2.4 Hydrologic Engineering

The Exelon Generation Company (EGC or the applicant) early site permit (ESP) site is located 6 miles (mi) east of Clinton, which is in 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, dry, or wet/dry hybrid cooling towers as the plant's normal heat sink (NHS). Clinton Lake would supply makeup water for the ESP facility's NHS. The UHS for the ESP facility would consist of mechanical draft cooling tower(s) with no water storage, if the selected reactor design for the ESP facility requires a UHS. The UHS, if required, would be a safety-related structure and, thus, must be designed, constructed, operated, and maintained as such. 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 ESP facility's UHS intake would be an integral part of the UHS and is, 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 feet (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 safety evaluation report (SER)). Clinton Lake has two arms, one on Salt Creek and the other on the North Fork of Salt Creek. These arms extend 14 miles and 8 miles, 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 acres (ac) at the normal level of 690 ft MSL. The ESP site is located about 3.5 miles northeast of the dam between the two arms of Clinton Lake, at a grade elevation of 735 ft MSL.

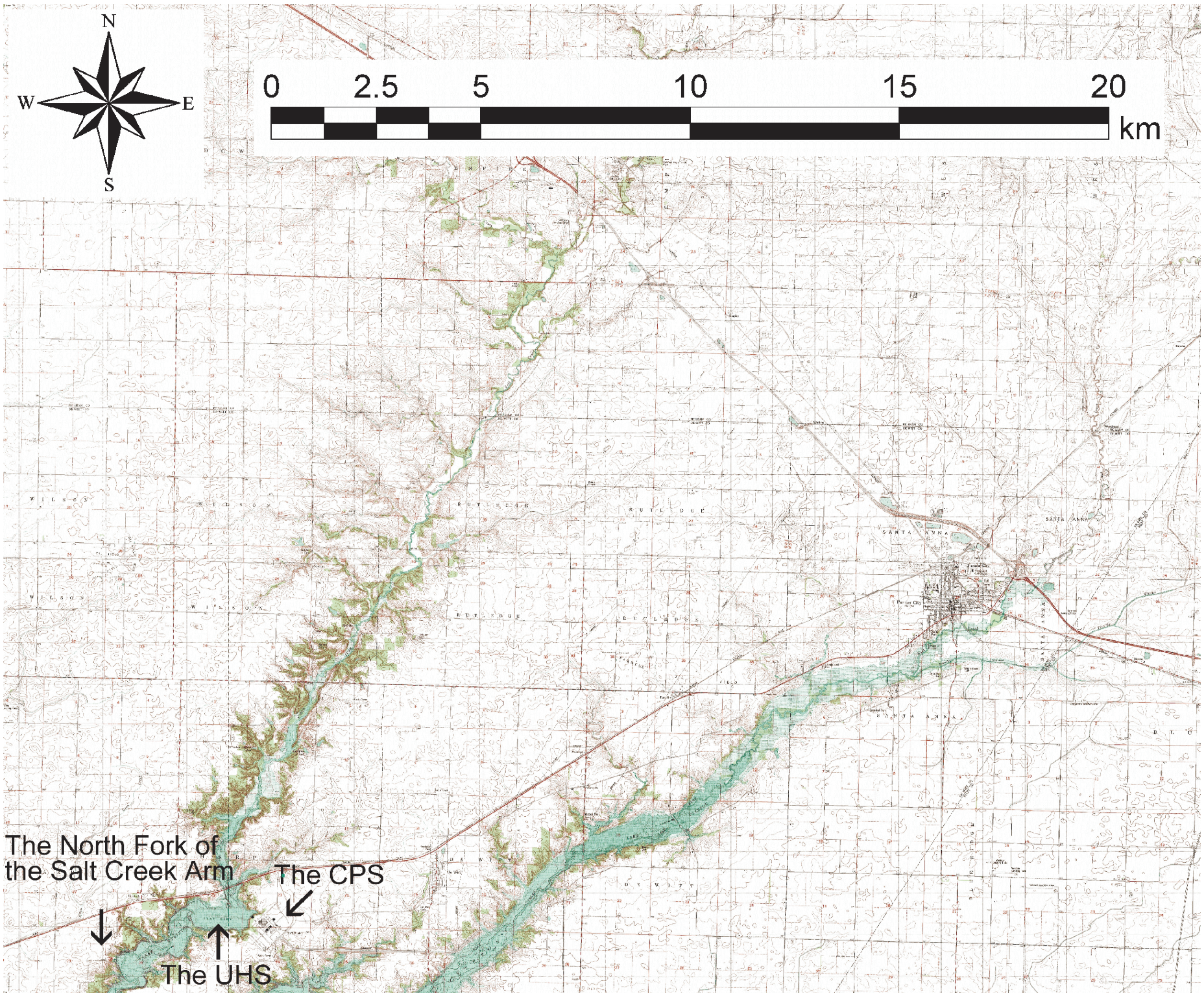

Figure 2.4-1 Clinton Lake

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-mile-long discharge flume. The hot discharge then travels through Clinton Lake to the North Fork of the Salt Creek arm (see Figure 2.4a-2 of this SER). Excess heat, which causes the water temperature to rise above the ambient equilibrium temperature, is primarily transferred from the lake's surface to the atmosphere through sensible, long-wave radiation and latent heat flux of evaporation.

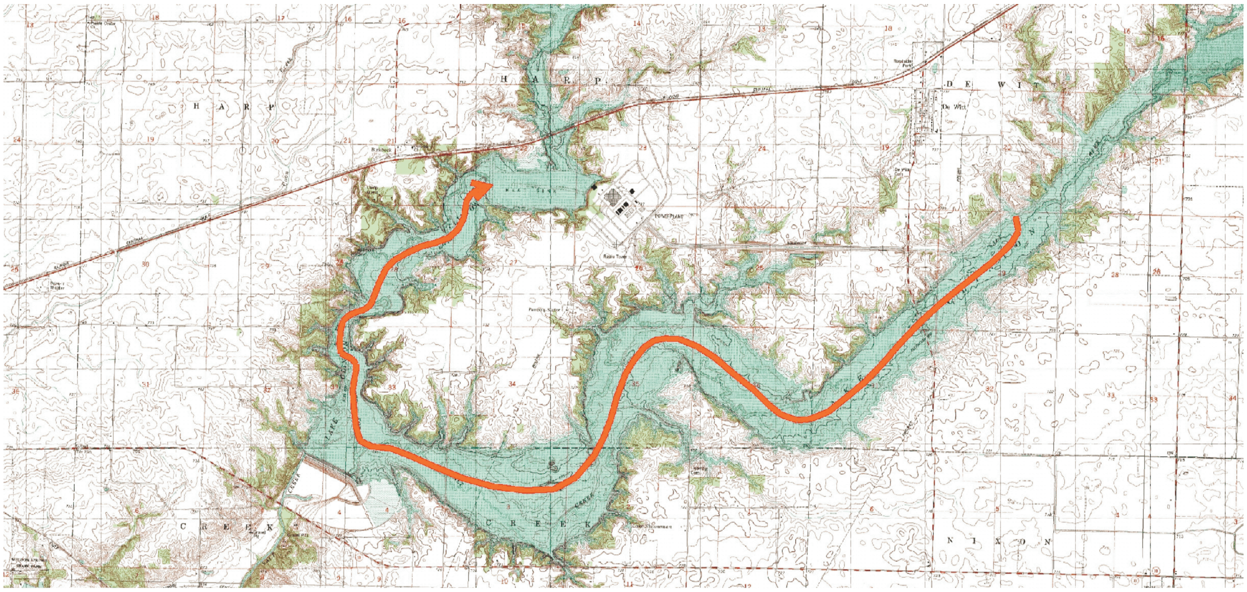

Figure 2.4-2 CPS once-through discharge and subsequent mixing and cooling path

The submerged dam is located approximately 1 mile 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 an elevation of 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 acre-feet (ac-ft) or 46.62 million cubic feet (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 UHS intake structure (see Figure 2.4-3 of this SER). The ESP facility UHS blowdown will be discharged to the discharge flume.

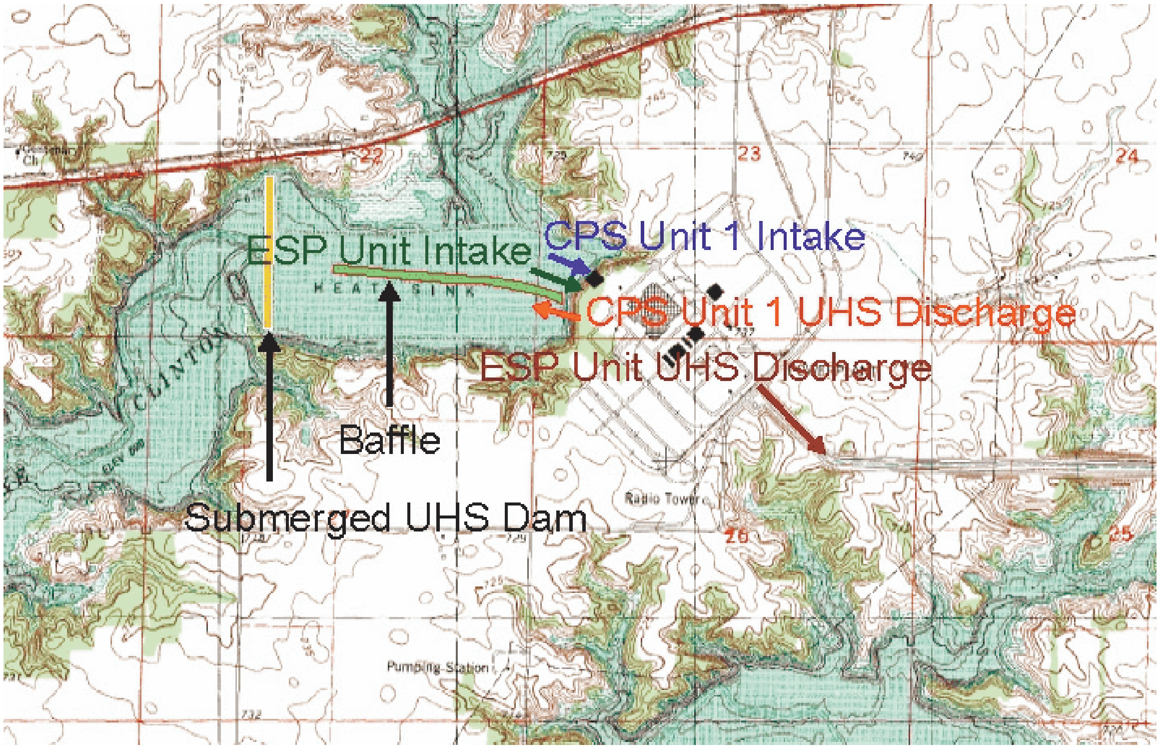

Figure 2.4-3 Proposed locations of ESP facility UHS intake and discharge

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 combined license (COL) application and construction phase and that no survey coordinates are established at the ESP stage.

The applicant stated that the location of the ESP facility's normal and UHS 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 of 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 path. The shutdown service water piping exits the CPS intake structure 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 the 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 inches (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 at 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 were to exceed 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 COL application.

Section 2.4.11.5 of the SSAR stated that a plant shutdown would be initiated if the water surface elevation in Clinton Lake were to fall to an elevation of 677 ft MSL. The applicant stated 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 stated that this minimum water surface elevation is based on an as yet unfinished design of the ESP facility intake structures. The applicant also noted 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 included 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 stated 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 noted 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, thereby cooling the facility to the design temperature. The applicant stated 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 stated that, since a safety analysis for the safe shutdown of the ESP facility has not yet been carried out, 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 revised SSAR Section 2.4.1.2 to add information regarding current dams upstream and downstream of Clinton Lake to support its statement that these 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 revised SSAR Section 2.4.1.2 to state that no reservoirs or dams upstream or downstream from Clinton Lake exist 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 further 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 the 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

Table 1.5-1 of the SSAR shows the applicant's conformance to U.S. Nuclear Regulatory Commission (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 Review Standard (RS)-002, Attachment 2, "Processing Applications for Early Site Permits," 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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 of the *Code of Federal Regulations* , (10 CFR) Part 52, "Early Site Permits; Standard Design Certification; and Combined Licenses for Nuclear Power Plants," and 10 CFR Part 100, "Reactor Site Criteria," as they relate to identifying and evaluating the 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. The applicant should describe in detail 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 determine whether the applicant met the requirements of the hydrologic aspects of 10 CFR Parts 52 and 100, the staff used the following specific criteria.

Section 2.4.1 of the SSAR 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, their 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 Section 2.4.1 of RS-002, Attachment 2. 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 the 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 stated that the catchment area of Salt Creek above Clinton Dam is about 296 square miles (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 the catchment area of Salt Creek above Clinton Dam to be approximately 2.4 percent less than that reported by the applicant.

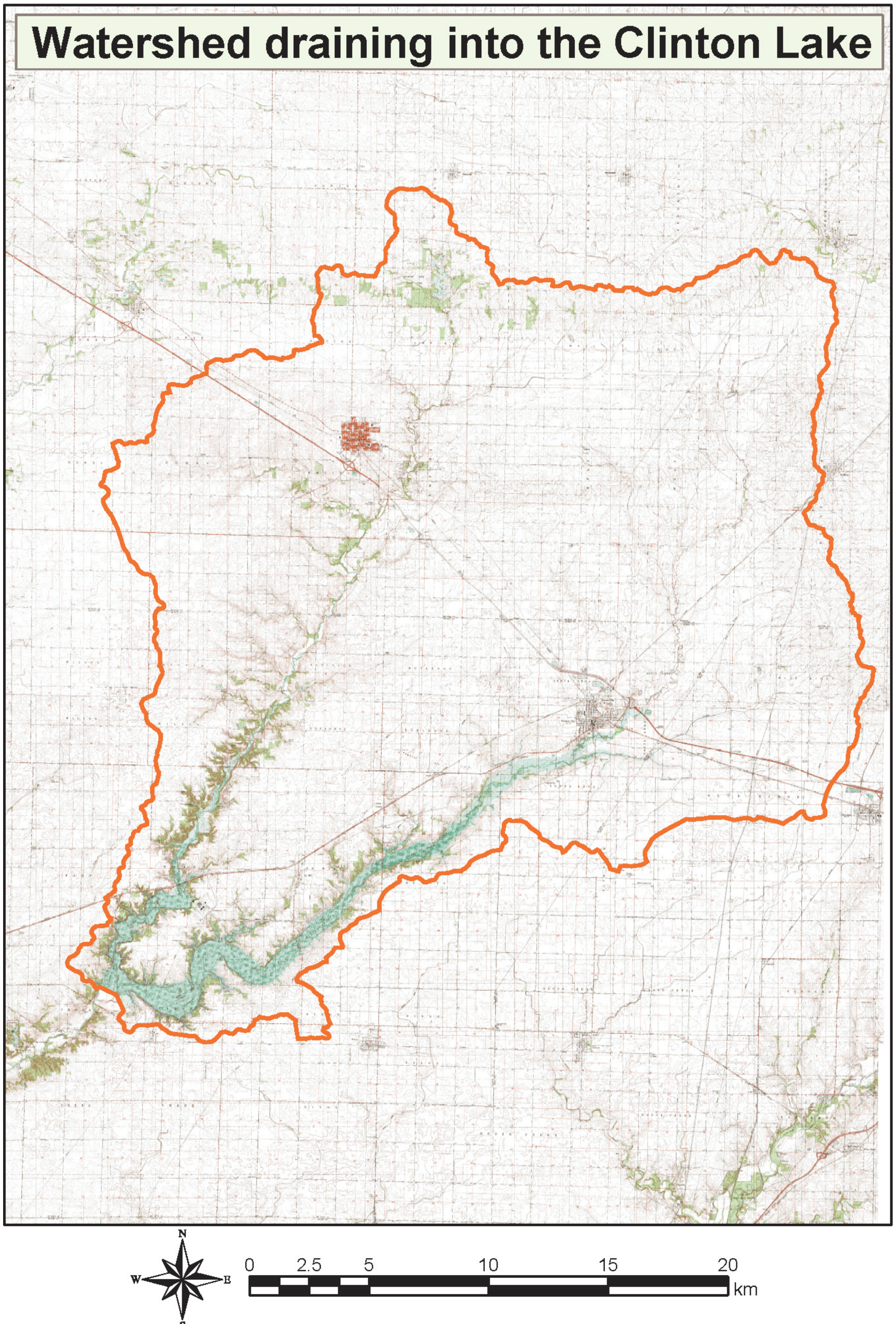

Figure 2.4-4 The watershed draining into Clinton Lake, delineated manually using topographic contours

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 miles 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 miles 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 at the ESP site. 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 staff determined that the applicant needed to define the extent of the vertical disturbance and the bounding elevations of all SSCs. Additionally, the staff determined that SSAR Figure 1.2-4 did 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 staff determined that the applicant needed to state whether it covers these through the site grade specified in the PPE or proposes separate criteria for these structures. This was **Open Item 2.4-1** of the draft safety evaluation report (DSER).

In response to DSER Open Item 2.4-1, dated April 26, 2005, the applicant stated that the bounding foundation embedment is 140 ft below grade. The applicant also stated that the specific vertical disturbance and elevations of each SSC depend on the chosen reactor design and therefore have not yet been determined. The applicant explained that at 140 ft below grade, the foundation basemat will rest in Illinoian glacial till, which is considered very good foundation material. The applicant stated that any excavation below 140 ft from site grade will not be significant and will only be required for purposes such as leveling.

The applicant stated that the bounding elevation for structures within the powerblock is 234 ft above grade, and the tallest structure for the ESP facility would be a natural draft cooling tower with a bounding elevation of 550 ft above grade, if such a tower were to be included in the reactor design selected for the ESP site.

The applicant stated that the UHS piping has also not been designed at the ESP stage because its need is dependent on whether the reactor design chosen for the facility requires a UHS. The applicant stated that its response to RAI 2.4.1-1 provides a general description of the location of UHS piping, which will be installed between the minimum elevation of the CPS shutdown service piping (635 ft MSL) and the plant grade (735 ft MSL). The applicant explained that the separation between the existing CPS piping and the ESP facility piping will be determined by the COL applicant and CPS management.

The applicant stated that if a UHS were to be required by the selected ESP facility reactor design, a UHS makeup water structure would also be required and would be built at the edge of Clinton Lake, approximately 65 ft south of the existing CPS intake facility structure. Therefore, the site grade of 735 ft MSL is not pertinent for the ESP facility's UHS makeup water intake structure. The applicant stated that it expects the bottom of the ESP facility UHS makeup water intake structure to be located at an elevation of 657.5 ft MSL. The final elevation of the basemat will also depend on the submergence requirement of selected intake pumps and the elevation of the inlet, which is between 670 ft MSL and 697 ft MSL. The applicant stated that the ESP facility UHS makeup water intake structure will be subject to probable maximum flood (PMF) in Clinton Lake's watershed and will be designed to protect safety-related equipment located within it.

Based on the applicant's response to DSER Open Item 2.4-1, the staff determined that the applicant provided sufficient details regarding the vertical extent of the disturbance and the bounding elevations of all SSCs that may be required and constructed for the ESP facility. The applicant does not have a specific reactor design at the ESP stage. Therefore, further details regarding safety-related piping for the ESP facility are not available. The staff will evaluate the safety of the ESP facility piping corridors during the COL stage, in accordance with applicable NRC regulations and regulatory guidance. The UHS makeup water intake structure, if the selected ESP facility reactor design were to require one, would be designed to protect it from PMF in the Clinton Lake watershed. The staff will also evaluate the safety of the ESP facility UHS makeup water intake structure during the COL stage, in accordance with applicable NRC regulations and regulatory guidance. Based on this review, the staff has determined that the COL or construction permit (CP) applicant needs to ensure that the ESP facility intake piping is installed with adequate clearance from the CPS facility piping. This is **COL Action Item 2.4-1**. On the basis of COL Action Item 2.4-1, the staff considers Open Item 2.4-1 to be resolved.

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. The staff had planned to include this proposed horizontal clearance of 50 ft as DSER Permit Condition 2.4-1. The staff had also planned to include a minimum vertical clearance equal to the larger of 6.6 ft or three times the diameter of the pipes as DSER Permit Condition 2.4-2. However, based on a review of the applicant's response to DSER Open Item 2.4-1 above, the staff determined that DSER Permit Conditions 2.4-1 and 2.4-2 are not necessary because COL Action Item 2.4-1 is sufficient to ensure that the ESP facility intake piping will be installed with adequate clearance from the CPS facility piping.

In RAI 2.4.1-2, the staff asked the applicant to identify any limits on plant operation for the ESP facility resulting from either water supply or intake water temperature. 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 whether sufficient margin exists 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 were to exceed 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 was insufficient. Therefore, the staff requested that the applicant 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.

In response to the RAI, 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 was not clear to the staff whether the PPE makeup flow rate, an average of 1.24 cubic feet per second (cfs) or 555 gallons per minute (gpm) and a maximum of 3.11 cfs or 1400 gpm, at the maximum inlet temperature of 95 EF, would be sufficient to remove all waste heat from the UHS cooling tower(s). Therefore, the staff determined that the applicant needed 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 staff determined that the applicant needed to demonstrate that the PPE makeup flow rate, an average of 555 gpm and a maximum of 1400 gpm, at the maximum inlet temperature of 95 EF, would be sufficient to remove all waste heat from the UHS cooling tower(s). In addition, the applicant needed to demonstrate that there would be no limits on plant operation caused by limited water supply or elevated water temperatures at the UHS intake for any facility constructed on the ESP site. This was DSER Open Item 2.4-2.

In response to DSER Open Item 2.4-2, in its submission to the NRC dated April 26, 2005, the applicant stated that SSAR Figure 3.2-1 shows a schematic representation of the complete UHS system, if one were to be required for the ESP facility, with its major components and the direction of water flow in the system, with the exception of the blowdown. The applicant stated that the design of the UHS depends on the reactor design yet to be chosen for the ESP facility, and the purpose of the conceptual design provided in the SSAR is to provide a bounding value for possible UHS makeup water needs. The applicant stated that each mechanical draft cooling tower that is part of a UHS will have a basin to provide makeup water to the emergency service water (ESW) pumps. The depth of the basin will depend on the requirements of the selected ESW pumps. The applicant stated that the normal ESW flow is 26,125 gpm, with a maximum of 52,250 gpm. The normal blowdown from the cooling tower will be 144 gpm, with a maximum of 700 gpm. The applicant stated that the total normal makeup flow including the blowdown is 555 gpm, with a maximum of 1400 gpm.

The applicant explained that the reactor suppliers provide makeup flow and evaporation rates from the cooling tower. The PPE table (SSAR Table 1.4-1) provides the bounding values. Blowdown is used to correct the concentration of impurities in the water. The applicant stated that the CPS UHS maximum temperature is 95 EF. Therefore, makeup to the ESP facility UHS cooling tower will not exceed the required UHS cold water temperature. The applicant stated that the capability of the flow rate to remove all waste heat is a design issue and will be reviewed at the COL stage. The applicant revised SSAR Sections 2.4.11.5 and 2.4.11.6 to address issues raised by DSER Open Item 2.4-2.

Based on the applicant's response to DSER Open Item 2.4-2, the staff determined that the detailed design of the ESP facility's UHS system is not yet completed because it depends on the type of reactor selected for the ESP facility. Therefore, issues raised in DSER Open Item 2.4-2 cannot be addressed until the COL stage when a detailed design of the UHS system is performed, if the selected reactor design type requires one. The staff will review the design of the ESP facility's UHS, if one were to be required by the selected reactor type, including its capacity to remove all waste heat under the most critical scenario in accordance with applicable NRC regulations and regulatory guidance at the COL stage. The staff determined that PPE values of makeup flow rate (555 gpm; item 3.3.9 in Table 1.4-1 of the SSAR) and maximum inlet temperature to the CCW heat exchanger (95 EF; item 3.2.1 in Table 1.4-1 of the SSAR), along with the site characteristic values provided in Table 2.3.1-6 of this SER, relate to maximum air temperature and maximum humidity and are important parameters that should be used in the design of the UHS cooling towers, if the selected reactor type for the ESP facility were to require a UHS. This is **COL Action Item 2.4-2**. On the basis of COL Action Item 2.4-2, the staff considers DSER Open Item 2.4-2 resolved.

