstream from the confluence of the North Fork of Salt Creek with Salt Creek, formed Clinton Lake (see Figure 2.4-1 of this SER). Clinton Lake has two arms, one on Salt Creek and the other on the North Fork of Salt Creek. These arms extend 14 mi and 8 mi, respectively, upstream from the dam. The top elevation of the dam is 711.8 ft mean sea level (MSL), with a crest width of 22.8 ft. The surface area of the lake is 4895 ac. The ESP site is located about 3.5 mi northeast of the dam between the two arms of Clinton Lake, at a grade elevation of 735 ft MSL.

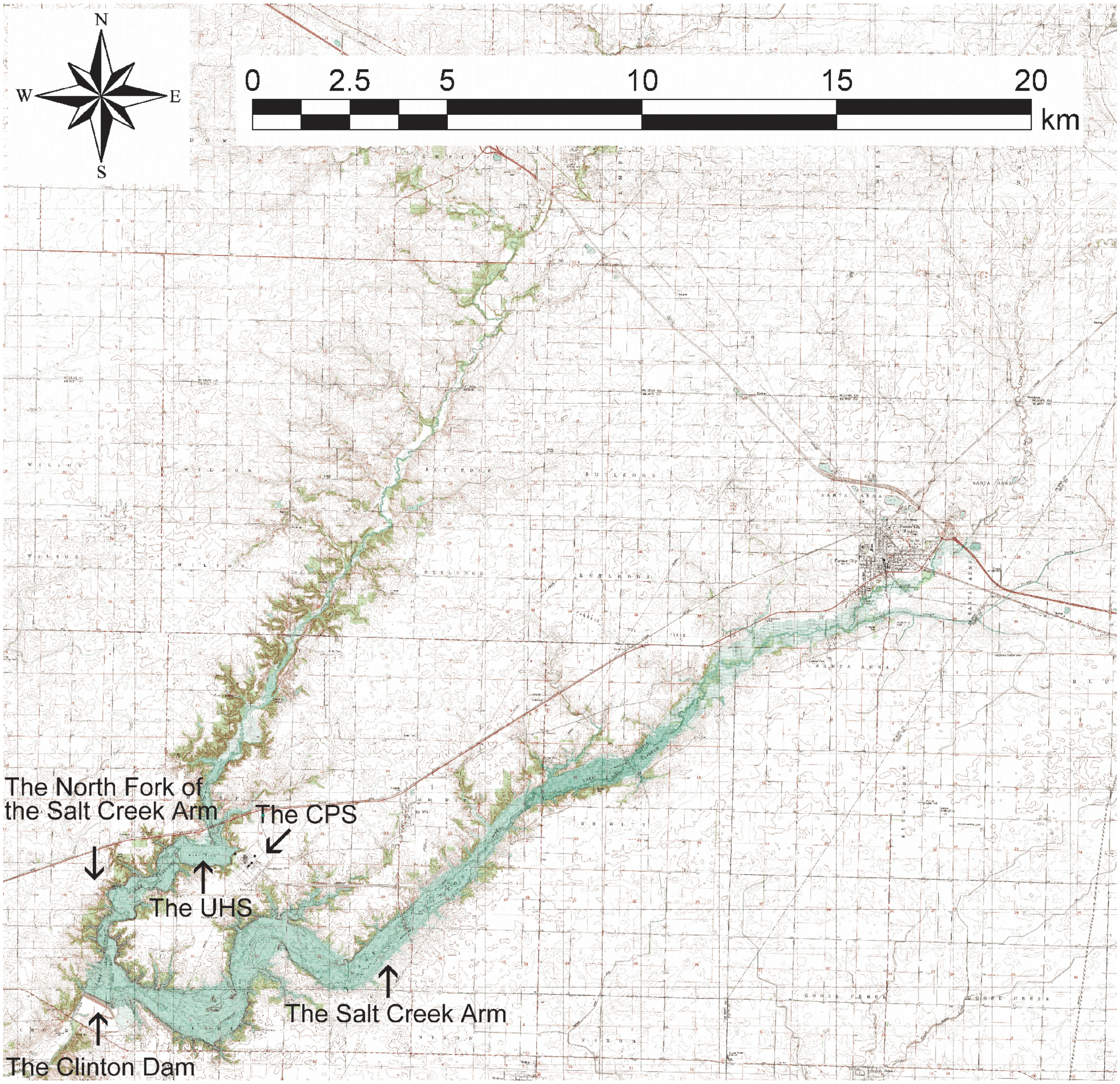

Figure 2.4-1 Clinton Lake

The water intake for CPS Unit 1 is located on the North Fork of Salt Creek. Outflow from CPS Unit 1 is discharged into the Salt Creek arm through a 3.4-mi long discharge flume. The hot discharge then travels through Clinton Lake to the North Fork of the Salt Creek arm (see Figure 2.4-2 of this SER). Excess heat, which causes the water temperature to rise above the ambient equilibrium temperature, is transferred from the lake's surface to the atmosphere through sensible, long-wave radiation and latent heat flux of evaporation.

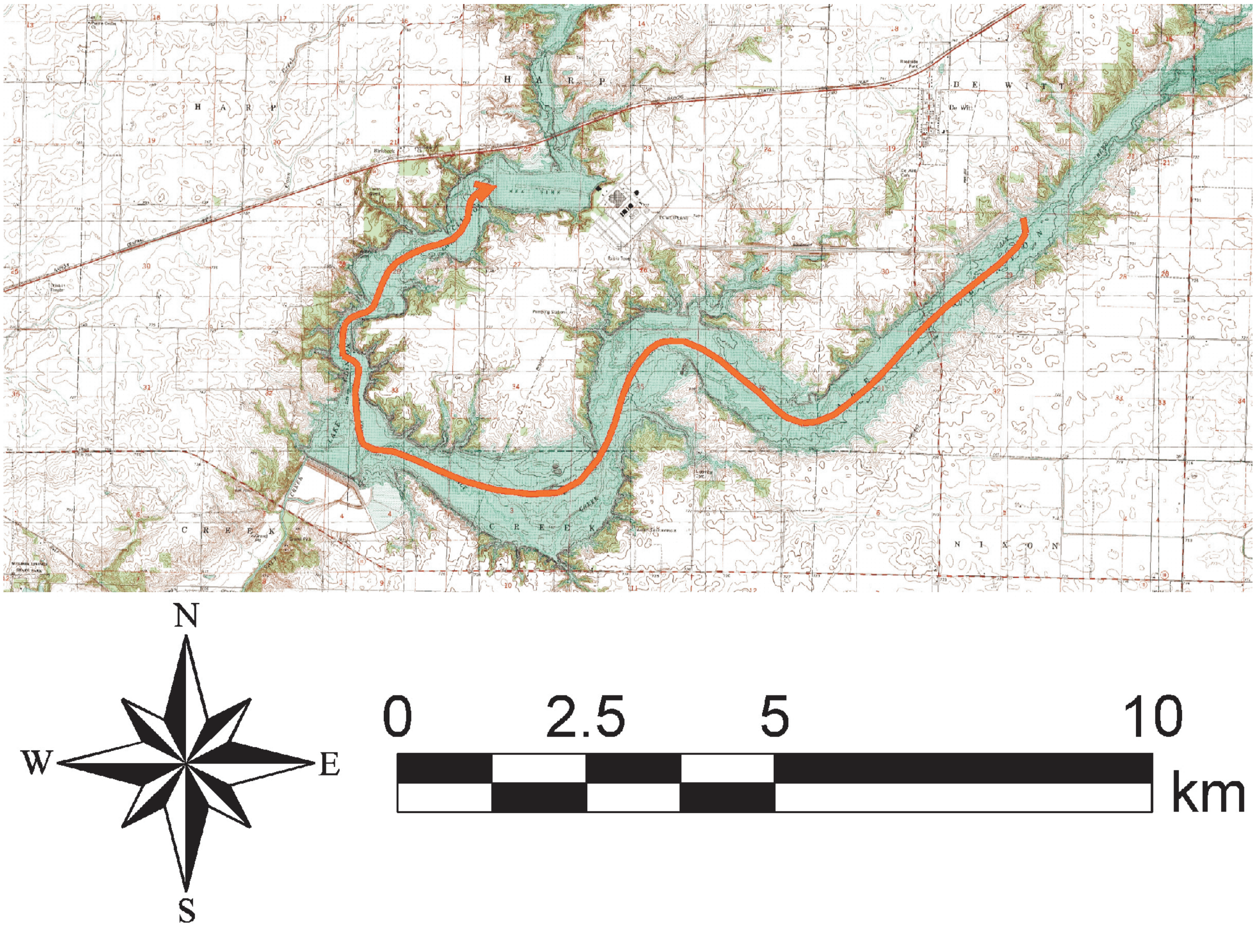

Figure 2.4-2 CPS once-through discharge and subsequent mixing and cooling path

The submerged dam is located approximately 1 mi west of the CPS intake structure. The top of the submerged dam is at elevation 675 ft MSL. A baffle dike divides the submerged UHS pond in approximately equal halves (see Figure 2.4-3 of this SER). The top of the baffle dike is at elevation 676 ft MSL. The UHS surface area at the design water surface elevation of 675 ft MSL is 158 ac with a total volume of 1067 ac-ft or 46.62 million ft^3.

The intake for CPS Unit 1 is located on the submerged UHS pond (see Figure 2.4-3 of this SER). During emergency operation, CPS Unit 1 UHS discharges into the submerged UHS pond downstream (i.e., south) of the baffle, allowing mixing and heat exchange to the atmosphere to occur before the discharge reaches the intake. The ESP facility would have a similar intake and UHS blowdown discharge layout (Figure 2.4-3).

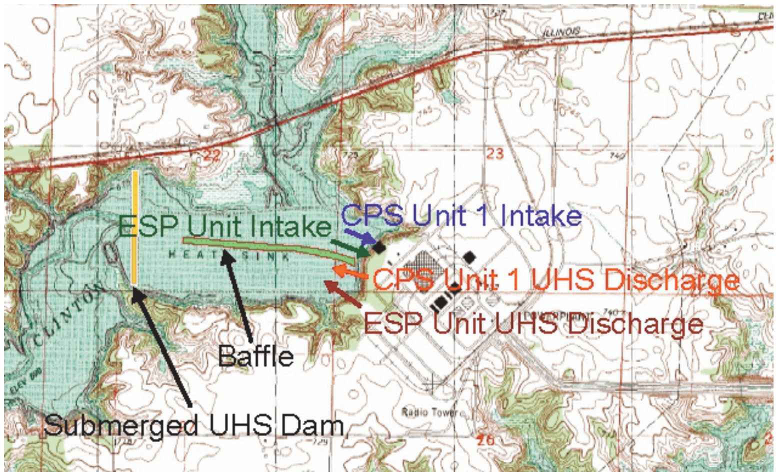

Figure 2.4-3 Location of the intake from and discharge into the submerged UHS pond

In Request for Additional Information (RAI) 2.4.1-1, the staff asked the applicant to provide survey coordinates (including elevations) for the bounding areas of all ESP facility safety-related structures, including intake tunnels and piping corridors. The staff also requested that the applicant provide coordinates of existing aquifers in bounding areas, particularly perched aquifers. In response to RAI 2.4.1-1, the applicant provided an updated figure to replace Figure 1.2-4 in Chapter 1 of the site safety analysis report (SSAR). The applicant stated that this figure shows the approximate location of safety-related structures, along with a grid system overlaid on the figure.

The applicant indicated that the safety-related structures for the ESP facility are the intake structures, the essential service water cooling towers, and some other structures that will be located within the ESP facility powerblock area. The applicant stated that the final sizes and locations of the safety-related structures will be determined after the selection of a reactor during the construction phase and that no survey coordinates are established at the ESP stage.

The applicant stated that the location of the ESP facility intake structures is approximately 65 ft south of the existing CPS intake structures. The applicant selected this location to route the ESP facility piping without disturbing the CPS shutdown cooling water piping that runs from the CPS UHS. The CPS piping exits to the east from the intake structures. The CPS nonsafety service water discharge and fire protection discharge exit near the north end and then turn northeast. The circulating water discharge piping exits the intake structures south of the service water pipe as a group of three pipes that combine into a single pipe, which then turns northeast to the turbine building. The circulating water piping for the abandoned CPS Unit 2 is located south of the CPS Unit 1 circulating water piping and follows the latter. The shutdown service water piping exits the CPS intake structures near its south end, then turns southeast and continues for 250 ft before turning east and then north to the CPS diesel generator and heating, ventilation, and air conditioning building. Two trains of shutdown service water and a fire protection line follow this path. The shutdown service water return lines are located above the supply lines, following the same path as the supply lines to about 175 ft, where supply lines turn east, then southwest, and finally slope downward to the discharge location in the CPS submerged UHS pond at an elevation of 675 ft MSL.

The applicant stated that the piping for the ESP facility would be routed in a manner similar to the existing CPS piping, with an expected horizontal distance of 50 ft maintained between the two sets of piping. The applicant stated that the ESP facility piping would be located south of the existing CPS piping and would be routed a sufficient distance south before it turned east in order to provide adequate clearance and cover where it passed over the sloping CPS discharge piping to the submerged UHS pond. The applicant stated that the ESP facility piping elevation would be selected to provide a vertical clearance of 3 ft 9 in. between itself and the existing CPS discharge piping. After crossing the existing CPS discharge piping, the ESP facility piping would continue east to the two cooling towers to provide makeup water. The applicant stated that the location and elevation of the ESP facility piping would not be established until after the pipe diameters were determined based on the selection of the reactor(s) for the ESP facility. The applicant stated that the ESP facility piping would include pipes for the makeup water supply to the NHS tower, the fire protection supply, and two trains of makeup water to the UHS cooling towers for the ESP facility.

The applicant stated that SSAR Section 2.4.13 discusses the regional and local ground water systems. The applicant stated that the ground water beneath the ESP site occurs in upper glacial deposits (Wisconsinan) and in the underlying Illinoian and Kansan tills. The applicant stated that, since these deposits are regional and not limited to any specific area within the ESP site, no specific coordinates delineate the aquifers underlying the ESP site. The applicant provided measured water levels at the ESP site obtained from borings and piezometers recently installed within the ESP site.

In RAI 2.4.1-2, the staff requested that the applicant identify any limits on plant operation resulting from either water supply or intake water temperature for the ESP facility (e.g., the need to derate or shut down the reactors if intake temperature exceeded a certain threshold). The staff also requested that the applicant estimate the frequency and duration of these operating limits. In response to RAI 2.4.1-2, the applicant stated that limits on plant operation resulting from water level and temperature are usually based on the volume and temperature of water in the UHS. The applicant noted that, since the design of the power station has not yet been finalized and the related safe-shutdown analysis has not yet been performed, it has not identified any operating limits resulting from water level and temperature. The applicant stated that these analyses will be performed as part of the design certification of the power plant or during combined license (COL) application.

Section 2.4.11.5 of the SSAR states that a plant shutdown would be initiated if the water surface elevation in Clinton Lake fell to an elevation of 677 ft MSL. The applicant states that this shutdown water surface elevation is not based on any safety analysis or related to the volume of water required in the submerged UHS pond. This water surface elevation is the minimum required for continued supply of normal cooling water for power generation. The applicant states that this minimum water surface elevation is based on an as yet unfinished design of the ESP facility intake structures. The applicant also notes that the intake structures may be designed to operate with a lower water surface elevation in Clinton Lake. The applicant carried out simulations of water surface elevations in Clinton Lake using 24 years of meteorological records since the construction of Clinton Dam. The applicant found that water surface elevations in Clinton Lake did not fall to an elevation of 677 ft MSL even with both the CPS Unit 1 and the ESP facility operating at 100-percent power. SSAR Section 2.4.11.3 includes the lake drawdown analysis under a 100-year drought, which indicates that the minimum water surface elevation in Clinton Lake would be 681.4 ft MSL, 4.4 ft above the shutdown level of 677 ft MSL.

The applicant states that thermal modeling for the ESP facility indicates that essentially all excess heat from the facility is dissipated to the atmosphere while the water is circulating back to the plant intake. The applicant also notes that ambient weather conditions directly affect intake temperatures more than plant operations. The water drawn directly from Clinton Lake for the ESP facility would be a small fraction of the total circulating flow through the cooling tower(s) and, thus, would have a minor impact on the temperature of water in the cooling tower basin. The applicant also indicated that the ESP facility would be capable of adding cooling tower makeup water to the inlet side of the cooling towers and, therefore, it would be cooled to the design temperature. The applicant claims that for these reasons no unit derating or shutdown of the ESP facility would occur because of elevated temperature of the makeup water. The applicant also states that, since no safety analysis for the safe shutdown of the ESP facility has been carried out yet, it has not made any assumptions regarding maximum water temperatures.

In RAI 2.4.1-3, the staff requested that the applicant provide references confirming that there are no existing dams, and that none are proposed upstream of Clinton Lake, that might affect the availability of water to the ESP site. In response to RAI 2.4.1-3, the applicant stated that it would revise SSAR Section 2.4.1.2 to add information regarding dams upstream and downstream of Clinton Lake to support the statement that the dams could not affect the availability of water at the ESP site.

The applicant stated that, with respect to future dams, a representative of the Illinois Department of Natural Resources (IDNR), Office of Water, Division of Water Resources Management, Dam Safety Section, advised that there are no recent or pending permits for recreational or water supply dams upstream of Clinton Lake.

The applicant will revise SSAR Section 2.4.1.2 to state that there are no existing reservoirs or dams upstream or downstream from Clinton Lake that could affect the availability of water to Clinton Lake. The applicant identified four recreational dams, two on the North Fork of Salt Creek upstream of Clinton Lake and two downstream of Clinton Lake. The applicant also stated that, because these dams were constructed for recreational purposes and have only limited storage capacities, water is not withdrawn from the watershed. The applicant also noted that the portion of Salt Creek downstream from Clinton Lake is not a likely candidate for changes that would result in additional demand since the flow in the creek is often low for long periods of time.

In RAI 2.4.1-4, the staff requested that the applicant provide information regarding proposed land use changes that might result in increased bed load in the tributaries upstream of Clinton Lake or sediment deposition in the submerged UHS pond. In response to RAI 2.4.1-4, the applicant stated that it had no information regarding proposed land use changes upstream of Clinton Lake. The applicant stated that the land upstream of Clinton Lake and the CPS submerged UHS pond is currently used primarily for agriculture. The maximum expected sediment load to the tributaries originates in early spring when soils are exposed and planting has not yet begun. The applicant explained that future development will tend to increase impervious area within the watershed and decrease the amount of soil erosion and subsequent delivery of sediment to tributaries.

In RAI 2.4.1-5, the staff asked the applicant to provide copies of references for the estimates of runoff and mean lake evaporation expressed as percentages of rainfall in SSAR Table 2.4-2. In response to RAI 2.4.1-5, the applicant included copies of data files for evaporation (1963 to 2002) and rainfall (1910 to 2002) obtained from the Midwest Regional Climate Center.

2.4.1.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to NRC regulatory guides (RGs). In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff will use to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant does not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it has correctly identified the applicable regulations and guidance.

Section 2.4.1 of RS-002, Attachment 2, provides the review guidance used by the staff to evaluate this SSAR section. The SSAR should address Title 10, Part 52, "Early Site Permits, Standard Design Certification, and Combined Licenses for Nuclear Power Plants," of the *Code of Federal Regulations* (10 CFR Part 52) and 10 CFR Part 100, "Reactor Site Criteria," as they relate to identifying and evaluating hydrologic features of the site. The regulations in 10 CFR 52.17(a) and 10 CFR 100.20(c) require the NRC to take into account the physical characteristics of a site (including seismology, meteorology, geology, and hydrology) to determine its acceptability for a nuclear power reactor. In addition, 10 CFR 100.20(c) addresses the hydrologic characteristics of a proposed site that may affect the consequences of radioactive material escaping from the facility. Factors important to hydrologic radionuclide transport, described in 10 CFR 100.20(c)(3), should be obtained from onsite measurements. The staff evaluated SSAR Section 2.4.1 in light of these requirements.

To satisfy the hydrologic requirements of 10 CFR Parts 52 and 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 structures, systems, and components (SSCs) of a nuclear power plant(s) (or a facility falling within a plant parameter envelope (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 would 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 would not pose an 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 Parts 52 and 100, SSAR Section 2.4.1 should form the basis for a hydrologic engineering analysis with respect to subsequent sections of the ESP application. Therefore, completeness and clarity are of paramount importance. Maps should be legible and adequate in 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. The SSAR should provide data on surface water users, location with respect to the site, type of use, and quantity of surface water used. 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), National Oceanic and Atmospheric Administration (NOAA), Soil Conservation Service (SCS), U.S. Army Corps of Engineers (USACE), or appropriate State and river basin agencies. The SSAR should describe all existing or proposed reservoirs and dams (both upstream and downstream) that could influence conditions at the site. Applicants may obtain such descriptions from reports of the USGS, U.S. Bureau of Reclamation (USBR), USACE, and others. Generally, reservoir descriptions of a quality similar to those contained in pertinent data sheets of a standard USACE hydrology design memorandum are adequate. The SSAR should provide tabulations of drainage areas, types of structures, appurtenances, ownership, seismic and spillway design criteria, elevation-storage relationships, and short- and long-term storage allocations.

2.4.1.3 Technical Evaluation

On May 11, 2004, the staff conducted a site visit in accordance with the guidance provided in RS-002, Attachment 2, Section 2.4.1. The staff used information from the site visit, digital maps, and streamflow data from the USGS and independently verified the hydrologic description provided in SSAR Section 2.4.1. The applicant provided information, including maps, charts, and data from Federal, State, and regulatory bodies, describing hydrologic characteristics and water use in the vicinity of the ESP site.

The staff verified the surface area of Clinton Lake using the USACE major dams map layer. This map layer dataset lists the surface area of Clinton Lake as 4895 ac.

In SSAR Section 2.4.1.2, the applicant states that the catchment area of Salt Creek above Clinton Dam is about 296 mi^2. The staff manually delineated the watershed draining into Clinton Lake using USGS topographic maps (Figure 2.4-4 of this SER). The staff determined the area of the manually delineated watershed as 289.2 mi^2. The staff-estimated catchment area of Salt Creek above Clinton Dam is approximately 2.4 percent less than that reported by the applicant.

The staff determined that the USGS has two streamflow gauges downstream of Clinton Dam and that no gauges are located upstream of the dam. The longest streamflow record exists at Salt Creek near USGS gauge 05578500 near Rowell, Illinois, approximately 12 mi downstream from the dam. The streamflow measured at this gauge includes the release from Clinton Lake, as well as runoff from an additional 46-mi^2 watershed downstream of Clinton Dam. The streamflow record at this gauge extends back to October 1942. Another streamflow gauge, USGS gauge 00579000 at Salt Creek near Kenney, Illinois, located approximately 18.6 mi downstream from the dam, was recorded from April 1908 through September 1912.

The staff determined that the upstream tributary inflow data are too limited to allow estimation of low water conditions and historical flood frequency. Consequently, the staff used an empirical approach to estimate these parameters, as more fully discussed in Sections 2.4.2 and 2.4.11 of this SER.

In RAI 2.4.1-1, the staff requested that the applicant provide additional information on survey coordinates (including elevations) for the bounding areas of all ESP facility safety-related structures, including intake tunnels and piping corridors. The staff requested that the applicant provide a layout of the intake tunnel and piping corridor from the lake to the ESP facility to determine the extent to which the COL applicant should address the layout as an interface item. The staff also asked for the locations of existing aquifers in the bounding areas, particularly perched aquifers. Although the applicant provided adequate information regarding the areal coordinates of the ESP site, it provided no information on the elevations required to define the bounding volume of the disturbed subsurface material. Therefore, the applicant should define the extent of the vertical disturbance and the bounding elevations of all SSCs. Additionally, SSAR Figure 1.2-4 does not identify either the elevations or the areal locations of the safety-related piping corridors. Since the intake pumps for the ESP facility UHS makeup water are safety-related structures, the applicant should state whether it covers these through the site grade specified in the PPE or proposes separate criteria for these structures. This is **Open Item 2.4-1**.

In response to RAI 2.4.1-1, the applicant stated that it expects the horizontal clearance between the existing CPS piping and the new ESP facility piping to be 50 ft. The staff determined that this proposed horizontal clearance is acceptable and will use this as a permit condition for the COL applicant. This is **Permit Condition 2.4-1**.

In addition, the applicant stated that it expected the vertical clearance between the existing CPS piping and the new ESP facility piping to be 3 ft 9 in. The staff believes that the vertical clearance should be based on the diameter of the ESP piping and a minimum vertical clearance allowing for some uncertainty in the location of the pipes for the existing unit. Therefore, the staff established a permit condition to ensure a minimum vertical clearance of 6.6 ft or 3 times the diameter of the pipes, whichever is larger. This is **Permit Condition 2.4-2**.

In RAI 2.4.1-2, the staff asked the applicant to identify any limits on plant operation resulting from either water supply or intake water temperature for the ESP facility. The staff requested that the applicant indicate the total service flow rate needed for the existing unit with once-through cooling systems and the integrated cooling flow demand for all units to determine if there is sufficient margin in the available water flow from the lake, accounting for any uncertainties associated with water and land use changes in the vicinity of the plant. It might become necessary to derate or shut down the reactors if the intake temperature exceeded a certain threshold. The staff also requested the applicant to estimate the frequency and duration of these operating limits. The staff determined that the applicant’s description of the ESP facility UHS system is not sufficiently complete. The applicant should provide a schematic representation of the complete ESP facility UHS system, including the intake, piping, any potential storage basins, the UHS cooling loop, and the cooling tower(s), clearly showing all components and water flow including discharges through these components. The applicant stated that the ESP facility UHS system will have the capability to add makeup water to the inlet side of the cooling tower(s). It is not clear if the PPE makeup flow rate, an average of 1.24 cfs or 555 gpm and a maximum of 3.11 cfs or 1400 gpm, at the maximum inlet temperature of 95 EF, is sufficient to remove all waste heat from the UHS cooling tower(s). Based on this discussion, the applicant needs to provide a schematic representation of the complete UHS system for any future facility on the ESP site, including the intake, piping, any potential storage basins, the UHS cooling loop, and the cooling tower(s), clearly showing all components and water flow including discharges through these components. In addition, the applicant needs to demonstrate that PPE makeup flow rate, an average of 555 gpm and a maximum of 1400 gpm, at the maximum inlet temperature of 95 EF, is sufficient to remove all waste heat from the UHS cooling tower(s) and that there are no limits on plant operation due to limited water supply or due to elevated water temperatures at the UHS intake for any facility constructed on the ESP site. This is **Open Item 2.4-2**.

In RAI 2.4.1-3, the staff requested that the applicant provide references confirming that no dams exist and that none are proposed upstream of Clinton Lake that might affect the availability of water for the ESP site. In response to RAI 2.4.1-3, the applicant stated that it will revise its application to mention four recreational dams, two on the North Fork of Salt Creek upstream of Clinton Lake and two downstream of Clinton Lake. The applicant provided information related to the construction date, dam height, and reservoir storage capacities of these dams. The applicant also stated that, because of the limited storage capacities of these reservoirs, water is not withdrawn from the watershed. The staff disagrees with the applicant in this assessment. Runoff from the Clinton Lake watershed feeds the reservoirs behind these dams and provides the water stored in these reservoirs.

The staff determined that the two reservoirs upstream of Clinton Lake have a maximum combined storage capacity of 194.23 ft^3 or 4446 ac-ft. This volume is small compared to the volume of Clinton Lake (at normal water surface elevation of 690 ft MSL, Clinton Lake has a volume of 74,200 ac-ft), and the effect of a flood wave resulting from a breach of these two dams coincident with a probable maximum flood (PMF) event in Clinton Lake's watershed is not significant. Section 2.4.4 of this SER presents an analysis and evaluation of the effects of failure of the two upstream dams. The staff determined that the applicant's response to RAI 2.4.1-3 is satisfactory.

