October 17, 2006

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
EXELON GENERATION COMPANY, LLC.	)	Docket No. 52-007-ESP
	)	
(Early Site Permit for Clinton ESP Site)	)	

NRC STAFF'S PREFILED DIRECT TESTIMONY ON HEALTH AND SAFETY ISSUES IN THE CLINTON ESP PROCEEDING

The questions and answers below constitute the NRC Staff's prefiled direct testimony on health and safety issues in the Clinton ESP proceeding. Appended to the testimony are affidavits and statements of professional qualifications for the associated reviewers, whose initials are indicated for each portion of testimony for which they have technical responsibility in the context of this mandatory hearing. In most portions of the testimony, useful citations – for example, to applicable regulations or to relevant pages of the Staff's review documents – have been included for reference.

a. SER Chapter 1, "Introduction" & Project Manager's Overview

Q1: Describe briefly the scope and chronology of the Staff's safety review.

A1: 1. (JS) The Staff's Safety Evaluation Report ("SER") presents the conclusions of the Staff's review of relevant portions of the ESP application and supplemental information provided by the Applicant. The ESP application includes (1) a description of the site and nearby areas that could affect or be affected by a nuclear power plant located on the site, (2) a safety assessment of the site on which the facility would be located, including an analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site, and (3) the proposed major features of an emergency plan. Specifically, the SER discusses the geography and demography of the site;

nearby industrial, transportation and military facilities; site meteorology; site hydrology; site geology, seismology, and geotechnical engineering; aircraft hazards; radiological effluent release dose consequences from normal operations; emergency planning and industrial security; accident analyses; and ESP quality assurance measures.

2. (JS) On September 25, 2003, Exelon Generation Company, LLC (the Applicant) filed an ESP application with the NRC; this application includes the site safety analysis report ("SSAR"), which describes the safety assessment of the site. Supplements were filed on November 23, 2005, and January 10, March 3 and April 14, 2006. Upon receipt of the original application the Staff reviewed the SSAR and produced a draft safety evaluation report ("DSER"), which it issued on February 10, 2005. At the time the DSER was issued, the Staff had not completed its review of seismology and geology, these issues were addressed in a supplemental DSER issued on August 26, 2005. Additionally, throughout the course of the review the Staff requested and received supplemental materials from the Applicant. The Applicant's responses to these Staff Requests for Additional Information ("RAIs") are included in the final SER.

3. (JS) The Advisory Committee on Reactor Safeguards ("ACRS") completed its review of the Application and of the Staff's DSER. SER at 18-1. The ACRS ESP subcommittee began a detailed review of the application and DSER in February 2005, and the ACRS ESP subcommittee met with representatives from Exelon and the NRC Staff on September 7, 2005. SER at 18-1. The ACRS issued an interim letter report in September 2005, and also met with the Staff in March 2006 to discuss resolution of open items and the responses to ACRS comments on the major elements of the ESP review. SER at 18-1. In its final letter report dated March 24, 2006, the ACRS concurred with the Staff's conclusions and concluded that the proposed site, subject to the permit conditions recommended by the Staff, can be used for nuclear power plants or modules having a total power generation rate of 2400 to 6800 MW

thermal without undue risk to public health and safety. SER at 18-1. The final SER was published (as NUREG-1844) in May 2006.

Q2: Describe briefly the primary regulatory guidance applicable to the Staff's safety review.

A2: 4. (JS) The NRC standards for review of an ESP application are outlined in 10 C.F.R. § 52.18. The NRC Staff conducts its reviews of ESP applications in accordance with guidance set forth in review standard RS-002. That review standard draws from the previously published NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*, as well as from NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants* (hereafter "ESRP").

Q3: Describe the general characteristics of the proposed Clinton ESP Site.