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 the existence of 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. Based on information provided by the applicant, the volumes of impoundments upstream of the Clinton lake are small enough to be negligible. Runoff from the Clinton Lake watershed feeds the reservoirs behind these dams and provides the water stored in these reservoirs.

However, the staff determined that the two reservoirs upstream of Clinton Lake have a maximum combined storage capacity of 194.1 million ft^3 or 4446 ac-ft. This volume is small compared to the volume of Clinton Lake (at a 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 PMF event in the Clinton Lake watershed is not significant. Section 2.4.4 of this SER presents an analysis and evaluation of the effects of a failure of the two upstream dams. Based on this evaluation, 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 did not have any information regarding proposed land use changes upstream of Clinton Lake. The staff determined that, for a site suitability evaluation, the applicant needed to provide an authoritative source that could include State or county planning officials who can either provide details of a development plan in the Clinton Lake watershed or verify the absence of such a plan. This was DSER Open Item 2.4-3.

In response to DSER Open Item 2.4-3, the applicant stated, in its submission to the NRC dated April 4, 2005, that it contacted the DeWitt County Planning and Zoning Office to obtain information regarding development plans in the Clinton Lake watershed. The applicant stated that the administrator of the DeWitt County Planning and Zoning Office referred to a Comprehensive Land Use Plan dated 1992 that is out of date and out of print. The administrator also indicated that no current plans exist to update this land use plan. According to the administrator, the county experienced a 7-percent decline in population from 1980 to 2000. Over the latter half of this period, though, there was a 1.2-percent increase in population. The administrator also provided the applicant with information related to a 40-ac residential development in Farmer City, with a 20-year plan for additional development of up to 217 ac. The applicant also contacted the acting administrator of Farmer City and confirmed the existence of an ongoing 40-ac development and another planning concept for a 200-ac commercial-industrial development project north of Farmer City.

Based on the applicant's response to DSER Open Item 2.4-3, the staff determined that the applicant provided sufficient information from authoritative sources to resolve its concerns expressed in DSER Open Item 2.4-3. Therefore, the staff considers DSER Open Item 2.4-3 resolved.

In response to RAI 2.4.1-4, the applicant also stated that increased impervious area within the Clinton Lake watershed associated with future development will reduce soil erosion and sediment discharge to tributaries. The staff disagreed with the applicant in this assessment. 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 increase in soil erosion decrease the volume of stored water in the submerged UHS pond, the staff would have to examine the adequacy of the submerged UHS pond capacity. Therefore, the staff determined that the applicant needed to provide additional justification for its conclusion that an increase in impervious area will not increase soil erosion. This was DSER Open Item 2.4-4.

In response to DSER Open Item 2.4-4, the applicant stated, in its submission to the NRC dated April 4, 2005, that sediment delivery rates from agricultural land are extremely variable and tend to be high in areas with fine-grained soil on sloping land, which are exposed to the direct impact of precipitation. The applicant stated that sediment delivery from urban land is also variable. Sources of sediment in urban lands may be fewer because of land cover, but urban drainage systems may be more efficient at delivering sediment to natural drainages (streams). The applicant stated that sediment delivery rates from both agricultural, as well as urban lands, depend on erosion control practices.

The applicant stated that stream bank erosion increases with a rise in peak flow rates and volumes. Since both agricultural and urbanization changes may increase runoff volume over native conditions, the applicant concluded that there may be some increase in sediment production. In its conversation with the applicant, the DeWitt County Administrator for Planning and Zoning indicated that new urban development incorporates storm water best management practices, including storm water detention, vegetated buffers, and construction erosion control. The applicant concluded that it is difficult to definitively establish whether an increase in urban land use will lead to an increase or decrease in soil erosion. The applicant stated that in either case, the impact would be small because the long-term potential development in the watershed amounts to less than 0.5 percent of the watershed area.

The staff reviewed the additional information provided by the applicant in its response to Open Item 2.4-4 and concluded that, based on the authoritative information included in the applicant's response, new development in the watershed for the foreseeable future is approximately 250 ac, or about 0.14 percent of the area of the Clinton Lake watershed (289.2 mi^2 or 185,092 ac). In addition, the staff concluded that since new development projects use storm water best management practices, the likely increase in sediment delivery to natural drainages in the watershed is small because of the relatively small size of the areas affected by development as compared to the overall size of the watershed. Therefore, the staff considers DSER Open Item 2.4-4 resolved.

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, 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 Section 2.4.1 of RS-002, Attachment 2, with regard to this objective.

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

2.4.2 Floods

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 miles on the North Fork of Salt Creek and approximately 8 miles 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 floodflow 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. The applicant 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, EGC stated 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 estimated that the maximum discharge of 7810 cfs recorded on April 13, 1994, had a recurrence interval of 25 years. The applicant further stated that, because of the presence of Clinton Dam, the 10-year recurrence interval floodflow at the Rowell gauge is reduced from 11,400 cfs to 6,200 cfs, and the 100-year recurrence interval floodflow is reduced from 29,900 cfs to 10,400 cfs.

In SSAR Section 2.4.2.2, the applicant stated 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 the PMF water surface elevation in the lake to be 708.8 ft MSL. The applicant provided 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 105^{th} Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours,” issued 1956. 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 105^{th} Meridian,” issued June 1978; and HMR 52, “Application of Probable Maximum Precipitation Estimates, United States East of the 105^{th} Meridian,” issued August 1982. 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 further 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 determining the PMP. The applicant stated that it updated the PMP information in the SSAR using four reports directly relating to estimating the PMP at a given location. The applicant provided brief descriptions of HMRs 33, 51, 52, and 53, “Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates,” issued April 1980.

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 the Clinton Lake 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 applied 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 would 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 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 hillslope 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 whether 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 staff asked the applicant to describe any active safety-related drainage systems that it would install 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 the 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) design selected for the ESP facility. The nominal grade elevation of 735 ft MSL provides more than 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 the design of a drainage system to handle maximum site precipitation without requiring any active components.

In Revision 4 of the SSAR, the applicant revised the maximum rainfall rate site characteristic to reflect information contained in HMR 52. The revised maximum rate for the 1-hr PMP is 18.15 in. and for the 5-minute PMP is 6.08 in. The applicant stated that these local PMP values will be used to mitigate impacts of local site flooding based on grading and drainage design at the COL stage.

The applicant stated in Revision 4 of SSAR Section 2.4.2.2 that the maximum water surface elevation (excluding the effects of coincident wind, storm surge, and seiche activity) that could be expected for Clinton Lake is 709.8 ft MSL. This elevation is based on flood calculations using a cumulative PMP depth of 27.8 in. The postulated PMP was preceded by a standard project storm (SPS) equal to 40 percent of the PMP depth. Methods for computing the maximum water elevation are discussed more fully in Section 2.4.3 of this SER and references to previous application of the USACE SPRAT computer program have been removed. The applicant stated that all safety related structures at the ESP facility will either be above the maximum combined effects Clinton Lake water surface elevation (716.5 ft MSL) or be designed to withstand the effects of inundation.

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 the NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the applicable NRC regulations. 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

Section 2.4.2 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 at 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. The applicant should describe in detail 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.

In those cases for 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 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 determine whether the applicant met the requirements related to the hydrologic aspects of 10 CFR Parts 52 and 100, the staff used the following specific criteria in RS-002, Attachment 2:

- 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, the applicant should base its conclusions upon conservative assumptions of storm and vegetation conditions likely to exist during storm periods when relating to the potential for any adverse effects of blockage of site drainage facilities by debris, ice, or snow. 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, Revision 2, "Design Basis Floods for Nuclear Power Plants," issued August 1977, provides guidance for estimating the design-basis flooding considering the worst single phenomenon 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 in 1981, recommended by the Water Resources Council (WRC), to determine the 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 square kilometers (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 NRC 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 2983 cfs and 25-year and 100-year floods of 6836 cfs and 8688 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-minute^2 PMP depth to estimate the PMP depths for other durations. Column 3 lists 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 hour	1.000	18.15
6 hours	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 for estimating 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 outline a detailed method for estimating PMP values for different durations for a desired drainage area.

The staff's independent estimates of 24-hour and 48-hour PMP values for the Clinton Lake 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 concluded 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 needed to provide a revised PMP estimate using the current criteria of HMR 51. This was DSER Open Item 2.4-5.

In response to DSER Open Item 2.4-5, the applicant stated, in its submission to the NRC dated April 4, 2005, that it agreed with the staff's independent estimate of PMP values obtained using the recommendations of HMR 51. The applicant noted that the PMF water surface elevations updated for HMR 51 PMP values would not change the ESP site from being considered a "dry site." However, the applicant conceded that the updated PMP values may be useful for assessing the impacts on site drainage during significant storm events. The applicant revised the SSAR to reflect its acceptance of the staff-estimated PMP values for the ESP site. The staff, therefore, considers Open Item 2.4-5 resolved.

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 needed to provide additional justification for why an increase in the area with impervious surface will decrease the duration of low-flow events. This was DSER Open Item 2.4-6.

In response to DSER Open Item 2.4-6, the applicant stated, in its submission to the NRC dated April 4, 2005, that the Clinton Lake watershed is not changing significantly. The applicant stated that the trend in long-term population is decreasing, and the trend in short-term population is flat. The applicant also stated that there is no information to support significant future changes in land use or increase in water demand upstream or downstream of the lake. The applicant stated that the long-term potential of development in land use is less than 0.5 percent of the Clinton Lake watershed.

The applicant stated that, in general, development of land use will reduce the amount of infiltration, thereby reducing the volume of water in the ground that produces baseflow during low-flow periods. Therefore, the applicant argued, the rate of flow during low-flow periods, as well as the duration of low-flow for those streams that will dry up, will be reduced. The applicant further stated that given the low rate of development in the Clinton Lake watershed and the required stormwater control practices for new development, it is reasonable to assume that no significant change in stream low-flows will occur.

The applicant explained that the State requires a minimum discharge of 5 cfs from the dam to Salt Creek downstream of Clinton Lake. To maintain this minimum discharge during dry periods, water is drawn from the large storage capacity in Clinton Lake. The applicant stated that the potential change in infiltration caused by future development is small and is not expected to significantly change the total volume of inflow to the lake. Therefore, the applicant reasoned, no significant change will occur in the ability of Clinton Lake to deliver the minimum required flow to Salt Creek downstream of the lake.

Based on the applicant's response to DSER Open Item 2.4-6, the staff determined that the change in the Clinton Lake watershed for the foreseeable future is so small (0.14 percent of the watershed area; see the staff's review of the applicant's response to DSER Open Item 2.4-4 in Section 2.4.1.3 of this SER) as compared to the overall size of the watershed, it would not result in significant changes in the duration of low-flows in the watershed. Based on the above review, the staff considers DSER Open Item 2.4-6 resolved.

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 concluded that the applicant did not provide an adequate basis for this statement. Since an increase in additional storage capacity could mitigate these low-flow periods, the staff found the applicant's response incomplete. The staff asked the applicant to provide references for projections from State or local authorities responsible for development plans in the area of concern to substantiate any prediction of future development. This was DSER Open Item 2.4-7.

In response to DSER Open Item 2.4-7, the applicant stated, in its submission to the NRC dated April 4, 2005, that it provided information on planned development for DeWitt County and Farmer City in its responses to DSER Open Items 2.4-3 and 2.4-6. The applicant stated that no significant development is planned within the Clinton Lake watershed. The limited development currently planned will use a ground water source for its water supply.

The applicant stated that Salt Creek downstream of Clinton Lake is not a good candidate for water withdrawal since flows released from the lake can be at the minimum required rate of 5 cfs for extended periods of time and would generally not be considered sufficient to support additional development.

Based on the applicant's responses to DSER Open Items 2.4-3, 2.4-6, and 2.4-7, the staff determined that the applicant provided sufficient information to conclude that there is only limited development planned within the Clinton Lake watershed. This limited development is not likely to increase significantly the water demand on Salt Creek. Based on the above review, the staff considers DSER Open Item 2.4-7 resolved.

SSAR Section 2.4.2 did 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 requested an estimate of the maximum height of such a hypothetical wave to address these safety concerns. In response to RAI 2.4.2-3, the applicant estimated that such a wave would be less than 1 ft, although it did not explain the basis for this estimated value. The staff examined 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 on 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 would not pose a risk to the ESP site. The inlet to the CPS screenhouse 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 CP or COL applicant should 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 **COL Action Item 2.4-3**.

The staff had planned to include the requirement that the COL applicant design the ESP intake structures to withstand the combined effects of PMF, coincident wind wave activity, and wind setup in DSER Permit Condition 2.4-3. However, based on the applicant's responses to DSER Open Items 2.4-1 and 2.4-2, the staff determined that the requirement of a UHS, and consequently the necessity of protecting its intake structures from flooding, is dependent on reactor design, which has not been selected at the ESP stage. Therefore, the staff determined that COL Action Item 2.4-3 is sufficient to ensure flood protection of the ESP facility's UHS intake structures, if the selected reactor design were to require one. Thus, it is not necessary to impose DSER Permit Condition 2.4-3.

SSAR Section 2.4.2 did 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 whether 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 determine whether 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 examined the potential for seiches in Section 2.4.5 of this SER. Except for the ESP intake structures, the staff concluded that, based on 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 did not pose a risk to the ESP site.

SSAR Section 2.4.2 did 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 design selected for the ESP facility.

The applicant estimated local intense precipitation at the ESP site for a 1-hour duration to be 13.5 in. and for a 5-minute (min) duration to be 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 remained open. Therefore, the staff asked the applicant to address the differences between the two estimates of local intense precipitation at the ESP site for a 1-hour duration and for a 5-minute duration. This was DSER Open Item 2.4-8.

In response to DSER Open Item 2.4-8, the applicant stated, in its submission to the NRC dated April 4, 2005, that the SSAR characterizes short-term intense precipitation at the site for 1-hour and 5-minute durations on the basis of information available from the CPS USAR. The information in the CPS USAR is based on recommended procedures found in the older HMR 33. The applicant reviewed the staff's estimates of local intense precipitation for 1-hour and 5-minute durations based on the currently applicable HMR 52 and agreed with them. The applicant agreed with the staff's estimates and revised the text in SSAR Section 2.4.2.3 accordingly. The staff determined that applicant's response to DSER Open Item 2.4-8 is satisfactory, and therefore, considers DSER Open Item 2.4-8 to be resolved. The staff-estimated local intense precipitation presented in Table 2.4-2 of this SER will be included as a site characteristic for the ESP site (see Table 2.4.14-1 of this SER).

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 CP or COL applicant should demonstrate that the flooding 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 such an event. This is **COL Action Item 2.4-4**. The staff had planned to include this requirement as DSER Permit Condition 2.4-4. However, the staff determined that the ESP facility site grading will partially depend on the chosen reactor type, which has not been designed at the ESP stage. The staff concluded that COL Action Item 2.4-4 is sufficient to ensure the safety of the ESP facility from flooding generated by local intense precipitation. Therefore, it is not necessary to impose DSER Permit Condition 2.4-4.

2.4.2.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to identifying and evaluating floods at the site. SSAR Section 2.4.2 conforms to Section 2.4.2 of RS-002, Attachment 2, as it relates 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 the requirements of 10 CFR Parts 52 and 100. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.2, the staff concludes that, by conforming to Section 2.4.2 of RS-002, Attachment 2, the applicant has met the requirements concerning floods at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). 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 40.2E N latitude and 88.8E W 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 stated 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, EM 1110-2-1411, "Standard Project Flood Determinations," issued March 1965. For the PMF runoff analysis, the applicant used an antecedent 48-hour SPS equivalent to 50 percent of the PMP, followed by 3 dry days, followed by the full 48-hour PMP storm. The applicant considered the precipitation to be uniformly distributed over the entire area of the watershed.

SSAR Section 2.4.3.2 stated that soils in approximately 90 percent of the drainage area of the Clinton Lake watershed 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 estimated an initial precipitation loss during the SPS of 1.5 in. and no initial precipitation loss during the PMP, based on communications with USACE on November 2, 1970. The applicant estimated an infiltration loss during SPS, as well as during PMP, of 0.1 inches per hour (in./h). Initial precipitation loss is the part of precipitation that is consumed by soil infiltration before runoff begins, and infiltration loss is part of the precipitation that is consumed by soil infiltration during the rest of the storm.

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 in 1948 in conjunction with the 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, which is 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 of 711 MSL caused by a 40-mile per hour (mph) wind wave runup. 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 mile, 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 mph, 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 employed 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. It used the SPRAT model to prepare the current discharge rating curve for the dam. The applicant stated that the presence of 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 wind speed coincident with the PMF for design of the CPS circulating-water screenhouse. The applicant stated that use of these wind speeds 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 the 40-mph wind speed 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 wind speed than that used previously in the USAR and SSAR might be appropriate. Using ANSI/ANS-2.8-1992, the applicant determined that a wind speed 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 wind speed 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 wind speed. 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 revised SSAR Sections 2.4.3.6 and 2.4.10 to include this updated estimation for wave runup.

After reviewing the conclusions of the staff's initial independent bounding analysis, the applicant elected to revise its application in order to provide the staff additional information to provide a basis for the staff's conclusions as documented in this report. In Revision 4 of the application, the applicant described its revised analysis. This new analysis did not rely on the applicant's earlier baseline calculation from the CPS USAR. The staff did not accept the applicant's initial approach as the applicant was unable to find adequate documentation of this earlier analysis.

In Revision 4 of the application, the applicant described an assessment of the PMF static flood elevation height based on a unit hydrograph analysis of the 72-hour PMP. The PMP was estimated using current National Weather Service guidance for deriving a PMP for the Clinton watershed (HMRs 51, 52, and 53). The applicant presented PMF calculations using two different synthetic unit hydrograph methods with two different conceptual watershed layouts. One conceptual layout included the lake and the two drainages associated with the Salt Creek and North Fork drainages as they enter Lake Clinton. The second conceptual layout further refined the two drainages into a total of seven sub-drainages. The applicant used the USACE Hydrologic Engineering Center (HEC) model HEC-HMS 3.0.0 computer code to estimate the variation of the lake level in response to the PMP.

The synthetic unit hydrograph method relies on estimates of lag time and precipitation losses. The applicant estimated time to peak using a relationship between drainage area and lag time developed for Illinois by the USGS (Mitchell, 1948). The applicant estimated the precipitation losses based on soil and land use data for the watershed. The most conservative estimate of hydrostatic flood elevation, due to the PMF based on results of the applicant's HEC-HMS analysis for the different synthetic unit hydrographs and conceptual layouts considered, was 709.8 ft MSL.

In Revision 4 of the application, the applicant estimated a maximum coincident wave runup of 6.4 ft based on calculations using the USACE's ACES version 1.07 code with a wind velocity of 52 mph. The applicant also estimated a probable maximum surge of 0.3 ft based on a wind velocity of 100 mph.

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 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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 the requirements of 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. The applicant should describe in detail 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.

In those cases for 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 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 General Design Criteria (GDC) 2, “Design Bases for Protection against Natural Phenomena,” of Appendix A, “General Design Criteria for Nuclear Power Plants, to 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities.” 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 staff uses one of the following three conditions as criterion for accepting the applicant’s PMF-related design basis:

(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 staff expects that the site grade should be well above the staff-assessed 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. The staff also used publications by NOAA and USACE 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 HMRs 51 and 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, 1000, and 5000 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 area of the Clinton Lake watershed. Figure 2.4-5 of this SER 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 the Clinton Dam Drainage Area

Area (mi^2)	Duration (hour)				
	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

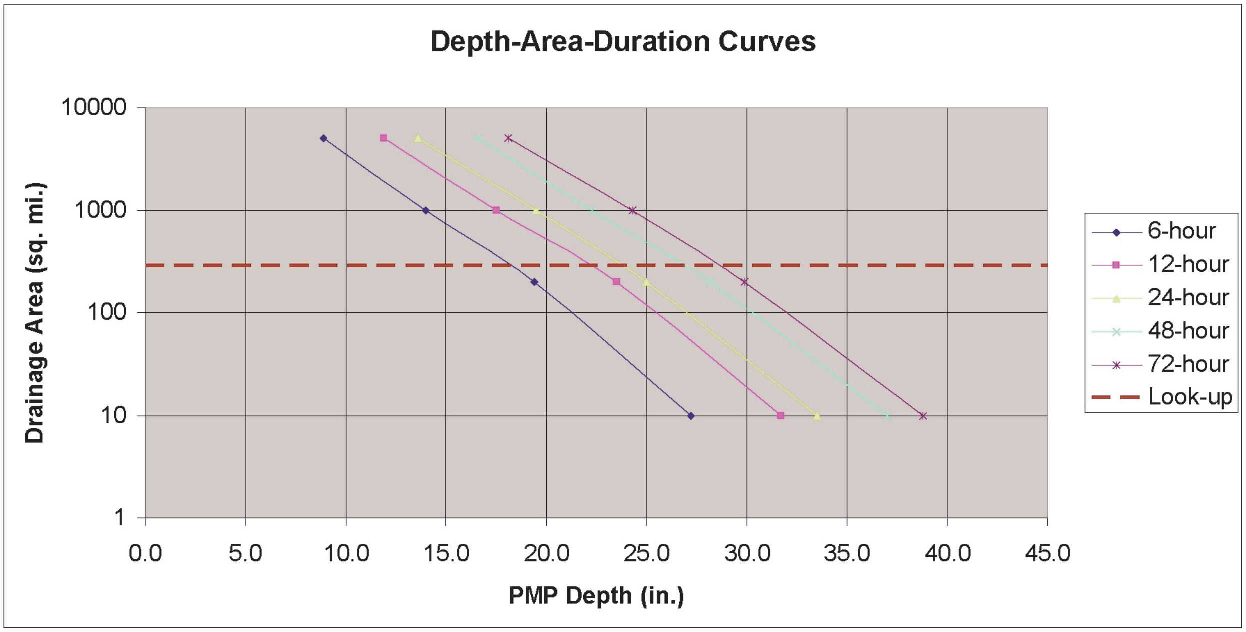

Figure 2.4-5 Depth-area-duration curves prepared for bracketing Clinton Dam drainage. The dotted horizontal line corresponds to a drainage area of 289.2 mi^2, equal to that of the Clinton Dam drainage area.

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

Clinton Lake PMP	Duration (hour)				
	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 the Clinton Dam drainage area (column 5 of Table 2.4-5 of this SER).

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

6-hour 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 independently verified the maximum hydrostatic (stillwater) elevation associated with a PMF at the ESP site. Since certain historical data (e.g., gauged inflows, observed lake elevations, etc.) were not available, multiple approaches were employed to provide a conservative basis.

The staff performed three analyses to estimate the water surface elevation of Clinton Lake near the ESP site during the PMF event. The first analysis bounded the water surface elevation by conservatively assuming no loss and instantaneous translation of the PMP into the lake. This bounding analysis was used to clearly establish that the site would remain dry. The second and third analyses refined the maximum water surface elevation estimate by relaxing some of the conservatism in the bounding analysis. These analyses were used to establish the site characteristic for the proposed ESP site intake structure and associated systems that may be placed below site grade.

The initial bounding analysis performed by staff conservatively estimated runoff by assuming that all watershed runoff instantaneously entered Clinton Lake. In this analysis, the runoff for each 6 hour duration during the PMP (Table 2.4-5) was computed by multiplying the PMP depth by the area of Clinton Dam's drainage. An infiltration loss rate of 0.0 in/hr was assumed to maximize the flood generated by the PMP storm. Based on these assumptions, runoff entering Clinton Lake had a peak discharge of 571,314 cfs.