In RAI 2.4.1-4, the staff requested that the applicant provide information regarding proposed land use changes in the watershed upstream of Clinton Lake. These changes might result in increased bed load in the tributaries upstream of Clinton Lake and increased sediment deposition in the submerged UHS pond. In response to RAI 2.4.1-4, the applicant stated that it does not have any information regarding proposed land use changes upstream of Clinton Lake. The staff determined that, for site suitability evaluation, the applicant needs to provide an authoritative source that may include State or county planning officials who can either provide details of a development plan in Clinton Lake's watershed or verify the absence of such a plan. This is **Open Item 2.4-3**.

The staff also disagreed with the applicant's statement that increased impervious area within Clinton Lake's watershed will result in a reduction of soil erosion and sediment discharge to tributaries. An increase in impervious area is likely to increase the volume of surface runoff, as well as decrease the time required to reach peak runoff in the watershed. Because of quicker and greater runoff, it is more likely that soil erosion will increase, not decrease. Should the resulting increased soil erosion decrease the submerged UHS volume in the lake, the staff would have to examine whether or not the UHS capacity is adequate. Therefore, the applicant needs to provide additional justification for why an increase in impervious area will not increase soil erosion. This is **Open Item 2.4-4**.

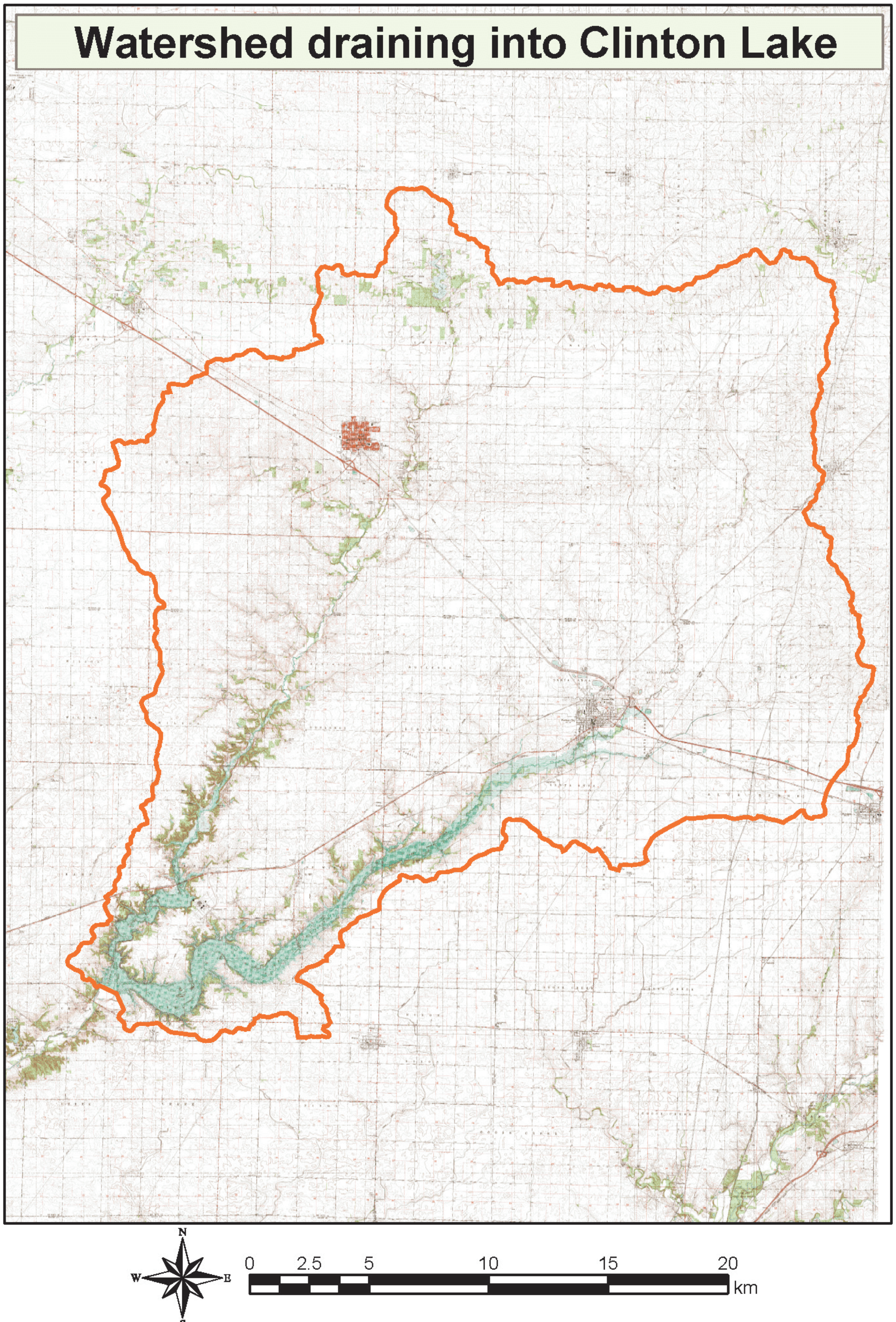

Figure 2.4-4 The watershed draining into Clinton Lake, delineated manually using topographic contours

In RAI 2.4.1-5, the staff requested that the applicant provide copies of references for the estimates of runoff and mean lake evaporation expressed as percentages of rainfall in SSAR Table 2.4-2. In response to RAI 2.4.1-5, the applicant provided evaporation and rainfall data obtained from the Midwest Regional Climate Center. The staff determined that the applicant's response is satisfactory.

2.4.1.4 Conclusions

As discussed above, with the exceptions of the open items noted in Section 2.4.1.3, the applicant provided sufficient information pertaining to the identification and evaluation of the general hydrologic characteristics of the site, including descriptions of rivers, streams, lakes, water-control structures, and users of these waters. SSAR Section 2.4.1 conforms to RS-002, Attachment 2, Section 2.4.1 with regard to this objective.

The review guidance in RS-002, Attachment 2, Section 2.4.1 provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating hydrologic features of the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.1, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.1, it has met the requirements for general hydrologic descriptions with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), except as noted in Section 2.4.1.3 above.

2.4.2 Floods

Clinton Lake was created to provide a reliable supply of cooling water for CPS. The watershed that drains into Clinton Lake has an area of approximately 289.2 mi^2. Clinton Dam is located about 1200 ft downstream from the confluence of the North Fork of Salt Creek with Salt Creek. Clinton Lake has two arms. These arms extend approximately 14 mi on the North Fork of Salt Creek and approximately 8 mi on Salt Creek, respectively.

2.4.2.1 Technical Information in the Application

SSAR Section 2.4.1.1 states that Clinton Lake significantly attenuates flood flow downstream from the dam and that no flows exceeding 10,000 cfs have been recorded at the Rowell streamflow gauge since the construction of the dam.

The applicant analyzed 22 years of flood data (January 1978 to September 2000) recorded at the Rowell gauge. SSAR Figure 2.4-5 shows the applicant-estimated peak flood frequency curve, and SSAR Table 2.4-4 presents peak flows at the gauge and Clinton Dam for various recurrence intervals. Exelon estimated peak flows at Clinton Dam by prorating peak flows at the gauge using the ratio of drainage area at the dam to that at the gauge. In SSAR Section 2.4.1.2, the applicant states that the catchment area of Salt Creek above Clinton Dam is 296 mi^2, and the drainage area at the Rowell gauge is 335 mi^2. The applicant estimated a mean annual flood of 3600 cfs at the gauge, corresponding to a recurrence interval of 2.33 years. The applicant also estimates that the maximum discharge of 7810 cfs recorded on April 13, 1994, has a recurrence interval of 25 years. The applicant also states that, because of the presence of Clinton Dam, 10-year recurrence interval flood flow at the Rowell gauge is reduced from 11,400 cfs to 6,200 cfs, and the 100-year recurrence interval flood flow is reduced from 29,900 cfs to 10,400 cfs.

In SSAR Section 2.4.2.2, the applicant states that the hydraulic design of the dam and the lake is based on a PMF with a standard project flood (SPF) as its antecedent condition. The applicant used an SPF equal to 50 percent of the PMF. The SPF occurred 3 days before the PMF. This flood sequence was routed through Clinton Lake using the USACE Spillway Rating and Flood Routing (SPRAT) computer program. The applicant-estimated PMF water surface elevation in the lake is 708.8 ft MSL. The applicant provides a freeboard of 3 ft to determine a top elevation of Clinton Dam of 711.8 ft MSL.

SSAR Section 2.4.2 states that the applicant obtained the probable maximum precipitation (PMP) using Hydrometeorological Report (HMR) 33, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours." The current standards, however, are American National Standards Institute (ANSI)/American Nuclear Society (ANS)-2.8-1992, "American National Standard for Determining Design Basis Flooding at Power Reactor Sites," issued July 1992; HMR 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian"; and HMR 52, "Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian." In RAI 2.4.2-1, the staff requested that the applicant explain why it did not use the current standards. The staff also requested that the applicant explain why an estimate based on HMR 33 is conservative relative to an estimate based on HMRs 51 and 52. In response to RAI 2.4.2-1, the applicant stated that it took the 48-hour PMP directly from the CPS updated safety analysis report (USAR). The applicant stated that it originally obtained or derived the PMP information in the CPS USAR from HMR 33. The applicant conceded that more recent procedures than those provided in HMR 33 are available for the determination of PMP. The applicant stated that, in order to update the PMP information in the SSAR, it reviewed four reports directly relating to estimation of PMP at a given location. The applicant provided brief descriptions of HMRs 33, 51, 52, and 53.

The applicant stated that the 48-hour all-season PMP based on HMR 33 and estimated for the 296 mi^2 drainage area is 25.2 in. The corresponding 24-hour all-season PMP, also obtained from HMR 33, is 22.6 in. The applicant used the procedure outlined in HMR 33 to estimate the 24- and 48-hour all-season PMP for a drainage area of 200 mi^2 and then adjusted it by a scaling factor of 0.94 for Clinton Lake's drainage area of 296 mi^2.

The applicant obtained 24- and 48-hour all-season PMP values for a drainage area of 200 mi^2 from HMR 51. It reported the all-season PMP values corresponding to these two durations as 25 in. and 28 in., respectively. The applicant then used the same scaling factor recommended by HMR 33 to the PMP values derived from HMR 51 and reported these area-adjusted values as 23.5 in. for the 24-hour all-season PMP and 26.3 in. for the 48-hour PMP.

In RAI 2.4.2-2, the staff requested that the applicant describe likely changes to both upstream land use and downstream water demand that could alter either the intensity or frequency of flood and low-flow conditions. In response to RAI 2.4.2-2, the applicant stated that a shift in upstream land use to a more impervious watershed will tend to generate more runoff from the same amount of precipitation and decrease the duration of low flows because more water would be available to the lake. The applicant stated that no change in the 100-year flood level is expected because of the lake's large flow attenuation capacity. The applicant also stated that water demand in Salt Creek is not likely to increase since the flow in the creek is low for long periods of time.

In RAI 2.4.2-3, the staff requested that the applicant document any historical hillslope failures in the watershed. The staff also requested the applicant analyze the ability of a hypothetical hillslope failure to impact the ESP facility. Hillslope failure could result in a water wave that might run up the bank near the ESP site and potentially affect its safety. The staff requested that the applicant estimate the maximum terminal height of such a hypothetical wave. In response to RAI 2.4.2-3, the applicant stated that, as discussed in Appendix A to SSAR Section 5.1.3.5, no landslides are documented for DeWitt County. The applicant also noted that, according to the Illinois State Geological Survey map of classified known landslides in Illinois, landslide potential at the ESP site is low and that hillslopes near the ESP site on Clinton Lake have been very stable for the past 30 years. If a landslide were to occur on these slopes, the applicant estimated that such a hypothetical hill slope failure would generate a maximum wave height of 0.4 ft.

In RAI 2.4.2-4, the staff requested that the applicant document any seismically induced seiches in Clinton Lake. In response to RAI 2.4.2-4, the applicant stated that it performed a literature search to determine if any seismically induced seiches had occurred in Clinton Lake or other lakes in the area. The applicant found that the occurrence of seiches and other seismic activity is extremely rare in the noncoastal Midwest, and it did not identify any seismically induced seiches in Clinton Lake. The applicant also stated that CPS personnel did not report any seiches in Clinton Lake during the 4.5-magnitude earthquake in June 2004.

In RAI 2.4.2-5, the staff requested that the applicant demonstrate that drainage capacity at the existing grade is sufficient to accommodate local intense precipitation. If the capacity is not sufficient, the applicant should describe any active safety-related drainage systems that would be installed for the ESP facility. In response to RAI 2.4.2-5, the applicant stated that the proposed plant site drains to the southeast, and there are no significant internally drained areas that might result in accumulation of stormwater during local intense precipitation. The applicant stated that proposed ESP buildings and site drainage components would also direct drainage in the southeast direction. The applicant would design the ESP facility so that local intense precipitation would not inundate any building or critical plant facility. The applicant stated that the ESP facility design might incorporate drainage features such as raised building entrance points, surface drains, subsurface drainage pipes, and surface drainage channels to Clinton Lake.

The applicant has not designed site drainage at the ESP facility because portions of this system will depend upon the reactor(s) selected for the ESP facility. The nominal grade elevation of 735 ft MSL provides more that 20 ft of elevation difference for drainage between the site grade and maximum flood water elevation in Clinton Lake. The applicant stated that this elevation difference is large enough to allow design of a drainage system to handle maximum site precipitation without requiring any active components.

2.4.2.2 Regulatory Evaluation

SSAR Table 1.5-1 describes the applicant’s conformance to the NRC RGs. In RAI 1.5-1, the staff requested that the applicant provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it correctly identified the applicable regulations and guidance.

Section 2.4.2 of RS-002, Attachment 2, provides review guidance used by the staff in evaluating this SSAR section. The acceptance criteria address 10 CFR Parts 52 and 100 as they relate to identifying and evaluating hydrologic features of the site. The regulations in 10 CFR 52.17(a) and 10 CFR 100.20(c) require the NRC to take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear reactor(s).

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

For those cases where a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility(s) for comparison with the hydrologic characteristics of the site. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting the limiting parameters from among the group. Important PPE parameters for safety assessment 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 and maximum allowable ground water level).

To meet the requirements of the hydrologic aspects of 10 CFR Parts 52 and 100, RS-002, Attachment 2, provides the following specific criteria:

- For SSAR Section 2.4.2.1, the potential flood sources and flood response characteristics of the region and site identified by the staff's review (described in the review procedures) are compared to those of the applicant. If similar, the applicant's conclusions are accepted. If, in the staff's opinion, significant discrepancies exist, the staff will request that the applicant provide additional data, reestimate the effects on a nuclear power plant(s) of 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 safety assessment estimate is more than 5 percent less conservative, the applicant should fully document and justify its estimate of the controlling level, or the applicant may accept the staff's estimate.

- For SSAR Section 2.4.2.3, the applicant's estimates of 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's 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 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 uses appropriate sections of the following documents to determine the acceptability of the applicant's data and analyses in meeting the requirements of 10 CFR Parts 52 and 100. RG 1.59, "Design Basis Floods for Nuclear Power Plants," provides guidance for estimating the design-basis flooding considering the worst single phenomenon and combinations of less severe phenomena. The staff uses publications by USGS, NOAA, SCS, USACE, applicable State and river basin authorities, and other similar agencies to verify the applicant's data relating to hydrologic characteristics and extreme events in the region. Sections 2.4.3 through 2.4.7 of RS-002, Attachment 2, discuss methods of analysis to determine the individual flood-producing phenomena.

2.4.2.3 Technical Evaluation

The staff obtained historical flows from USGS streamflow records for the Rowell gauge. The streamflow record at this gauge extends back to May 1908. The maximum observed peak discharge at Rowell before the construction of Clinton Dam was 24,500 cfs, recorded on May 16, 1968. The maximum observed peak discharge at Rowell after the construction of Clinton Dam was 7810 cfs, recorded on April 13, 1994.

Using historical data, the staff estimated peak annual discharge corresponding to several return periods at the Rowell gauge. The staff estimated pre-dam floods using peak annual discharge data from 1943 to 1977 and post-dam floods using data from 1977 to 2000. The staff used the procedure, "Guidelines for Determining Flood Flow Frequency," issued 1981, recommended by the Water Resources Council (WRC), to determine these floods corresponding to recurrence intervals of 2.33, 10, 25, 50, and 100 years. The staff estimated the pre-dam and post-dam floods, which are included in Table 2.4-1 of this SER. The staff obtained information regarding the floods at the Clinton Dam corresponding to the same recurrence intervals by prorating the estimated floods at the Rowell gauge by the ratio of drainage area at the dam to that at the gauge (748.9 km^2/867.6 km^2 = 0.8632).

Table 2.4-1 Pre-dam and Post-dam Floods Corresponding to Several Return Periods Estimated According to WRC Guidelines

Recurrence Interval (year)	Pre-dam Floods		Post-dam Floods	
	Rowell Gauge cfs	Clinton Dam cfs	Rowell Gauge cfs	Clinton Dam cfs
2.33	4,250	3,669	3,456	2,983
10	11,016	9,509	6,247	5,392
25	17,447	15,060	7,920	6,836
50	22,503	19,424	8,960	7,734
100	29,151	25,162	10,065	8,688

The staff estimated a post-dam mean annual flood of 2,983 cfs and 25-year and 100-year floods of 6,836 cfs and 8,688 cfs, respectively. The 10-year and 100-year floods at the dam decreased from 9,509 cfs and 25,151 cfs, respectively, to 5,392 cfs) and 8,688 cfs, respectively, after the construction of Clinton Dam.

According to HMR 52, local intense precipitation at the ESP site is equivalent to short-duration, 1-mi^2 PMP. The staff used HMR 52 guidelines to estimate 1-hour, 1-mi^2 PMP depth for the ESP site. Table 2.4-2 of this SER, Column 2, lists the multiplication factors recommended in HMR 52 that are applied to 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 Early Site Permit Site

Duration	Multiplier to 1-hour PMP depth	PMP depth in inches
5 min	0.335	6.08
15 min	0.528	9.58
30 min	0.759	13.78
1 h	1.000	18.15
6 h	1.493	27.10

The applicant used HMR 33 to estimate the PMP for watershed drainage into Clinton Lake; however, the current standards are HMRs 51 and 52. Section 2.4.3 of this SER describes the staff's independent PMP estimation for the watershed draining into Clinton Lake. In RAI 2.4.2-1, the staff requested that the applicant explain why it did not use these current standards and why an estimate based on HMR 33 is conservative relative to an estimate based on HMRs 51 and 52. In its response to RAI 2.4.2-1, the applicant described its method to estimate PMP values for Clinton Lake's drainage using HMR 51. The staff found that the applicant's procedure is inconsistent with the recommendations in HMR 51, which outlines a detailed method for estimating PMP values for different durations for a desired drainage area.

The staff's independent estimation of 24-hour and 48-hour PMP values for Clinton Lake's watershed are 4.9 percent and 6.3 percent higher, respectively, than the applicant's PMP values derived using HMR 33 for the same durations, as reported in the SSAR. The staff concludes that the applicant did not show that PMP values estimated using HMR 33 are conservative when compared to PMP values estimated using HMR 51. Therefore, the applicant needs to provide a revised PMP estimate using the current criteria of HMR 51. This is **Open Item 2.4-5**.

In RAI 2.4.2-2, the staff requested that the applicant describe likely changes to both upstream land use and downstream water demand. Upstream land use change may lead to increased intensity and frequency of flood risk to the ESP site. An increase in downstream water demand may affect low-flow conditions.

In response to RAI 2.4.2-2, the applicant stated that likely changes in upstream land use will not appreciably alter the flood risk at the site. Since the antecedent conditions used in PMF calculations will result in saturated soil conditions, any increases in impervious surface in the basin will not have a detectable impact on the PMF flood height. However, the staff concludes that the applicant's assertion that an increase in area with impervious surface will decrease the duration of low-flow events is not adequate. Increases in impervious surface also result in a reduction in recharge and the resulting ground water-derived baseflow. While the applicant's assertion of increased flow is correct for the long-term average flow, an increase in impervious surface area could result in a decrease in baseflow during dry periods. Therefore, the applicant needs to provide additional justification for why an increase in area with impervious surface will decrease the duration of low-flow events. This is **Open Item 2.4-6**.

In response to RAI 2.4.2-2, the applicant stated that the portion of Salt Creek downstream of Clinton Lake is not a candidate for an increase in demand. The applicant stated that Salt Creek is not a likely candidate for any diversion development because it historically has experienced extended periods of low flow. However, the staff concludes that the applicant did not provide adequate basis for this statement. Since an increase in additional storage capacity could mitigate these low-flow periods, the staff finds the applicant's response incomplete. The applicant should provide references to projections from State or local or authorities responsible for development plans in the area of concern to substantiate any prediction of future development. This is **Open Item 2.4-7**.

SSAR Section 2.4.2 does not provide sufficient information for the staff to determine the safety of the ESP site from seismically generated water waves. In RAI 2.4.2-3, the staff requested that the applicant document any historical hillslope failures in the watershed and analyze the ability of a hypothetical hillslope failure to impact the ESP facility. A hillslope failure could result in a water wave that might run up the bank near the ESP site, potentially affecting its safety. The staff requires an estimate of the maximum height of such a hypothetical wave to address these safety concerns, and in response to RAI 2.4.2-3 the applicant estimated that it is less than 1 ft, although it did not explain the basis for this value. The staff examines the potential for hillslope failure to induce waves in Clinton Lake in Section 2.4.6 of this SER. Except for the ESP intake structures, the staff concluded that, based upon the elevation of the ESP site relative to the lake and the distance of the ESP safety facilities from the shoreline (see revised SSAR Figure 1.2-4 in the attachment to RAI 2.4.1-1), water waves induced by hillslope failure do not pose a risk to the ESP site. The inlet to the CPS screen house is at an elevation of

670 ft MSL, and the new ESP intake would draw water from the same bottom elevation as that of the CPS intake structures. The staff determined that the ESP intake structures would be exposed to PMF water surface elevations, although the rest of the ESP site would be dry. The staff will require that the COL applicant design the ESP intake structures to withstand the combined effects of PMF, coincident wind wave activity, and wind setup, as discussed further in Section 2.4.3 of this SER. This is **Permit Condition 2.4-3**.

SSAR Section 2.4.2 does not provide sufficient information on seismically generated seiches. In RAI 2.4.2-4, the staff requested that the applicant document any seismically induced seiches in Clinton Lake to determine if such waves could affect the safety of the ESP site. In response to RAI 2.4.2-4, the applicant stated that it performed a search of existing literature to see if any seismically induced seiches had occurred in Clinton Lake or other lakes in the area. The applicant reported that seismic wave activity is extremely rare, and it did not identify any seismically induced seiche information. As an anecdotal note, the applicant stated that CPS personnel did not report any seiche activity in Clinton Lake during the magnitude 4.5 earthquake of June 2004. The staff examines the potential for seiches in Section 2.4.5 of this SER. Except for the ESP intake structures, the staff concluded that, based upon the elevation of the ESP site relative to the lake and the distance of the ESP safety facilities from the shoreline (see revised SSAR Figure 1.2-4 in the attachment to RAI 2.4.1-1), seismically induced seiches do not pose a risk to the ESP site.

SSAR Section 2.4.2 does not provide sufficient information for the staff to determine whether drainage capacity at the existing grade can accommodate local intense precipitation without affecting any safety-related structures for the ESP facility. In RAI 2.4.2-5, the staff requested that the applicant demonstrate that drainage capacity at the existing grade is sufficient to accommodate local intense precipitation, or describe any active safety-related drainage systems that would be installed for the ESP facility. In response to RAI 2.4.2-5, the applicant stated that it has not yet designed site drainage at the ESP facility, since portions of this system will depend upon the reactor selected for the ESP facility.

The applicant estimated local intense precipitation at the ESP site for a 1-hour duration of 13.5 in. and for a 5-minute duration of 4.3 in. Table 2.4-2 of this SER shows the staff's independent estimation of local intense precipitation, which is 2 percent higher than the applicant's estimate for a 1-hour duration and 41 percent higher than its estimate for a 5-minute duration. Because of these differences, the site characteristic of local intense precipitation at the ESP site remains open. Therefore, the applicant needs to address the differences between the applicant's and the staff's estimates of local intense precipitation at the ESP site for a 1-hour duration and for a 5-minute duration. This is **Open Item 2.4-8**.

The applicant stated that a drainage system at the ESP site can be designed to handle maximum site precipitation without requiring any active components. The NRC will require the COL applicant to demonstrate that the ESP site drainage from local intense precipitation at the ESP site can be discharged to Clinton Lake without relying on any active drainage systems that may be blocked during this event. This is **Permit Condition 2.4-4**.

2.4.2.4 Conclusions

As set forth above, with the exceptions of the open items noted in Section 2.4.2.3, the applicant provided sufficient information pertaining to identifying and evaluating floods at the site. SSAR Section 2.4.2 conforms to RS-002, Attachment 2, Section 2.4.2 as they relate to identifying and evaluating floods at the site.

The review guidance in Section 2.4.2 of RS-002, Attachment 2, provides that the SSAR should address 10 CFR Parts 52 and 100. Although the applicant has not specifically addressed the above regulations in its SSAR Section 2.4.2, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.2, the applicant has met the requirements of floods at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), except as noted in Section 2.4.2.3 above. Further, the staff finds that the applicant appropriately considered the most severe flooding that has been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.3 Probable Maximum Flood on Streams and Rivers

The ESP site is approximately 40.2 EN latitude and 88.8 EW longitude. The watershed draining into Clinton Lake is approximately 281.5 mi^2. The area of Clinton Lake is approximately 7.6 mi^2. Flooding in the watershed will lead to increased water surface elevation in Clinton Lake.

2.4.3.1 Technical Information in the Application

In SSAR Section 2.4.3.1, the applicant states that the watershed drainage area is 296 mi^2. It developed the PMP according to procedures outlined in HMR 33. The applicant estimated a total precipitation of 25.2 in. during the 48-hour PMP storm. The 48-hour PMP storm was temporarily distributed according to guidelines in USACE Civil Engineering Bulletin 52-8, “Standard Project Flood Determinations,” revised March 1965. The applicant used an antecedent 48-hour standard project storm (SPS) equivalent to 50 percent of the PMP, followed by 3 dry days, and finally by the full 48-hour PMP storm for the PMF runoff analysis. The precipitation was considered uniformly distributed over the entire area of the watershed.

The applicant estimated the maximum potential snow accumulation by combining the snow accumulation from a 100-year storm over an already existing 100-year snowpack. SSAR Section 2.3.1.2.3 shows the estimated weight of this combined snow accumulation as 35 psf.

SSAR Section 2.4.3.2 states that soils in approximately 90 percent of the drainage area belong to Flanagan silt loam, Drummer clay loam, and Huntsville loam, which are classified in SCS soil group B. The rest belong to Sawmill clay loam. The applicant estimates an initial precipitation loss during the SPS of 1.5 in. and no loss during the PMP, based on communications with the USACE on November 2, 1970. The applicant estimates an infiltration loss during SPS, as well as during PMP, of 0.1 in./hr.