A3: 5. (JS) The Clinton ESP[1] facility would be located approximately 700 feet south of the current Clinton Power Station ("CPS") facility, on the existing CPS property (with its associated 4895-acre, man-made cooling reservoir, Clinton Lake) in DeWitt County in east-central Illinois, about 6 miles east of the city of Clinton. SER at 1-4. Although Exelon has not selected a specific reactor type for the Clinton ESP site, it used available information from a range of possible facilities to create a plant parameter envelope ("PPE") representing bounding values for the proposed development. SER at 1-4. Depending on the reactor type selected, the ESP facility would consist of a single reactor or multiple reactors (or modules) of the same reactor type and could have a total core thermal power rating between approximately 2400 and 6800 MWt. SER at 1-4. Unlike the existing CPS Unit 1, which uses Clinton Lake for normal cooling processes, the Clinton ESP facility would use cooling towers; Clinton Lake would be

[1] The ESP site will be referred to in the Health and Safety Testimony as the Clinton ESP site; however, in the SER, the FEIS, and the "NRC Staff's Prefiled Direct Testimony on Environmental Issues in the Clinton ESP Proceeding," it is also referred to as the "EGC [Exelon Generation Company] ESP" or the "Exelon ESP."

used as the source of makeup water for the Clinton ESP facility cooling water systems. SER at 1-5.

Q4: What is the basis for the Applicant's plant parameter envelope, and how was it reviewed by the Staff?

A4: 6. (JS) The Applicant's PPE is based on various reactor designs that are either certified by the NRC, are in the certification process, or may be submitted for certification in the future. SER at 1-6. As discussed throughout the SER, the Staff reviewed the Applicant's PPE values and found them to be reasonable. SER at 1-7. The Staff identified certain PPE values as bounding parameters or controlling PPE values (bounding values are listed in Appendix A to the SER). SER at 1-7. Because the PPE is intended to bound multiple reactor designs, the NRC would review the actual design selected in a COL or construction permit application referencing any Clinton ESP to ensure that the design falls within the bounding parameters of the PPE. SER at 1-7.

Q5: Does the approach used by the Staff in its health and safety review differ from that used in the environmental review?

A5: 7. (JS) Yes. In general terms, there are some fundamental differences between the approaches used for the final safety evaluation report ("FSER") and the FEIS. The sources of these differences are the statutory and regulatory requirements for each review. The Staff's safety review is performed under the Atomic Energy Act and in accordance with the regulations in 10 C.F.R. Part 52. The environmental review is performed under NEPA as implemented in NRC regulations at 10 C.F.R. Part 51. Whereas the safety review is focused primarily on protecting the health and safety of the public, the environmental review considers a much broader range of impacts to the environment as a whole.

8. (JS, JL) The safety review generally focuses on the results of conservative analyses. For an environmental review under NEPA and Part 51, the Staff evaluates the reasonably foreseeable environmental impacts of issuing an ESP. In addition, the Staff has the latitude, if numerical data are not available, to qualitatively evaluate the impacts.[2] As an example, in considering χ/Q values the Staff used "typical" meteorological conditions in the FEIS (see FEIS at 5-63). "Typical" is defined as those conditions that give atmospheric dispersion factors that are exceeded [i.e., dispersion is less] 50 percent of the time. In contrast, for the Chapter 15 analyses in the FSER, the Staff used values for χ/Q associated with "adverse" meteorological conditions (defined as those conditions that give atmospheric dispersion factors that are exceeded no more than 5 percent of the time).

9. (JS) Another reason for differences in approach between the FEIS and the FSER is the matter of perspective. For example, both the FEIS and the FSER consider impacts related to hydrology. But in these two documents, the Staff is looking at hydrology for very different reasons. In the FEIS, the Staff is evaluating the impacts on the hydrology of the surrounding area of building and operating a nuclear plant (or plants). In the FSER, in contrast, the Staff is evaluating the potential impacts of local hydrology on the plant. Thus, in one case the Staff is looking from the inside out, and in the other case it is looking from the outside in. This difference in perspective leads to very different evaluations in relation to the same resource. Specifically, the analyses in the FSER address, for example, concerns related to the probable maximum flood, an issue unrelated to the environmental review. On the other hand, the analyses in the FEIS address concerns related to issues such as reductions in lake level, changes in flows, and the thermal plume.