The staff assumed instantaneous translation of the inflow wave through Clinton Lake using level pool routing and the stage-storage curve provided by the applicant (SSAR Figure 2.4 12). The stage-storage relationship was extended beyond elevation 708 ft MSL by extrapolation using the slope of the stage-storage curve.

The applicant provided the spillway rating curve for the Clinton Dam (SSAR Figure 2.4 12) that listed 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 above elevation 710 ft MSL by extrapolation using the slope of the stage-discharge relationship at elevation of 710 ft MSL. At elevations above the top of the dam, the staff assumed that water would spill along the entire dam face; the staff used a weir equation to compute the resulting discharge.

Results generated from the conservative, instantaneous translation, level pool routing method produced the reservoir inflow-outflow sequence shown in Figure 2.4-6 of this SER. Figure 2.4-7 of this SER shows the corresponding reservoir water surface elevations. The staff estimated the maximum hydrostatic (stillwater) water surface elevation using this extremely conservative and bounding approach to be 712.2 ft MSL.

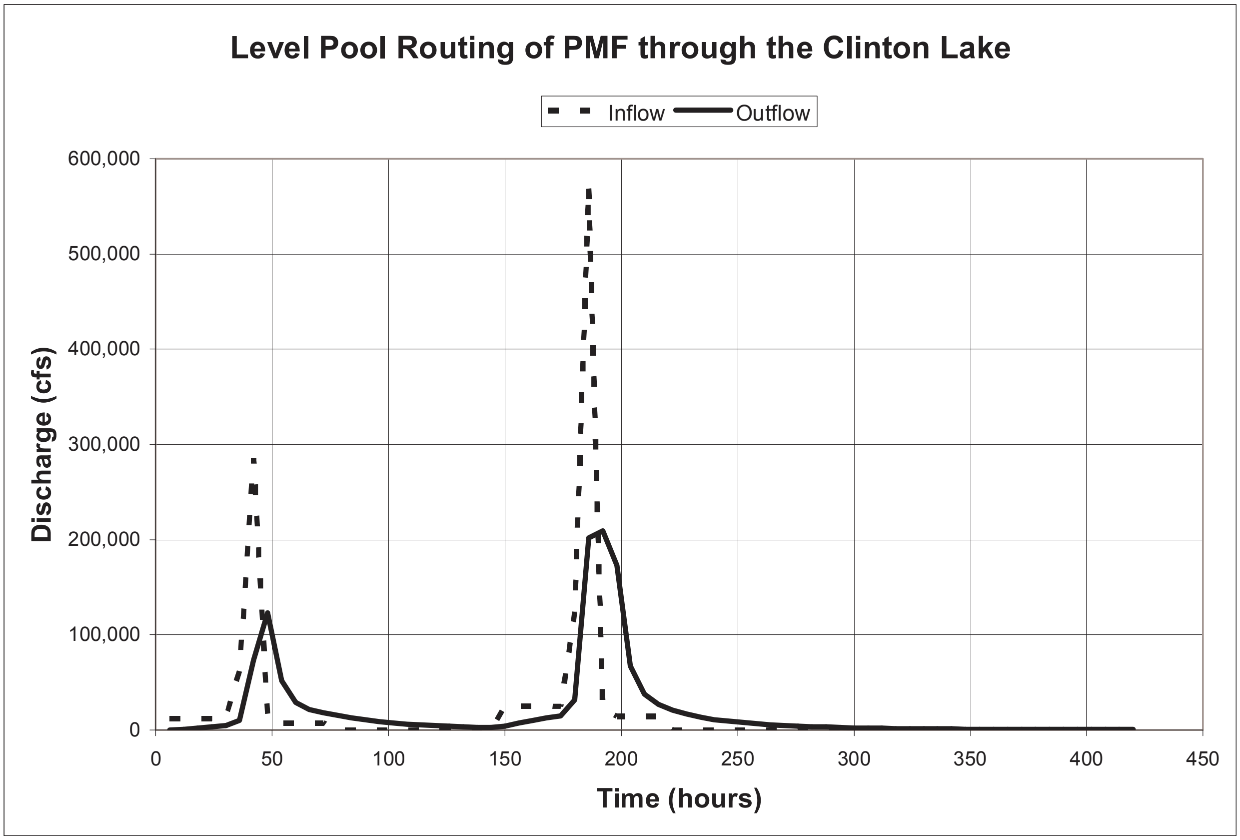

Figure 2.4-6 Inflow and outflow from Clinton Lake during the PMF event calculated using the instantaneous-translation level-pool routing method

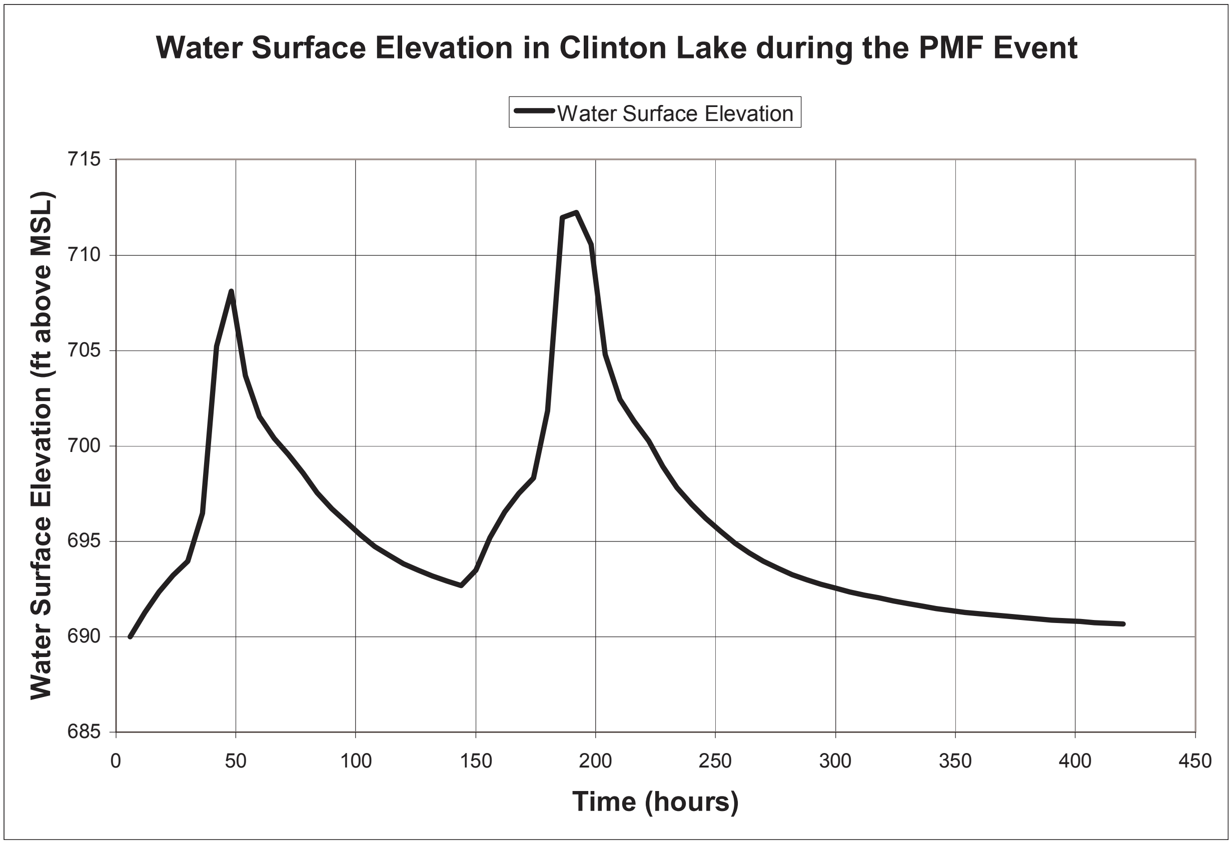

Figure 2.4-7 Water surface elevation in Clinton Lake during the PMF event calculated using the instantaneous-translation level-pool routing method

A second analysis was performed by staff using the HEC-HMS Version 3.0.0 computer code. The watershed was divided into eight sub-areas (Clinton Lake plus seven sub-basins) in the same manner as Revision 4 of the SSAR and with the following sub-areas: 1) Salt Creek headwater = 126.8 mi^2, 2) Salt Creek local area northeast = 5 mi^2, 3) Salt Creek local area northwest = 16.3 mi^2, 4) Salt Creek local area southeast = 6.2 mi^2, 5) Salt Creek local area southwest = 8.2 mi^2, 6) North Fork headwater = 111 mi^2, 7) North Fork local area = 15 mi^2, and 8) Clinton Lake area = 7.6 mi^2. The basins were connected together in the model so that outflow from the basins immediately entered the lake. This is a conservative assumption since the flow is not routed.

The Clinton Lake inflow hydrograph was estimated using the unit hydrograph approach. Synthetic unit hydrographs were developed to determine the runoff from each sub-basin area. The storm hydrograph entering Clinton Lake was computed based on two-hour unit hydrographs for each sub-basin. An antecedent storm equal in volume to 50% of the PMP, followed by three days of no rainfall, and followed by the full PMP volume (Table 2.4-5) was applied to the Clinton Lake watershed. In addition, the PMP used in the staff's analysis had a total volume of 28.7 in., which is more conservative compared to the applicant's value of 27.8 in.

One of the key parameters in the synthetic unit hydrograph method is the lag time. Values of lag times used by the applicant were based on limited published watershed data. The lag times used by the applicant and the staff ('standard lag' Table 2.4-6) in the HEC-HMS model were as follows: 1) Salt Creek headwater = 12.3 hrs, 2) Salt Creek local area northeast = 1.1 hrs, 3) Salt Creek local area northwest = 2.6 hrs, 4) Salt Creek local area southeast = 1.4 hrs, 5) Salt Creek local area southwest = 1.7 hrs, 6) North Fork headwater = 11.3 hrs, and 7) North Fork local area = 2.5 hrs. The selected lag values approximate those developed in Mitchell (1948) and the CPS USAR, although for the present analysis seven watershed sub-areas were used so corresponding values are not directly comparable. Since recent direct field data are not available, the lag time values are subjective. The staff appreciates the empirical nature of these coefficients and of the SCS method in general, which is generally not advised for use for areas larger than 2,000 ac (NOAA, 2006). To test the overall range of Clinton Lake PMF water surface elevations, the staff varied the lag time by shortening and increasing the lag time by 10 percent. Maximum Clinton Lake PMF water surface elevations are shown in Table 2.4-6 for these scenarios.

A second key parameter in the PMF computation method is the infiltration loss. The staff evaluated model sensitivity by reducing the constant loss parameter used by the applicant (0.1 in/hr) first by half (0.05 in/hr) and then eliminating infiltration altogether (0.0 in/hr loss). Computed time series of Clinton Dam outflow and Clinton Lake water surface elevation during the storm event are shown in Figure 2.4-8 and Figure 2.4-9, respectively. The maximum Clinton Lake PMF water surface elevations for this range of infiltration loss parameter values are shown in Table 2.4-6.

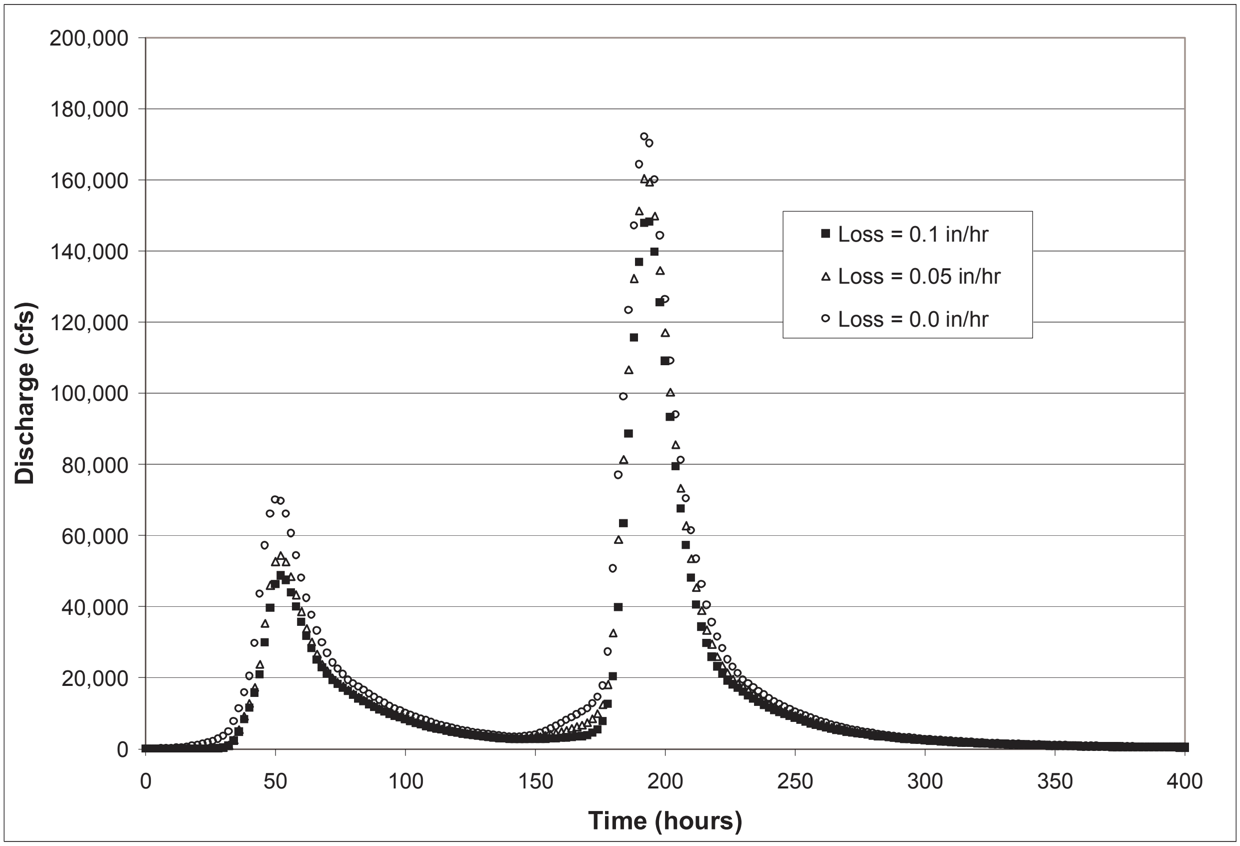

Figure 2.4-8 Inflow and outflow Hydrographs for Clinton Lake during the PMF event using the HEC-HMS model and the seven sub-basins + lake method

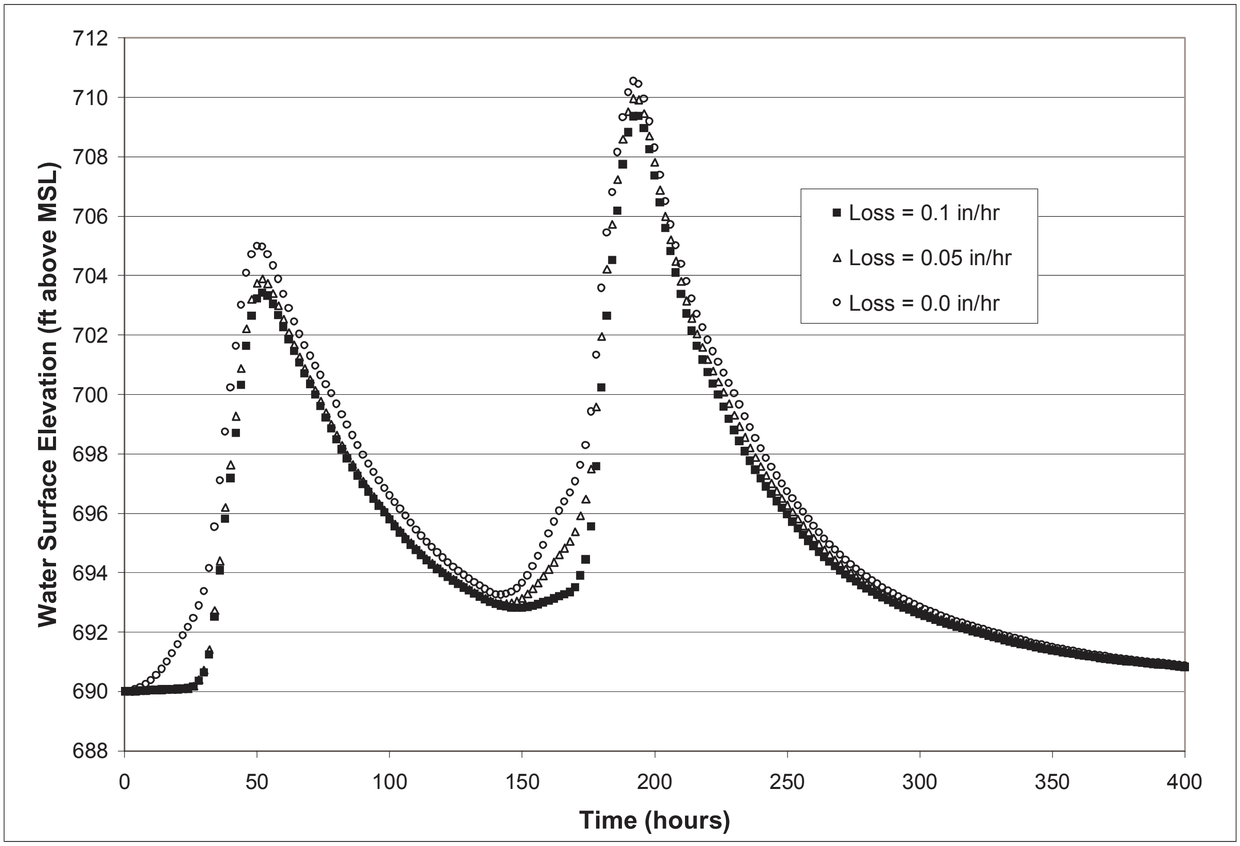

Figure 2.4-9 Water surface elevation of Clinton Lake during the PMF event using the HEC-HMS model and the seven sub-basins + lake method

The third analysis examined by staff also utilized HEC-HMS; however the watershed was divided into five sub-basins. Unit hydrographs following Mitchell (1948) and discussed in the CPS USAR were used. These unit hydrographs were made more conservative by shortening the time to peak by 33% and increasing the peak discharge by 20%. The Clinton Lake watershed was subjected to the same 50 percent PMP volume antecedent storm followed by the full PMP volume (Table 2.4-5) as the second analysis. For this analysis, the initial loss and constant loss rate were both set to zero. As in the second analysis, the routing from the five sub-basins to the Clinton Lake was instantaneous (no routing) and the PMP volume was 28.7 in.; both of which are conservative assumptions. The resulting maximum water surface elevation of Clinton Lake during the PMF was 710.6 ft MSL.

Results from the three analyses performed by staff are summarized in Table 2.4-6. Results from the initial bounding analysis clearly establish that the site would remain dry during the PMF event. The second and third analyses were used to establish the site characteristic for the intake structures and associated safety related systems located below site grade that might be inundated. Water surface elevation results from these analysis fell within 4% of the applicant's water surface elevation value. Based upon the consistency of the results of the various analyses, the staff finds that the applicant's value of 709.8 ft MSL for the maximum hydrostatic (stillwater) water surface elevation is reasonably conservative.

Table 2.4-6 Summary of Maximum PMF Water Surface Elevations (ft MSL) at the ESP Site

Method	Constant Infiltration Loss Rates (in/hr)		
	0.0	0.05	0.1
Instantaneous Translation	712.2		
SCS with Standard Lag	710.6	710.0	709.4
Mitchell Unit Hydrograph	710.6		

Method	Lag – 10%	Standard Lag	Lag + 10%
SCS with Loss = 0.1	709.9	709.4	709.0

The influence of coincident wind wave activity would cause an increase in the PMF 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 conservative wind velocity 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. Therefore, staff find that the applicant's value of 6.4 ft is reasonable.

A further increase of water surface elevation may result from storm surge, as discussed more fully in Section 2.4.5 of this SER. Storm surge would result in an additional increase in water surface elevation of 0.3 ft. Combining the effects of PMF (elevation 709.8 ft MSL), coincident wind wave activity (6.4 ft), and storm surge (0.3 ft), the staff estimated a resulting maximum water surface elevation at the ESP site of 716.5 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 COL applicant needs 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 716.5 ft MSL. COL Action Item 2.4-3, discussed in Section 2.4.2.3 of this SER, states this.

In response to RAI 2.4.3-1, the applicant stated that the presence of 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 revised the ESP application to remove reference to the hydraulic modeling. The staff determined that the applicant's response to RAI 2.4.3-1 is satisfactory.

With respect to the effects of wind speed on PMF water level elevation, the applicant stated in response to RAI 2.4.3-2 that use of these wind speeds 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. As such, the applicant determined 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.

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 Section 2.4.3 of RS-002, Attachment 2, with regard to this objective.

Section 2.4.3 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 PMFs on streams and rivers at the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.3, the staff concludes that, by conforming to Section 2.4.3 of RS-002, Attachment 2, 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 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 stated that no other dams exist either upstream or downstream of Clinton Dam. The applicant also indicated 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 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. 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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 10 100 as they relate to evaluating the hydrologic features of the site

- 10 CFR 100.23 as it relates to establishing the design-basis flood caused by a seismic dam failure

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

The regulations at 10 CFR Parts 52 and 100 are applicable to SSAR Section 2.4.4, which addresses the physical characteristics, including hydrology, the Commission considers 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 applicant should describe in detail 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 the 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.

In those cases for 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 site's hydrologic characteristics. 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 SSAR Section 2.4 include, but are not limited to, precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

The regulation at 10 CFR 100.23 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 at 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, Revision 3, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Reactors—LWR Edition," issued November 1978, 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.

The staff used the following criteria to meet the requirements of 10 CFR Part 52, 10 CFR Part 100, and 10 CFR 100.23, as they relate to dam failures:

- The staff will review the applicant's analyses and independently assess the coincident river flows at the site and at the dams being analyzed. ANSI/ANS-2.8-1992 provides guidance on acceptable river flow conditions to be assumed coincident with the dam failure event. To be acceptable, the applicant's estimates (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 estimates. If the applicant's estimates differ by more than 5 percent, the applicant should fully document and justify its estimates or accept the staff estimates.

- The applicant should identify the location of dams and potentially “likely” or severe modes of failure. The applicant also should identify dams or embankments for the purpose of impounding water for a nuclear power plant(s) that might be constructed on the proposed site, and discuss the potential for multiple, seismically induced dam failures and the domino failure of a series of dams. Applicants should use approved models of the USACE and the Tennessee Valley Authority to predict the downstream water levels resulting from a dam breach. First-time use of other models will necessitate complete model description and documentation. The staff bases its acceptance of the model (and subsequent analyses) on staff review of model theory, available verification, and application. In cases which assume something other than instantaneous failure, the conservatism of the rate of failure and shape of the breach should be well documented. The applicant should document a determination of the peak flow rate and water level at the site for the worst possible combination of dam failures, summary analysis that substantiates the condition as the critical permutation, and a description (and the bases) of all coefficients and methods used. In addition, the applicant should consider the effects of other concurrent events on plant safety, such as blockage of the river and waterborne missiles.

- The applicant also should consider the effects of coincident and antecedent flood flows (or low flows for downstream structures) on 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 use assumptions which cannot be demonstrated as conservative, applicants should use unsteady flow methods to develop flood levels at the site. References 7, 13, and 14 of RS-002 are acceptable methods; however, other programs could be acceptable with proper documentation and justification. The applicant should summarize computations, coefficients, and methods used to establish the water level at the site for the most critical dam failures. Coincident wind-generated wave activity should be considered in a manner similar to that discussed in Section 2.4.3 of RS-002.

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

2.4.4.3 Technical Evaluation

The staff 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 miles 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. The 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 added information to SSAR Section 2.4.1.2 regarding dams upstream and downstream of Clinton Lake to support its statement that such 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 revised 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 716.5 ft MSL. The staff plans to include 716.5 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 719.6 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.