SSAR Section 2.4.3.3 states that the applicant estimated a synthetic unit hydrograph for Salt Creek at the Rowell gauge, as described by the Illinois Division of Waterways (IDOW) in “Unit Hydrographs in Illinois,” issued 1948 with USGS. The applicant estimated the unit hydrograph at Clinton Dam by prorating the unit hydrograph values at the Rowell gauge by the ratio of drainage area at the dam to that at the gauge (see SSAR Figure 2.4-10).

The applicant also estimated unit hydrographs for five subareas of the watershed draining into Clinton Lake (see SSAR Figure 2.4-11) following the same synthetic method. The applicant computed lag times for each subarea according to the method proposed by IDOW. The applicant estimated flood hydrographs corresponding to the PMP for each subarea and combined these individual flood hydrographs, considering their previously estimated lag times for their corresponding subareas to obtain the PMF into Clinton Lake.

The applicant routed the PMF through Clinton Lake using the USACE SPRAT computer program. SSAR Figure 2.4-12 provides the spillway discharge corresponding to water surface elevation in Clinton Lake. The applicant assumed an initial water surface elevation for Clinton Lake of 690 ft MSL, the normal water surface elevation of the lake, before arrival of the PMF. The applicant also estimated the peak PMF discharge of 112,927 cfs under natural flow conditions in Salt Creek and a peak PMF inflow into the lake of 175,615 cfs.

The applicant estimated a water surface elevation corresponding to the PMF of 708.8 ft MSL and an elevation caused by 40-mi/h wind wave runup of 711 ft MSL. The applicant used the USACE Water Surface Profiles computer program to determine a water surface elevation at the ESP site resulting from backwater effects of 708.9 ft MSL.

The applicant estimated wind wave runup at the ESP site caused by significant (33-percent exceedance) and maximum (1-percent exceedance) winds. The applicant used a fetch of 0.8 mi, a water depth of 40.5 ft, and smooth ground with a slope of 3:1 (horizontal:vertical). The applicant estimated wind wave runups of 2.95 ft and 4.85 ft for significant and maximum wind speeds, respectively. The corresponding water surface elevations at the ESP site caused by wind action coincident with the PMF are 711.95 ft MSL and 713.8 ft MSL, respectively.

The applicant estimated a significant wave height of 2.2 ft at the dam site using a maximum wind speed of 40 mi/h, a water depth of 58 ft, and an upstream dam slope of 3:1 (horizontal:vertical). The water surface elevation corresponding to this wind wave runup coincident with the PMF is 711 ft MSL.

In RAI 2.4.3-1, the staff requested that the applicant describe the status of the USACE SPRAT computer program referenced in SSAR Section 2.4.3.3 and any software quality assurance measures that it used to augment use of this software in support of the ESP application. In response to RAI 2.4.3-1, the applicant stated that a significant portion of CPS dam design included preparation of a discharge rating curve. The SPRAT model was used to prepare the current discharge rating curve for the dam. The applicant stated that the ESP facility does not require revision of the discharge rating curve for the dam and, therefore, does not require use of the SPRAT model. The applicant proposed to revise the ESP application to indicate that the hydraulic modeling, including SPRAT runs and water surface profile estimations, were performed as part of the dam design and not as part of the ESP application.

In RAI 2.4.3-2, the staff asked the applicant to explain the bounding of the wave runup calculations through the examination of the combined events criteria indicated in ANSI/ANS-2.8-1992. The staff also requested that the applicant discuss coincident wave calculation and the basis for applying a 40-mph design wind. In response to RAI 2.4.3-2, the applicant stated that it had previously estimated a maximum wave runup elevation, caused by a sustained 40-mph overland wind speed acting on the PMF water surface elevation, at the dam and at the CPS site of 711 ft MSL and reported it in CPS USAR Section 2.4.2.2. Section 2.4.10 of the CPS USAR uses a 48-mph overland windspeed coincident with the PMF for design of the CPS circulating-water screen house. The applicant stated that use of these windspeeds did not result in any safety-related issues for CPS Unit 1 since it determined that the site grade is 22.2 ft above the wave runup water surface elevation and 27.1 ft above the PMF water surface elevation. Therefore, the applicant concluded that the CPS plant facility will not flood under any circumstances.

The applicant stated that the ESP facility site is considered to be a dry site, consistent with Condition 3 to Section 2.4.3 of RS-002, Attachment 2, and it will not be subject to flooding under any circumstances. The applicant also indicated that the operation of the ESP facility would not impact the potential for flooding at the existing dam or at the plant site. The applicant suggested that the use of any wind speed for the purpose of estimating wave runup effects on PMF water surface elevation would be inconsequential. The applicant stated that it retained the use of 40-mph windspeed in the ESP SSAR analysis to be consistent with the CPS USAR. The applicant's review of more recent information published in ANSI/ANS-2.8-1992 indicates that a greater windspeed than that used previously in the USAR and SSAR might be appropriate. Using ANSI/ANS-2.8-1992, the applicant determined that a windspeed of 52 mph should be used to estimate wave runup coincident with the PMF water surface elevation.

The applicant stated that it performed screening analyses to conservatively estimate the impact of a 52-mph windspeed on wave runup. The applicant estimated new wave heights of 3.81 ft for significant (33-percent probability) waves and 6.39 ft for maximum (1-percent probability) waves. These new wave heights are 0.94 ft and 1.58 ft greater than those estimated in the SSAR, which were based on a 40-mph windspeed. The applicant concluded that these increases are not significant because of a more than 20-ft difference in ESP site grade and the PMF water surface elevation in Clinton Lake.

In response to RAI 2.4.3-2, the applicant stated that it will revise the SSAR Sections 2.4.3.6 and 2.4.10 to include this updated estimation for wave runup.

2.4.3.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it has correctly identified the applicable regulations and guidance.

Section 2.4.3 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. The acceptance criteria address 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the hydrologic features of the site. The regulations in 10 CFR Parts 52 and 100 require the NRC to take into account a site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining the site's acceptability for a nuclear reactor(s).

To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100, the SSAR should describe the hydrologic characteristics of the site and region and contain a PMF analysis. This description should be sufficient to assess the site's acceptability and the potential for those characteristics to influence the design of SSCs important to safety for a nuclear power plant(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, would 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(s) for comparison with the hydrologic characteristics of the site. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting limiting values of the relevant parameters.

Specific criteria apply to the requirements regarding the hydrologic aspects of 10 CFR Parts 52 and 100.

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).

(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 assesses the flood level. It may make the assessment independently from basic data by detailed review 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, it should fully document and justify its estimates or accept the staff estimates.

When either 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 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 condition at the site, as well as coincident wind-generated wave activity.

2.4.3.3 Technical Evaluation

In its evaluation, the staff performed an independent analysis to verify the applicant's PMF analysis. The staff determined the PMP using HMR 51, HMR 52, and ANSI/ANS-2.8-1992. HMR 51 gives a set of charts showing the PMP depths for durations of 6, 12, 24, 48, and 72 hours corresponding to drainage areas of 10, 200, 1,000, 5,000, 10,000, and 20,000 mi^2. Using these charts, the staff determined PMP depths for drainage areas of 10, 200, 1,000, and 5,000 mi^2 for all durations given in Table 2.4-3 of this SER.

Using the values in Table 2.4-3, the staff prepared depth-area-duration curves following the guidelines of HMR 51 to bracket the drainage of Clinton Lake. Figure 2.4-5 shows these depth-area-duration curves. Using Figure 2.4-5 of this SER to determine the PMP depth values corresponding to a Clinton Dam drainage area of 289.2 mi^2, the staff constructed Table 2.4-4 of this SER.

Table 2.4-3 PMP Values in Inches Near Clinton Dam's Drainage Area

	Duration (h)				
Area (mi^2)	6	12	24	48	72
10	27.2	31.7	33.5	37.0	38.8
200	19.4	23.5	25.0	28.2	29.9
1000	14.0	17.5	19.5	22.3	24.3
5000	8.9	11.9	13.6	16.6	18.1

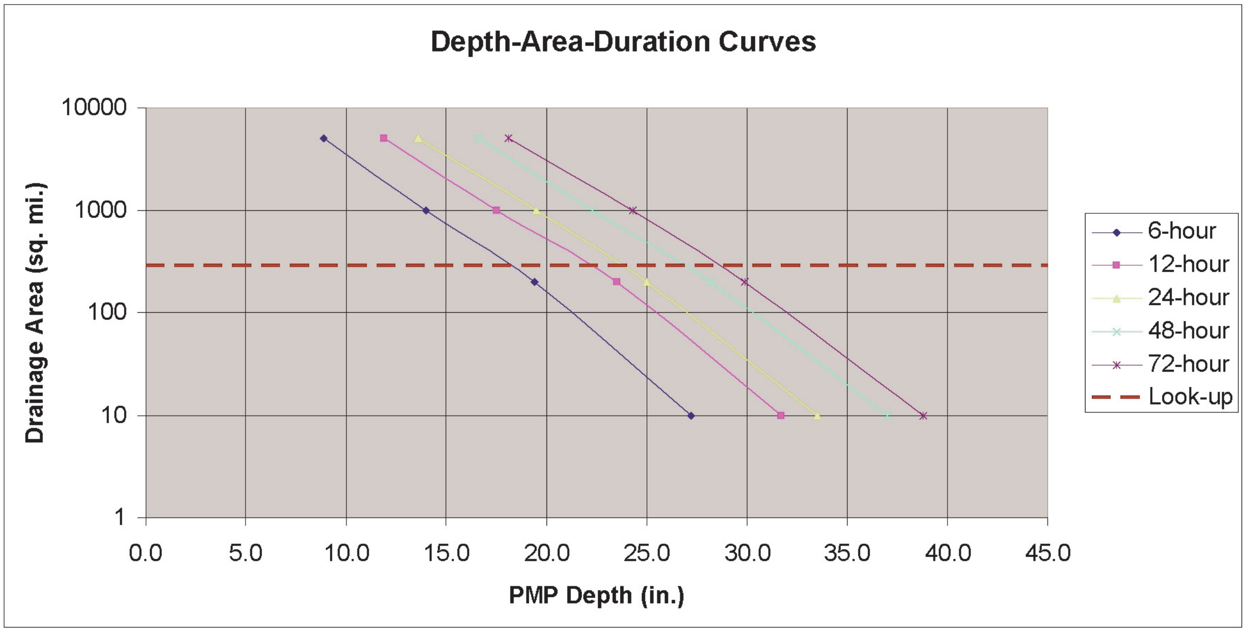

Figure 2.4-5 Depth-area-duration curves prepared for bracketing Clinton Dam drainage. The dotted horizontal line corresponds to a drainage area of 289.2 mi^2, equal to that of Clinton Dam's drainage area.

Table 2.4-4 PMP Depth-Duration Values in Inches for Clinton Dam's Drainage Area

Clinton Lake PMP	Duration (h)				
	6	12	24	48	72
289.2 mi^2	18.2	22.1	23.7	26.8	28.7

The staff used HMR 52 and ANSI/ANS-2.8-1992 to provide guidelines for distributing the PMP depths in time to create storm sequences during the PMP event. According to these guidelines, the staff computed incremental PMP depths corresponding to all 6-hour durations during the 72-hour PMP (Column 2 of Table 2.4-5 of this SER). The staff grouped the incremental depths into three 24-hour periods in descending order (Column 3 of Table 2.4-5 of this SER). The staff rearranged the PMP depths within each 24-hour group according to guidelines given by ANSI/ANS-2.8-1992 (Column 4 of Table 2.4-5 of this SER). Finally, the staff rearranged Column 4 according to the guidelines in ANSI/ANS-2.8-1992 to create the time distribution of the PMP storm over Clinton Dam's drainage area (Column 5 of Table 2.4-5 of this SER).

Table 2.4-5 Time Distribution of PMP for Clinton Dam's Drainage Area

6-h Period	Depth (in.)	Group No.	ANSI/ANS-2.8-1992 Rearrange	Time Distribution for PMP (in.)	Time (h)
1	18.16	1	0.79	0.79	6
2	3.95		3.95	0.79	12
3	0.79		18.16	0.79	18
4	0.79		0.79	0.79	24
5	0.79	2	0.79	0.79	30
6	0.79		0.79	3.95	36
7	0.79		0.79	18.16	42
8	0.79		0.79	0.79	48
9	0.46	3	0.46	0.46	54
10	0.46		0.46	0.46	60
11	0.46		0.46	0.46	66
12	0.46		0.46	0.46	72

The staff assumed that no precipitation losses occurred in order to maximize the flood generated by the PMP storm over Clinton Dam's drainage area.

The staff conservatively estimated runoff by assuming that the drainage instantaneously discharged to Clinton Lake. Under this assumption, the staff estimated the runoff corresponding to all 6-hour durations by multiplying the PMP depth corresponding to that 6-hour duration by the area of Clinton Dam's drainage and converting the volume of runoff into discharge. Table 2.4-6 of this SER shows the PMF thus obtained for Clinton Dam's drainage area.

Table 2.4-6 PMF into Clinton Lake

Time (h)	Runoff (in.)	Runoff (cfs)
6	0.79	24853
12	0.79	24853
18	0.79	24853
24	0.79	24853
30	0.79	24696
36	3.95	124267
42	18.16	571314
48	0.79	24696
54	0.46	14472
60	0.46	14472
66	0.46	14472
72	0.46	14472

The staff estimated the PMF assuming no precipitation loss and instantaneous translation through Clinton Lake using level pool routing (see Linsley Jr., et al, page 272). The staff used the stage-storage curve provided by the applicant (see SSAR Figure 2.4-12). This stage-storage curve lists spillway discharge for water surface elevations of 708 ft MSL and less. The staff extended this stage-storage relationship beyond water surface elevation 708 ft MSL to that corresponding to the top of the dam at 711.8 ft MSL using the slope of the stage-storage relationship at 708 ft MSL. The staff assumed that the incremental storage above water surface elevation 711.8 ft MSL was conservatively equal to that at an elevation of 711.8 ft MSL. This assumption is equivalent to a constant surface area of the lake above a water surface elevation of 711.8 ft MSL. Figure 2.4-6 of this SER shows the extended stage-storage relationship for Clinton Lake.

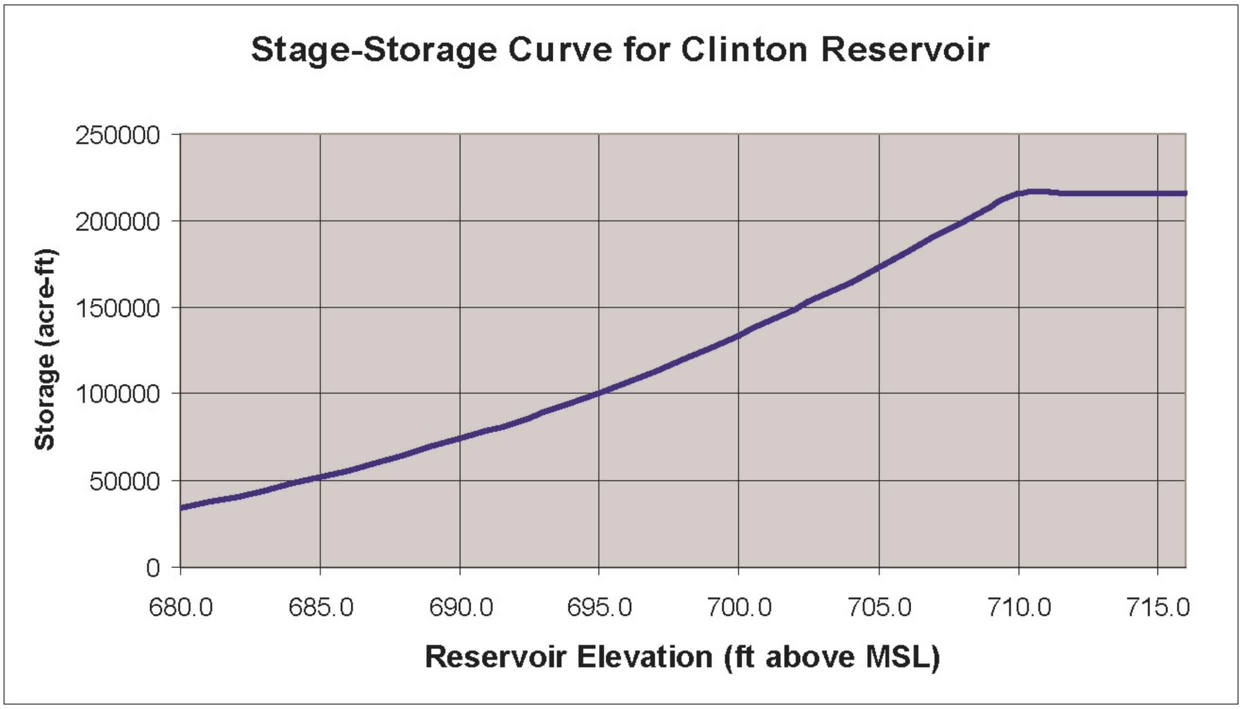

Figure 2.4-6 Stage-storage relationship for Clinton Dam

The applicant provides the spillway rating curve for the Clinton Dam (see SSAR Figure 2.4-12) that lists total combined discharge from service and auxiliary spillways corresponding to water surface elevations ranging from 690 ft MSL to 710 ft MSL. The staff extended this stage-discharge relationship beyond a water surface elevation of 710 ft MSL to 711.8 ft MSL using the slope of the stage-discharge relationship at a water surface elevation of 710 ft MSL. The staff assumes that the whole face of Clinton Dam acts as a broad-crested weir at water surface elevations above that corresponding to the top of the dam, 711.8 ft MSL. V.T. Chow, *Open Channel Hydraulics* (McGraw-Hill: New York, 1959), gives the discharge per unit width of a broad-crested weir as $q = CH^{3/2}$, where C is a coefficient ranging from 2.67 to 3.05, and H is the height of flow passing over the weir. The staff conservatively assumed a value of 2.67 for C (a smaller value of C results in smaller discharge, thereby increasing water surface elevation in the lake) and computed the discharge over the face of Clinton Dam corresponding to water surface elevations exceeding 711.8 ft MSL. Figure 2.4-7 of this SER shows the stage-discharge relationship for Clinton Dam extended to 716 ft MSL.

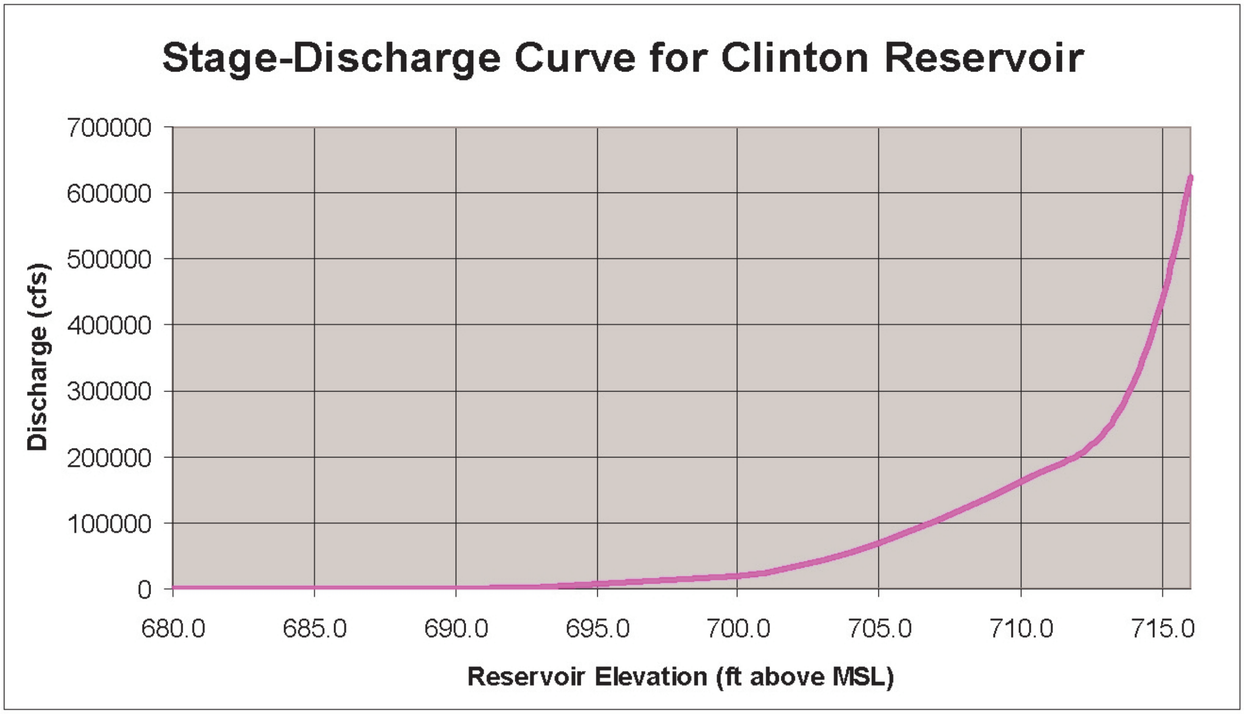

Figure 2.4-7 Stage-discharge relationship for Clinton Dam

The staff performed level pool routing that resulted in the reservoir inflow-outflow sequence shown in Figure 2.4-8 of this SER. Figure 2.4-9 of this SER shows the corresponding reservoir elevations. The staff estimated a maximum reservoir elevation during the PMF event of 714.79 ft MSL.

The influence of coincident wind wave activity caused an increase in the water surface elevation. The staff conservatively estimated the probable maximum windstorm (PMWS), as defined by ANSI/ANS 2.8-1992, to be equivalent to 100 mph. This windstorm is based upon the location of the site, which is within 150 mi of the Great Lakes. The staff estimated wave heights using the method outlined in the Coastal Engineering Manual with a site-specific fetch of 1.2 mi. The resulting significant (average height of the one-third highest waves) wave height is 3.9 ft, and the 1-percent maximum (average height of the largest 1 percent of all waves) wave height is 6.6 ft.

In response to RAI 2.4.3-1, the applicant stated that the ESP facility does not require that the discharge rating curve for the dam be revised and, therefore, does not require use of the SPRAT model. The applicant proposed to revise the ESP application to indicate that the hydraulic modeling including SPRAT runs and water surface profile estimations was performed as part of the dam design and not as part of the ESP application. The staff determined that the applicant's response to RAI 2.4.3-1 is satisfactory.

With respect to the effects of windspeed on PMF water level elevation, the applicant stated in response to RAI 2.4.3-2 that use of these windspeeds did not result in any safety-related issues for CPS Unit 1 since the site grade was determined to be 22.2 ft above the wave run-up water surface elevation and 27.1 ft above the PMF water surface elevation, with the conclusion that the CPS plant facility could not flood under any circumstances. The staff determined that the applicant's response to RAI 2.4.3-2 is satisfactory.

A further increase of water surface elevation resulting from storm surge, discussed more fully in Section 2.4.5 of this SER, resulted in an additional minor increase in water surface elevation of 0.3 ft. Combining the effects of PMF, coincident wind wave activity, and storm surge, the staff estimated a resulting maximum water surface elevation at the ESP site of 721.7 ft MSL. The staff, therefore, determined that the ESP site, excluding the ESP intake structures, is safe from flooding during a PMF event. For the ESP intake structure, the NRC will require the COL applicant to design the intake structures to withstand the combined effects of PMF, coincident wind wave activity, and wind setup of a water surface elevation of 721.7 ft. This is Permit Condition 2.4-3, as identified in Section 2.4.2.3 of this SER.

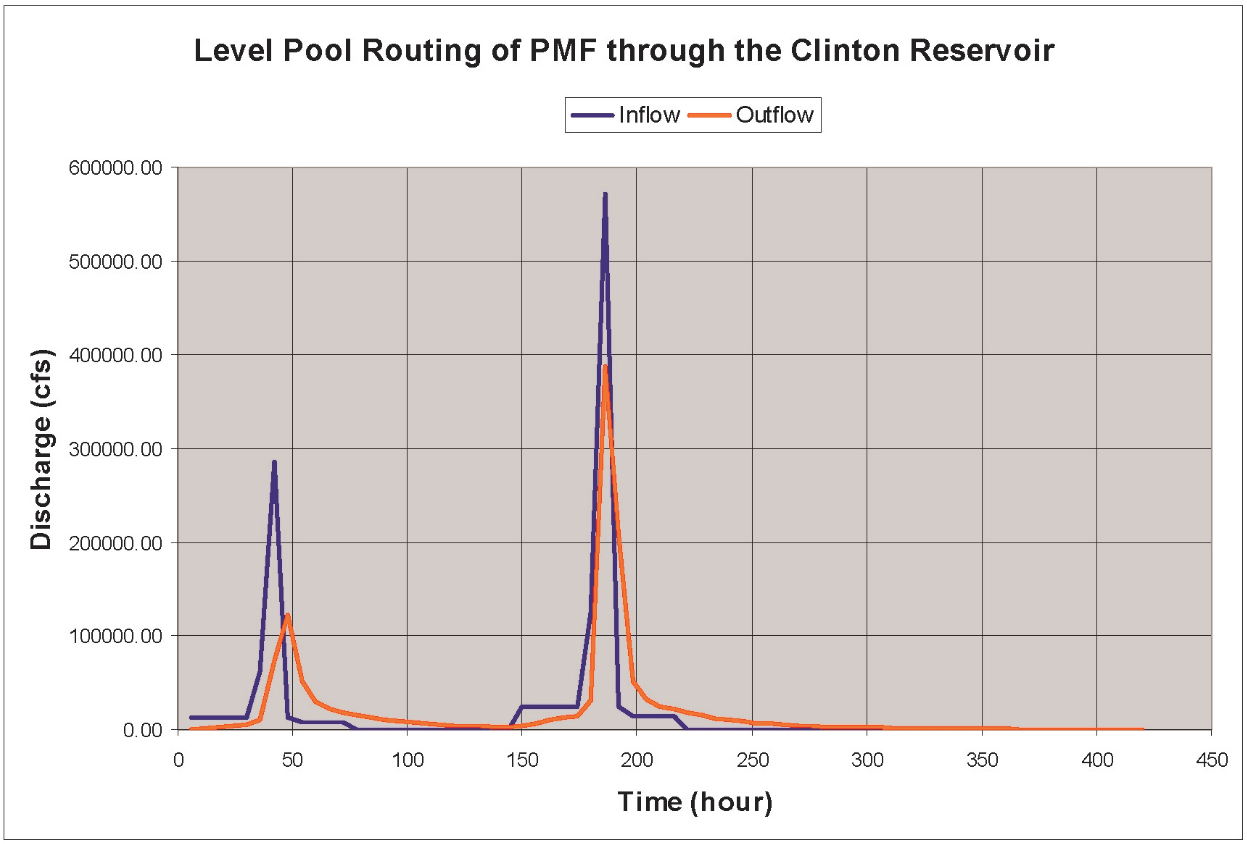

Figure 2.4-8 Inflow and outflow hydrographs for Clinton Lake during the PMF event

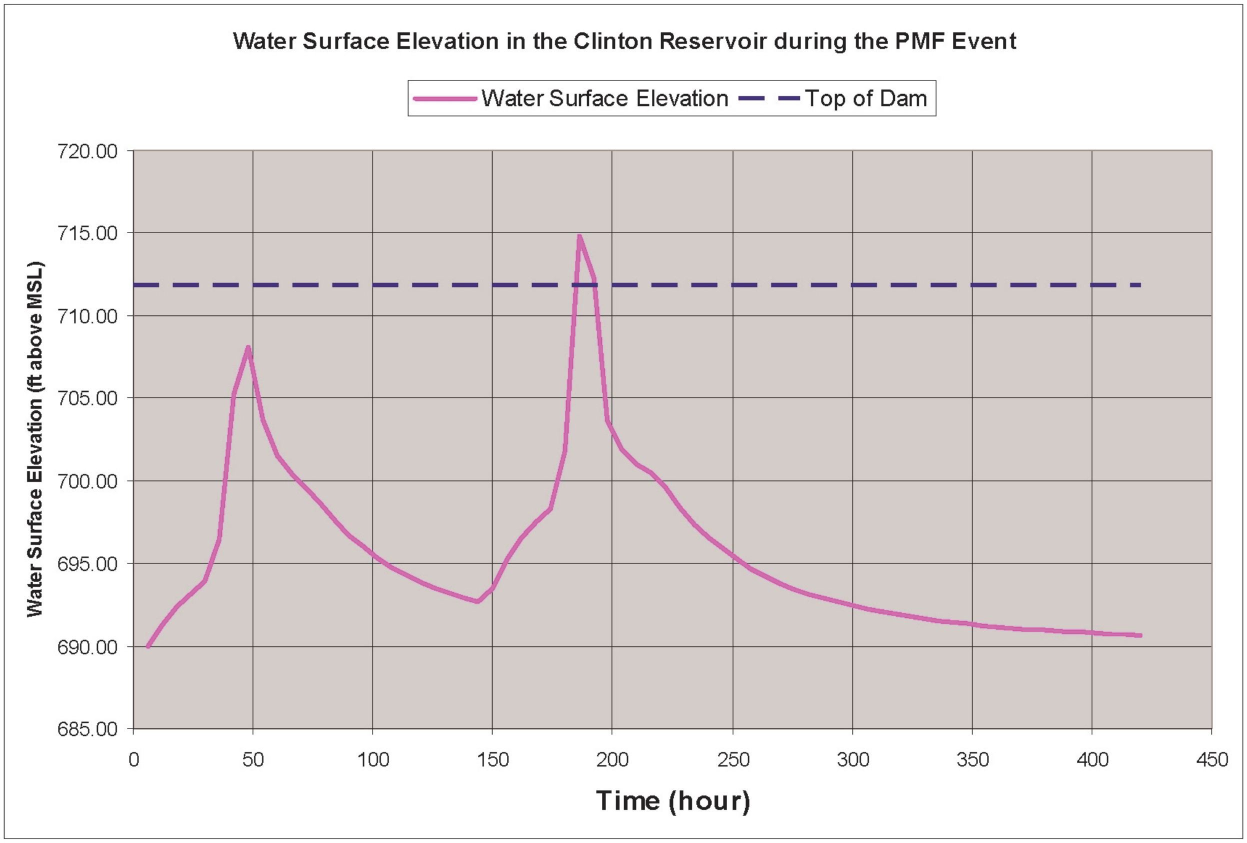

Figure 2.4-9 Water surface elevation in Clinton Lake during the PMF event

2.4.3.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of PMFs on streams and rivers at the site. SSAR Section 2.4.3 conforms to RS-002, Attachment 2, Section 2.4.3, with regard to this objective.