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[2] As stated in 10 C.F.R. § 51.70(d), "The analysis for all draft environmental impact statements will, to the fullest extent practicable, quantify the various factors considered. To the extent that there are important qualitative considerations or factors that cannot be quantified, these considerations or factors will be discussed in qualitative terms."

10. (JS) In summary, because of the differences in the basic goals of the analyses in the FEIS and the FSER, there are differences in the data used and the approaches applied by the Staff in the analyses. Based upon the reasoning described above, these differences are to be expected between the FEIS and FSER reviews.

Q6: More specifically, do differences in the two documents' analysis of the impacts for reactors other than the ABWR and the AP1000 affect the logic of the Staff conclusions?

A6: 11. (JS, JL) With respect to the difference between the FEIS and the FSER in connection with the treatment of certified and non-certified designs, the Staff reviewed how it addressed designs other than the ABWR and AP1000 in Section 5.10 of the FEIS and in Chapter 15 of the FSER. The Staff does not believe that the depth of its analyses for these designs is markedly different. In both the FEIS and the FSER, the analyses related to accidents focused on the ABWR and the AP1000 because of the level of information available for these designs. In the case of the FSER, the Staff had already evaluated accidents for these designs as part of the design certification reviews. So, in essence, most of the work had already been done. For the FEIS, the Staff was, for the first time, evaluating the environmental impacts of accidents for these designs at a site. For the other reactor designs in both the FEIS and the FSER, the Staff indicated that there was not as much information available, but the Staff judged the results for the ABWR and the AP1000 as likely to bound the results for the other designs. In both documents, the Staff indicated that, if a design other than the ABWR or AP1000 were chosen at the COL stage, the assumption that the results were bounded would have to be confirmed.

Q7: Where the Staff intends to confirm certain assumptions at the CP or COL stage, what is the nature of the "verification" to be conducted by Staff at the COL stage beyond assuring that the actual plant design falls within those bounds?

A7: 12. (JS) The Staff would conduct the verification of key assumptions at the COL stage in a manner similar to that employed during the review of the ESP application. For example, the Staff would review information provided by the applicant in its ER and during the Staff's audit, and perform an independent review of these matters, including obtaining and reviewing information from local, State, Tribal, and Federal authorities.

13. (JS) The Staff also identified 32 COL action items[3] in the SER (compiled in SER Appendix A) in order to ensure that particular significant design and construction issues are tracked and considered during the COL or CP stage.[4] The Staff determined that these COL action items do not affect its regulatory findings at the ESP stage and are more appropriately addressed at later stages in the licensing process. SER at 1-9. Finally, the Staff identified 6 permit conditions (also listed in Appendix A) to control various safety matters; the Staff will recommend the Commission impose if an ESP is issued. SER at 1-9, 1-10.

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[3] A COL action item is a tool, devised by the Staff, used to highlight significant issues that the Staff identified during the ESP or design certification review. These items should be considered by the Staff during the review of a COL application. COL action items are used by the staff to track significant design and construction issues associated with individual site characteristics that should be considered at the COL or CP stage.

[4] COL action items do not establish requirements; rather, they identify an acceptable set of information to be included in the site-specific portion of the safety analysis report submitted by a COL or CP applicant referencing a Clinton ESP. SER at 1-9.

b. SER, Chapter 2, "Site Characteristics";

Section 2.1, Geography and Demography

14. (JS) In Chapter 2 of the SER, the Staff evaluated a range of information concerning the site characteristics of the proposed Clinton ESP site. In particular, the Staff reviewed the application with respect to geography and demography; nearby industrial, transportation, and military facilities; meteorology; hydrology; and geology, seismology, and geotechnical engineering.