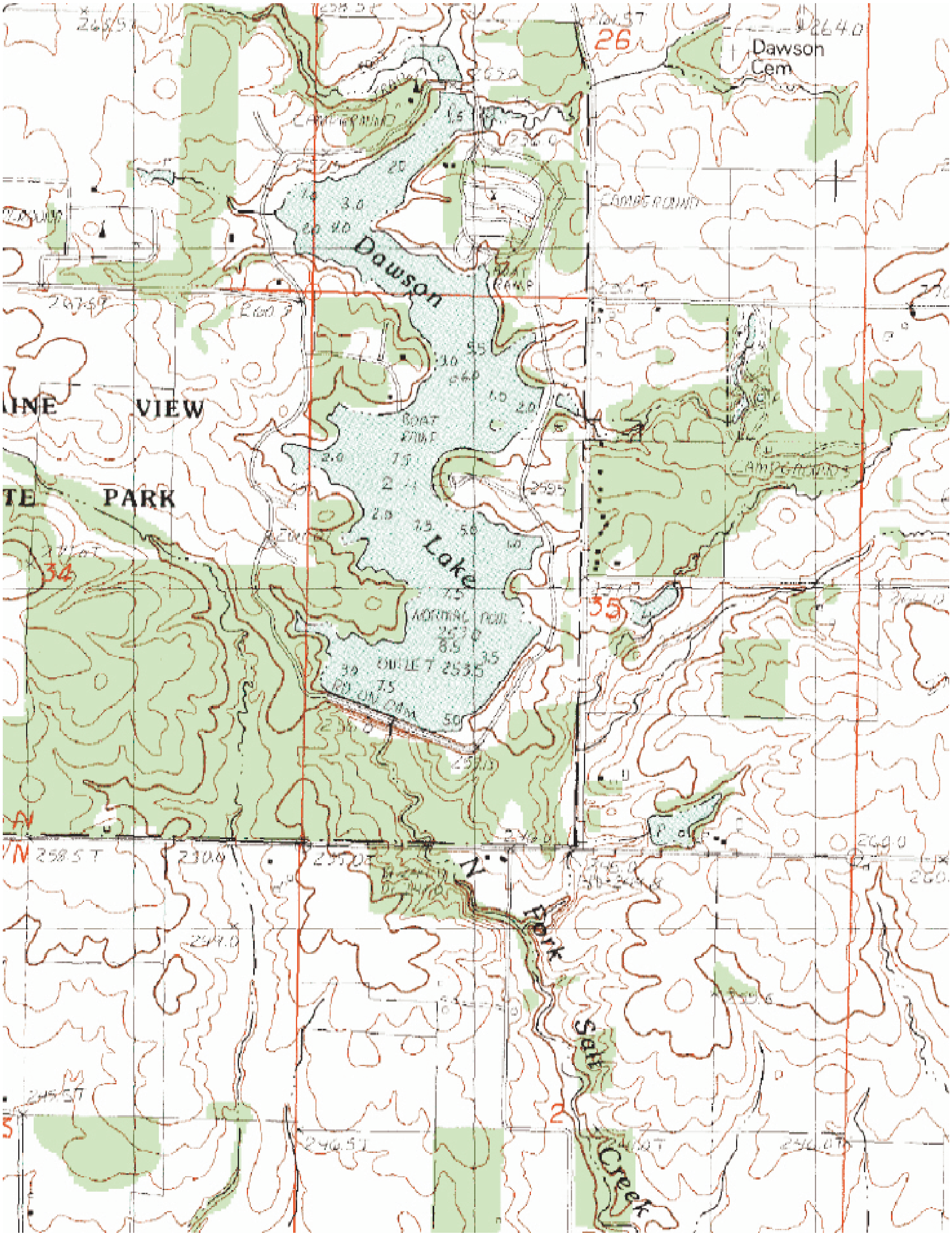

Figure 2.4-10 Dawson Lake and Dam located approximately 17.1 miles north-northeast of the ESP site. Dawson Lake is located on the North Fork of Salt Creek.

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 Section 2.4.4 of RS-002, Attachment 2, with regard to this objective.

Section 2.4.4 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 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 Section 2.4.4 of RS-002, Attachment 2, 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 miles east of the city of Clinton in DeWitt County, in central Illinois at elevation 735 ft MSL.

2.4.5.1 Technical Information in the Application

The applicant stated in Revision 0 of 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 the PMF condition. In Revision 4 of the SSAR, the applicant revised their approach to provide a higher level of conservatism, and the maximum storm surge at the site was stated as 0.3 ft. This value was computed using a wind speed of 100 mph, an effective fetch of 0.8 mi, and a water depth of 40.5 ft.

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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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. To determine whether the applicant met the relevant hydrologic requirements of 10 CFR Parts 52 and 100, the staff used the specific criteria 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). Further, RS-002, Attachment 2, 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.

In 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 identified 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).

If it has determined that surge and seiche flooding estimates are necessary to identify flood design bases, the staff will consider the applicant's analysis 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 USACE publications as described below.

- Combinations of surge levels and waves that may be critical to the design of a nuclear power plant(s) 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 the applicant elects Position 2 of RG 1.59, then it should demonstrate that the design basis for flood protection of all safety-related facilities identified in RG 1.29 is adequate in terms of the 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.

In this section of the safety assessment, the applicant may also justify 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 USACE, NOAA, and the staff are used for evaluating the conservatism of the applicant's estimates of severe windstorm conditions, as discussed in RG 1.59. The USACE and NOAA criteria call for variation of the basic meteorological parameters within given limits to determine the most severe combination that could result. The applicant's hydrometeorological analysis should be based on the most critical combination of these parameters.

The staff used data from the publications of NOAA, USACE, and other sources (such as tide tables, tide records, and historical lake level records) to substantiate antecedent water levels. These antecedent water levels should be as high as the "10-percent exceedance" monthly spring high tide, plus a sea level anomaly based on the maximum difference between recorded and predicted average water levels for durations of 2 weeks or longer for coastal locations or the 100-year recurrence interval high water for the Great Lakes. In a similar manner, independent staff analysis can evaluate the storm track, wind fields, effective fetch lengths, direction of approach, timing, and frictional surface and bottom effects 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 USACE, 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 USACE and other standard techniques are used to evaluate the potential for oscillation of waves at natural periodicity.

At the COL stage, the applicant will use the criteria and methods of USACE to evaluate the adequacy of protection from flooding, including the static and dynamic effects of broken, breaking, and nonbreaking waves. RG 1.102, Revision 1, "Flood Protection for Nuclear Power Plants," issued February 1976, provides further guidance on flood protection. RG 1.125, Revision 1, "Physical Models for Design and Operation of Hydraulic Structures and Systems for

Nuclear Power Plants," issued October 1978, provides guidance for using physical models in assessing flood protection.

2.4.5.3 Technical Evaluation

The staff conducted its review in accordance with Section 2.4.5 of RS-002, Attachment 2, 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 staff's independent evaluation performed 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 miles from the dam and 10 miles 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 (1984) the resulting solution is:

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

where ζ is the wind setup in ft; U is the wind speed 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.

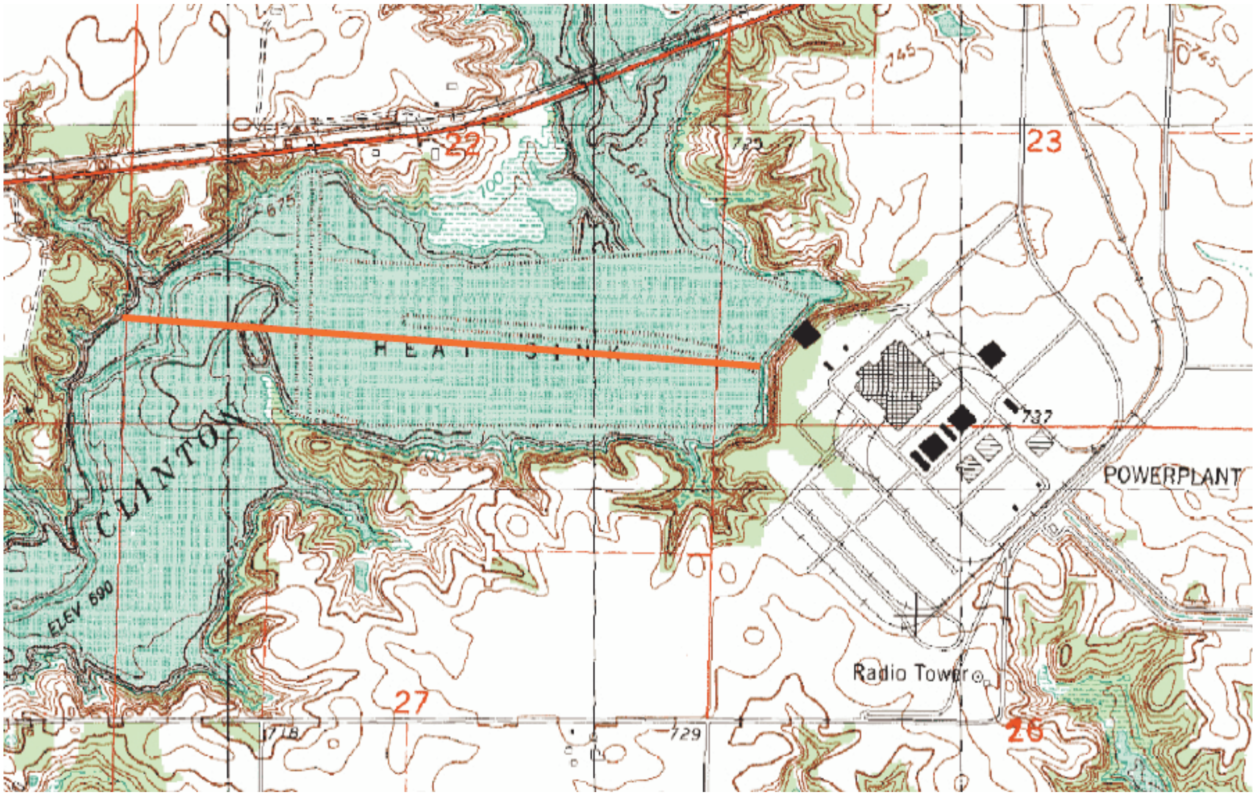

Figure 2.4-11 Clinton Power Station site and fetch length

One of the derivation assumptions in the wind setup equation above is that the wind speed 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 a 100-mph wind. This windstorm is based upon the location of the site, which is within 150 miles of the Great Lakes. The staff used this conservative value as the steady over-water wind speed 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 (Wilson, 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 feet per square second (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 concluded that meteorologically forced resonance is not likely. The staff also concluded 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 Section 2.4.5 of RS-002, Attachment 2, 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 Section 2.4.5 of RS-002, Attachment 2, 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). In addition, 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 miles 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 miles from the Clinton Dam to its confluence with the Sangamon River. The Sangamon River, from its confluence with Salt Creek, flows 40 miles to merge with the Illinois River north of Beardstown. The Illinois River flows 90 miles from its confluence with the Sangamon River to meet the Mississippi River near Grafton. The Mississippi River flows 1172 miles from its confluence with the Illinois River to the Gulf of Mexico (NOAA, 2004). The Gulf of Mexico is the body of open water directly downstream from Clinton Lake that is subject to seismically generated tsunamis.

2.4.6.1 Technical Information in the Application

The applicant stated in Revision 0 of SSAR Section 2.4.6 that "the site will not be subjected to the effects of tsunami flooding because the site is not adjacent to a coastal area." In Revision 3 of the SSAR, the applicant also considered the effects of a lake tsunami caused by a hillslope failure. The applicant's analysis produced a maximum tsunami height at 0.4 ft. Based on the elevation of the ESP site, the applicant concluded that landslide-induced tsunamis do not pose a risk to the site.

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 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 it addressed the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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 the hydrologic features of the site

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

The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require that the site's physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining its acceptability to host a nuclear reactor(s). The regulations at 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, the Commission considers 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 applicant should describe in detail sufficient to assess the acceptability of the site and the potential for a tsunami to influence the design of SSCs important to safety for a nuclear power plant(s) of specified type that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the most severe flooding likely to occur as a result of a tsunami would pose no undue risk to the type of facility proposed for the site.

In those cases for 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 parameters. Important PPE parameters for safety assessment identified in Section 2.4 include, but are not limited to, precipitation (e.g., maximum design rainfall rate and snow load) and the allowable site water level (e.g., maximum allowable flood or tsunami surge level and maximum allowable ground water level).

The regulation at 10 CFR 100.23(c) requires that geologic and seismic factors be considered when determining suitability of the site. This regulation also requires an investigation to obtain geologic and seismic data necessary for evaluating seismically induced floods and water waves. The regulation 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, as well as local features of coastal topography that might modify runup or drawdown. RG 1.70 provides more detailed guidance on the investigation of seismically induced flooding.

To determine whether the applicant met the requirements of 10 CFR Parts 52 and 100, as well as 10 CFR 100.23, with respect to tsunamis and the analysis thereof, the staff used the following specific criteria:

- If it has been determined that tsunami estimates are necessary to identify flood or low-water design bases, the staff will consider the analysis 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 on 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 the applicant adopts Position 2 of RG 1.59, it should show at the COL that the design basis for tsunami protection of all safety-related facilities identified in RG 1.29 is adequate in terms of the time necessary for implementation of any emergency procedures.

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

- This section of the 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

During its independent review, the staff found that, in extreme cases along coastal areas, the shoreline water level has risen to more than 50 ft for a 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 miles from the Great Lakes, the staff concluded 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, indicated 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 Section 2.4.6 of RS-002, Attachment 2, 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 Section 2.4.6 of RS-002, Attachment 2, 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 the design bases for tsunamis, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. Therefore, the applicant partially conforms to GDC 2, insofar as that analysis defines design bases related to tsunamis.

2.4.7 Ice Effects

The EGC ESP site is located on the shore of Clinton Lake, approximately 6 miles 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 miles 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 miles downstream from the Clinton Dam. The applicant reported 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, the ice jam raised the water surface by 2.7 ft.

The applicant stated 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 concluded 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 estimated 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 screenhouse is at elevation 670 ft MSL. The applicant stated that a water depth of 12.3 ft above the intake will be available for station operation, even under low-water conditions. The applicant concluded that the formation of a 10-in.-thick ice sheet will not block flow into the CPS screenhouse.

The applicant stated 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 stated that the UHS capacity will be maintained.

The applicant stated 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 described the possibility of an ice sheet formation on the surface of Clinton Lake in SSAR Section 2.4.7, but that section did 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 because a potential for formation of an ice sheet that could affect the intake structure exists, it will consider ice sheet effects at the COL stage. The applicant revised 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 stated 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 USACE, EM 1110-2-1612, “Engineering and Design—Ice Engineering,” issued in October 2002. 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 are 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 miles north of Clinton Lake. The applicant used air temperature data from Decatur, Illinois, located 10 miles 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 did 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 did 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 revised Chapter 2 of the SSAR and added a new section (Section 2.4.7.1) on frazil ice and anchor ice. The applicant stated 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 breaks loose from the streambed, it flows into Clinton Lake and forms or joins 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 screenhouse. 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 did 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 discussed this issue in two new paragraphs that it added to the end of SSAR Section 2.4.7, as well as in the new SSAR Section 2.4.7.1 provided in response to RAI 2.4.7-4.

The two new paragraphs that the applicant added to Section 2.4.7 state that no ice formation currently occurs in the discharge channel when the CPS Unit 1 is operating. The applicant expected no change to occur with the addition of the proposed ESP facility. The capacity of the discharge channel is approximately 3058.3 cfs or 1.37 million gpm at a discharge velocity of 1.5 feet per second (fps). The discharge from CPS Unit 1 is approximately 445,000 gpm of warm cooling water during the 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 stated that this combined discharge is well within the discharge capacity of the channel.

The applicant stated 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, leading to an increased potential for surface ice accumulation, particularly at locations away from the point of discharge. The applicant stated 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 stated that, if ice did form, it would remain on the surface, allowing unrestricted flow below the water surface. The applicant concluded that it did not expect jamming and clogging of the discharge channel because of icing.

SSAR Section 2.4.7 did 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 the ESP facility's 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 revised SSAR Section 2.4.7 to provide additional information on ice effects related to the ESP facility's UHS intake depth.

SSAR Section 2.4.7 provided an average thickness of an ice sheet on the surface of Clinton Lake. The staff needed 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 a 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 emergency cooling methods. The applicant stated that Clinton Lake is used as a source of makeup water for the ESP facility's UHS cooling towers and not as a heat sink. The applicant stated that if Clinton Dam were to be lost, any surface ice would also be expected to be 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, a small decrease in the capacity of the submerged UHS pond, which acts as the heat sink for CPS Unit 1, would occur. 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's 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.

In Revision 2 of the SSAR, the applicant stated that ice thickness calculations were carried out for the period 1902 through 2001. The applicant reported that the average ice sheet thickness over this period was 16.2 in. and that the maximum was 27.0 in. during 1977-78 winter. The applicant used accumulated freezing degree-days (AFDD) data from USACE Engineering Research and Development Center (ERDC) at the Cold Regions Research and Engineering Laboratory (CRREL) and the approach as described by ERDC/CRREL Technical Note 04-3. The applicant used a value of 0.8 for the ice cover condition coefficient. The applicant stated that the average AFDD was 409.9 with a maximum of 1141.5 (in Fahrenheit degree days) .

The applicant stated in Revision 2 of the SSAR that the openings of ESP intake structure will extend vertically from the water surface elevation to approximately 669 ft MSL, providing a vertical opening of about 21 ft when the Clinton Lake water surface elevation is at a normal pool level of 690 ft MSL. An ice sheet, equal in thickness to the maximum estimated ice-sheet thickness of 27.0 in., would potentially block only a small portion of the intake opening, leaving approximately 18.75 ft of vertical opening for water intake with initial lake water surface elevation at 690 ft MSL before ice formation, and a vertical opening of 5.75 ft if the initial lake water surface elevation were at the minimum of 677 ft MSL. The applicant stated that this vertical opening, combined with a normal horizontal dimension of the opening for an intake structure, would still be adequate for intake water requirements of the ESP plant.

The applicant stated in Revision 2 of the SSAR that no ice currently forms in the discharge channel with the CPS in operation, which discharges about 445,000 gpm of warm cooling water during winter months. The applicant reported that the capacity of the discharge canal at a flow velocity of 1.5 fps is 1,372,000 gpm, which will not be exceeded with the addition of approximately 12,000 gpm of warm blowdown water from the proposed ESP facility.

The applicant stated that there is some possibility of ice formation in the discharge channel if the ESP facility is operated alone and the CPS is offline, since the warm water discharge to the canal would be reduced to only 12,000 gpm. However, the applicant stated that any such ice would be thin, remain only on the surface, and not restrict flow in the discharge canal.

In Revision 2 of the SSAR, the applicant included a description of formation of frazil and anchor ice. The applicant stated that the current CPS facility water intake is designed to avoid obstruction from surface ice and accumulation of frazil ice by recirculating warm cooling water via a warming line back into the inlet to the screen house. The applicant noted that the warming line is designed to maintain a minimum water temperature of 40 °F during winter at the intake. The applicant reported that the CPS has not encountered a problem due to frazil ice accumulation on intake facilities.

The applicant stated in Revision 2 of the SSAR that a means to prevent the formation of frazil ice at the intake for essential service water cooling tower make-up would be provided, such as a warming line from the hot side of the cooling towers back to the intake. The applicant stated that the design of these features would support the operation of the ESP facility independent of the CPS facility.

The applicant estimated that approximately 326 ac-ft of liquid water would be displace by a 27.0 in ice sheet settling down on the UHS pond in the event of complete loss of the main dam. The applicant also estimated that an excess capacity of 395 ac-ft is normally available. Since the evaporation of water from the pond would be negligible in presence of complete ice cover, the applicant estimated that the net change would result in essentially the same excess capacity of liquid water in the UHS pond. If the main dam failure occurs with maximum ice thickness on the lake and the CPS facility not in operation, the UHS water normally reserved for CPS shutdown would also be available to the ESP facility. The applicant concluded that the UHS liquid water capacity is sufficient to support the combined emergency operation of CPS and the ESP facilities.

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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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. Further, RS-002, Attachment 2, 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.

In those cases for 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 staff used the following specific criteria in RS-002, Attachment 2:

- Publications of NOAA, 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 applicant should consider and evaluate if the following items are 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, the applicant should demonstrate 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(s) 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 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 the applicant reported. 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 using 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 718.5 ft MSL.

The staff estimated the all-season PMP depth for Clinton Lake’s drainage area in Section 2.4.3 of this SER using HMRs 51 and 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 a monthly PMP for areas exceeding 10 mi^2.

Methods for estimating a monthly PMP appear in HMR 33, but the current HMRs (i.e., HMRs 51 and 52) supersede that report. 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 the 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 a winter PMP and augmented by an ice-jam flood would be less critical than the all-season PMF.

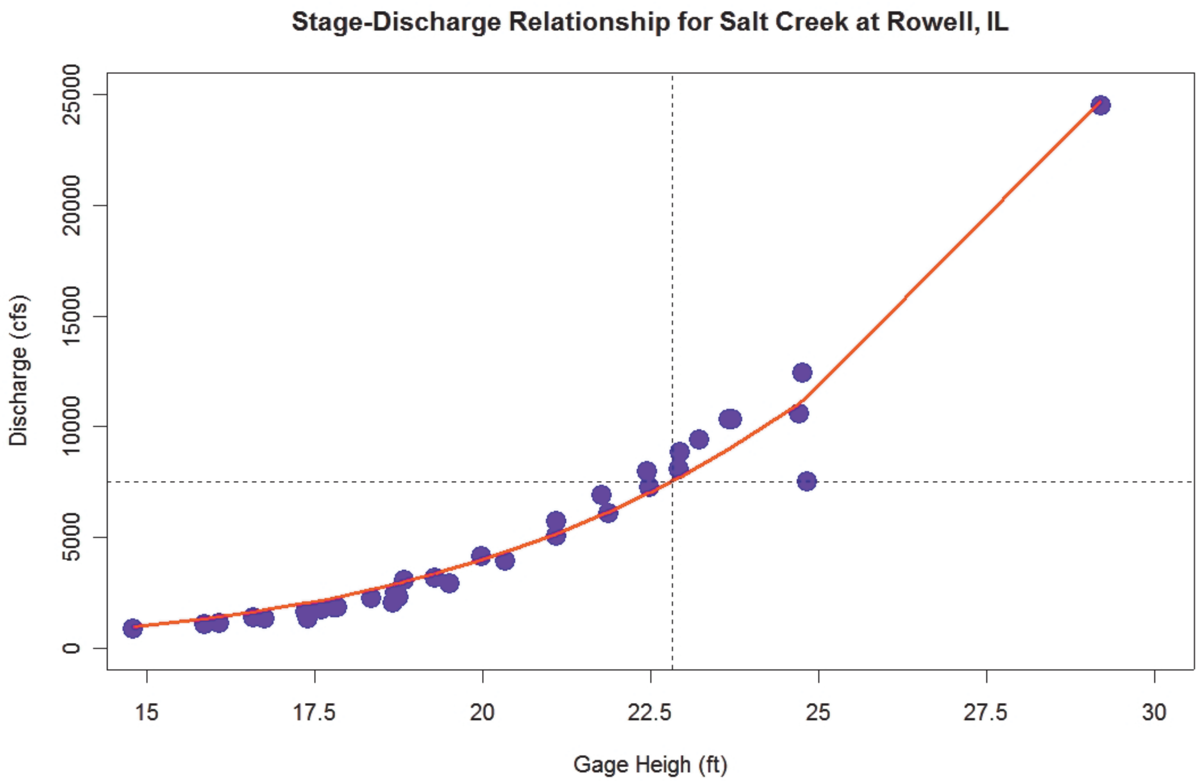

Figure 2.4-12 Stage-discharge relationship for Salt Creek at Rowell, IL

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).