Section 2.4.3 of RS-002, Attachment 2, provides that the SSAR should address 10 CFR Parts 52 and 100 as they relate to identifying and evaluating PMFs on streams and rivers at the site. Although the applicant did not specifically address the above regulations in its SSAR Section 2.4.3, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.3, it has met the requirements to identify and evaluate PMFs on streams and rivers at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the staff finds that the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing the stream and river design basis flood, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.4 Potential Dam Failures

2.4.4.1 Technical Information in the Application

In SSAR Section 2.2.4, the applicant states that no other dams exist either upstream or downstream of Clinton Dam. The applicant also indicates that failure of Clinton Dam will not result in a loss of water from the submerged UHS pond.

2.4.4.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff requested that the applicant provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that the applicant correctly identified the application regulations and guidance.

Section 2.4.4 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. The acceptance criteria are based on meeting the requirements of the following regulations:

- 10 CFR Parts 52 and 100 as they relate to evaluating hydrologic features of the site
- 10 CFR 100.23 as it relates to establishing the design-basis flood due to seismic dam failure

The regulations in 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 reactor or reactors.

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

For those cases where a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility(s) for comparison with the site's hydrologic characteristics. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting 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 in 10 CFR 100.23 requires consideration of geologic and seismic factors in the determination of site suitability. Pursuant to 10 CFR 100.23(c), the applicant must obtain geologic and seismic data for evaluating seismically induced floods, including failure of an upstream dam during an earthquake.

The regulation in 10 CFR 100.23 is applicable to Section 2.4.4 of RS-002, Attachment 2, because it requires investigation of seismically induced floods or low water levels that guide the Commission in its consideration of the suitability of proposed sites for nuclear power plants. RG 1.70, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Reactors, LWR Edition,” 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 the requirements of 10 CFR 100.23 provides reasonable assurance that, given the geologic and seismic characteristics of the proposed site, a nuclear power plant(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 meet the requirements of 10 CFR Parts 52, 100, and 10 CFR 100.23 as they relate to dam failures, the staff uses specific criteria. The staff will review the applicant’s analyses and independently assess the coincident river flows at the site and at the relevant dams. The ANSI/ANS-2.8-1992 standard provides guidance on acceptable river flow conditions to be assumed coincident with the dam failure event. The applicant’s estimates (which may include landslide-induced failures) of the flood discharge resulting from the coincident events should be no more than 5 percent less conservative than the staff’s estimates to be acceptable. If its estimates differ by more than 5 percent, the applicant should fully document and justify its estimates or accept the staff’s estimates.

The applicant should identify the location of dams and potentially likely or severe modes of failure. Applicants should also identify dams or embankments for the purpose of impounding water for a nuclear power plant(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. Applicants use models approved by the USACE and the Tennessee Valley Authority to predict the downstream water levels resulting from a dam breach. First-time use of other models necessitates complete model description and documentation. The staff bases its acceptance of the model (and subsequent analyses) on its review of model theory, available verification, and application. Where other than instantaneous failure is assumed, 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 as well as a summary analysis that substantiates the condition as the critical permutation, along with a description (and the basis) of all coefficients and methods used. The applicant should also consider the effects of other concurrent events on plant safety, such as blockage of the river and waterborne missiles.

The applicant should consider the effects of coincident and antecedent flood flows (or low flows for downstream structures) on initial pool levels. Use of the methods given in ANSI/ANS-2.17-1989, "Evaluation of Radionuclide Transport in Ground Water for Nuclear Power Sites," or J.O. Duguid and M. Reeves, "Material Transport Through Porous Media: A Finite Element Galerkin Model," (ORNL-4298, Oak Ridge National Laboratory, Environmental Science Division, Publication 733, March 1976) is acceptable for determination of initial pool levels. 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. Where calculated flood levels using simplified methods are at or above plant grade and using assumptions that cannot be demonstrated as conservative, applicants should use unsteady flow methods to develop flood levels at the site. Use of the methods given in K.L. Kipp, D.B. Cearlock and A.E. Reisenauer, "Mathematical Modeling of a Large, Transient, Unconfined Aquifer with a Heterogeneous Permeability Distribution," (paper presented at the 54th Annual Meeting of the American Geophysical Union, Washington, DC, April 1973), J. Rubin and R.V. James, "Dispersion-Affected Transport of Reacting Solutes in Saturated Porous Media: Galerkin Method Applied to Equilibrium Controlled Exchange in Unidirectional Steady Water Flow," (Water Resources Research, Volume 9, No. 5, October 1973) and G.F. Pinder, "A Galerkin-Finite Element Simulation of Groundwater Contamination on Long Island, New York," (Water Resources Research, Volume 9, No. 6, December 1973) of RS-002, Attachment 2, are acceptable; however, the staff would accept other programs with proper documentation and justification. The applicant should summarize computations, coefficients, and methods used to establish the site's water level 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, Attachment 2.

The staff uses appropriate sections of the guides described below to determine the acceptability of the applicant's data and analyses. 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 consulted maps published by the USGS to independently verify the applicant's statement that no other dams exist upstream of Clinton Dam. The staff found that a small impoundment called Dawson Lake, created by construction of a dam on the North Fork of Salt Creek, exists upstream of the ESP site. Dawson Lake is located approximately 17.1 mi north-northeast of the ESP site. Dawson Lake has a surface area of 152 ac, with an average depth of 9.8 ft and a storage capacity of 67.10 million ft^3 or 1541 ac-ft. Dawson Lake is mainly used for recreation.

The applicant should consider the effects of the failure of the Dawson Lake dam in SSAR Section 2.4.4. In response to RAI 2.4.1-3, the applicant stated that it will add information to SSAR Section 2.4.1.2 regarding dams upstream and downstream of Clinton Lake that supports the statement that the dams could not affect the availability of water at the ESP site.

The applicant stated that, with respect to future dams, a representative of the IDNR, Office of Water, Division of Water Resources Management, Dam Safety Section, advised that there are no recent or pending permits for recreational or water supply dams upstream of Clinton Lake.

The applicant will revise SSAR Section 2.4.1.2 to state that there are no existing reservoirs or dams upstream or downstream from Clinton Lake that could affect the availability of water to Clinton Lake. The applicant identified four recreational dams, two on the North Fork of Salt Creek upstream of Clinton Lake (Moraine View Dam on Dawson Lake, and Vance Lake Dam on Clyde Vance Lake) and two downstream of Clinton Lake (Weldon Springs State Park Lake Dam and Little Galilee Lake Dam).

The staff determined that the maximum combined storage capacity of the two reservoirs upstream of Clinton Lake is 4446 ac-ft. The original capacity of Clinton Lake at normal water surface elevation of 690 ft MSL, as determined by the staff using the stage-storage relationship for Clinton Lake given in CPS USAR Figure 2.4-14, is 74,200 ac-ft. The maximum combined storage capacities of the two reservoirs upstream of Clinton Lake is about 6 percent of the normal storage capacity of Clinton Lake. The staff determined, using the same stage-storage relationship for Clinton Lake, that an increase in storage by 4446 ac-ft with an initial water surface elevation in Clinton Lake of 690 ft MSL would result in an increase in water surface elevation of 3.1 ft. This estimate is very conservative, since it ignores water discharged over the service spillway when the water surface elevation in Clinton Lake exceeds its crest elevation of 690 ft MSL. Discharge over the service spillway reduces the water surface elevation in Clinton Lake, and the final increase in water surface elevation resulting from a breach of the two upstream dams is likely to be less than 3.1 ft.

The staff’s estimate of maximum water surface elevation in Clinton Lake because of PMF, wind setup, and wave runup, as discussed in Section 2.4.3 of this SER, is 721.7 ft MSL. The staff plans to include 721.7 ft MSL as a site characteristic in any ESP that might be issued for this application. Even if the maximum water surface elevation in Clinton Lake were to be augmented by 3.1 ft because of a breach of the two upstream dams, leading to a water surface elevation of 724.8 ft MSL in Clinton Lake, the ESP site, located at 735 ft MSL, would be safe from flooding. Therefore, the staff determined that the applicant’s response to RAI 2.4.1-3 is satisfactory.

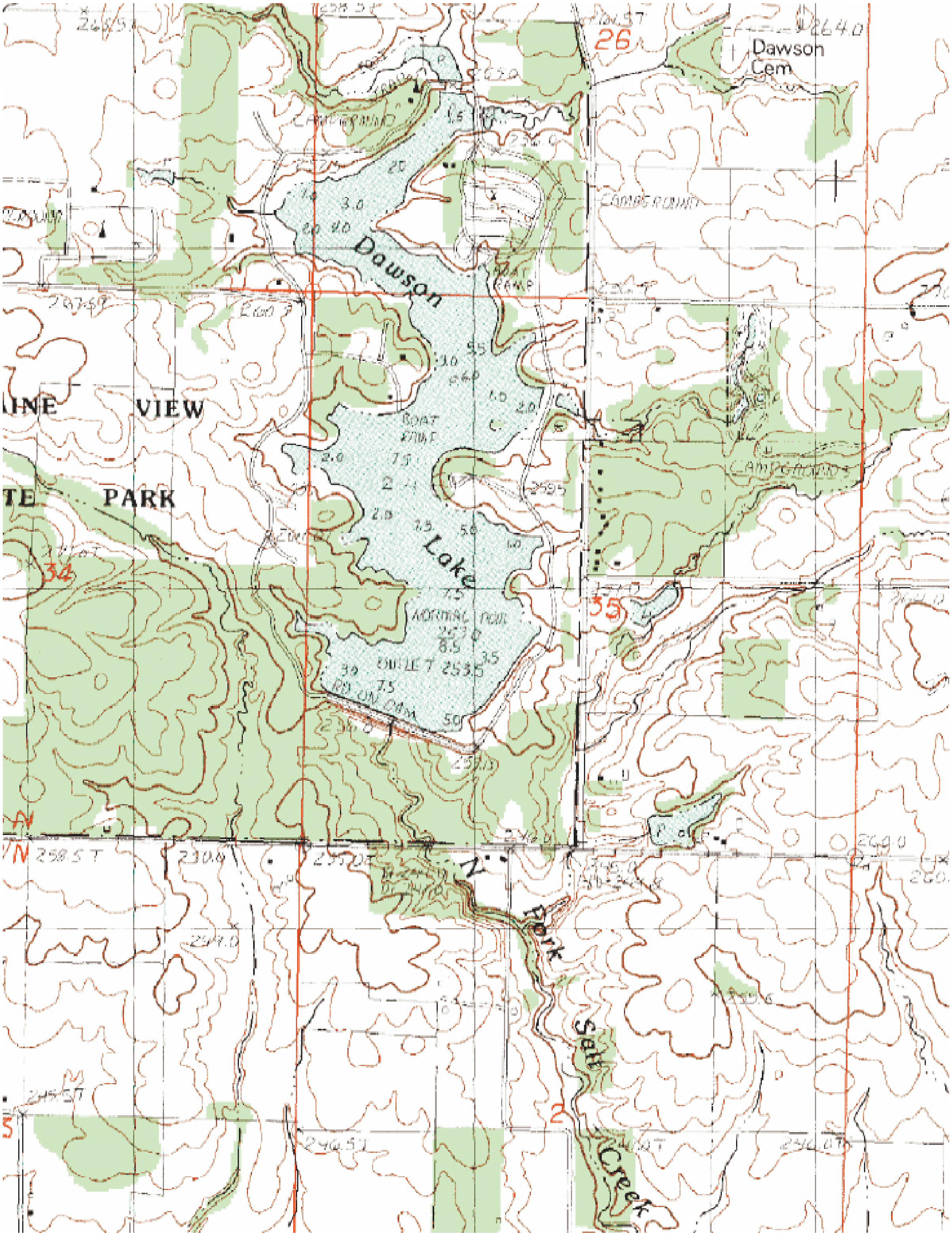

Figure 2.4-10 Dawson Lake and Dam located approximately 17.1 miles north-northeast of the ESP site. Dawson Lake is located on the North Fork of Salt Creek.

2.4.4.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to potential dam failures at the site. SSAR Section 2.4.4 conforms to RS-002, Attachment 2, Section 2.4.4, with regard to this objective.

Section 2.4.4 of RS-002, Attachment 2, provides that the SSAR should address 10 CFR Parts 52 and 100 as they relate to the identification and evaluation of potential dam failures at the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.4, the staff concludes that by conforming to RS-002, Attachment 2, Section 2.4.4, it has met the requirements for potential dam failures with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the staff finds that the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing the design basis dam failure, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.5 Probable Maximum Surge and Seiche Flooding

The EGC ESP site is located on the shores of Clinton Lake, approximately 6 mi east of the city of Clinton, DeWitt County, in central Illinois at elevation 735 ft MSL.

2.4.5.1 Technical Information in the Application

The applicant states in SSAR Section 2.4.5 that there are no large bodies of water near the ESP site where significant storm surges and seiche can occur. The applicant also stated that Clinton Lake is not large enough to develop surge and seiche conditions more critical than PMF conditions.

2.4.5.2 Regulatory Evaluation

SSAR Table 1.5-1 demonstrates the applicant’s conformance to the NRC RGs. The staff requested, in RAI 1.5-1, that the applicant provide a comprehensive listing of the NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff should use to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how it addresses the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that the applicant correctly identified the applicable regulations and guidance.

Section 2.4.5 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. The applicant must meet the requirements of 10 CFR Parts 52 and 100 as they relate to evaluating the hydrologic characteristics of the site. Specific criteria necessary to meet the relevant hydrologic requirements of 10 CFR Parts 52 and 100 are the regulations in 10 CFR 52.17(a) and 10 CFR 100.20(c), which require that the site’s physical characteristics (including seismology, meteorology, geology, and hydrology) be considered when determining its acceptability for a nuclear reactor(s). RS-002, Attachment 2, further states the following:

To satisfy the hydrologic requirements of 10 CFR Parts 52 and 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 due to 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 structures, systems, and components important to safety for a nuclear power plant or plants 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 storm surges or seiches would not pose an undue risk to the type of facility proposed for the site.

For those cases where 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting limiting values of parameters. Important PPE parameters for safety assessment 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 applicant's analysis is considered complete and acceptable if the following areas are addressed and can be independently and comparably evaluated from the applicant's submission.

- All reasonable combinations of probable maximum hurricane, moving squall line, or other cyclonic wind storm 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 Corps of Engineers publications as described below.

- Combinations of surge levels and waves that may be critical to design of a nuclear power plant or plants of 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 RG 1.59, Position 2, is elected by the applicant, the design basis for flood protection of all safety-related facilities identified in RG 1.29 should be shown to be adequate in terms of time necessary for implementation of any emergency procedures. The applicant should also demonstrate that all potential flood situations that could negate the time and capability to initiate flood emergency procedures are provided for in the less severe design basis selected.

This section of the safety assessment 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 development of probable maximum hurricanes for east and Gulf Coast sites, squall lines for the Great Lakes, and severe cyclonic wind storms for all lake sites by the Corps of Engineers, 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. The Corps of Engineers 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 of NOAA, the Corps of Engineers, 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% exceedance" monthly spring high tide, plus a sea level anomaly based on the maximum difference between recorded and predicted average water levels for durations of 2 weeks or longer for coastal locations or the 100-yr recurrence interval high water for the Great Lakes. In a similar manner, the storm track, wind fields, effective fetch lengths, direction of approach, timing, and frictional surface and bottom effects are evaluated by independent staff analysis to ensure that the most critical values have been selected. Models used to estimate surge hydrographs that have not previously been reviewed and approved by the staff are verified by reproducing historical events, with any discrepancies in the model being on the conservative (i.e., high) side.

Criteria and methods of the Corps of Engineers, as generally summarized in Reference 9 of RS-002, Attachment 2, are used as a standard to evaluate the applicant's estimate of coincident wind-generated wave action and runup.

Criteria and methods of the Corps of Engineers and other standard techniques are used to evaluate the potential for oscillation of waves at natural periodicity.

At the COL stage, criteria and methods of the Corps of Engineers are used 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. RG 1.125 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, Attachment 2, Section 2.4.5, and RG 1.59. The ESP site is located inland on the shores of Clinton Lake, formed by inundation of the North Fork of Salt Creek and Salt Creek by Clinton Dam, located approximately 1200 ft downstream of the confluence of the North Fork of Salt Creek with Salt Creek. Salt Creek flows west and joins with the Sangamon River, which in turn joins the Illinois River. The Illinois River is a tributary of the Mississippi River.

The ESP site is located at an elevation of 735 ft MSL. The staff concludes that the ESP site is not subject to storm surge from either the ocean or the Great Lakes.

The following describes the independent evaluation performed by staff to estimate seiche effects. Fetch length is one of the key parameters for determining wind setup and is generally based upon the longest straight-line distance from the site to the opposing shore. Although the site is approximately 3 mi from the dam and 10 mi from the upstream end of the reservoir, the longest straight-line distance to the opposing shore is approximately 6340 ft (see Figure 2.4-11 of this SER).

Irregular lake bathymetry and strong thermal stratification, which exists during various parts of the year, affect wind setup. An accurate determination of the wind setup that considers all of these complicating factors would require use of a multidimensional hydrodynamic and water quality model.

A simplified and conservative approach to estimate wind setup is to assume that the lake is not thermally stratified and can be represented as a uniform rectangular basin with one side equal to the fetch length. The staff assumed a uniformly distributed wind stress along the water surface in the direction of the fetch to simplify the hydrodynamic equations of motion and make it possible to obtain an analytic solution for the surface setup. As presented in N.S. Heaps, "Vertical Structure of Current in Homogenous and Stratified Waters,' (Ed. K. Hutter, *Hydrodynamics of Lakes,* Springer Verlag: New York, 1984), the resulting solution is:

$$\zeta = \frac{CU^2 L}{h}$$

where ζ is the wind setup in ft; U is the windspeed in mph; h is the average depth of the lake in ft; L is the fetch length in ft; and C is an empirical coefficient equal to approximately 1.5×10^{-7}. The staff used a value of 6340 ft for L. Bathymetry contours (see Figure 2.4-11 of this SER) indicate that the original river level was at an elevation of approximately 660 ft MSL. Since the water depth, h, is in the denominator, a smaller depth would produce a larger (i.e., more conservative) wind setup. Therefore, the staff used the relatively conservative average water depth value of 30 ft.

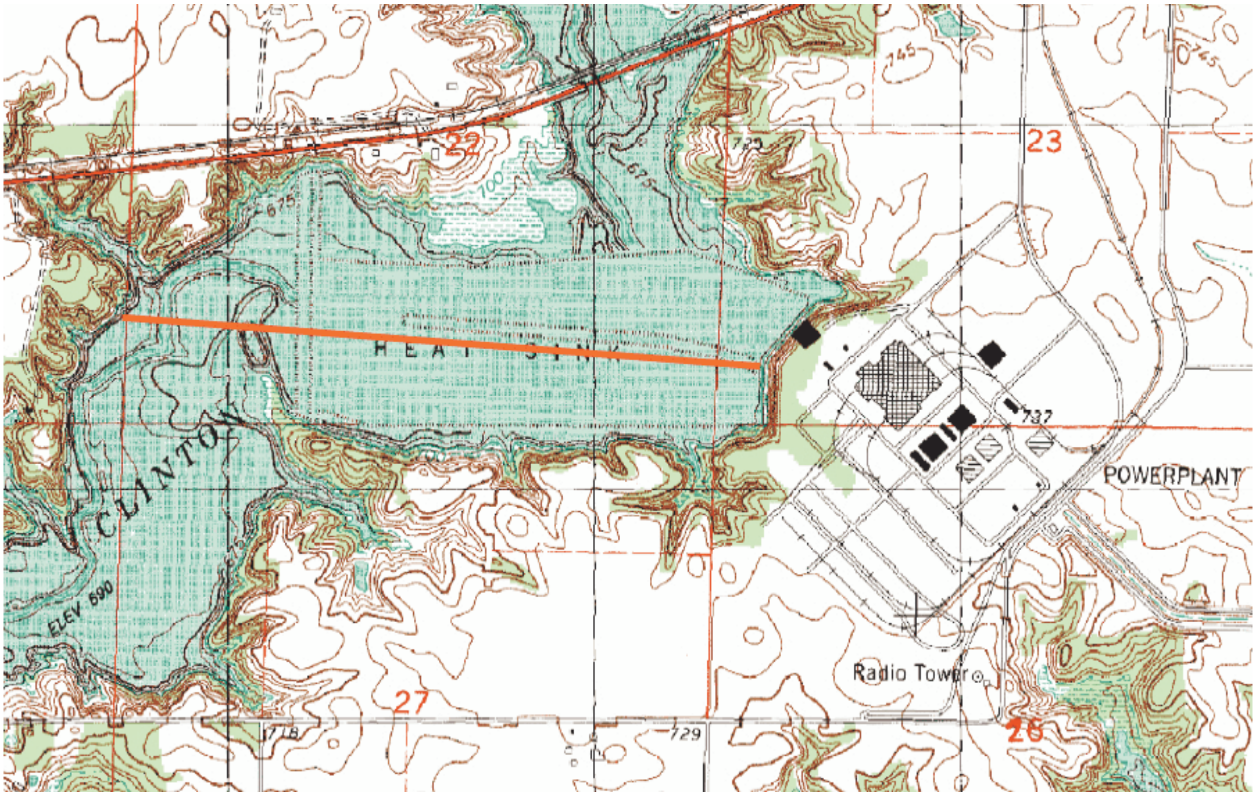

Figure 2.4-11 Clinton Power Station site and fetch length

One of the derivation assumptions in the wind setup equation above is that the windspeed is steady and uniformly blowing in the direction of maximum fetch. The staff conservatively estimated the PMWS, as defined by ANSI/ANS 2.8-1992 to be equal to 100 mph. This windstorm is based upon the location of the site, which is within 150 mi of the Great Lakes. The staff used this conservative value as the steady over-water windspeed in the wind setup equation.

Using these parameters, the staff estimated the resulting wind setup as 0.3 ft. The staff combined this increase in water surface elevation at the ESP site with the water surface elevation estimated as a result of the PMF and coincident wind wave activity to estimate the maximum water surface elevation at the site in Section 2.4.3 of this SER.

The staff estimated the period of oscillation resulting from seiche, along the fetch length line shown in Figure 2.4-11 of this SER, based on the theory for free oscillation of water of uniform depth and temperature in a rectangular basin (B.W. Wilson, “Seiches,” (*Advances in Hydoscience*, Volume 8, Academic Press: New York, 1972)):

$$T = \frac{2L}{\sqrt{gh}}$$

where T is the period of seiche motion in seconds; g is the acceleration resulting from gravity (32.2 ft/s^2); and L and h are as defined in the equation for wind setup.

The staff estimated the resulting seiche period to be approximately 6.8 minutes. This period is significantly shorter than meteorologically induced wave periods (e.g., synoptic storm pattern frequency and dramatic reversals in steady wind direction required for wind setup). Therefore, the staff concludes that meteorologically forced resonance is not likely. The staff also concludes that seismically induced seiche is unlikely in Clinton Lake because of the large difference between the period of oscillation resulting from seiche and that of seismically induced vibrations.

2.4.5.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of probable maximum surge and seiche flooding at the site. SSAR Section 2.4.1 conforms to RS-002, Attachment 2, Section 2.4.5 with regard to this objective.

Section 2.4.5 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating probable maximum surge and seiche flooding at the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.5, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.5, it has met the requirements to identify and evaluate probable maximum surge and seiche flooding at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). In addition, the seismically induced flooding analysis reflects the most severe seismic event historically reported for the site and surrounding area (with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated), and the staff concludes that the applicant partially conforms to GDC 2, insofar as that analysis defines design bases for seismically induced surge and seiche.

2.4.6 Probable Maximum Tsunami Flooding

The EGC ESP site is 6 mi east of the city of Clinton, in DeWitt County, located in central Illinois. It is adjacent to Unit 1 of the CPS on the shore of Clinton Lake, an impoundment on Salt Creek. Salt Creek flows 50 mi from the Clinton Dam to its confluence with the Sangamon River. The Sangamon River, from its confluence with Salt Creek, flows 40 mi to merge with the Illinois River north of Beardstown. The Illinois River flows 90 mi from its confluence with the Sangamon River to meet the Mississippi River near Grafton. The Mississippi River flows 1172 mi from its confluence with the Illinois River to the Gulf of Mexico (NOAA, 2004).

2.4.6.1 Technical Information in the Application

The applicant states that “the site will not be subjected to the effects of tsunami flooding because the site is not adjacent to a coastal area.” The applicant considered only tsunami flooding directly associated with seismically generated waves in open water that affect coastal areas.

2.4.6.2 Regulatory Evaluation

SSAR Table 1.5-1 presents the applicant's conformance to the NRC RGs. The staff requested, in RAI 1.5-1, that the applicant provide a comprehensive listing of the NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff should use to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how it addressed the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that the applicant has correctly identified the applicable regulations and guidance.