Q8: Describe the Staff's health and safety review with respect to the geography and demography of the proposed site.

A8: 15. (JL) The Applicant provided information on the site location, including the site boundary for a new unit in reference to the existing CPS; the site location with respect to political subdivisions and prominent natural and manmade features of the area within the 2.5-mile low-population zone ("LPZ") and 50-mile population zone; the surrounding topography; the distance (defined as a circular radius of 0.64 miles) to the nearest exclusion area boundary ("EAB"); the location of potential radioactive material release points; the distance from U.S. and State highways; and confirmation that no physical characteristics unique to the proposed ESP site that could pose a significant impediment to the development of emergency plans were identified. SER at 2-1, 2-2, 13-13. No persons live within either the CPS EAB or the proposed ESP site EAB, and the Staff verified that the exclusion area distance is consistent with the distance used in the radiological consequence analyses performed by both the Applicant and the Staff. SER at 2-2, 2-3. The Staff found that the Application contained sufficient information for the Staff to evaluate compliance with the siting evaluation factors in 10 C.F.R. Part 100 and 10 C.F.R. § 52.17, as well as with the radiological consequence evaluation factors in 10 C.F.R. § 50.34(a)(1).

16. (JL) The Staff found that the Applicant had provided and substantiated information concerning its plan to obtain legal authority sufficient for it to determine all activities within the designated exclusion area. The Staff also found that the Applicant had appropriately described the exclusion area and the methods by which it will control access to (and occupancy of) this exclusion area during normal operation and in the event of an emergency situation. SER at 2-6. The Staff concluded that the Applicant's exclusion area is acceptable and meets the requirements of 10 C.F.R. Part 100, subject to two proposed permit conditions: 1) that Exelon obtain an agreement granting it an exclusive and irrevocable option to purchase, enter a long-term lease, and/or other legal right in the land, before submitting any COL application referencing a Clinton ESP, and 2) that an ESP holder seeking to perform any authorized 10 C.F.R. § 52.25 limited work activities obtain the authority to undertake such activities on the ESP site, along with the corresponding right to implement the site redress plan if no plant is actually built on the ESP site. SER at 2-6, 2-7.

17. (JL) With respect to population density, the Staff compared and verified the Applicant's population data against U.S. Census Bureau data. The Staff reviewed population projections (extending to the year 2060), and found that the Applicant's projected population data, including for the transient population, cover an appropriate number of years (through the projected year for end of plant life) and are therefore reasonable.[5] SER at 2-9. The Staff also determined that population densities for the proposed ESP site would be well below 500

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[5] The Applicant assumed that the rate of population change would remain essentially constant between 2010 and 2060. There are, however, no additional population predictions for the counties involved through 2060. The U.S. Bureau of the Census has projected population growth nationally through 2050 and statewide through 2030; the Staff determined that the Applicant's intermediate projections for Illinois are not inconsistent with the Bureau's conclusions.

The regulatory guidance for assessing population considerations for site suitability recognizes the uncertainty inherent in population projections over extended periods (*See, e.g.,* RG 4.7, "Reactor Site Criteria"). In the event that population growth in the site vicinity departs from the presented data, the new data will be factored into emergency plans for the site in accordance with Section G, "Maintaining Emergency Preparedness," of Appendix E to 10 C.F.R. Part 50.

persons per square mile, in conformance with Regulatory Position C.4 in RG 4.7, Revision 2. SER at 2-10. Finally, as the LPZ is located entirely within the 10-mile emergency planning zone ("EPZ"), and comprehensive emergency planning for the protection of all persons within the 10-mile EPZ would include those persons within the LPZ, the Staff concluded that appropriate protective measures could be taken on behalf of the populace within the LPZ in the event of a serious accident. SER at 2-10, 13-13. Therefore, the Staff found that the proposed LPZ and population center distance meet the definitions in 10 C.F.R. § 100.3, and it concluded that the Applicant's population data and population distribution meet the requirements of 10 C.F.R. § 52.17 and 10 C.F.R. Part 100. SER at 2-10.