The maximum accumulated degree-days below freezing during the period of December 1, 1976, to May 31, 1977, was 1086.5 EF, as shown in Figure 2.4-13. The staff used Assur's method (Chow, 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.

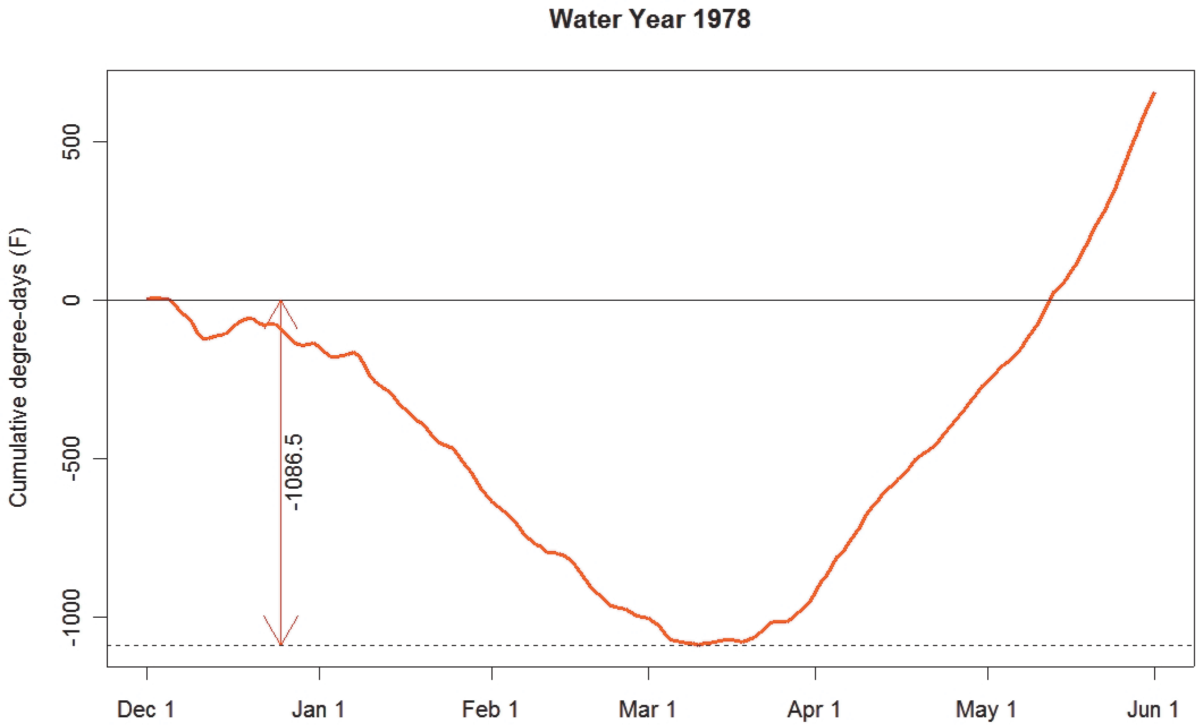

Figure 2.4-13 Accumulated degree-days since December 1, 1977, at the Decatur meteorologic station

SSAR Section 2.4.7 did 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 needed 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 a potential exists for an ice sheet to affect the intake structure, and the COL applicant would 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 would 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 **COL Action Item 2.4-5.** The staff had planned to include this issue as DSER Permit Condition 2.4-5. The staff had also planned to specify attributes of the ice sheet, such as its thickness, mass, and velocity, that the applicant should use for design of the ESP facility's UHS intake structures. The staff established maximum ice thickness based on its review of applicant's response to DSER Open Item 2.4-9 (see below). However, the need for a UHS intake structure will depend on whether the selected reactor type requires a UHS. The staff determined that COL Action Item 2.4-5 is sufficient to ensure the safety of the ESP facility's UHS intake structures, if the selected reactor design requires a UHS and concluded that it is not necessary to impose DSER Permit Condition 2.4-5.

SSAR Section 2.4.7 did not provide sufficient details about the estimation of ice sheet thickness. In RAI 2.4.7-2, the staff requested that the applicant provide details of the 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 was significantly greater than that of the applicant's. Therefore, the staff determined that the applicant needed to provide more details regarding the method and air temperature dataset it used in estimating the thickness of an ice sheet that may form on the surface of Clinton Lake. The staff also asked the applicant to demonstrate that the ice thickness estimate is adequate. This was DSER Open Item 2.4-9.

In response to DSER Open Item 2.4-9, the applicant stated, in its submission to the NRC dated April 26, 2005, that it obtained additional data, evaluated the differences between its and the staff's methods, and revised its estimate of ice thickness in Clinton Lake. The applicant presented the air temperature data and the method used for estimating the ice thickness in Clinton Lake in an attachment to its response.

The applicant stated that the above described evaluation established an expected maximum ice thickness of 24.8 in. for Clinton Lake, which should be used for determining the water available in the submerged UHS pond. The applicant stated that it based its estimation of expected maximum ice thickness on worst-case available air temperature data from the Decatur meteorologic station, which resulted in an estimated 1065 EF accumulated freezing degree-days. The applicant used procedures described in USACE EM1110-2-1612 (this document is also referred to as USACE (2002)) to estimate ice thickness as a function of estimated accumulated freezing degree-days. The applicant estimated the onset of ice layer formation in Clinton Lake based on observed freezing in another lake located approximately 180 miles north of Clinton Lake. The applicant disagreed with the staff's method for setting the onset of ice layer formation (the onset date affected the estimation of accumulated freezing degree-days) and the actual relationship used to estimate the ice thickness (the applicant claimed that the relationship used by the staff in the DSER did not consider recent advances in ice thickness estimation relationships).

The staff reviewed the applicant's response to DSER Open Item 2.4-9, including the additional data presented by the applicant and the details of the methods employed by the applicant for estimating ice thickness in Clinton Lake. The staff determined that the applicant used the same data as the staff had in preparing the DSER, except for the slightly longer duration of the dataset. The staff used air temperature collected at the Decatur meteorologic station for water years 1902–1999, and the applicant used air temperature data for all winters from 1896–2003. The longer dataset used by the applicant did not change the worst winter year (in terms of accumulated freezing degree-days) from that determined by the staff in its previous assessment.

The staff determined that there are two major differences in the revised ice-thickness procedure presented by the applicant in its response to DSER Open Item 2.4-9 as compared to the staff's previous procedure used in the DSER. The first difference is that the applicant used the estimation equation in USACE (2002), whereas the staff used Assur's 1956 equation in its DSER review. The second difference is that the applicant estimated the maximum accumulated freezing degree-days starting from an estimated freezeup onset date, whereas the staff used a fixed December 1 freezeup date in its DSER review. These two differences are discussed in detail below.

Ice Thickness Estimation Equation

Assur's ice-thickness estimation equation, which the staff used in the DSER, was published in 1956. The USACE (2002) estimation equation is more recent than Assur's estimation equation, although both equations estimate an ice thickness that is proportional to the square root of accumulated freezing degree-days. The difference between the two methods arises from the use of different coefficients of proportionality. Assur's equation applies a constant of proportionality of ($1.06 \times \alpha$), with different values for α recommended for ice sheets covered with moderate snow (α ranging from 0.65 to 0.75) and for ice sheets not covered with snow (α ranging from 0.85 to 0.9). Assur suggested a theoretical maximum value of 1.0 for α. The USACE (2002) equation applies a constant of proportionality α, only. The recommended value of α under windy, snow-free lake conditions is 0.8 and that under average lake conditions, in the presence of a snow cover, ranges from 0.5 to 0.7. Assur's equation is more conservative than the USACE (2002) equation because of the differences in the recommended values of α and the presence of 1.06 multiplier in Assur's equation. The staff used the most conservative α (equal to 0.9) recommended by Assur in the DSER review, which implies an ice sheet not covered with snow. For similar conditions, USACE (2002) recommends a maximum α of 0.8. Therefore, use of Assur's equation would yield an ice thickness 19 percent larger than that derived from the USACE (2002) equation for the same accumulated freezing degree-days.

The applicant stated in its response to DSER Open Item 2.4-9 that the USACE (2002) equation was more accurate because it was a refinement on the earlier method based on additional study. The staff's review of USACE (2002) did not provide any substantiation of this statement. The applicant did not provide any other reference that describes this refinement to enable the staff to assess the accuracy of the USACE (2002) equation in relation to Assur's equation. The applicant also stated that both ice-thickness estimation equations likely overestimate the ice thickness, but did not provide any references to substantiate this statement.

The staff contacted researchers at the USACE CRREL to determine the currently accepted standard for estimating ice thickness. Based on email communication with CRREL, the staff determined that USACE (2002) is the currently accepted standard for design ice engineering. Based on the above review, the staff determined that the USACE (2002) equation is acceptable for estimating the ice thickness in Clinton Lake and other safety-related water storage reservoirs, should any be required by the selected ESP plant reactor type.

USACE (2002) states that a differential equation describing the rate of thermal growth of an ice cover can be written based on several assumptions. These assumptions are (USACE, 2002):

1. Ice forms in a homogeneous, horizontal layer,
2. Ice grows only at its horizontal interface with water,
3. The thermal conditions in the ice layer are quasi-steady,
4. The heat flux from the water is negligible,
5. The heat flux is only in the vertical direction, and
6. The heat loss from the surface of the ice layer to the atmosphere is a linear function of the temperature difference between the surface of the ice layer and the air.

The first five assumptions above are appropriate for an ice cover formation on a lake surface when the horizontal extent of the ice cover is large compared to its thickness, and the lake is not very deep. The sixth assumption may be inaccurate at the beginning of ice formation when the ice cover is very thin.

The rate of thermal growth of ice can be expressed as

$$\frac{dh}{dt} = \frac{1}{\rho\lambda} \frac{(T_m - T_a)}{\left(\frac{h}{k_i} + \frac{1}{H_{ia}}\right)}$$

where h is ice thichness, t is time, T_m is temperature at ice and water interface, T_a is air temperature, k_i is thermal conductivity of ice, H_{ia} is heat transfer coefficient from the surface of the ice to the atmosphere, ρ is density of ice, and λ is latent heat of ice. The nonlinear differential equation above can be solved (USACE 2002) to yield

$$h_j = \sqrt{(B + h_k)^2 + 2A(U_j - U_k)} - B$$

where h_j is calculated ice thickness on jth day, h_k is ice thickness on kth day, either observed or calculated with $j > k$,

$$A = \frac{k_i}{\rho\lambda},\; B = \frac{k_i}{H_{ia}},\; U_j = \sum_{i=1}^{j} (T_m - T_{ai}), \text{ and } U_k = \sum_{i=1}^{k} (T_m - T_{ai}).$$

U_j and U_k are accumulated freezing degree-days between onset of freezeup and days j and k, respectively, with $U_j > U_k$, and T_{ai} is air temperature on ith day. If heat conduction through the ice cover is the controlling rate in overall energy flux (i.e., $k_i << H_{ia}$), B can be ignored. Additionally, if initial ice thickness is assumed to be zero (i.e., $U_k = 0$), then ice thickness on jth day is

$$h_j = \alpha\sqrt{U_j}$$

where

$$\alpha = \sqrt{\frac{2k_i}{\rho\lambda}}\,.$$

Maximum Accumulated Freezing Degree-Days

The applicant used accumulated freezing degree-days in the USACE (2002) ice-thickness estimation equation based on the most severe winter on record at Decatur, Illinois. The staff used this same winter in its DSER estimation of ice thickness for Clinton Lake. However, the applicant's estimate of accumulated freezing degree-days is 963 EF, as compared to the staff's DSER estimate of 1086.5 EF; the applicant's estimate is, 11.4 percent lower than the staff's DSER estimate.

The staff's review of the applicant's method for estimating accumulated freezing degree-days during winter revealed that the difference between the applicant and the staff's estimate arises mainly from the difference between the onset of freezeup determined by the applicant and that previously assumed by the staff. The applicant presented data for observed freezeup of Monona Lake, which is located approximately 180 miles north of Clinton Lake near Madison, Wisconsin. The Wisconsin State Climatology Office has maintained freezeup dates for Monona Lake since 1851. The applicant analyzed accumulated freezing degree-days and corresponding observed freezeup dates for Monona Lake for the winters from 1896 through 2003, and concluded that accumulated freezing degree-days ranging from a low of 80 EF to a high of 406 EF are required for Monona Lake to reach freezeup. The applicant argued that freezeup in Clinton Lake would be similar to that in Monona Lake, even though the two lakes have different average depths (15 ft for Clinton Lake as compared to 27 ft for Monona Lake). For the winter of 1977–78, the applicant estimated a freezeup date of December 27 for Clinton Lake, assuming that approximately the same number of accumulated freezing degree-days would be required for freezeup to occur for both lakes. The applicant estimated cumulative positive freezing degree-days from November 1 through the day before the observed freezeup date at Monona Lake and assumed that the date of freezeup at Clinton Lake would be the day with the same or nearly the same cumulative positive freezing degree-days. Based on this assumption, the applicant-estimated maximum accumulated freezing degree-days during the winter of 1977–78 is 963 EF, a reduction of 11.4 percent from the staff's DSER estimate of 1086.5 EF.

The staff contacted the Wisconsin State Climatology Office and talked to Dr. Edward Hopkins, the Assistant State Climatologist. Based on this conversation, the staff determined that lake freezeup data for the United States can be obtained from the National Snow and Ice Data Center located in Boulder, Colorado. The Wisconsin State Climatology Office has done some characterization of the extensive freezeup and ice observation it carries out and maintains for some of the Wisconsin lakes, including Monona Lake. According to this characterization (see http://www.aos.wisc.edu/%7Esco/lakes/icesum05.html), the median freezeup date for Monona Lake is December 15. The earliest Monona Lake froze was on November 22, 1880. The latest freezeup date was January 30, 1932.

During the conversation with Dr. Hopkins, the staff also became aware of a power plant that discharges warm water, run through its condenser, into Monona Lake. The staff's further investigation revealed that Madison Gas and Electric owns and operates Blount Station, which was constructed in 1902 with a maximum generating capacity of 200 megawatts (MW) (see http://www.mge.com/about/electric/blount.htm). Although more details of the Blount Station discharge are not available, the staff concluded that Monona Lake is not an appropriate lake to compare to Clinton Lake in terms of freezeup for two reasons. First, the warm water discharged from Blount Station into Monona Lake has some influence on its freezeup dates, particularly since 1902, affecting any estimation of freezeup dates under natural conditions using the observed freezeup of Monona Lake since 1902. An inspection of the time series of duration of ice cover (created by the Wisconsin State Climatology Office) on Monona Lake for the winters from 1851 to 2005 revealed a significant drop in the duration of ice cover immediately after construction of the Blount Station in 1902 (see http://www.aos.wisc.edu/%7Esco/lakes/monona-dur.gif), reflecting the effect of the power plant discharge on the freezing characteristics of the lake. Second, Monona Lake is significantly deeper (27 ft) than Clinton Lake (15 ft). Based on these reasons, the staff determined that the applicant's conclusion that Clinton Lake's freezeup is similar to that of Monona Lake is not appropriate.

The staff obtained freezeup data for lakes in the vicinity of Clinton Lake from the National Snow and Ice Data Center, but could not locate a lake with characteristics similar to those of Clinton Lake for an independent verification of the freezeup dates the applicant used in its analysis. Based on the characteristics of Monona Lake, accounting for the fact that its freezeup in winter is affected by discharge form Blount Station, the staff determined that it is not overly conservative to assume a freezeup date of December 1 for Clinton Lake. In years not affected by the Blount Station discharge, Monona Lake froze as early as November 22.

Based on the above review, the staff determined that ice thickness in Clinton Lake should be determined using a conservative freezeup date of December 1 and the USACE (2002) estimation equation. The staff's revised its estimate of maximum ice thickness in Clinton Lake to 26.4 in. as shown below.

$$h_i = \alpha \cdot \sqrt{AFDD} = 0.8 \times \sqrt{1086.5} = 26.4\, in$$

Based on the above review, the staff had planned to include a maximum ice thickness of 26.4 in. as a site characteristic in any ESP that may be issued for this site.

Subsequent to discussions with the applicant over concerns that December 1 may be too conservative (i.e., early in the winter season) for initiation of freeze-up, the staff reviewed USACE technical note ERDC/CRREL TN-04-3, "Methods to estimate River Ice Thickness Based on Meteorological Data" by K.D. White. This technical note recommends that freezing degree days (FDD) and AFDD be calculated starting October 1 of each water year. The technical note mentions that AFDD do not begin accumulating until the first sustained period of cold temperatures, and that the "zero AFDD" point be assigned to a day in late fall or early winter when the AFDD curve goes from a negative to a consistently positive slope.

The staff obtained AFDD data from ERDC located in Hanover, New Hampshire. ERDC calculated AFDD data based on mean daily air temperature recorded at the National Weather Service station in Decatur, Illinois, for water years 1902 to 2000. According to USACE (E-mail correspondence between Rajiv Prasad and Carrie M. Vuyovich), AFDD on any day of the winter season, $AFDD_n$, represents the accumulated difference between freezing and the average daily temperature for the previous *n* days. The accumulation process starts each fall before the average daily temperature has fallen below freezing. ERDC starts calculation of AFDD on August 1 of each year and the calculation ends July 31 of the following year. AFDD graph through a winter can show multiple peaks. Early in the winter, AFDD graph can also fall to zero during warm spells.

The staff extracted the "zero AFDD" date for each water year during 1902-2000 corresponding to maximum AFDD values. The "zero AFDD" date corresponding to maximum AFDD for water years on record varied from November 16 to March 5, with 14 percent falling in November, 60 percent in December, 21 percent in January, four percent in February, and one percent in March. Fifteen percent of “zero AFDD” dates preceded December 1. The staff determined that winter of water year 1978 (calendar years 1977-1978) was the coldest on record with a maximum AFDD of 1141.5 EF (Figure 2.4-14 below). The “zero AFDD” day for this year was November 25, 1977. The maximum AFDD occurred on March 10, 1978. The staff revised their estimate of maximum ice thickness in Clinton Lake to 27.0 in as shown below.

$$h_i = \alpha \cdot \sqrt{AFDD} = 0.8 \times \sqrt{1141.5} = 27.0\,in$$

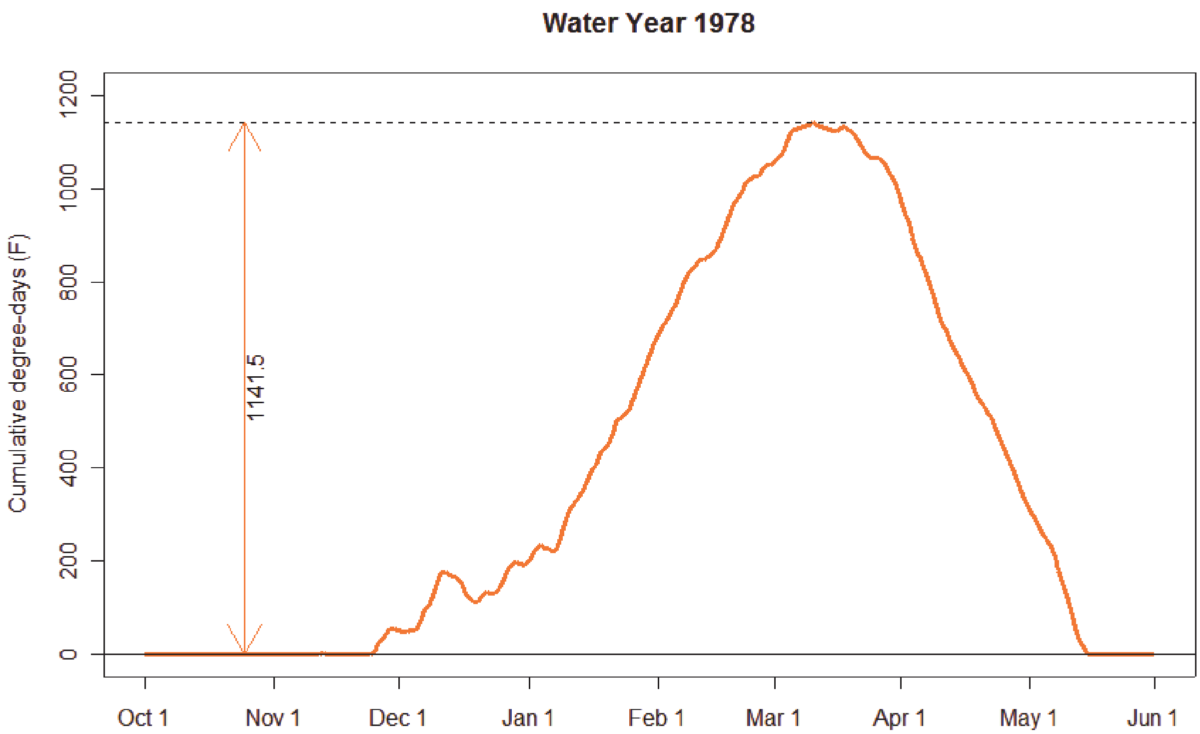

Figure 2.4-14 AFDD during 1977-78 as calculated by Engineering Research and Development Center, Hanover, New Hampshire.

The applicant revised its ice thickness estimation and described the revisions to the application in a letter dated December 21, 2005, to the NRC. The applicant stated that ice thickness was estimated for the Clinton Lake during the period 1902-2001. The applicant obtained AFDD data for Decatur, Illinois, from the ERDC and revised its estimation of ice thickness using the procedure described in the USACE Engineering and Design-Ice Engineering Manual (EM1110-2-1612) and USACE technical note ERDC/CRREL TN-04-3. The applicant used a value of 0.8 for the coefficient of ice cover condition (α in the equation above). The applicant reported that the mean ice thickness estimated over the period 1902-2001 is 16.2 in. with a maximum ice thickness of 27.0 in. during the 1977-78 winter.

The applicant stated further that the only ESP structure exposed to ice in Clinton Lake is the new ESP intake structure, which will be similar to, but smaller than the existing CPS intake structure. The intake openings of the ESP intake structure are expected to vertically extend from an elevation of 690 ft MSL, the normal water surface elevation in Clinton Lake, to 669 ft MSL providing an opening of approximately 21 ft within the lake. The applicant stated that the maximum estimated ice thickness of 27 in. (2.25 ft) would only block a relatively small portion of the total ESP intake opening with 18.75 ft of the opening still available for inflow. The applicant stated that if the water surface elevation in Clinton Lake falls to its minimum elevation of 677 ft MSL, the height of the intake opening will reduce to 5.75 ft, which, the applicant stated, is more than adequate to maintain required inflow for the ESP facility intake. These design issues will be reviewed by the staff at the COL stage according to existing NRC regulations and regulatory guidance.

The applicant also stated that the final intake structure design will include effects of applicable ice forces on the intake structure including those related to crushing, bending, buckling, splitting, or a combination of these. The applicant stated that the total force on the entire structure is important for the design of foundations to resist sliding and overturning, and local contact forces are important in the design of internal intake structural members and the external skin of the intake structure. As stated above, the design issues will be reviewed by staff at the COL stage according to existing NRC regulations and regulatory guidance.

Based on the above review, the staff proposes to include a maximum ice thickness of 27 in. as a site characteristic in any ESP that may be issued for this site. Therefore, the staff considers Open Item 2.4-9 resolved.

SSAR Section 2.4.7 did not provide sufficient detail for the staff to determine the relationship of the ESP facility's intake structure to the existing CPS intake structure and the depth of water over the intake during normal and low-water conditions. The staff needed 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's 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's intake structure. According to Figure 5.3-1 in the EGC ESP environmental report (ER), the ESP facility's 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 needed the bounding dimensions and critical elevations of the ESP facility's intake structure, including its conceptual plan and cross section, clearly indicating the elevation of the basemat, the elevation of the screenhouse opening, the elevation of the NHS makeup water intake pipe, the elevation of the UHS makeup water intake pipe, and their relationship to the existing lake bed. The staff asked the applicant to provide a schematic diagram clearly showing these items. This was DSER Open Item 2.4-10.