Section 2.4.6 of RS-002, Attachment 2, provides the following review guidance used by the staff in evaluating this SSAR section:

- 10 CFR Parts 52 and 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 in 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the site's physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining its acceptability to host a nuclear reactor or reactors. The regulations in 10 CFR Parts 52 and 100 are applicable to Section 2.4.6 of RS-002, Attachment 2, 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 Parts 52 and 100, the applicant's safety assessment 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 description should be sufficient to assess the acceptability of the site and the potential for a tsunami to influence the design of structures, systems, and components important to safety for a nuclear power plant or plants 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 tsunami would pose no undue risk to the type of facility proposed for the site.

For those cases where 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting limiting values of parameters. Important PPE parameters for safety assessment 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 in 10 CFR 100.23(c) requires that geologic and seismic factors be considered when determining suitability of the site. Section 100.23(c) requires an investigation to obtain geologic and seismic data necessary for evaluating seismically induced floods and water waves. Section 100.23(c) is applicable to Section 2.4.6 of RS-002, Attachment 2, because it requires investigation of distantly and locally generated waves or tsunami that have affected or could affect a proposed site, including available evidence regarding the runup or drawdown associated with historic tsunami in the same coastal region and local features of coastal topography that might modify runup or drawdown. More detailed guidance on the investigation of seismically induced flooding is provided in RG 1.70.

To meet the requirements of 10 CFR Parts 52 and 100, and 10 CFR 100.23, with respect to tsunami and the analysis thereof, the following specific criteria are used:

- If it has been determined that tsunami estimates are necessary to identify flood or low water design bases, the analysis will be considered complete if the following areas are addressed and can be independently and comparably evaluated from 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.

  — All models used in the analysis are verified or have been previously approved by the staff. 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 Corps of Engineers publications as described below.

  — If RG 1.59, Position 2, is adopted by the applicant, 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% less conservative than the staff's estimates. If the applicant's estimates are more than 5% 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 safety assessment will also be acceptable if it states 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 found during its independent review that, in extreme cases along coastal areas, the shoreline water level has risen to more than 50 ft for tsunami of distant origin and over 100 ft for tsunami waves generated near the earthquake's epicenter (NOAA, 2004). However, since the ESP site is located at an elevation of 735 ft MSL and is at a great distance from the coast and more than 93 mi from the Great Lakes, the staff concludes that the effects of even the largest ocean tsunami or a tsunami caused in the Great Lakes would not be high enough to exceed the elevation of the ESP site.

The staff also considered the potential for flooding along the shores of Clinton Lake near the ESP site that could result from a seismically induced hillslope failure. Such a wave would have the potential to cause a tsunami-like wave, as discussed in RG 1.59. The applicant's response to RAI 2.4.2-3, however, indicates that the slopes near the ESP site have been stable for the past 30 years, and that no landslides are documented for DeWitt County.

The updated SSAR Figure 1.2-4 (in response to RAI 2.4.1-1) displays the location of the essential safety-related features of the ESP site. All features, except the new intake structures, are located more than 600 ft from the shores of Clinton Lake at an elevation of 735 ft MSL, or 45 ft above the normal water surface elevation of Clinton Lake. The height of the hillslope banks directly opposite the ESP site is approximately 40 ft above the surface of the water. Waves generated from a hillslope failure on these banks would also need to transect the UHS pond and underwater dikes before reaching the ESP site, potentially removing energy from these waves as they pass over the shallow water zones. The staff therefore concluded that tsunami-like waves induced by hillslope failure do not pose a risk to the ESP site.

2.4.6.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of probable maximum tsunami flooding at the site. SSAR Section 2.4.6 conforms to RS-002, Attachment 2, Section 2.4.6 with regard to this objective.

Section 2.4.6 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating probable maximum tsunami flooding at the site. Although the applicant did not specifically address these regulations in SSAR Section 2.4.6, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.6, it has met the requirements to identify and evaluate tsunami flooding with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the staff finds that the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design bases for tsunamis, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated and, therefore, the applicant partially conforms to GDC 2, insofar as that analysis defines design bases related to tsunamis.

2.4.7 Ice Effects

The Exelon ESP site is located on the shore of Clinton Lake, approximately 6 mi east of the city of Clinton in Dewitt County, Illinois. Clinton Lake is an impoundment formed by construction of an earthen dam across Salt Creek about 1200 ft downstream from the confluence of the North Fork of Salt Creek with Salt Creek. The ESP site is located approximately 3.5 mi northeast of the dam.

The climate of central Illinois is typically continental, with cold winters and frequent short-period fluctuations in temperature, humidity, cloudiness, and wind direction. Alternating periods of steady precipitation (rain, freezing rain, sleet, or snow) and clear, crisp cold weather characterize winter.

2.4.7.1 Technical Information in the Application

The applicant used the USGS streamflow data measured at the Rowell gauge to identify ice formation in streams. The gauge is located approximately 12 mi downstream from the Clinton Dam. The applicant reports intermittent ice effects during the winter months. An ice jam recorded on February 11, 1959, resulted in a maximum gauge height of 24.84 ft and a peak discharge of 7500 cfs. The gauge datum was at elevation 610 ft MSL. The applicant estimated that a discharge of 7500 cfs corresponds to a gauge height of 22.14 ft and, consequently, that the ice jam raised the water surface by 2.7 ft.

The applicant states that the wintertime PMP depth in February is 13.8 in, 11.4 in. less than the 48-hour PMP depth for August of 25.2 in. The applicant concludes that the effects of an ice jam flood in combination with a wintertime PMF on the water surface in Clinton Lake would be less than that resulting from the summertime PMF.

The applicant estimates the average thickness of the ice sheet that could form on the surface of Clinton Lake as 10 in., neglecting the heat discharged into the lake during operation of any station units. The design water level of the UHS is 675 ft MSL, and the inlet to the CPS screen house is at elevation 670 ft MSL. The applicant states that a water depth of 12.3 ft above the intake will be available for station operation even under low-water conditions. The applicant concludes that the formation of a 10-in. thick ice sheet will not block flow into the CPS screen house.

The applicant states that low-flow conditions resulting from ice jams on streams upstream of the ESP site will not affect the UHS because of its submerged conditions. The applicant states that the UHS capacity will be maintained.

The applicant states that the only ESP facility safety-related structure exposed to the ice sheet formed on the surface of Clinton Lake would be the intake structure. The intake structure would be similar to, but considerably smaller than, the existing intake structure. The new intake would be located at the same depth as the existing intake.

The applicant describes the possibility of an ice sheet formation on the surface of Clinton Lake in SSAR Section 2.4.7, but that section does not describe the possibility nor the impact of a collision of the ice sheet or a breakaway chunk of the ice sheet with the intake structure. The staff requested, in RAI 2.4.7-1, that the applicant discuss the potential for ice sheet collision impacts on the intake structure and quantify the force of this impact. In response to RAI 2.4.7-1, the applicant stated that since there is a potential for formation of an ice sheet that could affect the intake structure, it will consider ice sheet effects at the COL stage. The applicant will revise SSAR Section 2.4.7 to state that the force resulting from the interaction of a moving ice sheet and a structure results from crushing, bending, buckling, splitting, or a combination of these modes. The total force on the entire structure is important in designing foundations that resist sliding and overturning. Contact forces over small areas are important for designing the internal structural members and external skin of the structure.

SSAR Section 2.4.7 states that the expected average thickness of an ice sheet that may form on the surface of Clinton Lake is 10 in. The staff requested, in RAI 2.4.7-2, that the applicant explain how it estimated the ice sheet thickness identified in SSAR Section 2.4.7 and provide the input assumptions for this estimation. In response to RAI 2.4.7-2, the applicant stated that it calculated the ice thickness using the method described in the USACE Engineering and Design—Ice Engineering Manual (EM1110-2-1612). General assumptions in the applicant's calculation included an ice formation period of November through February and little snow accumulation on the ice surface. Since there were no records for freezeup of Clinton Lake, the applicant determined an approximate date based on observed freezeup dates for Lake Monona in Madison, Wisconsin, which is of similar size and volume as Clinton Lake and is located approximately 180 mi north of Clinton Lake. The applicant used air temperature data from Decatur, Illinois, located 10 mi south of Clinton Lake, to estimate freezing degree-days for the winter seasons of 1978 through 2003. The applicant used a conservative coefficient of ice cover (0.8) that assumed a windy lake with no snow cover. The applicant reported a maximum ice thickness of 22.2 in. and an average thickness of 14.2 in. The applicant will revise the SSAR to include additional information on ice depth.

SSAR Section 2.4.7 does not provide sufficient detail for the staff to determine the relationship of the ESP intake structure to the existing CPS intake structure. It was also not possible to determine the depth of water over the intake during normal and low-water conditions. The staff requested in RAI 2.4.7-3 that the applicant describe the relationship, including the layout and depth, of the ESP intake relative to the current CPS intake. In response to RAI 2.4.7-3, the applicant stated that the ESP facility intake will be located 65 ft west of the existing CPS plant intake. The applicant stated that the bottom concrete slab of the CPS intake structure is located at an elevation of 657.5 ft MSL, and the intake extends from an elevation of 670 ft MSL to an elevation of 697 ft MSL. The elevation of the bottom of Clinton Lake is 668.5 ft MSL. The applicant stated that the layout of the ESP facility intake would be similar to the CPS plant intake. The bottom of the ESP facility intake would be located at an elevation of 670 ft MSL, and the inlet opening would extend upwards to at least the normal water surface elevation in Clinton Lake, which is 690 ft MSL. The applicant stated that the basemat of the ESP facility intake would be located at an approximate elevation of 657.5 ft MSL; the final elevation would depend on the submergence required by the pumps. The applicant also stated that the ESP facility intake pumps would be mounted at an approximate elevation of 699 ft MSL, the same elevation as the CPS intake pumps.

SSAR Section 2.4.7 does not provide sufficient detail regarding formation of frazil and anchor ice on or near the intake structure. The staff requested, in RAI 2.4.7-4, that the applicant describe site characteristics for frazil and anchor ice formation. In response to RAI 2.4.7-4, the applicant stated that it will revise Chapter 2 of the SSAR and add Section 2.4.7.1, "Frazil Ice and Anchor Ice." The applicant will state in the new SSAR Section 2.4.7.1 that accumulation of frazil and anchor ice can cause blockages of intake water systems. This ice accumulates on trash racks or screens in the intake pathway. Frazil ice has a fine, small, needle-like structure or thin, flat, circular plates of ice suspended in water. In supercooled water, frazil ice particles can adhere to form clusters or flocs that can accumulate in trash racks or screens. Frazil ice on the surface of supercooled water can form floating ice pans. Frazil ice can also form as hanging dams on the bottom of a solid ice sheet. Anchor ice is submerged ice attached to the streambed. Generally, anchor ice forms in shallow, turbulent waters. The applicant stated that conditions that might lead to formation of frazil or anchor ice could occur in streams that empty into Clinton Lake but are not expected in the intake structure area. The applicant stated that when anchor ice broke loose from the streambed, it would flow into Clinton Lake and form or join with the cover ice on the lake. The applicant concluded that this anchor ice would not interfere with the operation of the ESP facility intake structure.

The applicant stated that the CPS water intake is designed to avoid obstruction from surface ice and accumulation of frazil ice by circulating waste heat through a warming line back to the inlet of the screen house. This warming line is designed to maintain a minimum water temperature of 40 EF at the intake during winter operation. The applicant stated that the CPS plant has not experienced operational problems because of frazil ice accumulation in the intake.

The applicant stated that the ESP facility intake would be located in the vicinity of the existing CPS intake. The applicant stated that a warming line from the hot side of the cooling towers would be provided to the ESP facility intake to prevent formation of frazil ice at the intake for NHS cooling tower makeup. The applicant also stated that it would design these features independently of the existing CPS facility.

SSAR Section 2.4.7 does not provide sufficient information regarding formation of ice in the lake or near the intake structure during periods when the existing unit is nonoperational, thus eliminating the heat load to Clinton Lake. The staff requested, in RAI 2.4.7-5, that the applicant discuss the impacts to ice formation if the existing unit were no longer operating. In response to RAI 2.4.7-5, the applicant stated that it discusses this issue in two new paragraphs that will be added to the end of SSAR Section 2.4.7 and in the new Section 2.4.7.1 provided in response to RAI 2.4.7-4.

The two new paragraphs that will be added to Section 2.4.7 state that no ice formation currently occurs in the discharge channel when the CPS Unit 1 is in operation. The applicant expects no change to occur with the addition of the proposed ESP facility. The capacity of the discharge channel is approximately 3058.3 million cfs or 1.37 million gpm at a discharge velocity of 1.5 fps. The discharge from CPS Unit 1 is approximately 445,000 gpm of warm cooling water during winter months. The ESP facility would add a blowdown water discharge of 12,000 gpm, increasing the discharge in the channel to 457,000 gpm. The applicant states that this combined discharge is well within the discharge capacity of the channel.

The applicant states that there is some possibility of ice formation on portions of the discharge channel if only the ESP facility is in operation. Under these circumstances, warm water discharge to the channel would be significantly reduced, resulting in a lower heat output and a lower flow velocity, and leading to an increased potential for surface ice accumulation, particularly at locations away from the point of discharge. The applicant states that the ice accumulation would be much thinner than the predicted normal lake accumulation because of the heat and velocity components of the ESP facility discharge. The applicant also states that, if ice did form, it would remain on the surface, allowing unrestricted flow below the water surface. The applicant concludes that jamming and clogging of the discharge channel because of icing is not expected.

SSAR Section 2.4.7 does not provide sufficient detail for the staff to determine if formation of ice on the lake and near the intake structure could constrain intake depth. The staff requested, in RAI 2.4.7-6, that the applicant discuss whether ice sheet formation is likely to constrain the ESP facility UHS intake depth. In response to RAI 2.4.7-6, the applicant stated that ice sheet formation in Clinton Lake will not constrain ESP facility UHS intake depth. The applicant stated that the thickness of ice cover is a small percentage of the intake height, and warming water used to prevent formation of frazil ice will retard the formation of an ice cover in the immediate area of the intake trash racks or screens. The applicant stated that it will revise SSAR Section 2.4.7 to provide additional information on ice effects related to ESP facility UHS intake depth.

SSAR Section 2.4.7 provides an average thickness of an ice sheet on the surface of Clinton Lake. The staff needs to understand if such an ice sheet formation, coupled with a loss of Clinton Dam and subsequent draining of the main lake, could lead to loss of capacity of the submerged UHS pond. The staff requested, in RAI 2.4.7-8, that the applicant describe the reduction in UHS capacity caused by a loss of Clinton Dam during periods when an ice sheet is covering the lake. In response to RAI 2.4.7-8, the applicant stated that the UHS for the ESP facility will consist of cooling towers if the selected reactor type does not use passive cooling methods. The applicant stated that Clinton Lake is used as a source of makeup water for the ESP facility UHS cooling towers and not as a heat sink. The applicant stated that if Clinton Dam is lost, any surface ice would be expected to be also lost since it floats on the surface. The applicant also stated that, if this surface ice sheet were to drop to an elevation equal to the top of the submerged UHS pond, there would be a small decrease in the capacity of the submerged UHS pond, which acts as the heat sink for CPS Unit 1. The applicant stated that during this condition, additional heat removal capacity would be available in the submerged UHS pond in the form of latent heat of fusion of ice. The applicant also stated that adequate water for makeup to the ESP facility UHS cooling towers would be available since the required shutdown of CPS after a dam failure would supply heat to the submerged UHS pond and convert the ice back into water.

2.4.7.2 Regulatory Evaluation

SSAR Table 1.5-1 presents the applicant's conformance to the NRC RGs. The staff requested, in RAI 1.5-1, that the applicant provide a comprehensive listing of the NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 addressed the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that the applicant has correctly identified the applicable regulations and guidance.

Section 2.4.7 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. Acceptance criteria for this section are based on meeting the requirements of 10 CFR Parts 52 and 100, as they relate to identifying and evaluating the hydrologic features of the site. RS-002, Attachment 2, further states the following:

Compliance with 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the site's physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining its acceptability for a nuclear power reactor. To satisfy the hydrologic requirements of 10 CFR Parts 52 and 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 power plant or plants of a specified type (or falling within a PPE) that might be constructed on the proposed site. Ice-related characteristics historically associated with the site and region should be described, and an analysis should be performed 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 power plant or plants 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 would 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting 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 Parts 52 and 100, as they relate to ice effects, the following specific criteria included in RS-002, Attachment 2, apply:

- Publications of NOAA, the USGS, USACE, and other sources are used to identify the history and potential for ice formation in the region. 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 found 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 as in the second item above. If this cannot be shown, it should be demonstrated that alternate sources of water that could be protected from freezing are available 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 dynamic loading caused by floating ice should be included in the structural design basis. (This item is to 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 power plant or plants of a specified type (or falling within a PPE) that might be constructed on the proposed site, it should be demonstrated that an alternate safety-related water supply would not also be adversely affected.

- 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 applicant reported on an ice jam on Salt Creek at Rowell that formed on February 11, 1959. The staff searched the USACE historical Ice Jam Database and found two reported ice jams on Salt Creek near Rowell. One of these jams was the February 11, 1959, ice jam reported by the applicant. This ice jam resulted in a maximum gauge height of 24.84 ft. The staff found that the mean daily discharge in Salt Creek near Rowell on this day was 6800 cfs and the peak discharge was 7500 cfs, according to the USGS streamflow observations in the NWISWeb Data for the Nation Web site. The other ice jam was reported on January 8, 1996. This ice jam resulted in low-water conditions on January 8 and 9 with a daily mean discharge of 8.5 cfs. Examination of daily streamflow records at Rowell shows a decrease in daily mean discharge from 13 cfs on January 1 to a low of 8.5 cfs on January 8 and 9, and a return to 13 cfs on January 16, 1996.

The staff prepared a stage-discharge relationship from available gauge heights for peak streamflow at the Rowell gauge and used data from the period before the construction of Clinton Dam. Figure 2.4-12 of this SER shows this stage-discharge relationship. Using this relationship, the staff estimated a stage of 22.8 ft corresponding to a discharge of 7500 cfs, and an ice-jam-induced stage increase of 2.0 ft. If an ice-jam-induced flood were to augment the PMF, the maximum expected water surface elevation in Clinton Lake would be 723.7 ft MSL.

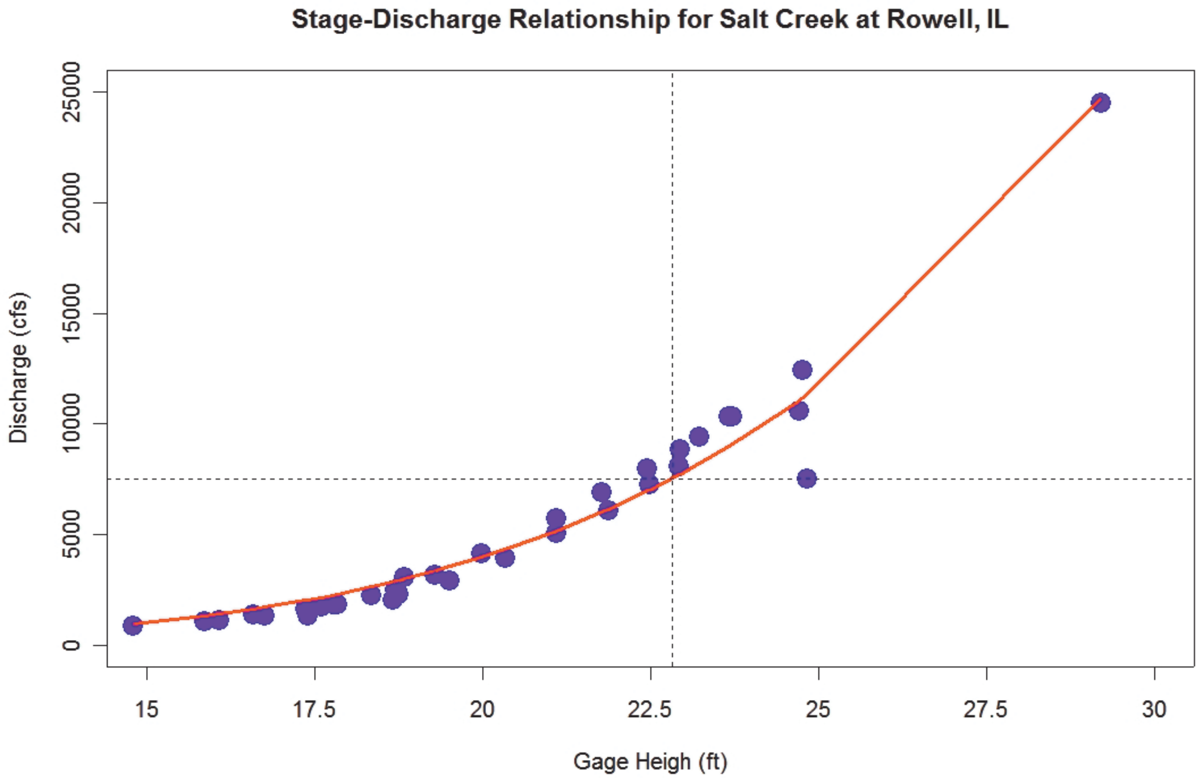

Figure 2.4-12 Stage-discharge relationship for Salt Creek at Rowell, IL

The staff estimated the all-season PMP depth for Clinton Lake's drainage area in Section 2.4.3 of this SER using HMR 51, HMR 52, and ANSI/ANS-2.8-1992. The 48-hour PMP depth was 26.8 in. and the 72-hour PMP depth was 28.7 in. The National Weather Service's current HMRs do not provide a method to estimate PMP for each month for areas exceeding 10 mi^2. Methods for estimation of monthly PMP appeared in HMR 33, but that report has been superseded by the current HMRs. The staff independently confirmed that the 48-hour winter PMP depth is less than the all-season 48-hour PMP depth. The staff's estimate of all-season PMP using the current HMRs is greater than the applicant's winter and all-season PMP. The staff concluded that a flood generated by winter PMP and augmented by an ice-jam flood would be less critical than the all-season PMF.

The staff independently estimated the likely surface ice thickness that might form near the intake structures. During this estimation, the staff used mean daily air temperatures recorded at the Decatur, Illinois, meteorologic station. Maximum and minimum daily air temperatures at this station are available for water years 1902 to 1999. The staff estimated cumulative degree-days starting December 1 through May 31 for each water year. The most severe cumulative degree-days below freezing occurred in water year 1978 (see Figure 2.4-13 of this SER).

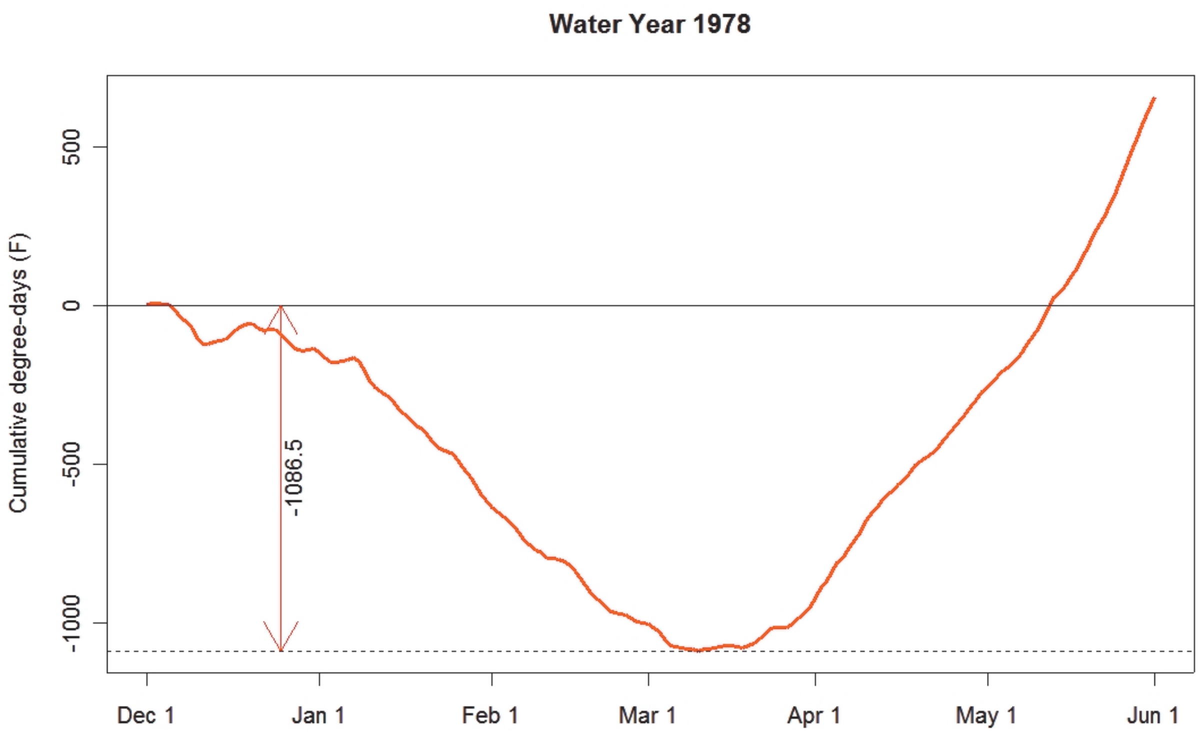

Figure 2.4-13 Accumulated degree-days since December 1, 1977, at the Decatur meteorologic station

The maximum accumulated degree-days below freezing during the period of December 1, 1976, to May 31, 1977, was 603.6 EC (1086.5 EF), as shown in Figure 2.4-13. The staff used Assur's method (*Handbook of Applied Hydrology*, 1964) to estimate a maximum ice thickness of 31.4 in. The staff determined that it is possible for an ice sheet to form for extended periods in Clinton Lake.

SSAR Section 2.4.7 does not describe the possibility and potential impact of a collision of the ice sheet or a breakaway chunk of the ice sheet with the intake structure. The staff needs to evaluate the possibility of any limitations on the performance of safety-related intakes subsequent to such an impact. In RAI 2.4.7-1, the staff requested that the applicant discuss this potential collision and its impact on the ESP facility intake structure. In response to RAI 2.4.7-1, the applicant stated that there is a potential for ice sheet effects on the intake structure, and the COL applicant will consider these effects at the COL stage. Since the ESP facility intake structure is safety related and the potential for ice formation is a site-induced condition, the COL applicant will need to demonstrate that the intake structure can withstand the effects of any ice sheet crushing, bending, buckling, splitting, or a combination of these modes. This is **Permit Condition 2.4-5**. This permit condition will include further details when the applicant and staff establish the estimates of ice thickness, mass, velocity, and other attributes that the COL applicant should use as design input. (See Open Item 2.4-9 of this SER.)

SSAR Section 2.4.7 does not provide sufficient details of the estimation of ice sheet thickness. In RAI 2.4.7-2, the staff requested that the applicant provide details of ice sheet thickness estimation including the input assumptions for the method employed. The staff performed its own independent estimation of the thickness of an ice sheet that may form on the surface of Clinton Lake. The staff used air temperature data from the Decatur meteorologic station as described above. The staff's estimate of ice sheet thickness is significantly greater than that of the applicant. Therefore, the applicant needs to provide more details regarding the method and air temperature data set used in estimating the thickness of an ice sheet that may form on the surface of Clinton Lake and demonstrate that the ice thickness estimate is adequate. This is **Open Item 2.4-9**.