In response to DSER Open Item 2.4-10, the applicant stated, in its submission to the NRC dated April 4, 2005, that the EGC ESP ER Figure 5.3-1 is a cross section of Clinton Lake looking away from the CPS intake; the 668 ft MSL elevation refers to the lake and not the plant intake structure. The applicant stated that the design of the ESP intake structure will depend upon the reactor selected for the ESP facility and, therefore, no schematic diagrams of the intake structure are available at the ESP stage. The applicant noted that SSAR Section 2.4.7 provides the approximate elevation of the screenhouse openings and mentions that the ESP intake structure will be similar to the existing CPS intake structure except that it will be smaller. The intake opening(s) to the ESP intake structure will extend vertically from an elevation of 690 ft MSL or higher to approximately 669 ft MSL. The applicant stated that the basemat of the ESP intake structure is expected to be located similarly to that of the CPS intake structure, which is located at an elevation of 657.5 ft MSL. The final design elevation of the ESP intake basemat will depend on the submergence requirements of the ESP UHS makeup water pumps. The applicant also stated that there will be no intake pipe since vertical intake pumps will be located in suction bays behind the intake screens. The applicant stated that the lake bottom at the intake is at an elevation of 668.5 ft MSL.

The staff's concern in DSER Open Item 2.4-10 was to verify that the ESP UHS makeup pumps will have sufficient submergence within the intake structure to ensure that no interference is caused by any ice sheet that may form on the surface of Clinton Lake during low-water conditions in the lake. The staff reviewed the applicant's response to DSER Open Item 2.4-10 and concluded that sufficient design details of the ESP UHS makeup water pumps are not available at the ESP stage to justify a schematic diagram of the proposed ESP intake structure. The staff will evaluate the design of the ESP intake structure at the COL stage in accordance with NRC regulations and regulatory guidance to ensure the safety of the ESP facility. Based on this review, the staff considers DSER Open Item 2.4-10 resolved (see COL Action Item 2.4-7).

SSAR Section 2.4.7 did not provide sufficient detail regarding formation of frazil and anchor ice on or near the intake structure. The staff needed 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's 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 **COL Action Item 2.4-6**. The staff planned to include this item as DSER Permit Condition 2.4-6. However, the need for an ESP facility UHS intake structure is dependent on whether the selected reactor design requires a UHS. Since the reactor design has not been selected at the ESP stage, the staff determined that COL Action Item 2.4-6 is sufficient to preclude the formation of frazil and anchor ice on the ESP facility's UHS intake inlet, should the selected reactor design require one. The staff concluded, therefore, that it is not necessary to impose DSER Permit Condition 2.4-6.

SSAR Section 2.4.7 did 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. Second, the staff was concerned with ice formation in Clinton Lake and not in the discharge channel. COL Action Item 2.4-6 will ensure that the minimum intake water temperature is 40 EF at all times and, in the event that CPS Unit 1 is 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 did not provide sufficient detail for the staff to determine whether the formation of ice on the lake and near the intake structure could constrain intake depth. The staff needed 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's 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 staff determined that the ESP facility's UHS intake needs to be located below an elevation of 674.4 ft MSL. According to ER Figure 5.3-1, the ESP facility's 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 location of the ESP facility's UHS intake at an elevation of 668 ft MSL. This is **COL Action Item 2.4-7**. The staff had planned to include this item as DSER Permit Condition 2.4-7. However, the need for an ESP facility UHS intake structure depends on whether the selected reactor design requires a UHS. Since the reactor design has not been selected at the ESP stage, the staff determined that COL Action Item 2.4-7 is sufficient to ensure that the ESP facility's UHS intake will be located at an elevation of 668 ft MSL. The staff concluded, therefore, that it is not necessary to impose DSER Permit Condition 2.4-7.

SSAR Section 2.4.7 provided 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, thus resulting 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 a 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 requested in 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's UHS, and not as a heat sink. However, in its response to the RAI, the applicant took credit for heat of fusion of ice available for heat removal, even though it 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 disagreed, therefore, that heat of fusion of ice is available for cooling needs.

The staff determined that 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 was **DSER Open Item 2.4-11**.

In response to DSER Open Item 2.4-11, the applicant stated, in its submission to the NRC dated April 26, 2005, that the amount of water displaced by the settling of an ice sheet into the submerged UHS pond following a catastrophic failure of Clinton Dam, while an ice sheet was already present on the surface of Clinton Lake, would be approximately 300 ac-ft. The applicant estimated this displacement using the top surface area of 158 ac for the submerged UHS pond multiplied by an ice sheet thickness of 24.8 in. and then accounting for the ratio of the density of ice to the density of water, which is 0.917 (158 ac x 24.8 in. / 12 in./ft x 0.917 = 299.4 ac-ft).

The applicant stated that its previous assumption that the ice would float away in the event that Clinton Dam broke was based on the scenario with both the CPS and the ESP facility operating. The applicant stated that excess capacity in the submerged UHS pond is greater with the ice sheet covering the surface than without the ice sheet because the ice cover would restrict evaporation from the submerged UHS pond to a negligible amount. The applicant stated that excess volume in the submerged UHS pond corresponding to both ice-covered and open-water scenarios is provided in response to DSER Open Items 2.4-14 and 2.4-16.

The applicant also stated that if complete failure of the Clinton Dam were to take place while an ice sheet was covering the submerged UHS pond, but CPS was not operating, then the volume usually reserved for the CPS UHS cooling requirements (approximately 327 ac-ft over 30 days) would also be available to the ESP facility's UHS makeup (approximately 87 ac-ft over 30 days) and would be sufficient to meet the ESP facility's UHS requirements.

The staff reviewed the applicant's response to DSER Open Item 2.4-11 and concluded that it provided enough information to quantify a reduction in water storage capacity of the submerged UHS pond resulting from the presence of surface ice in Clinton Lake. Based on the staff's revised estimate of maximum ice thickness (see the discussion above related to DSER Open Item 2.4-9) in Clinton Lake, the staff estimated that the volume of displaced liquid water caused by this ice sheet settling into the submerged UHS pond is approximately 326 ac-ft (158 ac x 27.0 in / 12 in/ft x 0.917 = 326.0 ac-ft). The staff also used the information provided by the applicant in response to Open Item 2.4-11 to help resolve other open items related to the submerged UHS pond water storage capacity.

In a letter dated December 21, 2005, the applicant revised its maximum ice thickness estimate to 27.0 in. The applicant also revised its earlier response to Open Item 2.4-11 in this letter and revised its estimate of reduction in the storage capacity within the submerged UHS pond in presence of surface ice. The applicant stated that the reduction of storage capacity in the submerged UHS pond due to an ice sheet 27.0 in. in thickness will be approximately 326 ac-ft. Based on applicant's revised response to Open Item 2.4-11, the staff determined that applicant's revised ice thickness is identical to the staff's independent estimate. Therefore, the staff considers Open Item 2.4-11 resolved.

2.4.7.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of ice effects at the site. SSAR Section 2.4.7 conforms to Section 2.4.7 of RS-002, Attachment 2, 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 did 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 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 miles 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's 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 stated 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 screenhouse 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 evaluated the capacity of the lake under a design drought with a 100-year recurrence interval. The applicant committed to maintain the lake water surface elevation at 677 ft MSL even during a 100-year drought. The applicant stated 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 stated 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 an 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 estimated the PMF level in Clinton Lake to be 708.8 ft MSL and the maximum level, corresponding to wave runup acting on the PMF level, to be 711.95 ft MSL. The top of the dam is at a slightly lower elevation of 711.8 ft MSL. The applicant estimated that the duration for which wave action on a PMF level would lead to overtopping of the dam as 2.5 hours. The applicant stated 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 stated in SSAR Section 2.4.8.1.2 that the ESP facility would require no changes to the service spillway. 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 an 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 stated 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 stated 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 estimated 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 stated 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 stated 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 screenhouse 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. 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 screenhouse. 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 to be 3.8 and 11.8 fps, respectively, 43 hours after the main dam breach. The maximum velocity estimated on the face of the baffle dike is 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 are 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 stated in SSAR Section 2.4.8.2 that the existing CPS discharge flume would convey the blowdown discharge from the ESP facility to the Salt Creek finger of Clinton Lake. The applicant stated 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 stated 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 change to the discharge flume. The discharge flume is located to the east of the plant area and runs due east towards Clinton Lake. The applicant stated 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 miles, 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 fill 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 an 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-megawatt electric (MWe) power generation facilities. The applicant stated that this design considers 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 it to be 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 loss-of-coolant accident (LOCA) and a loss of offsite 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 whether 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 stated that the CPS 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 stated that the ESP facility would 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's UHS-required water, equal to 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 declines to less than 849 ac-ft so that dredging would occur 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 Section 9.2.5.3 of the CPS USAR, 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 revised SSAR Section 2.4.8.1.5 to provide additional information regarding its estimation of the 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. 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 updated 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, "Low Flows of Illinois Stream for Impounding Reservoir Design," of the Illinois State Water Authority, issued 1964.

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. The applicant estimated Inflow into the lake 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. The applicant assumed the downstream discharge through the dam to be a minimum of 5 cfs when the lake level was at or below the 690 ft MSL spill elevation. The drought analysis did not allow the lake level to exceed 690 ft MSL. The analysis did allow the discharge 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 a 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 applicant divided the forced evaporation rate from the CPS USAR by 0.7 to obtain the forced-evaporation rate for a 100-percent load factor. The applicant then divided the resulting forced-evaporation rate by two 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 a 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 it developed a model based on the method of Langhaar to determine the amount of forced evaporation. The model was validated based on its agreement with the results of an earlier study by Edinger. The applicant then applied the model 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 was the total, or the sum of natural and forced evaporation. Forced evaporation was 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 applicant carried out the drawdown calculations on a monthly time step. EGC calculated a net volume gain or loss 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. It then repeated these calculations 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 per month (ac-ft/mo). The applicant stated that the total amount of water available during the 100-year drought is 2400 ac-ft/mo. The applicant estimated that the amount of available water in excess of that needed for the CPS unit is 1300 ac-ft/mo 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/mo. The applicant estimated that the amount of available water in excess of that needed for the CPS unit is 2000 ac-ft/mo during the 50-year drought.

The applicant also stated that the available water quantities are expected to 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 were to be 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's 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.

In Revision 4 of the SSAR, the applicant stated that the probable maximum flood water surface elevation is 709.8 ft MSL. The applicant also stated that any overtopping wave would only produce a spray because of riprap placed on the upstream face of the dam. The applicant stated that the downstream face of the dam is protected against gully erosion by grass and therefore, any overtopping resulting in spray on the downstream face is not expected to result in significant damage to the dam.

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 the 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 applicant should include details in its analysis of cooling water canals and reservoirs 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.

In those cases for 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 stated 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 stated 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 stated 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, 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's UHS system would be 73.6 x 1.33 x 1.2 = 117.4 ac-ft. The staff's estimate was considerably different from the applicant's estimate of 87 ac-ft. The staff determined that the applicant needed to justify its makeup water requirements for the proposed UHS. This was DSER Open Item 2.4-12.

In response to DSER Open Item 2.4-12, the applicant stated, in its submission to the NRC dated April 4, 2005, that the difference between the EGC and the NRC estimates of the 30-day makeup water needed for the ESP facility's UHS is the result of double counting of the blowdown in the NRC estimate. The applicant explained that if the average makeup flow rate of 555 gpm (SSAR Table 1.4-1, item 3.3.9) used by the NRC in its calculations, which includes blowdown, were replaced by 411 gpm (SSAR Table 1.4-1, item 3.3.7), the 30-day makeup water volume needed for the ESP UHS system would be 87 ac-ft.

The staff reviewed the applicant's response to DSER Open Item 2.4-12 and verified that the applicant's calculations were accurate. The staff also verified that the 30-day makeup water volume required by the ESP facility's UHS, excluding blowdown, would be 87 ac-ft. Based on the above review, the staff considers DSER Open Item 2.4-12 resolved.

The staff concluded that the applicant needed to provide additional details on the ESP facility's normal and UHS systems and their cooling water requirements to allow determination of the maximum PPE heat rejection parameters. The applicant needed to provide a commitment to specific ESP facility normal and UHS systems for the staff to conclude this review. The staff needed this information at the ESP stage to evaluate the adequacy of the water stored in the submerged UHS pond available for the ESP facility. This was DSER Open Item 2.4-13.

In response to DSER Open Item 2.4-13, the applicant stated, in its submission to the NRC dated April 4, 2005, that SSAR Table 1.4-1 provides the maximum PPE heat rejection requirements and, therefore, the staff need not determine them.

The applicant stated that the ESP facility NHS will be a mechanical draft cooling or a natural draft cooling tower system. The applicant stated that the NHS cooling tower may use dry cooling in combination with wet cooling, or only wet cooling, depending on the selected reactor type for the ESP facility. The applicant also stated that a commercial decision might be made to use wet/dry cooling to limit the amount of evaporation and maintain plant operation during drought periods.

The applicant stated that the ESP facility's UHS, if one were required by the selected reactor type, would consist of a mechanical draft cooling tower(s). The applicant also stated that some of the reactor types that could be used for the ESP facility use passive cooling or air blast cooling and do not require a UHS. The applicant argued that because not all reactor types that could be used for the ESP facility require a UHS, the SSAR was written to recognize that a UHS will be provided only if required.

The applicant stated that the adequacy of the submerged UHS pond volume available for the ESP facility cannot be determined until the design of the ESP facility is determined. The applicant stated that at the ESP stage, it was only possible to determine the volume of water available in the submerged UHS pond that could be utilized for safe shutdown of the ESP facility.

The staff reviewed the applicant's response to DSER Open Item 2.4-13 and determined that, as stated in the SSAR and as reiterated by in its response, it is possible that the ESP facility may require a water-cooled UHS. The actual design of the NHS and UHS is an issue that is beyond the scope of this ESP review. However, site characteristics that govern and may limit the design of the NHS and UHS must be established at the ESP stage. The COL or CP applicant needs to conclusively establish that any water-cooled UHS that may be required by a reactor type selected for the ESP facility will be designed to a maximum 30-day makeup water requirement not exceeding 87 ac-ft. This is **COL Action Item 2.4-8.** The COL or CP applicant also needs to establish that the ESP facility's NHS is designed such that there is no over-reliance on the UHS for frequent plant shutdowns. This is **COL Action Item 2.4-9.** Therefore, the staff considers DSER Open Item 2.4-13 to be resolved.

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 agreed that a depth-averaged temperature model would indeed be conservative for temperature; however, the increased heat loss would come, in part, from increased forced evaporation. This implies that a depth-averaged model may not be conservative in terms of the volumetric analysis. 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 two 992-MWe units originally planned. The applicant did not provide the volume requirements for the existing single uprated 1138.5-MWe CPS facility. The staff concluded that inadequate information exists to review the earlier modeling study on which the applicant relied. The staff determined that the applicant needed to provide the volume requirements of the UHS for the CPS, taking into consideration the latest power uprate. This was DSER Open Item 2.4-14.

In response to DSER Open Item 2.4-14, the applicant stated, in its submission to the NRC dated April 26, 2005, that the required capacity of the UHS for the CPS uprated Unit 1 is 586 ac-ft. The applicant-estimated CPS shutdown cooling water consumptive use is 327 ac-ft, obtained by multiplying the consumptive water use of 590 ac-ft for the two originally planned CPS units by the ratio of the uprated CPS unit shutdown heat load to the shutdown heat load of the two CPS units originally planned (590 ac-ft x 99,973 BTU / 180,455 BTU = 327 ac-ft). The required capacity of the UHS (i.e., 586 ac-ft) includes 327 ac-ft consumptive use for the CPS facility, 3 ac-ft for fire protection, 35 ac-ft for sedimentation from a 100-year flood, and 221 ac-ft for sediment inflow during SSE liquefaction.

The staff reviewed the applicant's response to DSER Open Item 2.4-14 and determined that the consumptive water use for the uprated CPS facility is 327 ac-ft. The applicant provided enough information to resolve the issue stated in DSER Open Item 2.4-14. Therefore, the staff considers DSER Open Item 2.4-14 resolved.

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 a discussion of flow velocities over the crest and toe of the submerged UHS dam is an unnecessary detail for an ESP review and it revised the appropriate section of the SSAR 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. Such measures should protect these structures against erosion. The staff determined, therefore, that the applicant specified erosion protection measures and that its 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 a 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 to 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 needed 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 was DSER Open Item 2.4-15.

In response to DSER Open Item 2.4-15, the applicant stated, in its submission to the NRC dated April 26, 2005, that the 5-year-duration drought was used to evaluate Clinton Lake in the original lake study and the more recent evaluation of the uprated CPS. The applicant stated that, for consistency, the same duration drought was also used for the current ESP application. The applicant also stated that a review of duration of the drought indicated that it is still appropriate rather than a shorter duration drought of significantly lower inflow estimate.

The applicant stated that the storage capacity of Clinton Lake is large enough that short duration droughts of 1 to 2 years do not create critical conditions. The applicant’s simple mass-balance calculation with zero inflow indicated that it will take approximately 20 months for Clinton Lake to drop from an initial water surface elevation of 690 ft MSL to the CPS and ESP facility shutdown water surface elevation of 677 ft MSL. The applicant also stated that with an extreme low inflow of 0.04 in. every month, the lake can support normal plant operation for approximately 29 months.

The applicant stated that its review of inflow values associated with the current 5-year-duration drought indicated that shorter-duration droughts are embedded within the 5-year drought used in its analysis for the ESP application. The applicant stated that CPS USAR Table 2.4-24 shows the “5-year duration” drought used in the analysis for the ESP application. The first year of the 5-year drought had a cumulative runoff volume of 0.85 in., which is close to the 45-year recurrence interval, 1-year inflow volume of 0.91 in. shown by Table 4 of the Stall (1964) report. The applicant argued that the 1-year, 50-year recurrence interval drought is thus accounted for in the first year of the 5-year-duration drought. Similarly, the applicant argued, that the first 2 years of the 5-year drought had a cumulative inflow of 4.9 in. as compared to the 45-year recurrence interval, 2-year inflow volume of 4.94 in., reported by Stall (1964). Also, the 5-year duration of the CPS USAR analysis had a cumulative inflow of 24 in., as compared to 23 in. reported in Stall (1964). The applicant stated that similar comparisons and conclusions are also valid for the 100-year recurrence interval drought that it used in the ESP drought analysis.

The staff reviewed the applicant’s response to DSER Open Item 2.4-15 and adopted a simpler way to envelop the effects of severe, sustained drought in the Clinton Lake watershed on the lake and its ability to sustain operation of the CPS and the ESP facility. The staff conservatively estimated the rate of fall in water surface elevation in Clinton Lake during drought conditions by assuming that (1) both the CPS and the ESP facility were operating at 100 percent of their respective capacities, (2) there was no inflow into the lake, (3) Clinton Lake was discharging the minimum required 5 cfs downstream of the dam, and (4) the natural evaporation from the lake was set to a conservatively high estimate equal to the 8.35 inches per month (in./mo) of evaporation reported by Roberts and Stall (1967) for July 1936.

The staff estimated the forced evaporation for the existing CPS by assuming that all heat produced by the CPS which was not converted into electrical energy would be dissipated as latent heat of evaporation from Clinton Lake. This assumption resulted in an estimated 38 cfs of forced evaporation caused by the heat load from the CPS. The forced evaporation for the ESP facility was assumed equal to the PPE value of 70.2 cfs, reported in SSAR Table 1.4-1, item 2.4.7. The staff assumed that the total outflow from the Clinton Lake, consisting of natural evaporation, forced evaporation caused by the presence of the CPS and ESP facilities, and the downstream release from the dam would occur with the water surface area of Clinton Lake fixed at a conservatively low value of 2550 ac corresponding approximately to a water surface elevation of 677 ft MSL, thereby resulting in a correspondingly larger water surface drop rate.

The staff-estimated the maximum water surface drop rate in Clinton Lake to be 41.1 in./mo. Based on this conservatively estimated water surface drop rate, the staff determined that it will take approximately 18 days for the water surface in Clinton Lake to fall from 679 ft MSL to 677 ft MSL.

While it is possible for a more rapid decrease in water surface elevation in Clinton Lake to occur in the presence of a more severe combination of starting water surface elevation, low inflow, and little precipitation, the staff considers the 18-day period required for the water surface elevation to fall from 679 ft MSL to 677 ft MSL indicative of Clinton Lake's large capacity, which allows a gradual decrease in its water surface elevation, even under extreme droughts. The staff concluded, therefore, that water surface elevation in Clinton Lake does not fall rapidly and sufficient time will be available to plant operators before the low-water surface elevation shutdown threshold is reached to plan a shutdown of the proposed ESP facility without endangering its safety, even under severe drought conditions. The staff also concluded that the water surface elevation in Clinton Lake does not fall near the low-water surface elevation shutdown threshold frequently enough to result in an excessive reliance of the ESP facility on its UHS, if one were required. Based on the above review, the staff considers DSER Open Item 2.4-15 resolved.

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
- a fire water requirement of 3 ac-ft
- minimum cooling water capacity of 590 ac-ft required for 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 were to fail, or the water surface elevation in Clinton Lake were to fall to 675 ft MSL, some loss in the storage capacity of the submerged UHS pond would be likely 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 DSER Open Item 2.4-12, the staff concluded that the applicant needed to establish that the submerged UHS pond has adequate capacity to provide makeup water to the ESP facility UHS. This was DSER Open Item 2.4-16.

In response to DSER Open Item 2.4-16, the applicant stated, in its submission to the NRC dated April 26, 2005, that the required capacity of the submerged UHS pond was established based on maximum evaporative loss from the facilities and temperature limitations of 95 EF at the plant intakes.

The applicant stated that the design capacity of the submerged UHS pond with water surface elevation at 675 ft MSL and a top water surface area of 158 ac is 1067 ac-ft. The applicant estimated the 30-d total UHS cooling requirement for the CPS and the ESP facility to be 327 ac-ft and 87 ac-ft, respectively. Additionally, 3 ac-ft may be required for fire protection, 35 ac-ft for sediment accumulation from a 100-year flood event, and 221 ac-ft for sediment inflow caused by liquefaction during an SSE. The applicant-estimated water use for all these requirements is 673 ac-ft, leaving 394 ac-ft of excess capacity in the submerged UHS pond.

The applicant stated that it determined the maximum evaporative loss from the submerged UHS pond during warm weather conditions when atmospheric cooling may be limited. The applicant argued that with an ice cover on the lake, evaporative loss would be limited to a negligible quantity. Under this scenario, the applicant estimated the CPS UHS cooling needs for 30 days as 0 ac-ft. Given a 30-day UHS makeup requirement for the ESP facility of 87 ac-ft, 3 ac-ft for fire protection, 35 ac-ft for sediment accumulation from a 100-year flood event, and 221 ac-ft for sediment inflow caused by liquefaction during an SSE, the applicant estimated that the excess capacity in the submerged UHS pond during ice-covered conditions would be 421 ac-ft, allowing for a loss of liquid water displace by a 24.8-in thick ice sheet approximately equal to 300 ac-ft (158 ac x 24.8 in. / 12 in./ft x 0.917 = 299.4 ac-ft, as stated by the applicant in response to DSER Open Item 2.4-11). The applicant thus concluded that the excess capacity in the submerged UHS pond accounting for the ESP facility's 30-day UHS makeup water requirement is greater with an ice sheet formed on the surface of the submerged UHS pond than without ice formation.

The staff reviewed the applicant's response to DSER Open Item 2.4-16 and determined that the negligible evaporative loss argument is acceptable when an ice sheet is covering the submerged UHS pond. The staff's revised estimate of the maximum thickness of an ice sheet that may form on Clinton Lake is 27 in. (see discussion related to DSER Open Item 2.4-9 above). Based on this revised maximum ice thickness, the volume of liquid water displaced, if this ice sheet were to settle down into the submerged UHS pond, is approximately 319 ac-ft (see discussion related to DSER Open Item 2.4-11 above).