SSAR Section 2.4.7 does not provide sufficient detail for the staff to determine the relationship of ESP facility intake structure to the existing CPS intake structure and the depth of water over the intake during normal and low-water conditions. The staff needs this information to evaluate the performance limitations of the intakes during icy or low-water conditions. In RAI 2.4.7-3, the staff requested that the applicant describe the relationship, including its layout and depth, of the ESP facility intake relative to the current CPS intake. The applicant's response to RAI 2.4.7-3 did not resolve the staff's concern about the precise layout of the ESP facility intake structure. According to the CPS environmental report (ER) Figure 5.3-1, the ESP facility UHS intake would be located at an elevation of 668 ft MSL, which is below the lake bottom mentioned in the RAI response. The staff needs the bounding dimensions and critical elevations of the ESP facility intake structure, including its conceptual plan and cross section, clearly indicating elevation of the basemat, elevation of the screen house opening, elevation of the NHS makeup water intake pipe, elevation of the UHS makeup water intake pipe, and their relationship to the existing lake bed. The applicant needs to provide a schematic diagram clearly showing these items. This is **Open Item 2.4-10**.

SSAR Section 2.4.7 does not provide sufficient detail regarding formation of frazil and anchor ice on or near the intake structure. The staff needs this information to assess the adequacy of the intake structure during prolonged cold conditions. In RAI 2.4.7-4, the staff requested that the applicant describe site characteristics for frazil and anchor ice formation. In response to RAI 2.4.7-4, the applicant described a warming line that is used to maintain a minimum water temperature of 40 EF in the CPS intake and suggested a similar approach for the ESP facility. Based on the applicant's proposed approach, the COL applicant will have to design the ESP facility UHS intake to maintain a minimum water temperature of 40 EF at all times to preclude formation of frazil and anchor ice on the intake inlet. This is **Permit Condition 2.4-6**.

SSAR Section 2.4.7 does not provide sufficient information regarding formation of ice in the lake or near the intake structure during periods when the existing unit is nonoperational, thus eliminating the heat load to Clinton Lake. In RAI 2.4.7-5, the staff requested that the applicant discuss the impacts to ice formation if the existing unit were no longer operating. The staff determined that the applicant's response to RAI 2.4.7-5 was inadequate for two reasons. First, the applicant did not discuss the impact of ice formation when CPS Unit 1 was no longer operating and, second, the staff was concerned with ice formation in Clinton Lake and not in the discharge channel. Permit Condition 2.4-6 would ensure that the minimum intake water temperature was 40 EF at all times and, in the event that CPS Unit 1 was no longer in operation, the ESP facility would be shut down when the intake water temperature fell below 40 EF.

SSAR Section 2.4.7 does not provide sufficient detail for the staff to determine if formation of ice on the lake and near the intake structure could constrain intake depth. The staff needs this information to evaluate the adequacy of safety-related intakes. In RAI 2.4.7-6, the staff requested that the applicant discuss whether ice sheet formation is likely to constrain the ESP facility UHS intake depth. Based on a minimum safe ESP facility shutdown water surface elevation of 677 ft MSL, reduced by the staff-estimated maximum ice sheet thickness of 31.4 in., the ESP facility UHS intake needs to be below an elevation of 674.4 ft MSL. According to ER Figure 5.3-1, the ESP facility UHS intake would be located at an elevation of 668 ft MSL. The staff concluded that the ice sheet formed on Clinton Lake would not constrain the intake. This is predicated on the ESP facility UHS intake being located at an elevation of 668 ft MSL. This is **Permit Condition 2.4-7**.

SSAR Section 2.4.7 provides an average thickness of an ice sheet on the surface of Clinton Lake. It is possible that some loss in capacity of the submerged UHS pond could occur if such an ice sheet formation were coincident with a loss of Clinton Dam and could result in the draining of the main lake. In RAI 2.4.7-8, the staff requested that the applicant describe the reduction in submerged UHS pond capacity caused by a loss of Clinton Dam coincident with an ice sheet covering the lake. The applicant’s RAI response that surface ice on the submerged UHS pond would float away in the event of a complete loss of Clinton Dam is not a conservative assumption. The staff determined that it is conservative to assume that surface ice could remain in the submerged UHS pond upon the loss of Clinton Dam, leading to reduced water storage capacity in the submerged UHS pond. Similarly, the applicant’s RAI response that drop of surface ice below the top of the submerged UHS dam upon loss of Clinton Dam would lead to a small reduction in capacity in the submerged UHS pond is not a conservative assumption. The applicant did not quantify this loss of capacity in the submerged UHS pond, as originally asked by RAI 2.4.7-8.

The applicant’s response to RAI 2.4.7-8 is neither consistent nor conservative for several additional reasons. The applicant stated that Clinton Lake would be used as a source of makeup water for the ESP facility UHS, and not as a heat sink, yet in its response to the RAI the applicant took credit for heat of fusion of ice available for heat removal, even though the applicant argued that most of the surface ice would float away and be lost. The staff agrees with the applicant that the submerged UHS pond should not be considered a heat sink for the ESP facility UHS. The staff disagrees, therefore, that heat of fusion of ice is available for cooling needs.

The applicant should quantify the reduction in water storage capacity of the submerged UHS pond in the event of a complete loss of Clinton Dam coincident with the presence of surface ice. This is **Open Item 2.4-11**.

2.4.7.4 Conclusions

As set forth above, with the exceptions of the open items noted in Section 2.4.7.3 of this SER, the applicant provided sufficient information pertaining to the identification and evaluation of ice effects at the site. SSAR Section 2.4.7 conforms to RS-002, Attachment 2, Section 2.4.7 with regard to this objective.

Section 2.4.7 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating ice effects at the site. Although the applicant does not specifically address the above regulations in SSAR Section 2.4.7, the staff concludes that by conforming to RS-002, Attachment 2, Section 2.4.7, it has met the requirements to identify and evaluate ice effects at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), except as noted in Section 2.4.7.3 above. Further, with the exceptions noted, the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design basis information pertaining to ice effects, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.8 Cooling Water Canals and Reservoirs

Clinton Lake, an impoundment formed by construction of an earthen dam across Salt Creek about 1200 ft downstream from the confluence of the North Fork of Salt Creek with Salt Creek, was constructed to provide cooling water for the CPS. The ESP site is approximately 3.5 mi northeast of the dam.

Unit 1 of CPS uses a once-through cooling system to dissipate heat from the turbine condenser. A discharge flume is provided to convey CPS Unit 1 circulating water discharge to the Salt Creek finger of Clinton Lake. The UHS for CPS Unit 1 is water held behind a submerged dam constructed within the North Fork of Salt Creek in Clinton Lake. The applicant refers to this water source as the submerged UHS pond.

The ESP facility would also use Clinton Lake as the source of cooling water. The applicant proposed that the ESP facility use a closed cooling system with wet cooling tower(s). The UHS for the ESP facility would consist of a mechanical draft cooling tower(s) with no water storage. The submerged UHS pond using the new intake would supply any makeup water required for the ESP facility UHS for a period of 30 days. Therefore, the new intake would be a safety-related structure.

2.4.8.1 Technical Information in the Application

The applicant states in SSAR Section 2.4.8.1 that it would use Clinton Lake as a source of raw water for the ESP facility. The applicant would add a new intake structure near the existing CPS Unit 1 screen house to supply water to the ESP facility. The ESP facility would use cooling tower(s) for normal cooling and possibly also for safety-related cooling. The lake would supply makeup water for evaporation and blowdown losses from the tower(s).

The applicant evaluates the capacity of the lake under a design drought with a 100-year recurrence interval. The applicant commits to maintain the lake water surface elevation at 677 ft MSL even during a 100-year drought. The applicant states in the SSAR that, if necessary, it would use a power reduction program to minimize makeup water requirements to maintain the lake water surface elevation at 677 ft MSL.

The applicant states in SSAR Section 2.4.8.1.1 that no changes would be made to the Clinton Dam for the ESP facility. The dam, a homogeneous earthfill dam with a maximum height of 65 ft above the bed of Salt Creek, is 3040 ft long. The top of the dam is at an elevation of

711.8 ft MSL. Both the upstream and downstream faces of the dam have side slopes of 3:1 (horizontal to vertical). The upstream face has a 18-in. thick riprap for protection against erosion from a 50 mph wind wave on the normal pool level of the lake. On the downstream face, seeded topsoil provides protection against erosion from rainfall. An 18-in.-thick riprap is also provided. At the toe of the dam, for protection against tailwater erosion, there is an 18-in.-thick riprap designed for 50-mph wind acting on a 100-year tailwater flood level.

The applicant estimates the PMF level in Clinton Lake at 708.8 ft MSL and the maximum level, corresponding to wave runup acting on PMF level as 711.95 ft MSL. The top of the dam is at an elevation slightly lower at 711.8 ft MSL. The applicant estimates that the duration for which wave action on a PMF level would lead to overtopping of the dam is 2.5 hours. The applicant states that this overtopping would occur in the form of a fine spray and that this spray falling on the downstream face of the dam would not result in any significant damage to the dam.

The applicant states in SSAR Section 2.4.8.1.2 that no changes to the service spillway would be required for the ESP Facility. The service spillway is designed to pass the design flood of 100-year recurrence interval with a water surface elevation of 697 ft MSL in the lake. The service spillway, located on the west abutment of the dam, is an uncontrolled concrete ogee semicircular in plan, with a crest length of 175 ft, and a crest elevation of 690 ft MSL. The height of the concrete ogee is 10 ft. Water is discharged from the ogee through a 80-ft-wide concrete chute into a stilling basin, and a discharge canal conveys the water from the stilling basin to the main channel of Salt Creek. Riprap extends for 80 ft downstream from the stilling basin as protection against erosion. Peak discharge through the service spillway corresponding to the 100-year flood is 11,450 cfs, and that corresponding to the PMF is 33,200 cfs.

The applicant states that it used the 100-year flood water level in the lake as the basis for determining the crest elevation of the auxiliary spillway. The auxiliary spillway functions only during floods greater than the 100-year flood. The crest of the auxiliary spillway is at an elevation of 700 ft MSL, to allow the 100-year flood to discharge entirely through the service spillway.

The applicant states in SSAR Section 2.4.8.1.3 that the ESP facility requires no changes to the auxiliary spillway. The auxiliary spillway is located to the east of the dam and is designed to pass floods greater than the 100-year flood, including the PMF. The auxiliary spillway is of the open-cut type, with a crest length of 1200 ft and a crest elevation of 700 ft MSL. The applicant estimates peak discharge through the auxiliary spillway during the PMF as 102,800 cfs. The maximum water velocity at the crest is 14 ft/s. The crest control section of the auxiliary spillway is 25 ft wide and consists of asphalt concrete. To protect the crest against scouring, concrete cutoffs and riprap are provided upstream and downstream of the crest.

The applicant states in SSAR Section 2.4.8.1.4 that the ESP facility would require no changes to the lake outlet works. The lake outlet works are located on the west abutment of the dam, 160 ft east of the service spillway. The primary function of the lake outlet works is to release a minimum flow of 5 cfs downstream of the dam. The lake outlet works consist of a submerged concrete intake, a 36-in.-diameter entrance pipe, a control house with three sluice gates, and a 48-in.-diameter outlet pipe, which terminates at the spillway stilling basin. The crest of the intake structure for the outlet works is at an elevation of 686 ft MSL, with an inlet diameter of 84 in. transitioning to a 36-in.-diameter throat. A trash rack and a vortex breaker are provided at the inlet. The sluice gates regulate the downstream releases. The gates are manually operated from the top of the control house.

The applicant states in SSAR Section 2.4.8.1.5 that the existing submerged UHS pond would serve as the source of makeup water for the safety-related cooling tower(s) for the ESP facility when water from Clinton Lake was not available. The new intake structure, which would be located next to the existing screen house for the CPS intake, would supply the makeup water. The applicant judged the capacity of the submerged UHS pond to be sufficient to meet the safety-related cooling water requirement for the existing CPS unit, as well as to meet the makeup water requirement for the safety-related cooling tower(s) of the ESP facility for 30 days.

The applicant states that there would be no change in the flowpath through the submerged UHS pond as a result of the ESP facility. The UHS pond consists of a submerged pond behind a submerged dam constructed across the North Fork of Salt Creek. This submerged dam is located 1 mi west of the CPS Unit 1 screen house. The top of the submerged dam is at an elevation of 675 ft MSL; its top width is 30 ft, and its length is 2350 ft. The submerged dam consists of homogeneous compacted backfill material, and both of its faces have a side slope of 5:1 (horizontal to vertical). A 2-ft-thick compacted soil-cement layer covers the top and both faces of the submerged dam. The surface area of the submerged UHS pond at the design elevation of 675 ft MSL is 158 ac, and its corresponding volume is 1067 ac-ft.

The top of the baffle dike within the submerged UHS pond is at an elevation of 676 ft MSL. A 3-ft-thick compacted soil-cement layer covers the dike. The baffle dike is 3300 ft long.

The applicant analyzed flow conditions over the submerged UHS dam resulting from a sudden breach of the main dam. A 100-ft-wide breach extending from the top of the dam to the creek bed was assumed to occur during the PMF event with the water surface elevation of the lake at 708.8 ft MSL. The applicant analyzed the flow conditions over the submerged UHS dam using the level-pool routing procedure and estimated water surface elevations upstream and downstream of the submerged UHS dam. The applicant estimated maximum velocities at the crest and at the toe of the submerged UHS dam as 3.8 and 11.8 fps, 43 hours after the main dam breach. The maximum velocity estimated on the face of the baffle dike was 1.2 fps.

The applicant also estimated velocities over the submerged UHS dam and the baffle dike during a PMF event with the lake level at the 100-year drought elevation of 682.3 ft MSL. Estimates of these maximum velocities over the submerged UHS dam and the baffle dike were 2.1 and 2.6 fps, respectively.

The applicant concluded that during both scenarios, the main dam breach and the occurrence of a PMF with the lake at the 100-year drought elevation, the compacted soil-cement layer would protect the submerged UHS dam and the baffle dike.

The applicant states in SSAR Section 2.4.8.2 that the existing CPS discharge flume would convey the discharge from the ESP facility to the Salt Creek finger of Clinton Lake. The applicant states that the discharge flume was designed to carry a maximum flow of 3057 cfs that would be discharged from CPS Unit 1 and the abandoned CPS Unit 2. The applicant states that because of the abandonment of CPS Unit 2, current flow in the discharge flume is only 50 percent of its design capacity.

The applicant states that there would be no changes to the discharge flume because of the ESP facility. The discharge flume is located to the east of the plant area and runs due east towards Clinton Lake. The applicant states that the discharge point of the flume into Clinton Lake provides an effective cooling surface area of 3650 ac in Clinton Lake. The flume has a bottom width of 120 ft, a side slope of 3:1 (horizontal to vertical), a total length of 3.4 mi, and a nonscouring design velocity of 1.5 fps. The minimum freeboard of 3.8 ft is provided in the flume. A 6-in.-thick crushed stone layer covers the side slopes of the flume for protection against erosion from wind wave action, and riprap on the lakeside of the embankment fills protects against erosion resulting from wind wave action in the lake. Two drop structures are provided along the flume to adapt it to ground topography and to prevent scouring in the flume. Both drop structures are 70 ft wide. One drop structure is designed for a 18-ft drop, and the second is designed for a 26-ft drop.

The staff requested, in RAI 2.4.8-1, that the applicant explain how it calculated the cooling water needs for the CPS and ESP facilities as discussed in SSAR Section 2.4.8.1.5. In response to RAI 2.4.8-1, the applicant stated that it used the LAKET model, which is a one-dimensional lake temperature prediction program, to estimate the 30-day cooling water needs for emergency shutdown of CPS Unit 1. The applicant performed the LAKET modeling as part of the CPS UHS design to support two 992-MWe power generation facilities. The applicant stated that this design considered the volume of cooling water required for the two CPS facilities, loss in the submerged UHS pond capacity resulting from sedimentation from a 100-year flood event and from liquefaction resulting from a seismic event, and the volume of water required for fire protection. This analysis established the minimum design volume of the CPS submerged UHS pond as 849 ac-ft.

The applicant stated that the UHS for the ESP facility would consist of new cooling tower(s) that would provide necessary heat dissipation but require makeup water. The applicant estimated the 30-day makeup water volume based on the 30-day makeup water estimate from the PPE, plus a 33 percent factor for blowdown, and an additional 20 percent factor for overall margin. The applicant stated that the 30-day makeup volume for the ESP facility would be 87 ac-ft.

The applicant stated that it periodically measures the volume in the submerged UHS pond and recently measured the volume as 1022 ac-ft. The applicant stated that, if the CPS UHS 30-day minimum design volume of 849 ac-ft were subtracted from the recently measured volume of the submerged UHS pond, the remaining available volume would be 173 ac-ft, which is 86 ac-ft greater than that required for the ESP facility. The applicant concluded that the current CPS submerged UHS pond has sufficient capacity to serve both CPS Unit 1 and to provide makeup for the new nuclear unit(s).

The applicant stated that it also checked the surface area of the submerged UHS pond, as it is the single most important factor in controlling the heat dissipation from the CPS heat sink. The design surface area of the CPS submerged UHS pond at a water surface elevation of 675 ft MSL is approximately 150 ac. The applicant stated that the as-built surface area of the submerged UHS pond at a water surface elevation of 675 ft MSL is 158 ac, slightly larger than the design surface area. The applicant stated that a 0.5-ft reduction in the water surface elevation of the submerged UHS pond would be expected if a volume of 87 ac-ft, equal to the 30-day ESP facility UHS makeup water requirement, were withdrawn. The applicant concluded that the design heat dissipation capacity of the CPS submerged UHS pond would be maintained while accounting for the ESP facility UHS makeup water requirements.

The applicant provided a review of the original CPS UHS modeling using the LAKET program. The applicant stated that it performed the original analysis to determine the maximum possible starting water temperature in the submerged UHS pond without exceeding the 95 EF UHS outlet temperature that could exist during a two-unit LOCA and a loss of off-site power (LOOP). The applicant stated that the model was updated in 1985, and a sensitivity test was performed in 1986. The applicant stated that it estimated maximum temperatures in the submerged UHS pond at various depths during this sensitivity analysis to determine if dredging would be necessary to remove accumulated sediment. The analysis also determined the maximum submerged UHS pond water temperature that will allow shutdown of one of the units from 100-percent power load without exceeding the maximum allowable UHS outlet temperature of 95 EF. The analysis indicated that the maximum allowable UHS outlet temperature of 95 EF for CPS will not be exceeded with an initial submerged UHS pond volume of 590 ac-ft and an initial submerged UHS pond water temperature ranging from 84 to 95 EF.

The applicant stated that a review of the model documentation indicated that the input to the original 1995 LAKET model and the additional modeling performed in 1985 and 1986 were based on worst-case or most-conservative environmental parameters. The applicant stated that it examined temperatures in Salt Creek downstream from Clinton Lake for the period before 1975 and for recent time periods. The applicant found no significant changes in temperature between these two periods and concluded that the original model results are still applicable.

The applicant noted that it based the previous modeling on a one-dimensional vertically and laterally averaged approach, which does not account for thermal stratification. The applicant stated that thermal stratification would result in higher surface temperatures than the depth-averaged value, resulting in enhanced heat transfer to the atmosphere, thus making model predictions more conservative by predicting a lower heat transfer rate than would actually be expected to occur. The applicant stated that the existing intake structure is located such that it draws water from the deeper part of the lake. The new ESP facility intake structure would also be designed to draw water from the deeper part of the lake. The applicant reasoned that, since deeper water is likely to be cooler because of thermal stratification, the initial model approach and its results remain valid for the ESP application.

The applicant stated that the submerged UHS pond for the CPS is designed to provide sufficient water and cooling capacity to safely shut down two 992-MWe boiling water reactors (BWR) units and maintain the plant in the shutdown condition for a period of 30 days. The minimum submerged UHS pond design volume of 849 ac-ft accounts for the minimum cooling capacity of 590 ac-ft to meet the 95 EF service water inlet maximum temperature, the fire protection requirement of 3 ac-ft, a loss in capacity because of sedimentation from a 100-year flood of 35 ac-ft, and a loss in capacity because of sedimentation from liquefaction of 221 ac-ft. Currently, the CPS consists of a single 1138.5-MWe facility. The applicant concluded that the minimum submerged UHS pond design volume of 849 ac-ft, based on two 992-MWe BWR units, is sufficient for the single existing 1138.5-MWe CPS facility.

The applicant conducts annual surveys as part of the submerged UHS pond sedimentation monitoring program, and it also monitors sediment accumulation after a major flood passes through the cooling lake. The Monitoring Program Reports 20–23 (1998–2002) indicate that, immediately following the dredging in 1991, the volume of the submerged UHS pond was 1054 ac-ft and, in 2001, the volume declined to 1022 ac-ft because of sedimentation.

The applicant expects the ESP facility to require a maximum of 87 ac-ft of cooling water from the submerged UHS pond for its 30-day emergency shutdown supply. The applicant estimated that a minimum volume of 935 ac-ft in the submerged UHS pond would be available for the existing CPS unit assuming none of the ESP facility UHS required water of 87 ac-ft is returned to the submerged UHS pond. The applicant concluded that this scenario allows for a reserve volume of 86 ac-ft for sediment accumulation based on the 2001 measured volume of the submerged UHS pond.

The applicant stated that it would maintain adequate volume in the submerged UHS pond for the requirements of the existing CPS unit and makeup for the proposed ESP facility UHS to account for the minimum required volume of 849 ac-ft for the CPS unit and the minimum required volume of 87 ac-ft for the ESP facility. The applicant stated that, if it elected to construct an additional nuclear power plant at the site, it would modify the current practice of dredging the submerged UHS pond when its capacity reduces to less than 849 ac-ft so that dredging occurred when the capacity of the submerged UHS pond decreased to 936 ac-ft. The applicant stated that the estimated annual sedimentation amount is 5 ac-ft. The applicant also stated that while dredging should occur based on volume measurements of the submerged UHS pond, the new dredging threshold of 936 ac-ft would be expected to result in dredging at least once every 23 years.

The applicant stated that the relationship between the surface area and the volume of the submerged UHS pond based on the design and as-built data found in the September 1975 and April 1985 modeling indicates that the immediate reduction in existing volume by 87 ac-ft would result in a decrease of the water level in the submerged UHS pond of approximately 0.5 ft. The applicant stated that this change in water level would not significantly impact the surface area. The applicant estimated that the new surface area would remain the same or larger than the design surface area, indicating that the heat rejection capacity of the submerged UHS pond would be maintained. The applicant also stated that, according to the CPS USAR Section 9.2.5.3, the total heat rejection to the submerged UHS pond over 30 days following an emergency shutdown of the CPS unit, would be less than that assumed during the design of the UHS. The applicant concluded that the original modeling of the UHS is still applicable for the new proposed conditions.

The applicant stated that it will revise SSAR Section 2.4.8.1.5 to provide additional information regarding its estimation of cooling water requirements.

The staff requested, in RAI 2.4.8-2, that the applicant discuss how it estimated the flow velocities over the crest and toe of the submerged UHS dam as discussed in SSAR Section 2.4.8.1.5. The staff also asked the applicant to provide figures indicating where the toe of the UHS dam is located relative to the fill shown in SSAR Figures 2.4-14 and 2.4-15 of the ESP application. In response to RAI 2.4.8-2, the applicant stated that the SSAR Section 2.4.8.1.5 discussion of flow velocities over the crest and toe of the submerged UHS dam is an unnecessary detail for an ESP review and that it would revise this section by removing the discussion of velocities over the crest.

The staff requested, in RAI 2.4.8-3, that the applicant describe lake drawdown calculations. In response to RAI 2.4.8-3, the applicant stated that it will update SSAR Section 2.4.11.1, which discusses the Clinton Lake drawdown evaluation, to provide additional details of this evaluation.

In its RAI response, the applicant stated that it considered runoff, evaporation, and forced evaporation in the drawdown evaluation. The applicant stated that it had established two 5-year design droughts with return periods of 50 and 100 years and obtained low-flow data for both design droughts from the CPS USAR. The original low-flow data came from Bulletin 51 of the Illinois State Water Authority, titled “Low Flows of Illinois Stream for Impounding Reservoir Design.”

The applicant stated that it used the normal lake water surface elevation of 690 ft MSL as the starting water surface elevation during the drawdown evaluation. The applicant obtained lake stage-storage relationship information from the CPS ER based on the original lake volume of 74,200 ac-ft at normal lake water surface elevation. Inflow into the lake was estimated on a monthly basis by multiplying the rainfall runoff expressed as a depth by the watershed area. Outflow from the lake was assumed to consist of downstream discharge, net lake evaporation minus lake precipitation, forced evaporation resulting from existing plant operation, seepage loss, and cooling water consumed by the ESP facility. Downstream discharge through the dam was assumed to be a minimum of 5 cfs when the lake level was at or below the 690 ft MSL spill elevation. During this drought analysis, the lake level was not allowed to exceed 690 ft MSL. The discharge was allowed to be greater than 5 cfs, if inflow would increase the lake level above the spillway elevation of 690 ft MSL. The CPS USAR provided data on net lake evaporation minus lake precipitation data for both design droughts.

The applicant stated that it developed forced evaporation data for the existing CPS unit from data given in the CPS USAR. The initial forced evaporation data were based on two 992-MWe BWR plants operating at 70-percent load factor. Forced evaporation is defined as the additional evaporation resulting from an increase in lake water temperature caused by the discharge of cooling water to the lake from the once-through cooling system for the two original plants. The applicant subsequently revised the forced evaporation rate for the two originally proposed plants to estimate the rate for the single, uprated existing CPS unit. The CPS Unit 1 was uprated from its original 992-MWe rating to 1138.5 MWe in 2002. The forced evaporation rate from the CPS USAR was divided by 0.7 to obtain the forced-evaporation rate for a 100-percent load factor. The resulting forced-evaporation rate was then divided by 2 because only one of the two originally planned units was constructed. This new forced-evaporation rate was again adjusted for the plant uprate by multiplying by a factor of 1.147 (1138 divided by 992).

The applicant stated that it had recently checked the forced-evaporation rates for the original 992-MWe plant operating at 100-percent load factor. Forced and natural evaporation occur simultaneously as the circulating cooling water flows through the cooling loop. To differentiate between the amounts of natural and forced evaporation, the applicant determined the equilibrium temperature of the lake on a monthly basis using monthly meteorologic data over the period of record. The applicant stated that the equilibrium temperature is the temperature of water in the lake about 1 ft below the surface where the heat input to the lake is exactly balanced by the heat output from the lake. The applicant stated that the equilibrium temperature is determined by performing a heat balance for solar heat gain, heat loss by convection, evaporative cooling, and radiant heat transfer from the water to the surroundings. The amount of natural evaporation is determined based on the equilibrium temperature.

The applicant stated that a model based on the method of Langhaar (1953) was developed to determine the amount of forced evaporation. The model was validated based on good agreement with results of an earlier study by Edinger (1989). The model was then applied to simulate the cooling lake for each month using monthly average climatic conditions over the period of record. The applicant stated that the evaporation estimated by this model is the total, or the sum of natural and forced evaporation. Forced evaporation is the difference between the total and previously estimated natural evaporation.

The applicant stated that the analysis for the existing CPS unit and the ESP facility assumed a 100-percent load factor during their respective operations. It was assumed that each design drought would begin in January of the first year. Seepage loss was assumed to be 0.5 percent of the lake capacity per month. The drawdown calculations were carried out on a monthly time step. A net volume gain or loss was calculated by subtracting losses and adding gains to the initial lake volume for each month to obtain the initial lake volume for the next month. The applicant used the lake stage-surface area and stage-volume relationship from the CPS ER to estimate lake water surface elevation and area for the next month. These calculations were repeated for the 50-year and the 100-year drought.

The applicant also determined the amount of cooling water available during the droughts. The average annual water consumption for the existing CPS unit at 100-percent load factor is 1100 ac-ft/month. The applicant stated that the total amount of water available during the 100-year drought is 2400 ac-ft/month. The applicant estimated that the amount of available water in excess of that needed for the CPS unit is 1300 ac-ft/month during the 100-year drought. The applicant stated that based on the drawdown analysis corresponding to the 50-year drought, the total amount of water available during the 50-year drought is 3100 ac-ft/month. The applicant estimated that the amount of available water in excess of that needed for the CPS unit is 2000 ac-ft/month during the 50-year drought.

The applicant also stated that the available water quantities maintain the lake water surface elevation at or above the CPS minimum lake elevation of 677 ft MSL with both the existing CPS unit and the proposed ESP facility in operation.

The staff requested, in RAI 2.4.8-4, that the applicant describe how it estimated the UHS capacity loss resulting from sediment or debris during extreme events. In response to RAI 2.4.8-4, the applicant stated that the ESP facility would use the safety-related cooling tower(s) as the UHS, if one was required, and would use the CPS submerged UHS pond only as a source of makeup water. For this reason, sediment or debris does not directly affect the ESP facility UHS.

The applicant stated that, according to soil surveys of Illinois, early spring rains in areas where soil is exposed because of farming can cause extensive erosion when the soil surface is partially frozen leading to greater runoff. The applicant stated that the highest 24-hour PMP occurs in the summer and fall (June through September), with the monthly PMP value ranging from 24.4 to 31.2 in. The applicant reasoned that the occurrence of the PMP would not be coincident with the conditions for maximum runoff.

The applicant stated that the design of the CPS UHS pond considered four failure modes:

(1) loss of cooling water inventory because of its displacement by alluvial flow slides into the UHS,

(2) loss of the service water system because of blockage of the service water pump intakes from unstable soil flow blocking or entering the intake structure,

(3) loss of UHS circulation pattern because of local slides producing dams or dikes across the circulation channel,

(4) loss of UHS water as a result of the UHS dam or its flanks breaching because of a combination of seismic loading, liquefaction, and washout.

The applicant stated that, in addition to the storage requirements for cooling purposes and fire water supply, the submerged UHS pond was designed to account for sedimentation. The design of the submerged UHS pond considered sediment inflow from liquefaction and an associated loss in capacity of 221 ac-ft, fire water storage capacity of 3 ac-ft, minimum cooling water capacity of 590 ac-ft required to meet the 95 EF shutdown service water inlet temperature, and loss in capacity of 35 ac-ft from sedimentation resulting from a 100-year flood.

2.4.8.2 Regulatory Evaluation

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

Compliance with 10 CFR 52.17(a) and 10 CFR 100.20(c) requires consideration of the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability for a nuclear power reactor. To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100, the applicant's safety assessment should contain a description of 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 of 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. The 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 safety assessment described in SSAR Section 2.4 include, but are not limited to, cooling needs (e.g., adverse local meteorological conditions, high ambient temperature).

2.4.8.3 Technical Evaluation

The staff visually inspected the site during the site safety analysis visit on May 11, 2004. The staff determined that the SSAR accurately describes the intakes, discharge canals, outfalls, and reservoirs near the ESP site.

The applicant states in SSAR Section 2.4.8.1 that the ESP facility would use cooling tower(s) for the normal cooling of the power plant. In addition, the applicant states in SSAR

Section 2.4.8.1 that the UHS system for the ESP facility might also use cooling tower(s). In the same section, the applicant states that a lake drawdown analysis, to be performed at the design stage, would indicate whether a load reduction to the ESP facility, or a wet/dry hybrid cooling tower system, might be necessary to maintain water surface elevation in Clinton Lake at or above 677 ft MSL during a 100-year drought.

According to the PPE table (SSAR Table 1.4-1 of the SSAR, item 3.3.9), average makeup water for the UHS system with mechanical draft cooling tower(s) is 555 gpm. This makeup water flow is equivalent to a volume of 73.6 ac-ft over a 30-day period. The staff estimated that applying a 33-percent factor for blowdown, and an overall 20-percent margin, the 30-day makeup water needed for the ESP facility UHS system would be 73.6 x 1.33 x 1.2 = 117.4 ac-ft. The staff's estimate is considerably different from the applicant's estimate of 87 ac-ft. The applicant needs to justify its makeup water requirements for the proposed UHS. This is **Open Item 2.4-12**.

The staff concludes that the applicant needs to provide additional details on the ESP facility normal and ultimate heat sink systems and their cooling water requirements to allow determination of the maximum PPE heat rejection parameters. The applicant should provide a commitment to specific ESP facility normal and ultimate heat sink systems for the staff to conclude this review. The staff needs this information at the ESP stage to evaluate the adequacy of the UHS volume available for the ESP facility. This is **Open Item 2.4-13**.

The staff requested, in RAI 2.4.8-1, that the applicant explain how it calculated the cooling water needs for the CPS Unit 1 and the ESP facility. In response to RAI 2.4.8-1, the applicant described earlier modeling performed for the original analysis of the CPS UHS. The model used (LAKET) is apparently no longer available for independent evaluation by the staff. The documentation of earlier applications of the model is limited to the description provided in the CPS USAR. The applicant stated that the depth-averaged temperature model would be more conservative than a stratified model since the higher surface temperatures would result in increased heat loss. The staff agrees that a depth-average temperature model would indeed be conservative for temperature; however, the increased heat loss would come, in part, from increased forced evaporation. This implies that in terms of the volumetric analysis a depth-averaged model may not be conservative. The applicant stated that the UHS for CPS was designed for two units of which only one was constructed. The UHS volume requirements for the ESP facility would be far less than the requirements for the original planned two 992-MWe units. The applicant did not provide the volume requirements for the existing single uprated 1138.5-MWe CPS facility. The staff concludes that there is inadequate information to review the earlier modeling study on which the applicant relied. The applicant needs to provide the volume requirements of the UHS for the CPS taking into consideration the latest power uprate. This is **Open Item 2.4-14**.

The staff requested, in RAI 2.4.8-2, that the applicant discuss how it computed the flow velocities over the crest and the toe of the submerged UHS dam. The staff also asked the applicant to provide figures indicating where the toe of the submerged UHS dam is located with respect to the fill shown in SSAR Figures 2.4-14 and 2.4-15. In response to RAI 2.4.8-2, the applicant stated that discussion of flow velocities over the crest and toe of the submerged UHS dam is an unnecessary detail for an ESP review and that it will revise the appropriate section to remove the discussion of the flow velocities. SSAR Section 2.4.8.1 describes stabilization of the submerged UHS dam and the baffle dike with compacted soil-cement. These measures should protect these structures against erosion. The staff has determined, therefore, that erosion protection measures have been specified and that the applicant's response is satisfactory.

The staff requested, in RAI 2.4.8-3, that the applicant describe its lake drawdown calculations. In response to RAI 2.4.8-3, the applicant described an analysis of changes in pool elevation resulting from droughts of 5-year duration with a recurrence period of 50 and 100 years. The applicant did not provide a basis for selecting the 5-year duration drought over a shorter drought duration which would provide much lower inflow, albeit for a shorter duration. The staff, based on an independent reading of the report from an earlier study conducted by the Illinois State Water Survey that the applicant used as the basis for the assumed low-flow conditions, concluded that a drought period of shorter duration with the same recurrence period could result in considerably more challenging conditions for lake level. For instance, based on data in the report for the Rowell gauge on Salt Creek, using a recurrence interval of 40 years, the inflows (expressed as area averaged runoff) for the 1-year drought and 5-year drought are approximately 1 in. and 23 in., respectively. The applicant relied on the CPS USAR as the basis for its values of natural evaporation and precipitation. It performed the analysis using a spreadsheet calculation and provided the spreadsheet as Attachment C with its responses to RAIs 5.2-1 and 5.2-2 generated from the staff's review of the applicant's ER. The staff reviewed the applicant's narrative response to RAI 2.4.8-3, the associated spreadsheet calculations, and the Illinois State Water Survey report on low flows of Illinois streams. The staff concluded that the applicant needs to provide a rationale for using the 5-year drought duration as opposed to a shorter duration drought with a significantly lower inflow estimate. This is **Open Item 2.4-15**.

The staff requested, in RAI 2.4.8-4, that the applicant describe how it estimated UHS capacity loss because of sediment or debris loads during extreme events. In response to RAI 2.4.8-4, the applicant stated that the ESP facility would use cooling tower(s) as the UHS and would only use the submerged UHS pond as a source of makeup water. The applicant explained that for this reason, sediment or debris would not directly affect the ESP facility UHS.

The applicant stated that the design of the UHS considered the following factors:

- loss of storage capacity because of sediment inflow from liquefaction, equal to 221 ac-ft,
- with a fire water requirement of 3 ac-ft,
- minimum cooling water capacity of 590 ac-ft required for the CPS Unit 1,
- loss in capacity of 35 ac-ft from sedimentation resulting from a 100-year flood.

The staff's estimate of ice sheet formation in Clinton Lake indicated that the maximum ice thickness could reach 31.4 in. Under these icing conditions, if the main dam failed, or the water surface elevation in Clinton Lake fell to 675 ft MSL, it is likely that there would be some loss in the storage capacity of the submerged UHS pond because the ice sheet would settle down into the pond behind the submerged UHS dam. The staff conservatively estimated this loss in capacity by multiplying the surface area of the submerged UHS pond at elevation 675 ft MSL by the maximum thickness of the ice sheet. The staff estimated that the loss in submerged UHS pond capacity because of icing would be 413 ac-ft. Based on this estimate and the issue described in Open Item 2.4-12, the staff concludes that the applicant needs to establish that the submerged UHS pond has adequate capacity to provide makeup water to the ESP facility UHS. This is **Open Item 2.4-16**.

The applicant stated that it monitors the CPS UHS for sediment accumulation periodically and after a major flood passes through the submerged UHS pond. The applicant committed to perform necessary dredging to prevent the accumulation of sediment from exceeding the capacity provided for sediment storage in the design. The staff will evaluate the applicant's response to open items listed in this section to consider the adequacy of submerged UHS pond monitoring and dredging. The pond monitoring and dredging frequencies may need to be included as a permit condition. The applicant needs to establish the monitoring and dredging needs for the UHS pond for the combined operation of the CPS facility and a future facility consistent with the PPE parameter for maximum thermal discharge. This is **Open Item 2.4-17**.

2.4.8.4 Conclusions

As set forth above, with the exceptions of the open items noted in Section 2.4.8.3, the applicant has provided sufficient information pertaining to identifying and evaluating cooling water canals and reservoirs at the site. SSAR Section 2.4.8 conforms to Section 2.4.8 of SRP (NUREG-0800) as applicable to an ESP site and as they relate to identifying and evaluating cooling water canals and reservoirs at the site.

The review guidance in SRP Section 2.4.8 provides that the SSAR should address 10 CFR Parts 50 and 100, as they relate to identifying and evaluating cooling water canals and reservoirs at the site. Although the applicant has not specifically addressed the above regulations in its SSAR Section 2.4.8, the staff concludes that by conforming to SRP Section 2.4.8 the applicant has met the requirements of cooling water canals and reservoirs at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3), except as noted in Section 2.4.8.3 above. Further, with the exception noted, the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design basis information related to cooling water canals and reservoirs, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.9 Channel Diversions

Relatively thin deposits of Quaternary glacial drift dominate the regional surface geology in the vicinity of the ESP site. During the Quaternary period, continental glaciation caused widespread glacial deposition in the region. The deposits at the ESP site are consistent with the regional deposits and are classified as part of the Pleistocene Series, consisting predominantly of glacial or glacially derived sediments of glacial till, outwash, loess (a windblown silt), glaciolacustrine deposits, and alluvium.

Four major periods of glaciation occurred during the Pleistocene time, including the Wisconsinan, Illinoinan, Kansan, and Nebraskan. The Wisconsinan is the youngest period, and the Nebraskan is the oldest. The ESP site includes Wisconsinan deposits. Thick sequences of gently dipping Paleozoic sedimentary rock underlie most of the regional Quaternary glacial materials.

2.4.9.1 Technical Information in the Application

The applicant states in SSAR Section 2.4.9 that no historical evidence of channel diversion in the Salt Creek or the North Fork of Salt Creek upstream of the Clinton Dam exists. The applicant states that, based on topographic characteristics and geologic features of the drainage basin, landslides that might lead to blockage of streamflow into Clinton Lake are not possible. The applicant also notes that, as discussed in SSAR Section 2.4.7, the history of ice jam formation does not indicate streamflow diversion during the winter months.

In RAI 2.4.9-1, the staff asked the applicant to reference studies related to the geological features or other characteristics that preclude any likelihood of channel diversion upstream of the ESP site. In response to RAI 2.4.9-1, the applicant stated that it performed a study of geological features and other characteristics related to the potential for channel diversion upstream of the ESP site specifically for the ESP application. The applicant indicated that this site-specific examination did not rely on any previously published studies other than topographic maps. The applicant further stated that its examination of the topographic maps of Salt Creek and the North Fork of Salt Creek did not reveal evidence of natural channel diversions, such as oxbow lakes or broad, well-developed floodplains.

The applicant stated that the creeks and streams in the watershed generally occur in well-defined valleys. Any diversion of water out of these valleys into an adjacent drainage basin would require sufficient energy to overcome the topography and cut a new drainage channel. The applicant stated that, based on the physical characteristics of the drainage area and the creek system, it is unlikely that a potential, naturally occurring channel diversion would shift water out of the Clinton Lake watershed. The applicant also stated that it would revise SSAR Section 2.4.9 to add this clarification.

2.4.9.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations, applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant does not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it correctly identifies the applicable regulations and guidance.

The staff used the review guidance provided in Section 2.4.9 of RS-002, Attachment 2, to evaluate this SSAR section. These acceptance criteria relate to 10 CFR Parts 52 and 100, insofar as they require that the site evaluation consider the hydrologic characteristics of the site. The regulations in 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 the acceptability of a site for a nuclear reactor.

Channel diversion or realignment poses the potential for flooding or for an adverse effect on the supply of cooling water for a nuclear power plant(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 would 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 the relevant parameters.

To meet the requirements of 10 CFR Parts 52 and 100, as they relate to channel diversion, the following specific criteria are used:

- 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, "Ultimate Heat Sink for Nuclear Power Plants," provides guidance on acceptable UHS criteria.

2.4.9.3 Technical Evaluation

The staff developed a basic understanding of the geomorphology of the region during the site visit on May 11, 2004. The staff's search did not produce any evidence of major channel diversion in Salt Creek or the North Fork of Salt Creek. Channel diversions usually occur in relatively flat, deep alluvial plains where the river channel meanders greatly.

Section 2.4.7 of this SER evaluates channel diversion resulting from ice effects; Section 2.4.11 of this SER evaluates channel diversion resulting from low-water conditions.

SSAR Section 2.4.9 does not provide details of historical or geological evidence of possible diversions and meandering of Salt Creek and the North Fork of Salt Creek upstream of the ESP site. The staff contacted the USGS Illinois Water Science Center to obtain references of channel diversion studies carried out on Salt Creek and the North Fork of Salt Creek. The USGS Illinois Water Science Center stated in an email communication to the staff that no channel diversion studies had been carried out on these streams.

To evaluate the impact of channel diversion on the ESP facility, the staff considered a hypothetical scenario in which both the North Fork of Salt Creek and the Salt Creek arms migrate, resulting in no subsequent inflow into Clinton Lake. Since channel migration usually happens during high flow or flood events, the staff assumed that Clinton Lake would be at normal pool should channel migration occur. Subsequent to channel migration, inflow into

Clinton Lake would stop, and water surface elevation would start to decrease because of losses caused by natural and forced evaporation, downstream release, and ground water recharge. During the initial period following channel migration, it is expected that the submerged UHS pond would remain intact. The staff determined that sufficient time would be available following the onset of channel migration to safely shut down the ESP facility using the UHS system. The staff concluded, therefore, that, even if channel migration stopped all inflow into Clinton Lake, it would not adversely affect the safety of the ESP facility.

2.4.9.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of channel diversion at the site. SSAR Section 2.4.9 conforms to RS-002, Attachment 2, Section 2.4.9, with regard to this objective.

Section 2.4.9 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating channel diversion at the site. Although the applicant does not specifically address the above regulations in SSAR Section 2.4.9, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.9, it has met the requirement to identify and evaluate channel diversion at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design basis information related to channel diversions, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.10 Flooding Protection Requirements

The proposed ESP site grade is at an elevation of 735 ft MSL.

2.4.10.1 Technical Information in the Application

SSAR Section 2.4.3.6 estimates the design-basis flood elevation at the ESP site to be 713.8 ft MSL. This elevation includes the effects of flooding from a PMF caused by the PMP over the Clinton Dam’s drainage area, wind setup, and wave runup. The applicant stated that all safety-related SSCs for the ESP facilities would be located at the existing site grade of 735 ft MSL. The applicant, therefore, concluded that the only safety-related ESP facility structure that would be affected by flooding in Clinton Lake would be the new ESP facility UHS intake structures. The applicant states in the SSAR that it would design the ESP facility UHS intake for flood protection of all safety-related equipment located in the intake structures.

The applicant also states that the design of the ESP facility UHS intake would consider wind wave forces caused by a sustained 48-mph overland windspeed acting on the PMF water surface elevation, as well as those caused by a sustained 67-mph overland windspeed acting on the normal water surface elevation in Clinton Lake. The applicant notes that the design would consider both breaking and nonbreaking waves.

The applicant states that the flooding effects of local PMP are design related and will be considered at the COL stage.

The staff requested, in RAI 2.4.10-1, that the applicant discuss the difference in methods it used to determine the design windspeeds of 40 mph, mentioned in SSAR Sections 2.4.3.6 and 2.4.10, and the design windspeeds of 48 mph and 67 mph windspeeds, mentioned in SSAR Section 2.4.10. In response to RAI 2.4.10-1, the applicant stated that the CPS USAR considered the 40-mph overland windspeed to act on the PMF water surface elevation. The applicant also stated that the design of the circulating water screen house for the CPS Unit 1 considered a 48-mph overland windspeed coincident with the PMF water surface elevation. The applicant noted that use of these design windspeeds did not result in any safety issues and concluded that the CPS plant would not flood under any circumstances. The applicant also stated that the ESP site is considered to be a dry site, consistent with Condition 3 of Section 2.4.3, of RS-002, Attachment 2. The applicant further stated that the operation of the ESP facility would not impact the potential for flooding at the existing dam or at the plant site. Therefore, the applicant concluded that the calculation of wave runup effects on PMF water surface elevations is inconsequential. The applicant stated that the ESP analyses retained the design windspeeds to be consistent with the previously completed CPS USAR analyses.

The applicant stated that a review of the more recent ANSI/ANS-2.8-1992 (ANSI 1992) information indicated that a windspeed of somewhat greater magnitude (i.e., 52 mph) is more appropriate for estimating wave runup height coincident with PMF water surface elevation. The applicant provided a revision to SSAR Sections 2.4.3.6 and 2.4.10 in the RAI response, using a windspeed of 52 mph.

2.4.10.2 Regulatory Evaluation

As required by 10 CFR 100.20(c), the PMF must be estimated 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, would 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting the limiting values of the relevant parameters.

To meet the requirements of 10 CFR Parts 52 and 100, as they relate to flooding protection, the following specific criteria are used:

- 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

During its review of the SSAR, the staff estimated the maximum water surface elevation at the site for the design-basis flood to be 721.7 ft MSL. The applicant estimated its value by combining the effects of PMF, coincident wind wave activity, and wind setup. Both coincident wave activity and storm surge require use of a windspeed, which was conservatively estimated by the staff to be 100 mph. This value is based upon the PMWS, as defined by ANSI/ANS 2.8-1992 (ANSI 1992), and is based upon the location of the site being within 150 mi of the Great Lakes. The staff estimated the local intense precipitation rate for the ESP site to be 18.15 in./hr in Section 2.4.2.3 of this SER. Table 1 in this report provides the complete hyetograph for the 6-hour local intense precipitation. Except for the new ESP facility UHS intake structures, the ESP site grade (elevation 735 ft MSL) is above the design-basis flood elevation.

The staff's evaluation assumed that all safety-related SSCs would be placed at or above the applicant-stated ESP site grade, except for the new ESP facility UHS intake structures, which are known to be located below plant grade. As stated previously in Sections 2.4.2.3 and 2.4.3.3 of this SER, the COL applicant would need to design the ESP facility intake structures to withstand the combined effects of PMF, coincident wind wave activity, and wind setup. This is Permit Condition 2.4-3.

2.4.10.4 Conclusions

As set forth above, with the exceptions of the open items noted in Section 2.4.10.3, the applicant has provided sufficient information pertaining to identifying and evaluating flooding protection requirements at the site. SSAR Section 2.4.10 conforms to SRP Section 2.4.10 as applicable to an ESP site and as they relate to identifying and evaluating flooding protection requirements at the site.

The review guidance in SRP Section 2.4.10 provides that the SSAR should address 10 CFR Parts 50 and 100, as they relate to identifying and evaluating flooding protection requirements at the site. Although the applicant has not specifically addressed the above regulations in its SSAR Section 2.4.10, the staff concludes that, by conforming to SRP Section 2.4.10, the applicant has met the requirements of flooding protection requirements at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c)(3), except as noted in Section 2.4.10.3 above. Further, the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design basis information for flood protection, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.11 Low-Water Considerations

The ESP site is adjacent to Clinton Lake, which provides cooling water for the current CPS Unit 1 and would provide cooling water for the proposed ESP facility. Events, such as low lake elevation, seiches, wind-induced set down, and intake blockages from sediment or ice, may reduce or limit the availability of cooling water at the site.

Clinton Lake, created by the Clinton Dam, would provide the normal cooling makeup water supply for the ESP facility. The submerged UHS pond, created by a submerged dam across the North Fork of Salt Creek within Clinton Lake, would provide 30-day emergency cooling makeup water for the ESP facility UHS system.

Normal operation of the ESP facility would use cooling tower(s), operated with water drawn from cooling tower basin(s). The basins in turn would receive makeup water from the lake.

2.4.11.1 Technical Information in the Application

The applicant used a design drought with a recurrence interval of 100 years to determine the minimum water surface elevation in Clinton Lake. This analysis considered factors that affect the water surface elevation in Clinton Lake, such as runoff, evaporation, and forced evaporation.

The applicant stated that a drawdown analysis of Clinton Lake for the original CPS, which consisted of two 992 MWe units operating at a 70-percent load factor was performed. This analysis assumed the starting water surface in Clinton Lake to be equal to the normal pool water surface elevation of 690 ft MSL. The drawdown analysis assumed a minimum reservoir release rate of 5 cfs. This analysis also assumed a seepage loss rate of 0.5 percent of the lake capacity per month. The applicant stated that the original CPS drawdown analysis evaluated the ability of Clinton Lake to provide cooling tower(s) makeup water to the ESP facility in addition to meeting the cooling water requirements of the existing CPS Unit 1. The applicant stated that the previous forced evaporation rate estimate was based on heat rejection from CPS. In the ESP facility evaluation, the applicant adjusted this estimate by (1) dividing the original estimate by two, since only one of the two units originally planned was constructed, (2) dividing by 0.7 to conservatively adjust the forced-evaporation rate for a 100-percent load factor, and (3) multiplying by 1.2 to conservatively adjust for the additional heat load caused by the power uprate of the existing CPS Unit 1.

The applicant stated that the new drawdown analysis performed for the ESP facility determined that the quantity of water available for cooling tower(s) makeup during a 50-year drought is 15,808 gpm, and the quantity available during a 100-year drought is 10,222 gpm. These available water quantities would maintain the water surface elevation in Clinton Lake at or above the CPS minimum required water surface elevation of 677 ft MSL while both the CPS Unit 1 and the ESP facility were in operation.

The applicant stated that the available water quantity during drought conditions would be sufficient to provide makeup water for both the safety and nonsafety cooling systems' cooling towers for some of the reactors being considered for the site, which use either evaporative or wet cooling. The applicant stated that the bounding reactor plant cooling system makeup demand would require the use of a wet/dry cooling tower for a turbine plant's cooling systems to reduce either the evaporation rate or the heat discharge to the lake, so that the demand would not exceed the available water supply from Clinton Lake.

The applicant stated that surges, seiches, or tsunami conditions were not likely to occur in Clinton Lake or the submerged CPS UHS pond because no large body of water exists near the ESP site. Therefore, the applicant concluded that these conditions would not produce or affect low-water conditions at the ESP site.

The applicant stated that the effects of drought on water surface elevations in Clinton Lake were evaluated to determine if the operation of the existing CPS plant would be sustained during dry periods. This analysis established a minimum water surface elevation of 677 ft MSL in Clinton Lake for the safe operation of the CPS plant. The applicant stated that a water surface elevation below 677 ft MSL in Clinton Lake would require a shutdown of the CPS plant to avoid loss of safety-related plant cooling water.

The applicant stated that the drawdown analysis for the ESP site accounted for inflows generated from direct rainfall and storm runoff, normal evaporation, forced evaporation caused by plane cooling and resulting in increased lake water temperature, seepage losses, and a minimum discharge from the dam for downstream flow requirements. This drought analysis was based on the existing, uprated CPS, which consists of one 1138.5 MWe BWR operating at 100-percent load, as well as on the PPE value for ESP plant consumption.

The applicant stated that the results of the drawdown analysis established the minimum lake water surface elevation during 50- and 100-year droughts as 685 ft MSL and 681.4 ft MSL, respectively. The applicant stated that both of these minimum lake water surface elevations are above the CPS minimum safety-related lake water surface elevation of 677 ft MSL.

The applicant stated that, based on inquiries to Federal and State regulatory agencies, no future plans exist to use Salt Creek water upstream of Clinton Lake. The applicant also stated that any future use of Salt Creek water upstream of the ESP site would not affect the availability of safety-related cooling water supply because of the submerged condition of the UHS pond.

The applicant stated that the water required for the ESP facility would be supplied from a new intake structure located next to the existing CPS intake structure. This new intake would use Clinton Lake as its source of water and would also have the capability to draw water from the existing submerged UHS pond as an alternate source of makeup water for the safety-related cooling tower(s). The new intake structure would house traveling screens, fire pumps, cooling tower makeup pumps, and safety-related cooling tower makeup pumps. The applicant stated that the makeup water pumps for the safety-related cooling tower(s) would be designed to operate with a suction water surface elevation at least 1 ft below the lowest water surface elevation to which the submerged UHS pond could fall after 30 days of operation without makeup water.

The applicant stated that, in the event of a severe drought that could reduce the water surface elevation in Clinton Lake to 677 ft MSL or below, the ESP facility would be shut down.

The applicant stated that the essential service water cooling tower(s) would provide the UHS cooling function for the ESP facility. These cooling tower(s) would require makeup water from Clinton Lake. The applicant stated that the makeup water requirements range from 250 gpm during normal operation up to a maximum of 700 gpm during a normal shutdown. The total makeup water requirement for postaccident shutdown and cooldown for a 30-day period is approximately 21.4 million gallons or an average makeup requirement of 495.2 gpm over the 30-day period.

The applicant stated that, in the unlikely event of a failure of the main dam and complete loss of Clinton Lake, the existing submerged UHS pond would supply makeup water to the ESP facility's safety-related cooling tower(s). The applicant stated that the existing CPS UHS pond is a submerged pond within Clinton Lake formed by the construction of a submerged dam across the North Fork of Salt Creek. The submerged UHS pond is adjacent to the ESP facility's intake structure where the makeup water pumps for the ESP facility's safety-related cooling tower(s) would be located. The applicant stated that the maximum return water temperature from the ESP facility's safety-related cooling tower(s) would be 94.7 EF, based on a 10 EF approach and a maximum wet bulb temperature of 84.7 EF. The applicant also stated that blowdown from the ESP facility's safety-related cooling tower(s) would be discharged to the existing CPS discharge flume. The applicant stated that credit was taken for return of the blowdown water volume to the submerged UHS pond when determining the capability of the submerged UHS pond to supply water to the CPS and the ESP facility.