The staff also determined that the applicant used the design capacity of the submerged UHS pond (1067 ac-ft) while estimating the volume of excess water in the submerged UHS pond. The applicant reported, in response to DSER Open Item 2.4-17 (see discussion related to DSER Open Item 2.4-17 below), that the storage capacity of the submerged UHS pond in 2004 was reduced to 991 ac-ft by sediment accumulation. The staff determined that the present storage capacity of the submerged UHS pond must be used to establish excess capacity within it. Most of the CPS 30-day UHS consumptive loss would occur as evaporation from the free water surface under elevated water temperature condition. The presence of an ice sheet on most of the surface of the UHS pond would prevent evaporation from the water surface in contact with the ice sheet. Therefore, the CPS 30-day UHS consumptive loss would be reduced to an insignificant amount. The staff determined the excess capacity to be approximately 318 ac-ft without an ice-cover on the lake (991 ac-ft - (327 ac-ft for CPS 30-day UHS consumptive loss + 3 ac-ft for fire + 35 ac-ft for 100-year flood sedimentation + 221 ac-ft liquefaction sedimentation from SSE + 87 ac-ft for ESP facility 30-day UHS makeup)) = 318 ac-ft), and approximately 319 ac-ft with an ice-sheet covering the surface of the submerged UHS pond (991 ac-ft - {insignificant CPS 30-day UHS consumptive loss + 3 ac-ft for fire + 35 ac-ft for 100-year flood sedimentation + 221 ac-ft liquefaction sedimentation from SSE + 87 ac-ft for ESP facility UHS 30-d makeup + 326 ac-ft lost to ice sheet)) = 319 ac-ft).

In its letter dated December 21, 2005, the applicant revised its estimate of maximum ice thickness in Clinton Lake. The applicant also revised its response to Open Item 2.4-16 in this letter. The applicant stated that reduction in water storage capacity of the submerged UHS pond due to an ice sheet 27.0 in. in thickness will be approximately 326 ac-ft. The applicant estimated the excess water storage capacity within the submerged UHS pond to be approximately 395 ac-ft, based on a total available capacity of 1067 ac-ft. Applicant's estimate (approximately 395 ac-ft) therefore, is larger than staff's estimate (318 or 319 ac-ft). This difference is due to different total storage capacities of the submerged UHS pond used by the applicant and the staff. The applicant stated in response to Open Item 2.4-17 below that the total storage capacity of the submerged UHS pond was reduced to 991 ac-ft in 2004 due to sediment accumulation. As stated above, staff determined that the current storage capacity of the submerged UHS pond must be used to determine excess water storage capacity within it. Due to this difference, the staff's estimate of excess capacity in the submerged UHS pond is much smaller than that stated by the applicant. Nevertheless, the staff estimate of excess capacity in the submerged UHS pond is adequate to provide makeup water to the ESP facility UHS, if one is needed by the selected reactor type. The staff's proposed COL Action Item 2.4-10, stated below, requires that the submerged UHS pond will be dredged frequently to ensure that adequate liquid water will be available for the ESP facility UHS, if a UHS is required by selected reactor type. The frequency of dredging will be established at the COL stage. Therefore, the staff considers DSER Open Item 2.4-16 resolved.

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 evaluated the applicant's response to open items listed in this section to consider the adequacy of submerged UHS pond monitoring and dredging. The staff determined that the applicant needed to establish the monitoring and dredging requirements 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 was DSER Open Item 2.4-17.

In response to DSER Open Item 2.4-17, the applicant stated, in its submission to the NRC dated April 26, 2005, that the NRC staff appeared to have confused the actions of the ESP applicant and those of the CPS operators. The applicant stated that the CPS operators monitor the CPS UHS for sediment accumulation, not the applicant. The applicant also stated that it did not commit to dredging the CPS UHS. The applicant also stated that the ESP review stage is inappropriate for establishing operational requirements for the ESP facility, since a water-cooled UHS may not even be required for some potential ESP facility reactor types.

The applicant stated that monitoring reports from 1991 to 2004 show a nominal reduction of 63 ac-ft in the water storage capacity of the submerged UHS pond (from 1054 ac-ft in 1991 to 991 ac-ft in 2004), a loss rate of 4.85 ac-ft/year. The applicant stated that the submerged UHS pond will have an excess capacity of 394 ac-ft, even if the ESP facility were to use a water-cooled UHS. At the stated sedimentation rate, the applicant estimated that the submerged UHS pond would require dredging once every 81 years (394 ac-ft / 4.85 ac-ft/year = 81.2 year). Based on this reasoning, the applicant stated that it did not propose a dredging frequency in the ESP application. The applicant stated that the need for dredging will be evaluated at the COL stage based on the final design of the ESP facility and the results of the CPS UHS sedimentation monitoring reports.

The staff reviewed the applicant's response to DSER Open Item 2.4-17 and determined that, based on the PPE information provided in the SSAR, a water-cooled UHS may be required by the selected ESP facility reactor type. Since the safety of the water-cooled ESP facility UHS will depend on the water availability within the submerged UHS pond, the submerged UHS pond is a safety-related facility for the proposed ESP facility. The staff also determined that site characteristics related to the submerged UHS pond that may be used for design of a future water-cooled ESP facility UHS must be established at the ESP stage. The sediment accumulation rate of 4.85 ac-ft/yr is a normal sediment accumulation rate over the last 13 years only, which may be subject to large increases during years of extreme flood events in the Clinton Lake watershed. Since the submerged UHS pond is a safety-related facility for the ESP facility based on the description in the SSAR, the monitoring and any required dredging of the submerged UHS pond is the responsibility of the ESP facility operators and will be determined at the COL stage. This is **COL Action Item 2.4-10**. Based on the above review, the staff considers DSER Open Item 2.4-17 resolved.

The staff had planned to include the submerged UHS pond monitoring and dredging frequencies as a permit condition. However, the reliance of the ESP facility UHS on water available in the submerged UHS pond is dependent on the selected reactor type requiring a UHS. The staff concluded therefore that COL Action Item 2.4-10 is sufficient to ensure that adequate liquid water will be available for the ESP facility's UHS, if one is required by the selected reactor design and no additional permit conditions are necessary.

2.4.8.4 Conclusions

As set forth above, the applicant 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 NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," issued July 1981 (hereafter referred to as the SRP), as applicable to an ESP 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 did not specifically address the above regulations in SSAR Section 2.4.8, the staff concludes that by conforming to SRP Section 2.4.8 the applicant has met the requirements for 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 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.

2.4.9.1 Technical Information in the Application

The applicant stated in SSAR Section 2.4.9 that is no existing historical evidence of channel diversion in the Salt Creek or the North Fork of Salt Creek upstream of the Clinton Dam. The applicant stated 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 noted 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 requested 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. In Revision 4 of the SSAR, the applicant added information to reflect the above clarification.

2.4.9.2 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 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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 at 10 CFR 52.17(a), 10 CFR 100.20(c), and 10 CFR 100.21(d) require that the NRC take into account the physical characteristics of the site (including seismology, meteorology, geology, and hydrology) when determining 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.

In those cases for 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 determine whether the applicant met the requirements of 10 CFR Parts 52 and 100, as they relate to channel diversion, the staff used the following specific criteria:

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

- Historical diversions and realignments should be discussed.

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

- If applicable, the safety consequences of diversion and the potential for high- or low-water levels, caused by upstream or downstream diversion, to adversely affect safety-related facilities, water supply, or the UHS should be addressed. RG 1.27, “Ultimate Heat Sink for Nuclear Power Plants,” issued January 1976, 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, and Section 2.4.11 of this SER evaluates channel diversion resulting from low-water conditions.

SSAR Section 2.4.9 did 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 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 migrated, eliminating 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 a normal pool level, 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 were to stop 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 Section 2.4.9 of RS-002, Attachment 2, 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 did not specifically address the above regulations in SSAR Section 2.4.9, the staff concludes that, by conforming to Section 2.4.9 of RS-002, Attachment 2, 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 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 estimated the design-basis flood elevation at the ESP site to be 713.8 ft MSL. This elevation included 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 could be affected by flooding in Clinton Lake would be the new ESP facility's UHS intake structures. The applicant stated in the SSAR that it would design the ESP facility UHS intake for flood protection of all safety-related equipment located within the intake structures.

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

The applicant stated 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 wind speeds of 40 mph, mentioned in SSAR Sections 2.4.3.6 and 2.4.10, and the design wind speeds of 48 mph and 67 mph, 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 wind speed to act on the PMF water surface elevation. The applicant also stated that the design of the circulating water screenhouse for the CPS Unit 1 considered a 48-mph overland wind speed coincident with the PMF water surface elevation. The applicant noted that use of these design wind speeds 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 wind speeds 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 information indicated that a wind speed 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 wind speed of 52 mph.

In Revision 4 of the SSAR, the applicant stated that the maximum hydrostatic PMF water surface elevation is 709.8 ft MSL and, combined with other effects, the maximum water level of Clinton Lake near the ESP facility is 716.5 ft MSL. The applicant noted that the ESP facility grade is approximately 19 ft above the maximum combined effects elevation and 25 ft above the hydrostatic PMF elevation. The applicant stated that the only safety-related equipment below these elevations is the new ESP intake structure, which would be designed with adequate flooding protection.

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.

In those cases for 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 determine whether the applicant met the requirements of 10 CFR Parts 52 and 100, as they relate to flooding protection, the staff used the following specific criteria:

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

2.4.10.3 Technical Evaluation

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 NRC staff independently estimated this 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 wind speed, which was conservatively estimated by the staff to be 100 mph. This value was based upon the PMWS, as defined by ANSI/ANS 2.8-1992, and was recommended for the location of the site being within 150 miles of the Great Lakes. The staff estimated the local intense precipitation rate for the ESP site to be 18.15 in./h in Section 2.4.2.3 of this SER. Table 2.4-2 of this SER in this report provided 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 will need to design the ESP facility's intake structures to withstand the combined effects of PMF, coincident wind wave activity, and wind setup. This is COL Action Item 2.4-3 as stated in Section 2.4.2.3 of this SER.

2.4.10.4 Conclusions

As set forth above, the applicant has provided sufficient information pertaining to 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.

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 did not specifically address the above regulations in 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 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 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's UHS system.

Normal operation of the ESP facility would use a cooling tower(s), operated with water drawn from a cooling tower basin(s). The basin(s) 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. The applicant's 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 would be 15,808 gpm, and the quantity available during a 100-year drought would be 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 reactor designs being considered for the site which use 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 it evaluated the effects of drought on water surface elevations in Clinton Lake to determine whether 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 plant 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 were 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 a new intake structure located next to the existing CPS intake structure would supply the water required for the ESP facility. 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 possessing 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 4.

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 $180{,}455 \times 10^6$ BTU for 30 days. The heat load from the single, uprated CPS unit is $99{,}973 \times 10^6$ 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 is constructed, it might reduce the allowable sediment accumulation in the submerged UHS pond.

In Revision 2 of the SSAR, the applicant described an assessment similar to the one described above in order to determine the amount of cooling water available during drought periods. The applicant stated that the excess available water on an annual average basis after satisfying CPS consumptive demand is 1,300 ac-ft/month (9,500 gpm) during the 100-year drought event and 2,000 ac-ft/month (15,100 gpm) during the 50-year drought event.

2.4.11.2 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 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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.

In those cases for 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 at 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 essential design cooling water flow, as well as the maximum design flow for normal plant needs at power and at shutdown.

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

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

For essential water supplies, the low-flow/low-level design for the primary water supply source is based on the probable minimum low flow and low level resulting from the most severe drought that can reasonably be considered for the region. The low-flow/low-level site parameters for operation should not allow shutdowns caused by inadequate water supply to trigger the frequent use of emergency systems.

Low Water Resulting from Surges, Seiches, or Tsunami

For coastal sites, the applicant should postulate the appropriate probable maximum hurricane wind fields at the ESP stage to estimate the maximum winds blowing offshore, thus creating a probable minimum surge level. The applicant should estimate low water levels on inland ponds, lakes, and rivers caused by surges 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 applicant should present the data used to allow an independent determination. The applicant may use the staff-accepted data and methods of NOAA, USGS, SCS, USBR, and USACE.

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 ER), 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 results from 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 caused by 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 miles. This gauge is minimally affected by streamflow regulation and is comparable in the size of its contributing area (227 mi^2) to that of the drainage area (289.2 mi^2) contributing flow to Clinton Lake. To estimate inflows into Clinton Lake, the staff scaled the streamflow observed at Kikapoo Creek by the ratio of contributing area at Clinton Dam to the contributing area at the Waynesville gauge. 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 staff considered the results to be 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 Roberts and Stall (1967) was 8.38 in. for July 1936. After correcting for lake area, the staff's analysis resulted in a conservative estimate of the maximum drop in the lake water surface elevation of 4.85 ft/mo.

At this rate of decline, the staff determined that the drop of the lake water surface elevation would be gradual enough for the operators to react and safely shut down the ESP facility before the minimum operating threshold was reached.

The applicant stated in SSAR Section 2.4.11.1 that, for some of the reactor designs 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 (DSER 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). The staff determined that this schematic should clearly show all components and the water flow, including discharges through these components.

The applicant stated 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, especially under severe drought conditions. The applicant stated 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 staff had planned to include the water surface elevation of 677 ft MSL in Clinton Lake as the shutdown water surface elevation for the ESP facility in a permit condition. The staff determined that the requirement for an ESP facility UHS is dependent on the selected reactor type, which has not been determined at the ESP stage. In the event that the reactor type selected for the ESP facility requires a UHS, the COL applicant will need to develop a plant shutdown protocol when the water surface elevation in Clinton Lake falls to 677 ft MSL. This is **COL Action Item 2.4-11**.

The staff independently estimated the volume of available water in the submerged UHS pond that may be used for the combined operation of the CPS and the ESP facility's UHS systems based on the applicant's response to DSER Open Items 2.4-9, 2.4-11, 2.4-14, 2.4-16, and 2.4-17. Resolution of the open items mentioned above resolves confirmatory Item 2.4-1. The staff's estimate of minimum excess water storage capacity in the submerged UHS pond after accounting for water required by the CPS UHS consumptive use, the ESP facility UHS makeup, sedimentation, fire protection, and icing was approximately 318 ac-ft, as stated in Section 2.4.8.3 of this SER. The monitoring and dredging frequencies for the submerged UHS pond will be determined at the COL stage, as stated by COL Action Item 2.4-10 in Section 2.4.8.3 of this SER.

2.4.11.4 Conclusions

As set forth above, 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 Section 2.4.11 of RS-002, Attachment 2 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 did not specifically address the above regulations in SSAR Section 2.4.11, the staff concludes that, by conforming to Section 2.4.11 of RS-002, Attachment 2, 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 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 provided 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 described 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 identified 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 stated that 65 percent of public ground water supplies are pumped from the Mahomet Bedrock Valley aquifer. Within 15 miles of the site, alluvial aquifers provide the public water supply only for Heyworth. No public water supply within the 15-mile 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 stated 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 reported 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} feet per day (ft/d).

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

The SSAR described the ground water flowpath from the ESP site in limited detail. The SSAR also did not specify precise locations of the ESP facility. The staff requested the applicant, in RAI 2.4.1-1, to provide locations for the proposed ESP facility. Section 2.4.1.1 of this SER discusses the applicant's response to the RAI.

No changes were made in Section 2.4.13 in Revision 4 of the application.

2.4.12.2 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 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 reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

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 measurements. 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 could 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. The applicant should determine the static and dynamic engineering properties of the materials underlying the site, 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 determine whether the applicant met the requirements of the hydrologic aspects of 10 CFR Parts 52 and 100, the staff used the following specific criteria:

- 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 the 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 stated that ground water would not be used for either normal or safety-related plant operations. In the DSER, the staff planned to include a condition in any ESP that might be issued for the applicant's proposed ESP site to prohibit such use. The staff had planned to include this requirement as DSER Permit Condition 2.4-8. However, the staff determined that normal and safety-related requirements for the ESP facility depend on the selected reactor type, which has not been determined at the ESP stage. The staff concluded, therefore, that a COL action item is sufficient to ensure that ground water will not be used in normal or safety-related plant operations for the ESP facility and it is not necessary to impose DSER Permit Condition 2.4-8. This is **COL Action Item 2.4-12**.

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 DSER 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 concluded 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 ESP facility. It was 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 staff determined that the applicant needed to provide the potential impact of future construction for the ESP facility on the piezometric gradient for the ESP site. This was DSER Open Item 2.4-18.

In response to DSER Open Item 2.4-18, the applicant stated, in its submission to the NRC dated April 4, 2005, that if dewatering were to be used during construction, the potential impact on the piezometric gradient at the ESP site would be expected to be a localized, short-term impact to ambient ground water elevations. The applicant stated that it used site hydrogeology, water surface elevation information obtained during the CPS site investigations, and impacts during lake filling to anticipate the impact during operation and construction of the ESP facility. The applicant stated that, based on measured water surface elevations, ground water gradients, and occurrence of springs, the North Fork of Salt Creek and Salt Creek have been in the past, and continued to be after the construction of Clinton Lake, the discharge zone for shallow ground water at the ESP site.

The applicant stated that ER Section 5.2.1.2.4 discusses the estimated change in water surface elevation in Clinton Lake after the addition of the ESP facility. The applicant stated that its estimates for reduction in annual average water surface elevation in Clinton Lake are 0.2 ft with a cooling system for the ESP facility and 0.7 ft with a wet cooling system. The applicant stated that the estimated reduction in water surface elevation in Clinton Lake after addition of the ESP facility is within the observed seasonal variation of water surface elevations in wells located in the Wisconsinan deposits, which is 5 ft, as reported in SSAR Section 2.4.13.3. Therefore, the applicant concluded that the predicted reduction in water surface elevation in Clinton Lake after addition of the ESP facility would not significantly change the piezometric surface in the vicinity of the ESP facility.

The applicant stated that if dewatering is required during construction of the ESP facility, the ground water elevations and gradients are expected to be impacted during the construction up to a depth equal to the PPE embedment depth. However, the applicant argued, once construction of the ESP facility is completed, the ground water in the vicinity of the ESP facility would return to equilibrium and the regional ground water flow pattern would be reestablished towards the lake. The applicant also stated that because of the low permeability of the shallow glacial material at the ESP site, sudden changes in ground water would be minimal at the ESP site. The applicant also stated that since no permanent dewatering system would be installed at the ESP site, there would be no long-term impact to ground water conditions at the ESP site.

The applicant stated that design of the excavation and the dewatering system would consider the amount of water to be removed based on the embedment depth and the lateral extent of the depression in ground water table caused be dewatering. The impacts resulting from this dewatering on the ground water system would be evaluated during preconstruction monitoring for the ESP facility. The applicant stated that the preconstruction monitoring program, identified as preapplication in the SSAR and the ER, will include the following:

- installation of additional shallow and deep piezometers spaced at suitable intervals away from the ESP facility, between the ESP facility and the CPS facility, and use of piezometers located near Clinton Lake to help define the lateral continuity of sand layers

- monthly monitoring of water surface elevations in the piezometers to verify hydrostatic loading on power plant foundation and flow directions and to estimate dewatering volume

- installation of a 12-in. test well to perform a long-term pumping test to evaluate potential impact of dewatering and dewatering volume

The applicant stated that the number, depths, and locations of the piezometers and the test well would be determined after the design of the ESP facility is better defined. The data collected from the piezometers and the test well would be used to define baseline ground water conditions at the ESP site and to determine ground-water-related design elevations. The applicant stated that these data would also be used to identify additional locations where ground water conditions may need to be monitored during the construction of the ESP facility.

The staff reviewed the applicant’s response to DSER Open Item 2.4-18 and carried out its own independent estimation of the time required for ground water at the ESP site to return to 95 percent of its initial predewatering elevation. The staff used the unconfined one-dimensional ground water flow equation with the conservative assumption of no additional recharge into the soil during this time. The staff’s conservative estimate for the time required for ground water to return to 95 percent of its predewatering elevation exceeded 5 years.

The applicant’s description of the effluent-holding facility presumed (see Sections 2.4.13.1 and 2.4.13.3 of this SER) that no scenario will exist in which liquid radioactive effluent could be released above the ambient ground water table, including the scenario in which the effluent-holding facility could be flooded, raising the release point above the ambient ground water table. The staff agreed that under these assumptions, release of liquid radioactive effluent to ambient ground water can be precluded. Therefore, the staff determined that it is necessary to ensure that the hydraulic gradient will always point inwards into the radwaste holding and storage facility from ambient ground water during construction and operation of the ESP facility, including the time during which recovery of ground water occurs to near its predewatering elevation. This is **Permit Condition 3**. Based on the above review, the staff considers DSER Open Item 2.4-18 resolved.

The applicant estimated the average ground water velocity in the following manner:

velocity = hydraulic gradient x saturated hydraulic conductivity/effective porosity.

While the staff agreed that the equation is technically accurate, the applicant used very limited data to estimate the three values required to derive the velocity. Based on one of two field permeability tests, the applicant selected the higher of the two values, $2.6x10^{-6}$ 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 staff required the applicant to explain why such limited data represent a basis for a velocity estimate. In addition, the staff asked the applicant to provide values for the hydraulic gradient, saturated hydraulic conductivity, and effective porosity measured at the ESP site. This was DSER Open Item 2.4-19.

In response to DSER Open Item 2.4-19, the applicant stated, in its submission to the NRC dated April 26, 2005, that it conducted a geotechnical investigation in July and August of 2002 within the footprint of the ESP facility. The applicant stated that the results of this investigation indicated that the geotechnical conditions at the ESP site were consistent with those reported previously by CPS investigations. Based on this information, the applicant concluded that the CPS data were representative of the ESP site.

The applicant stated that it based its estimation of the ground water gradient on a maximum head loss of 55 ft over a distance of 640 ft from the site to the edge of the floodplain of the North Fork of Salt Creek. The applicant stated that according to the CPS USAR, the impoundment created by the Clinton Dam resulted in a shift of the ground water-surface water interface southeast of its original location towards the CPS. However, the resulting hydraulic gradient from CPS to the lake was reduced, even though the water level in the North Fork of Salt Creek rose to 690 ft MSL after the impoundment. The applicant thus argued that use of the CPS hydraulic gradient is conservative.

The applicant stated that it took the hydraulic conductivity and effective porosity values from the CPS USAR, and, although there were just a few measurements for Wisconsinan Till, the values used in the SSAR are relatively consistent with field and laboratory measurements for Illinoian Till, also collected during the CPS investigations. The applicant concluded that for this reason, the soil properties used in the SSAR are representative of the ESP site.

The applicant stated that it will collect additional hydrogeologic data as part of the COL preconstruction monitoring program; it will use these data to verify the hydraulic gradient, flow directions, and ground water velocity, if these parameters are needed for the COL evaluations.

The staff reviewed the applicant’s response to DSER Open Item 2.4-18 and determined that the applicant did not provide additional data to verify the conservativeness of the ground water hydraulic gradient or that of soil properties. The CP or COL applicant will need to undertake additional geotechnical characterization to establish conservative ground water flow velocities and conservative soil properties representative of the hydrogeologic conditions at the ESP site. This is **COL Action Item 2.4-13.** Therefore, the staff considers DSER Open Item 2.4-18 resolved.

The staff had planned to include DSER Permit Condition 2.4-9 for the ESP holder to demonstrate that an inward pointing hydraulic gradient will be maintained for all credible water table conditions and for the applicant to implement a monitoring plan to ensure the maintenance of this gradient condition. This requirement is now stated as Permit Condition 3 above.

2.4.12.4 Conclusions

As set forth above, 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 Section 2.4.12 of RS-002, Attachment 2, 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 did not specifically address the above regulations in SSAR Section 2.4.12, the staff concludes that, by conforming to Section 2.4.12 of RS-002, Attachment 2, 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 stated 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.