The applicant stated that the submerged UHS pond has sufficient water storage capacity for shutdown operation of the CPS, as well as providing makeup water for the ESP facility shutdown for a period of at least 30 days and beyond, if necessary. The applicant stated that it might be necessary to reduce the allowable accumulated sediment volume in the submerged UHS pond to provide adequate additional capacity for makeup water to the ESP facility's safety-related cooling towers.

The applicant stated that it determined the amount of makeup water required by the ESP facility's safety-related cooling tower(s) for a 30-day period based on the reactor plant within the applicant's PPE with the bounding UHS heat load. The amount of water that would be evaporated to provide postaccident shutdown cooling is 2.87 million ft^3. The applicant conservatively increased this water quantity by one-third to provide allowance for blowdown to limit the concentration of impurities in the cooling tower basin to four times the concentration in the lake. The applicant stated that this number is conservative since blowdown would be terminated during an accident and normal operation would be at a concentration ratio higher than four.

The applicant stated that the original design of the submerged UHS pond was based on the heat load from the shutdown of one CPS unit under LOCA conditions and one CPS unit under LOOP conditions, with a total integrated heat load of 180,455x10^6 BTU for 30 days. The heat load from the single, uprated CPS unit is 99,973x10^6 BTU for 30 days under LOCA or LOOP conditions. The applicant estimated that this value is approximately 55 percent of the CPS submerged UHS pond design heat load, thereby indicating that considerable margin is available. The applicant stated that a review of the original CPS submerged UHS pond design revealed that withdrawal of water to provide makeup for the ESP facility's safety-related cooling tower(s) would have only a small impact on heat transfer from the submerged UHS pond.

The applicant stated that the reliability of the submerged UHS pond to provide a supply of water during drought conditions is enhanced by the location of the pond with respect to the adjacent ground water table. The applicant stated that, because the pond is normally submerged in Clinton Lake and the normal water surface elevation sets the base level for the adjacent ground water during low flow or loss of the main dam, water stored in upstream alluvium would replenish water in the submerged UHS pond. The applicant further stated that the Salt Creek watershed would also provide a source of water for long-term cooling following loss of the Clinton Lake dam. The applicant estimated that the watershed can supply 400 gpm at the minimum mean daily flow and 16,150 gpm at the minimum mean monthly flow. The required makeup flow to the ESP facility's UHS cooling tower(s) during normal operation would be 250 gpm and would bound the requirement after shutdown was achieved.

The applicant stated that it monitors the submerged UHS pond for sediment accumulation periodically and after a major flood passes through Clinton Lake. The applicant stated that, after the ESP facility was constructed, it might reduce the allowable sediment accumulation in the submerged UHS pond.

2.4.11.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations, applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant does not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it correctly identifies the applicable regulations and guidance.

Acceptance criteria for this section relate to the following regulations and criteria:

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

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

The regulations in 10 CFR Parts 52 and 100 require, in part, that the evaluation of a nuclear power plant site consider hydrologic characteristics. To satisfy the requirements of 10 CFR Parts 52 and 100, the applicant's SSAR should describe the surface and subsurface hydrological 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, resulting from river blockage or diversion, tsunami runup and drawdown, and dam failure. These characteristics may reduce or limit the available supply of cooling water for safety-related SSCs. Meeting the requirements of 10 CFR Parts 52 and 100 provides assurance that severe hydrologic phenomena, including low-water conditions, would 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting the limiting values of the relevant parameters.

As required by 10 CFR 100.23, siting factors, including cooling water supply, must be evaluated for a nuclear power plant site. 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 block the flow of cooling water, tsunami runup and drawdown, and dam failures.

The regulations in 10 CFR 100.23 apply 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 block 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 power plant(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 plant(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.

Low Flow in Rivers and Streams

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 probable maximum hurricane 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, Attachment 2, are applicable 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 tsunami 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 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) that are already in effect or under discussion by the responsible Federal, State, regional, or local authorities and that may affect the water supply for a nuclear power plant(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

The staff performed two independent analyses to determine if the Normal Plant Heat Sink (NPHS) might suddenly and/or frequently fail, which would result in excessive reliance of the ESP facility on the UHS. Failure was defined as the lake water surface elevation dropping below the level that would require shutdown and possible reliance on the UHS. One analysis considered the frequency that the lake water surface elevation would drop below a specific level. The other analysis evaluated the maximum rate at which the lake water surface elevation could drop.

In response to RAI E5.2-1 (issued to request additional information related to the applicant's environmental report), the applicant described a numerical calculation of lake water surface elevation changes for the 24 year period of record from June 1, 1978, to April 31, 2002. The applicant provided information on the predicted pool elevation, assuming the ESP facility had been operating during this period. The applicant used a water budget approach, wherein the change in lake storage is the result of an imbalance between inflows and outflows. The applicant considered inflows from direct precipitation onto the lake and upstream drainage. Outflow was assumed to be the sum of natural evaporation, induced evaporation due to the existing CPS Unit 1, and direct evaporation from the ESP facility operating with wet cooling towers.

To estimate the tributary inflows, the applicant's analysis estimated monthly average runoff yield coefficients (ratio of runoff to rainfall). These coefficients were multiplied by the recorded rainfall during the period of record to generate a runoff record. These estimates would not necessarily provide conservative estimates in warm dry years and, therefore, the staff applied a different approach.

The staff found an adjacent streamflow gauge on Kikapoo Creek at Waynesville, Illinois. The drainage of Kikapoo Creek is adjacent to the North Fork of Salt Creek, and is located to the northwest of the ESP site. The distance of the Kikapoo Creek gauge at Waynesville from the Clinton Dam is approximately 15.3 mi. This gauge is minimally affected by streamflow regulation, and is comparable in size of its contributing area (227 mi^2) to that of the drainage area (289.2 mi^2) contributing flow to Clinton Lake. The staff scaled the streamflow observed at Kikapoo Creek at Waynesville, Illinois, by the ratio of contributing area at Clinton Dam to the contributing area at the Waynesville gauge to estimate inflows into Clinton Lake. The time period of the estimated inflow record is January 28, 1948, to September 30, 2001.

The staff performed a bounding analysis and found the magnitude of low water conditions to be more severe than those predicted by the applicant. However, the lack of pool elevation data made it impossible for the staff to perform an adequate calibration and verification of the approach. Because of this limitation, the results were considered inconclusive. The second analysis performed by the staff assessed the maximum rate at which the lake water surface elevation could be expected to drop.

The staff assumed that the induced evaporation rate caused by the existing CPS Unit 1 was equal to the total reject heat load (i.e., the reject heat load was entirely converted to latent heat of water vapor) or 38 cfs of evaporation. As some of the heat load would be lost to back radiation and conductive heat exchange, this is a conservative assumption. From the PPE table, the consumptive water loss of the ESP facility was estimated to be 70.2 cfs. The highest monthly evaporation rate recorded by W.J. Roberts and J.B. Stall, “Lake Evaporation in Illinois,” Board of Investigation 57, State Water Survey Division, State of Illinois, Urbana (1967) was 8.38 in. for July 1936. After correcting for lake area, this results in a conservative estimate of the maximum drop in the lake water surface elevation as 4.85 ft/month. Even at this rate of decline, the drop of the lake water surface elevation would be gradual enough for the plant operators to react and safely shut down the plant before minimum operating threshold was reached.

The applicant states in SSAR Section 2.4.11.1 that, for some of the reactors under consideration for the ESP facility, the available water in Clinton Lake would be sufficient for both safety-related and normal turbine cooling water requirements. However, the applicant stated that the cooling makeup water demand for the bounding reactor within the applicant’s PPE would require the use of a wet/dry hybrid cooling tower system for normal turbine cooling. In Section 2.4.1.3 of this SER, the staff identified the need (Open Item 2.4-2) for a schematic representation of the complete ESP facility UHS system including the intake, piping, any potential storage basins, the UHS cooling loop, and the cooling tower(s). This schematic should clearly show all components and the water flow including discharges through these components.

The applicant states in SSAR Section 2.4.11.5 that the makeup water pumps for the safety-related cooling tower(s) would be designed to operate with a suction water surface elevation at least 1 ft below the lowest water surface elevation that the submerged UHS pond could fall to after 30 days of operation without makeup to the pond. The staff identified several open items in DSER Section 2.4.8.3 related to the applicant’s ESP facility water requirements and lake drawdown estimation, specially under severe drought conditions. The applicant states that, in the event of a severe drought that may reduce the water surface elevation in Clinton Lake to 677 ft MSL or below, station shutdown operation would be followed for the ESP facility. The water surface elevation of 677 ft MSL in Clinton Lake would be identified as the shutdown water surface elevation for the ESP facility, and would be imposed as a permit condition on the COL applicant after completion of the staff’s review.

Resolution of open items mentioned above is needed for staff to independently estimate the volume of available water in the submerged UHS pond for the combined operation of the existing and the proposed facility. This is **Confirmatory Item 2.4-1**. In order to ensure that 30-day UHS water supply for all facilities will be available, submerged UHS pond monitoring and dredging frequencies may need to be included as a permit condition, as stated by Open Item 2.4-17 in DSER Section 2.4.8.3.

2.4.11.4 Conclusions

As set forth above, and with the exceptions of the open items noted in Section 2.4.11.3 of this SER, the applicant provided sufficient information pertaining to the identification and evaluation of the low-water considerations of the site. SSAR Section 2.4.11 conforms to RS-002, Attachment 2, Section 2.4.11 with regard to this objective.

Section 2.4.11 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the low-water considerations of the site. Although the applicant does not specifically address the above regulations in SSAR Section 2.4.11, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.11, it has met the requirements for low-water conditions with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), except as noted in Section 2.4.11.3 of this SER. Further, the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design basis information for low-water conditions, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.12 Ground Water

The EGC ESP site lies within the Central Lowlands Physiographic Province. Aquifers in the Central Lowlands occur in unconsolidated sand and gravel of the Quaternary age and consolidated sandstone, limestone, and dolomite of the Paleozoic age. At the proposed EGC ESP site, alluvium along the floodplains overlays glacial drift deposits.

2.4.12.1 Technical Information in the Application

The applicant provides a description of regional and site hydrogeology and ground water conditions in Section 2.4.13 of the SSAR. The applicant generally used the CPS USAR to derive the information presented in the SSAR, including the subsurface site characterization performed for the two previously proposed CPS units, as well as the ongoing monitoring for the constructed CPS Unit 1. The applicant reported that it obtained an additional four borings within the ESP footprint as part of its pre-ESP application activities; these borings further confirm the site geologic conceptual model presented previously in the USAR.

The applicant describes the regional geologic stratigraphy of unconsolidated alluvium and glacial drift and outwash over a consolidated sedimentary bedrock. Local ESP site conditions are consistent with the regional conditions. The following paragraphs summarize the applicant’s description of the regional and local hydrogeologic characteristics of various strata.

The alluvium, composed of varying amounts of clay, silt, sand, and gravel, is located within floodplains around stream corridors. In locations where the alluvium contains relatively thick lenses of sand and gravel, it can represent a viable water-bearing aquifer. Water in the alluvium is generally unconfined. Borings in the vicinity where the submerged CPS UHS pond is now located recorded alluvial deposits from 6 ft to 48 ft.

A thick layer of glacial drift and outwash underlies much of the region. The total thickness of the glacial drift and outwash ranges from less than 50 ft to more than 400 ft. This stratum of Wisconsinan-aged, Illinoian-aged, and Kansan-aged deposits is composed of heterogeneous mixtures of clay, silt, sand, and gravel. Drift material is dominated by clayey silts or silty clays, whereas outwash materials are dominated by sand and gravel. Water in the drift and outwash is generally confined. Regional ground water movement is dominated by flow through unconsolidated glacial outwash in glacial bedrock valleys, such as the Mahomet Bedrock Valley, the axis of which lies near the ESP site. The glacial outwash provides the source of much of the ground water supply used regionally. At the ESP site, glacial drift and outwash occur a few feet below the surface. Based on strata exposed during excavation of the CPS facility and borings conducted for the CPS facility and the ESP application, the applicant identifies the depth and thicknesses of the Wisconsinan, Illinoian, and Kansan strata. The Wisconsinan deposits extend from a few feet below the surface to about 698 ft MSL. The Illinoian deposits extend from the bottom of the Wisconsinan deposits to 572 ft MSL. The total thickness of the three drift layers average 237 ft. At the ESP site, water in the Wisconsinan stratum is unconfined, whereas water in the Illinoian and Kansan strata is confined.

The bedrock beneath the glacial drift and outwash is Pennsylvanian-aged shale, siltstone, limestone, and underclay. Valleys in the bedrock formed by geologic processes and filled with glacial drift and outwash are significant hydrogeologic structures throughout the region. Water in the bedrock formations is under confined conditions.

The dominant source of ground water for regional water use is from the glacial outwash in bedrock valleys. Based on the CPS USAR, the applicant states that 65 percent of public ground water supplies are pumped from the Mahomet Bedrock Valley aquifer. Within 15 mi of the site, alluvial aquifers provide the public water supply only for Heyworth. No public water supply within the 15-mi radius of the proposed site uses bedrock wells. The applicant stated that the ESP facility will not use ground water for either normal or safety-related plant operations.

The applicant states that the inundation of Salt Creek and the North Fork of Salt Creek resulted in changes to the local water table, with ground water flowing toward Clinton Lake. The presence of Clinton Lake’s relatively stable pool elevation represents an important boundary condition in describing the flow of ground water in the upper strata from the ESP site towards the lake.

The applicant reports the results of field, as well as laboratory, estimates of permeability. Laboratory estimates of permeability were based on grain size analysis and constant-head or falling-head permeability tests with 18 soil samples from various locations and geologic units. The applicant used one of these permeability estimates with its associated porosity and the water table gradient near the ESP site to estimate the velocity in the upper aquifer to be 2.5×10^{-3} ft/d.

The applicant proposes to maintain an inward piezometric gradient to any structure that may receive water to ensure movement into the structure rather than out of the structure. The applicant also proposes a design in which inward gradients would not be reversed over the range of observed water table fluctuations.

The SSAR describes the ground water flowpath from the ESP site in limited detail. The SSAR also does not specify precise locations of the ESP facility. The staff asked the applicant, in RAI 2.4.1-1, to provide locations for the proposed ESP facility. The applicant’s response to this RAI is discussed in Section 2.4.1.1 of this SER.

2.4.12.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it has correctly identified the applicable regulations and guidance.

Acceptance criteria for this section relate to the following regulations and criteria:

- 10 CFR Parts 52 and 100 require that the site evaluation consider hydrologic characteristics.

- 10 CFR 100.23 sets forth the criteria to determine the suitability of design bases for a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site with respect to the seismic characteristics of the site. It also requires that the adequacy of the cooling water supply for emergency and long-term shutdown decay heat removal be ensured, 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 site's physical characteristics (including seismology, meteorology, geology, and hydrology) must be considered when determining its acceptability for a nuclear power reactor.

As required by 10 CFR 100.20(c)(3), the applicant must address factors important to hydrological radionuclide transport using onsite characteristics. To satisfy the hydrologic requirements of 10 CFR Part 100, the staff's review of the applicant's safety assessment should verify the description of ground water conditions at the proposed site, as well as how those conditions would be affected by the construction and operation of a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the site. Meeting this requirement provides reasonable assurance that ground water at or near a proposed site will not be significantly affected by the release of radioactive effluents from a plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site.

The regulation at 10 CFR 100.23 requires that geologic and seismic factors be considered 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 that the physical properties of materials underlying the site be considered when designing a system to supply cooling water for emergency and long-term shutdown decay heat removal. The regulation at 10 CFR 100.23 is applicable to Section 2.4.12 of RS-002, Attachment 2, because it addresses the 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 plant(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 would 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting the limiting values of parameters. Important PPE parameters for safety assessment described in 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 meet the requirements of the hydrologic aspects of 10 CFR Parts 52 and 100, the following specific criteria are used:

- A full, documented description of regional and local ground water aquifers, sources, and sinks is necessary. In addition, the type of ground water use, wells, pump and storage facilities, and the flow needed for a nuclear power plant(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 be compared to RG 1.27 guidelines. The bases and sources of data should be adequately described and referenced.

- A description of present and projected local and regional ground water use should be provided. Existing uses, including amounts, water levels, location, drawdown, and source aquifers should be discussed and tabulated. Flow directions, gradients, velocities, water levels, and the 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 power plant(s) of specified type (or falling within a PPE) that might be constructed on the site and any potential 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. The bases and sources of data should be described and referenced. References 6 through 12 of RS-002, Attachment 2, discuss certain studies of ground water flow problems.

- The need for and extent of procedures and measures to protect present and projected ground water users, including monitoring programs, should be discussed. These items are site-specific and will vary with each application.

2.4.12.3 Technical Evaluation

Based on a review of a USGS document (Lloyd and Lyke, 1995), the staff determined that the applicant's description of regional hydrogeologic conditions is accurate. The staff further determined that the SSAR adequately describes onsite and offsite ground water use. The applicant states that ground water would not be used for either normal or safety-related plant operations. The staff plans to include a condition in any ESP that might be issued for the applicant's proposed ESP site that will prohibit such use. This is **Permit Condition 2.4-8**.

Prior construction for the CPS facility has altered, and future construction for the ESP facility would again alter, the subsurface environment. The replacement of existing soils with fill and cement would alter the current subsurface environment and these changes would likely alter the local ground water flow patterns. The staff requested, in RAI 2.4.1-1, that the applicant define the extent of the region (including elevation) of the ESP facility. While the applicant provided the coordinates of the areal extent of the facility, it did not provide information as to the depth of the facility or associated disturbance, as discussed previously in Open Item 2.4-1 (Section 2.4.1.3 of this SER).

To characterize the local subsurface environment sufficiently to understand the ground water flowpaths, the staff requested, in RAI 2.4.13-1, more information regarding the local subsurface environment. Based on the location of the plant relative to the piezometric boundary condition represented by Clinton Lake, as well as the applicant's commitment to avoid using ground water for normal or safety-related plant uses, the staff concludes that any direct impacts to the ground water system during plant operation would be small and very localized. However, the applicant did not bound the possible indirect impact of an overall drop in the lake pool elevation caused by the additional consumptive use of water associated with the ESP facility. Such a drop in elevation might alter the piezometric surface in the vicinity of the plant. It is also unclear to the staff that construction down to the PPE embedment depth could be performed without dewatering systems that could possibly reverse the piezometric gradient for the existing CPS unit. The applicant needs to provide the potential impact of future construction for the ESP facility on the piezometric gradient for the ESP site. This is **Open Item 2.4-18**.

The applicant estimated the average ground water velocity as follows:

Velocity = Hydraulic Gradient x Saturated Hydraulic Conductivity/Effective Porosity.

While the staff agrees that the equation is technically accurate, the applicant used very limited data to estimate the three values required to estimate the velocity. Based on one of two field permeability tests, the applicant selected the higher of the two values, 2.6×10^{-6} ft/d. For the porosity value, only one value (25 percent) was available for the Wisconsinan Till. The hydraulic gradient value (0.086) was based on the maximum head loss from the site to the floodplain of the North Fork of Salt Creek. The applicant should explain why such limited data represent a basis for a velocity estimate. In addition, the applicant should provide values for the hydraulic gradient, saturated hydraulic conductivity, and effective porosity measured at the ESP site. This is **Open Item 2.4-19**.

Critical to the applicant's conclusion that accidental releases of radioactive liquids would not be able to escape the ESP facility is the condition that piezometric gradients would constantly push water into the facility and, therefore, would not allow liquids to escape out of the facility. The staff agrees that this is a viable mechanism to ensure no releases. The staff plans to include the following condition in any ESP that might be issued for the proposed site. The ESP holder must demonstrate that for all credible water table conditions an inward-directed gradient will be constantly maintained and the applicant must implement a monitoring plan to ensure the maintenance of this gradient condition. This is **Permit Condition 2.4-9**.

2.4.12.4 Conclusions

As set forth above, and with the exceptions of the open items noted in Section 2.4.12.3 of this SER, the applicant provided sufficient information pertaining to the identification and evaluation of the ground water characteristics at the site. SSAR Section 2.4.12 conforms to RS-002, Attachment 2, Section 2.4.12 with regard to this objective.

Section 2.4.12 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the ground water characteristics at the site. Although the applicant does not specifically address the above regulations in SSAR Section 2.4.12, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.12, it has met the requirements to identify and evaluate ground water characteristics at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), except as noted in Section 2.4.12.3 above.

2.4.13 Accidental Releases of Liquid Effluents to Ground and Surface Waters

The EGC ESP site lies within the Central Lowlands Physiographic Province. Aquifers in the Central Lowlands occur in unconsolidated sand and gravel of the Quaternary age and consolidated sandstone, limestone, and dolomite of the Paleozoic age. At the proposed EGC ESP site, alluvium along the floodplains overlays glacial drift deposits.

The requirements of 10 CFR 100.20(c)(3) provide the site suitability determination factors related to accidental releases to the liquid pathway. This regulation outlines factors important to hydrologic radionuclide transport, such as soil, sediment, and rock characteristics; adsorption and retention coefficients; ground water velocity; and distances to the nearest body of surface water, which must be obtained from onsite measurements.

2.4.13.1 Technical Information in the Application

In the two paragraphs comprising SSAR Section 2.4.12, the applicant states that it is extremely unlikely that effluents can move out of facilities containing liquid radioactive wastes because of the high water table elevation. The applicant’s position is that the high water table would result in an inward-directed hydraulic gradient that would allow ground water into the facility but not out of the facility.

The applicant identifies the closest surface water withdrawal for drinking water purposes to be 245 mi downstream at Alton, Illinois.

2.4.13.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant’s conformance to NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations, applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to hydrologic aspects of site characterization for an ESP. Although the applicant does not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff finds that it has correctly identified the applicable regulations and guidance.

Acceptance criteria for this section relate to the following regulations and criteria:

- 10 CFR Parts 52 and 100, as they relate to the evaluation of a site's hydrologic characteristics with respect to the consequences of the escape of radioactive material from the facility.

Compliance with 10 CFR Parts 52 and 100 requires that local geological and hydrological characteristics be considered when determining the acceptability of a nuclear power plant site. The geological and hydrological characteristics of the site may have a bearing on the potential consequences of radioactive materials escaping from a nuclear power plant(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) were to 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 Section 2.4.13 of RS-002, Attachment 2, because the reviewer evaluates site hydrologic characteristics with respect to the potential consequences of radioactive materials escaping from a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. Radionuclide transport characteristics of ground water and surface water environments are reviewed with respect to accidental releases in order to ensure that current and future users of ground water and surface water are not adversely affected by an accidental release of radioactive materials. RGs 1.113, Revision 1, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," and 4.4, "Reporting Procedure for Mathematical Models Selected to Predict Heated Effluent Dispersion in Naturally Water Bodies," provide guidance in selecting and using surface water models for analyzing the flow field and dispersion of contaminants in surface waters.

Meeting the requirements of 10 CFR Parts 52 and 100 provides reasonable assurance that accidental releases of liquid effluents to ground water and surface water, as well as 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. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting the limiting values of parameters. Important PPE parameters for safety assessment described in 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 meet the requirements of 10 CFR Parts 52 and 100 with respect to accidental releases of liquid effluents, the following specific criteria are used:

- Radionuclide transport characteristics of the ground water environment with respect to existing and future users should be described. The estimates and bases for the 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 for use in postulating 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. Acceptance is based on the staff's 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 be the guide in selecting 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 provides guidance in selecting and using surface water models. References 7 through 15 of RS-002, Attachment 2, discuss the transport of fluids through porous media.

2.4.13.3 Technical Evaluation

The two paragraphs comprising SSAR Section 2.4.12 state that it is extremely unlikely that effluents can move out of facilities containing liquid radioactive wastes because of the high water table elevation. The applicant's position is that the high water table results in an inward-directed hydraulic gradient that would allow ground water into the facility but not out of the facility.

In RAI 2.4.12-1, the staff requested additional information regarding the likelihood for liquid effluents to reach a surface water body. The applicant provided data on the historical water surface elevations in the two upper till strata (i.e., the Wisconsinan and Illinoian). The lowest value recorded was 710.8 ft MSL in the Illinoian. The applicant reported the site grade as 735 ft MSL and the maximum embedment depth from the PPE. However, the applicant should also specify the maximum elevation at which any liquid radioactive waste releases can occur in the proposed ESP facility. This is **Open Item 2.4-20**.

Critical to the applicant's conclusion that accidental releases of radioactive liquids would not be able to escape the proposed ESP facility is the condition that piezometric gradients would constantly push water into the facility and, therefore, would not allow liquids to escape out of the facility. The staff agrees that this is a viable mechanism to ensure no releases. However, the applicant should demonstrate that for all credible water table conditions an inward-directed gradient will be constantly maintained. As noted in Section 2.4.12.3 of this SER, a monitoring plan will be needed to ensure the maintenance of this gradient condition (Permit Condition 2.4-9). The COL applicant will need to utilize a design in which radioactive liquid waste releases would not occur at any elevation greater than the minimum design water table elevation outside the facility. The staff plans to include this condition in any ESP that might be issued for the applicant's proposed ESP site. This is **Permit Condition 2.4-10**.

The staff concludes that the applicant needs to provide a thorough description of the local hydrologic setting, both that which exists currently and that which is expected after the disruption associated with the ESP construction activities, to assure the staff that an inward gradient will be maintained. This is **Open Item 2.4-21**.

2.4.13.4 Conclusions

As set forth above, and with the exceptions of the open items noted in Section 2.4.13.3 of this SER, the applicant provided sufficient information pertaining to the identification and evaluation of accidental release of liquid effluents in ground water and surface water at the site. SSAR Section 2.4.13 conforms to RS-002, Attachment 2, Section 2.4.13 with regard to this objective.

Section 2.4.13 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the accidental release of liquid effluents in ground water and surface water at the site. Although the applicant does not specifically address the above regulations in SSAR Section 2.4.13, the staff concludes that, by conforming to RS-002, Attachment 2, Section 2.4.13, it has met the requirements to identify and evaluate the accidental release of liquid effluents to ground water and surface water at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c), except as noted in Section 2.4.13.3 of this SER.

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	Open Item 2.4-1
Site Grade	735 ft MSL
Highest Ground Water Elevation	733.5 ft MSL
Flood Elevation	721.7 ft MSL
Low Water Elevation	Confirmatory Item 2.4-1
Local Intense Precipitation	18.15 in. during 1 hr
Snow Load	35 lb/ft2
Lake Surface Icing	Open Item 2.4-9
Frazil and Anchor Ice	The ESP site is subject to frazil and anchor ice formation (see Permit Condition 2.4-6).
Distance to the Closest Surface Water	Open Item 2.4-1
Location of Aquifers Used by Large Population for Domestic, Municipal, Industrial, or Irrigation Water Supplies	The nearest public water supply for Heyworth is 15 miles from the ESP site.
Hydraulic Conductivity	Open Item 2.4-19
Hydraulic Gradient	Open Item 2.4-19
Porosity	Open Item 2.4-19
Absorption and Retention Coefficients for Radioactive Materials[1]	Open Items 2.4-20 and 2.4-21

[1]This site characteristic should not impact site safety provided that the hydraulic gradient towards the site and away from Clinton Lake is maintained and monitored (see Permit Conditions 2.4-9 and 2.4-10).