The applicant identified the closest surface water withdrawal for drinking water purposes to be 242 miles downstream at Alton, Illinois.

In Revision 4 of SSAR Section 2.4.12, the applicant states that the issue of a possible groundwater pathway for liquid effluents will be reviewed at the COL stage.

2.4.13.2 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 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 reviewed this portion of the application for conformance with the applicable regulations, and considered the corresponding regulatory guidance, as identified below.

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. The applicant should plan for special precautions 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. The staff reviews radionuclide transport characteristics of the ground water and surface water environments with respect to accidental releases to ensure that current and future users of ground water and surface water are not adversely affected by an accidental release 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," issued April 1977, and 4.4, "Reporting Procedure for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Water Bodies," issued May 1974, 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.

In those cases for 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 determine whether the applicant met the requirements of 10 CFR Parts 52 and 100 with respect to accidental releases of liquid effluents, the staff used the following specific criteria in accordance with Section 2.4.13 of RS-002:

- 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 stated 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 staff determined that the applicant should also specify the maximum elevation at which any liquid radioactive waste releases can occur in the proposed ESP facility. This was DSER Open Item 2.4-20.

In response to DSER Open Item 2.4-20, the applicant stated, in its submission to the NRC dated April 4, 2005, that the maximum elevation at which any radioactive releases can occur within the ESP facility would depend on the chosen reactor design. The applicant also stated that the associated minimum ground water elevation would also depend on the chosen reactor design and the final location of the ESP structures. The applicant noted that the COL applicant would address how the chosen design will preclude any liquid radioactive releases above the ground water table.

The staff reviewed the applicant's response to DSER Open Item 2.4-20. The staff's concern in Open Item 2.4-20 related to the release of liquid radioactive effluent to ground water such that it could be carried to Clinton Lake along with the regional ground water flow from the ESP site to the lake. The applicant's position on this issue is that the facility containing the radioactive effluent would be located below the ambient ground water table and would be maintained at atmospheric pressure. The applicant argued that because of this design, ground water in contact with the effluent-holding facility would be under hydrostatic pressure greater than atmospheric pressure. Therefore, ground water adjacent to the walls of the effluent-holding facility would tend to flow into the facility, and ground water in contact with the base of the effluent-holding facility would also tend to flow into the facility, thereby precluding any release of radioactive effluent into the ground water at the ESP site.

The staff determined that the applicant's description of the effluent-holding facility presumed that no scenario would exist in which the liquid radioactive effluent could be released above the ambient ground water table, including the scenario in which the effluent-holding facility could be flooded, raising the release point above the ambient ground water table. The staff agreed that under these assumptions, release of liquid radioactive effluent to ambient ground water can be precluded. However, the COL or CP applicant would need to demonstrate that there will be no likely scenario that could lead to liquid radioactive release to the ambient ground water, either above the ambient ground water table or below it. This is **COL Action Item 2.4-14**. Further, the COL or CP applicant would be required to put a ground water monitoring system in place to ensure that the hydraulic gradient would always point inwards into the radwaste holding and storage facility from ambient ground water during construction and operation of the ESP facility, including the time during which recovery of ground water occurs to near its predewatering elevation. This is Permit Condition 3, as stated in Section 2.4.12.3 of this SER. The staff also determined that a permit condition requiring a radwaste facility design for a future reactor with features to preclude any and all accidental releases of radionuclides into any potential liquid pathway is necessary. This is **Permit Condition 4**. Based on the above review, the staff considers DSER Open Item 2.4-20 resolved.

The staff had planned to include a requirement that the COL applicant would 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 as DSER Permit Condition 2.4-10. However, Permit Condition 4, stated above, requires a radwaste facility design that will preclude any and all accidental releases of radionuclides into any potential liquid pathway and, therefore, sets more restrictive criteria than that stated by DSER Permit Condition 2.4-10. Thus, the staff concluded that it is not necessary to impose DSER Permit Condition 2.4-10.

The staff concluded that the applicant needed 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 was DSER Open Item 2.4-21.

In response to DSER Open Item 2.4-21, the applicant stated, in its submission to the NRC dated April 4, 2005, that SSAR Section 2.4.13.3 and Section 5 of Appendix A to the SSAR thoroughly describe the local hydrologic setting that currently exists at the ESP site. The applicant stated that the local hydrologic setting after the disruption associated with the construction of the ESP facility is expected to be similar to the existing hydrologic setting. The applicant stated that localized, short-term impacts to ambient ground water elevations may occur during the construction of the ESP facility, but the applicant expects that the relatively low permeability of the shallow glacial material that exists at the ESP site would help minimize these impacts during the construction.

The applicant stated that, since the final ground water elevations at the ESP site would depend on the plant design for and the location of the ESP facility within the identified ESP footprint, the ground water system would be monitored during the COL preconstruction and construction phases, as well as during the preoperation and operation phases of the ESP facility. The applicant listed the following objectives for the ground water monitoring program:

- measurement of ground water elevations at a monthly frequency to verify hydrostatic loadings and flow directions before construction of the ESP facility (preconstruction monitoring)

- daily measurements of ground water elevations during the active construction phase to determine the impact of dewatering (construction monitoring)

- monthly measurements of ground water elevations after the construction of the ESP facility to evaluate any hydrologic changes caused by operation of the ESP facility (preoperational monitoring)

- extension of preoperational monitoring for 5 years or until ground water conditions stabilize (operational monitoring)

The applicant stated that these monitoring programs were also discussed in ER Sections 6.3.1.3, 6.3.2.3, 6.3.3.3, and 6.3.4.3, respectively.

The staff reviewed the applicant's response to DSER Open Item 2.4-21. The staff's concern in Open Item 2.4-21 was related to ensuring that the hydraulic gradient of the ambient ground water at the ESP site was always directed inwards towards the effluent-holding facility to preclude any scenario in which a discharge of radioactive effluent from the effluent-holding facility could reach the regional ground water flow system and thus eventually the accessible environment (The Clinton Lake). Based on the applicant's response to DSER Open Items 2.4-20 and 2.4-21, the staff determined that the preclusion of radioactive effluent discharge into the ambient ground water system at the ESP site is primarily and crucially dependent on the hydraulic gradient pointing from the ambient subsurface into the effluent-holding facility. The staff also determined that it is essential to institute a ground water monitoring program at the ESP site to continuously monitor and verify that the central assumption for the preclusion of radioactive releases to ground water is not violated. The staff stated this requirement as Permit Condition 3 in Section 2.4.12.3 of this SER. The staff will also require that this monitoring system be kept in place and the monitoring program be kept in operation for the life of the ESP facility, including its decommissioning. This is **Permit Condition 5**. Therefore, the staff considers DSER Open Item 2.4-21 to be resolved.

2.4.13.4 Conclusions

As set forth above, 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 Section 2.4.13 of RS-002, Attachment 2, 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 did not specifically address the above regulations in SSAR Section 2.4.13, the staff concludes that, by conforming to Section 2.4.13 of RS-002, Attachment 2, 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.

2.4.15 Thermal Discharges

2.4.15.1 Normal Plant Heat Sink

The ESP site is adjacent to Clinton Lake, which provides cooling water for the current CPS Unit 1. Events that may reduce or limit the availability of additional cooling water at this site include low lake elevation, seiches, wind-induced set down, and intake blockages from sediment or ice. Section 2.4 of this SER discusses these events.

The NPHS water supply for the ESP facility would be obtained from Clinton Lake, created by the Clinton Dam. Normal operation of the ESP facility would use a cooling tower(s) operated with water drawn from a cooling tower basin(s).

2.4.15.1.1 Technical Information in the Application

In Section 3.2.1 of the SSAR, the applicant provided a brief description of the NPHS.

In SSAR Section 3.2.1.2, the applicant stated that the flow from the normal cooling system to the cooling towers would be 1,200,000 gpm. This slow rate reflects the recirculation of water within the cooling system. Water would be withdrawn from Clinton Lake to make up for water lost from evaporation and to limit the concentration of impurities in the cooling water. The applicant stated that the cooling tower blowdown would normally be 12,000 gpm, with a maximum of 49,000 gpm.

The applicant stated that the maximum NPHS load during normal operation would be 15.08×10^9 Btu per hour (Btu/h), with a maximum discharge temperature of 100 EF. The staff had intended to identify these values as DSER) Permit Conditions 3.2-1 and 3.2-2. Section 2.4.15.1.3 of this SER provides a more detailed discussion of this issue.

The discharge temperature is based on a design approach of 15 EF and a maximum wet bulb temperature of 85 EF. The applicant stated that a wet bulb temperature of 77.2 EF would only be exceeded 1 percent of the time and that the maximum wet bulb temperature is 84.7 EF.

2.4.15.1.2 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 SSAR Section 3.2 addresses thermal discharges as required by 10 CFR 52.17(a)(1)(iv), which states that an ESP should describe the anticipated maximum levels of thermal effluents each facility will produce.

The staff maintains that additional regulatory guidance for the purposes of ESP are found in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing and Production and Utilization Facilities," and in 10 CFR 100.23(c). Two general design criteria (GDC) are particularly relevant—GDC 2, "Design Bases for Protection Against Natural Phenomena," and GDC 44, "Cooling Water." The staff also maintains that two RGs are applicable—RGs 1.27 and 1.70, Revision 3. Also, an ESP applicant need not demonstrate compliance with the GDC.

Acceptance criteria for this section relate to the following regulations:

- 10 CFR Parts 52 and 100 require that a site evaluation consider hydrological characteristics.

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

The regulations in 10 CFR Parts 52 and 100 require that the hydrological characteristics of a potential nuclear power plant site be considered in the site evaluation. In particular, the UHS for the cooling water system may consist of water sources affected by, among other things, site hydrological characteristics that may reduce or limit the available supply of cooling water for safety-related SSCs. Such characteristics include those resulting from river blockage or diversion, tsunami runup and drawdown, and dam failure.

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

The regulation at 10 CFR 100.23 requires the evaluation of siting factors, including the cooling water supply, for a potential 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, diversion, or other failures that may block the flow of cooling water, tsunami runup and drawdown, and dam failures.

This regulation also applies to SSAR Section 3.2 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 or diversion 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 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; such needs may fall within a PPE (e.g., the stored water volume of the cooling water ponds), if an applicant uses that approach. Specifically, these needs include the maximum essential design cooling water flow, as well as the maximum design flow for normal plant needs at power and at shutdown.

2.4.15.1.3 Technical Evaluation

The NPHS has no safety function and is not required for shutdown or accident mitigation. However, in the event that the NPHS fails frequently and suddenly, there would be excessive reliance on the UHS. This is the only safety-related consideration associated with the NPHS. Section 2.4.15.2 of this SER discusses the UHS.

The staff performed two independent analyses to confirm whether the NPHS could be expected to fail both suddenly and frequently. Failure was defined as a situation in which the lake water surface elevation drops below the level that would require shutdown and possible reliance on the UHS. One staff 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 the changes in lake water surface elevation for the 24-year period of record from June 1, 1978, to April 31, 2002. The applicant provided information on the pool elevation that would be predicted if the ESP facility had operated during this period. The applicant used a water budget approach in which the change in lake storage results from an imbalance between inflows and outflows. The applicant considered inflows from direct precipitation onto the lake and upstream drainage. The applicant assumed outflow to be the sum of natural evaporation, induced evaporation caused by the existing CPS Unit 1, and direct evaporation from the EPS facility operating with wet cooling towers.

To estimate the tributary inflows, the applicant's analysis estimated monthly average runoff yield coefficients (i.e., the ratio of runoff to rainfall). The applicant then multiplied these coefficients by the recorded rainfall during the period of record to generate a runoff record. By considering only rainfall (and not snowfall), the applicant's approach resulted in conservative annual water yield estimates. However, this approach would not necessarily provide conservative estimates in warm, dry years. Therefore, the staff applied a different approach.

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

The staff analysis found the frequency and 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 applicant's approach, thus rendering the results nonconclusive. However, the staff's second analysis did adequately assess the rate at which the lake water surface elevation could be expected to drop.

The staff assumed that the induced evaporation 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. This assumption is conservative because some of the heat load would be lost to back radiation and conductive heat exchange. From the PPE table, the consumptive water loss of the ESP facility was estimated to be 70 cfs. The highest monthly evaporation rate recorded by Roberts and Stall (1967) is 8.38 in. for July 1936. Correcting for the lake area, this results in a conservative estimate of the drop in the lake water surface elevation of 4.85 ft/mo. Even at this rate of decline, the drop of the lake water surface elevation would be gradual enough for the plant to react well before the UHS system would be required.

As noted above in Section 2.4.15.1.1 of this SER, the staff had intended to impose the applicant-stated maximum NPHS load during normal operation equal to 15.08×10^9 Btu/h and the maximum discharge temperature of 100 EF as DSER Permit Conditions 3.2-1 and 3.2-2. As explained above, the staff used the total reject heat load from the NPHS and assumed that all of it is lost as evaporation. During this analysis, discharge temperature was not a limiting factor. The staff's analysis showed that at the conservatively estimated rate of evaporation, a drop in Clinton Lake's water surface elevation would be gradual. Based on this conclusion, the staff determined that it is not necessary to impose DSER Permit Conditions 3.2-1 and 3.2-2.

2.4.15.1.4 Conclusions

As set forth above, the staff concludes that the applicant provided sufficient information to show that the NPHS is likely to be able to perform its function consistent with the maximum thermal discharge assumed in the PPE) (SSAR Table 1.4) and that the consequences of the NPHS operation on the UHS are acceptable and do not lead to frequent plant shutdown or frequent use of the UHS.

2.4.15.2 Ultimate Heat Sink

The ESP site is adjacent to Clinton Lake, which provides cooling water for the current CPS Unit 1. The applicant proposed that the ESP facility's UHS would share the same source of water as the existing plant. Events that might potentially reduce or limit the availability of cooling water for the ESP facility's UHS at this site include low lake elevation, seiches, wind-induced set down, and intake blockages from sediment or ice. Section 2.4 of this SER discusses these events.

Although the UHS provides a critical safety function, the NPHS has no safety function and is not required for shutdown or accident mitigation. The only safety-related consideration associated with the NPHS relates to a situation in which the NPHS fails suddenly and frequently enough that the ESP facility would be required to rely excessively on the UHS. Section 2.4.15.1 of this SER discusses the NPHS.

2.4.15.2.1 Technical Information in the Application

In Section 3.2.2 of the SSAR, the applicant provided a brief description of the UHS. In Section 3.2.2.1, the applicant stated that, in accordance with RG 1.27, the UHS system would consist of a minimum of two redundant cooling trains. In response to RAI 3.2.2-1, the applicant provided a schematic of the water circulation in the UHS system.

In Section 3.2.2.2, the applicant further stated that the maximum discharge flow from the UHS cooling system to the cooling towers would be 26,125 gpm during normal operation and 52,250 gpm during shutdown. This flow rate reflects the recirculation of water within the cooling system. Water would be withdrawn from Clinton Lake to make up for water lost from evaporation and to limit the concentration of impurities in the cooling water. The applicant stated that the cooling tower evaporation rate would normally be 411 gpm, with a maximum of 700 gpm.

The applicant stated that the maximum UHS load during normal operation would be 225x10^6 Btu/h and 411.4x10^6 Btu/h during shutdown, with a maximum discharge temperature of 95 EF in both cases.

The applicant indicated that the UHS pond is a submerged pond created by a submerged dam across the North Fork of Salt Creek downstream of the plant intake. This submerged pond maintains adequate capacity for 30 days of UHS operation in case the Clinton Lake Dam fails. This UHS pond would be shared with the existing CPS Unit 1. A baffle in the UHS pond is part of the UHS system design for the existing unit. In response to RAI 3.2.2-2, the applicant stated that the maintenance of the integrity of the UHS baffle is not required for the ESP facility's UHS operation.

2.4.15.2.2 Regulatory Evaluation

In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of the NRC regulations applicable to its ESP SSAR. In its response to RAI 1.5-1, the applicant stated that SSAR Section 3.2 addresses thermal discharges as required by 10 CFR 52.17(a)(1)(iv), which states that an ESP should describe the anticipated maximum levels of thermal effluents each facility will produce.

The staff believes that additional applicable regulations are GDC 2 and 44, as well as 10 CFR 100.23(c), and the applicable regulatory guides are RGs 1.27 and 1.70. However, an ESP applicant need not demonstrate compliance with the GDC.

Acceptance criteria for this section relate to the following regulations:

- 10 CFR Parts 52 and 100 require that the evaluation of a site consider hydrological characteristics.

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

The regulations at 10 CFR Parts 52 and 100 require that the evaluation of a nuclear power plant site consider the hydrological characteristics of the site. To satisfy the requirements of

10 CFR Parts 52 and 100, the 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 affected by, among other things, site hydrological characteristics that may reduce or limit the available supply of cooling water for safety-related SSCs. Site hydrological characteristics that may reduce or limit the flow of cooling water include those resulting from river blockage or diversion, tsunami runup and drawdown, and dam failure.

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

The regulation at 10 CFR 100.23 requires the evaluation of siting factors, including the cooling water supply, for a potential 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, diversion, or other failures that may block the flow of cooling water, tsunami runup and drawdown, and dam failures.

The regulation at 10 CFR 100.23 applies to this section because the UHS for the cooling water system consists of water sources that are subject to natural events that may reduce or limit the available supply of cooling water (i.e., the heat sink). Natural events, such as river blockages or diversion 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 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; such needs may fall within a PPE (e.g., the stored water volume of the cooling water ponds), if an applicant uses that approach. Specifically, these needs include the maximum essential design cooling water flow, as well as the maximum design flow for normal plant needs at power and at shutdown.

2.4.15.2.3 Technical Evaluation

The staff reviewed the capacity requirements for the UHS pond in Section 2.4 of this SER. In addition, the staff independently evaluated the evaporation rates estimated for the UHS system based on the latent heat of water and the reject heat load stated in the PPE and found the applicant’s estimates to be consistent with a conservative value of consumptive water requirements for a UHS pond.

The applicant stated that the maximum UHS load during normal operation is 411.4×10^6 Btu/h, with a maximum discharge temperature of 95 EF. The staff had intended to identify these values as DSER Permit Conditions 3.2-3 and 3.2-4. However, at the ESP stage, a specific reactor type for the ESP facility is not known. Therefore, it is also not known whether a UHS will be required by the ESP facility. In the event that the ESP facility does require a UHS, the staff used the PPE evaporation rate for the UHS equal to 411 gpm for 30 days to establish excess capacity within the submerged UHS pond. As discussed in Section 2.4.8.3 of this SER, the staff determined that the submerged UHS pond has an excess capacity of approximately 318 ac-ft. Based on this review, the staff concluded that DSER Permit Conditions 3.2-3 and 3.2-4 are not required.

2.4.15.2.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the NPHS to determine that the consequences of the NPHS operation on the UHS are acceptable and should not lead to frequent plant shutdown or frequent use of the UHS. Therefore, the staff concludes that the applicant has met the requirements of 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing design-basis information for the UHS with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.16 Site Characteristics Related to Hydrology

Based on the staff review of SSAR Section 2.4, the following site characteristics should be incorporated in any ESP that might be issued for the proposed site.

Table 2.4-7 Proposed Site Characteristics Related to Hydrology

SITE CHARACTERISTIC	VALUE
Proposed Facility Boundaries	Figure 2.4-15
Site Grade	735 ft MSL
Highest Ground Water Elevation	733.5 ft MSL
Probable Maximum Flood (PMF) maximum hydrostatic water surface elevation	709.8 ft MSL
Coincident Wind Wave Activity (to add to the PMF water surface elevation)	6.4 ft
Storm Surge (to add to the PMF water surface elevation)	0.3 ft
Combined Effects Maximum Water Surface Elevation	716.5 ft MSL
Local Intense Precipitation	18.15 in. during 1 hour
Lake Surface Icing	27.0 in.
Maximum Cumulative Degree-Days	1141.5 in Fahrenheit
Frazil and Anchor Ice	The ESP site is subject to frazil and anchor ice formation.

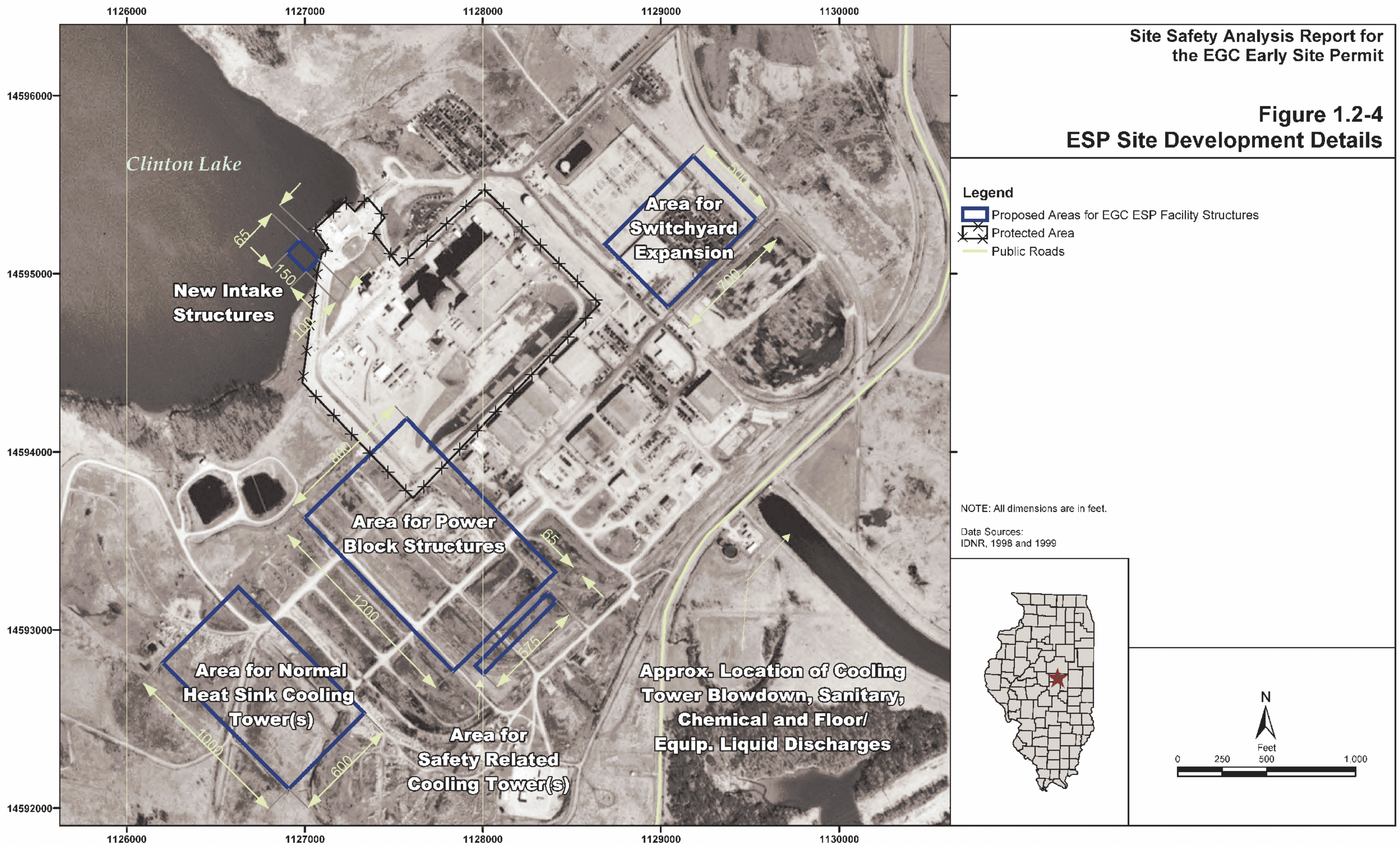

Figure 2.4-15 The proposed facility boundary for the ESP site