Section 2.2, Nearby Industrial, Transportation, and Military Facilities

Q9: Describe the Staff's health and safety review with respect to nearby industrial, transportation, and military facilities.

A9: 18. (KC) The Applicant provided information on the relative location and separation distance of the ESP site from industrial, military, and transportation facilities and routes, including air, ground, and water traffic; pipelines; and fixed manufacturing, processing, and storage facilities. SER at 2-11. Noting that the ESP site is in a rural and agricultural area, the Applicant stated that only 3 small industrial facilities exist within 5 miles of the ESP site, and that no industrial facilities, pipelines, or other developments are located in the proposed exclusion area other than CPS. SER at 2-11. Five pipelines cross the CPS property, one of which passes within 1 mile of the ESP site. SER at 2-11. The Applicant identified four small private airstrips within 6 miles of the ESP site, and it stated that Clinton Lake is the only navigable waterway in the vicinity of the ESP site. SER at 2-13. The Staff, in its review, applied the regulatory positions and criteria in RG 1.91 and RG 1.78, Revision 1. The ESP facility would be located adjacent to the existing CPS facility, therefore the Staff also considered the CPS

updated safety analysis report ("USAR"), which identifies and evaluates the potential hazards from nearby industrial facilities. SER at 2-14. The Staff did not identify any relevant facilities not previously noted by the Applicant and, after consideration of the Application and RAI responses and its independent review, the Staff concluded that the Applicant identified all potentially hazardous activities on and near the site. SER at 2-14, 2-15.

19. (KC) The Staff reviewed the Applicant's probability analyses of potential accidents involving hazardous materials or activities on and near a new nuclear unit at the ESP site, including flammable vapor clouds, aircraft crashes, and toxic chemicals. SER at 2-15. The Staff also reviewed the Applicant's analyses of the consequences of accidents involving nearby industrial, military, and transportation facilities to determine if any should be identified as design-basis events. SER at 2-15. Based on the CPS USAR (concerning airway and airport facilities, rail shipments and onsite chemical storage at CPS), and also on the distance of the potential ESP facility from the worst-case train tank explosion accident, the Staff determined that the Applicant's analyses used the appropriate data and analytical models, that the Applicant properly identified potential accidents related to the presence of hazardous materials or activities on or near the ESP site that could affect a nuclear unit represented by the chosen PPE, and that the Applicant properly identified accidents that should be considered as design-basis events at the COL or CP stage. SER at 2-15, 2-17, 2-18. Since Exelon has not determined the specific design of the ESP facility, the Staff concluded it will need to review certain potential accidents (including some that might affect control room habitability) at the COL stage, using the guidance in Section 6.4 of the SRP. SER at 2-15, 2-17, 2-18. Therefore, the Staff concluded that the site location is acceptable with regard to accidents that could affect a nuclear unit (based on the Applicant's PPE) that might be constructed on the site, and that the site location meets the requirements of 10 C.F.R. § 52.17(a)(1)(vii), 10 C.F.R. § 100.20(b), and § 100.21(e). SER at 2-18.

Section 2.3, Meteorology

Q10: Describe the Staff's health and safety review with respect to meteorology.

A10: 20. (RH) The Staff found, as stated in Sections 2.3.1.4, 2.3.2.4, 2.3.4.4, and 2.3.5.4 of the SER, that the Applicant's identification and consideration of the meteorological characteristics of the site and surrounding area meet the requirements of 10 C.F.R. 100.20(c)(2),[6] 10 C.F.R. 100.21(c),[7] and 10 C.F.R. 100.21(d).[8] Although the Applicant did not identify all the applicable regulations and regulatory guidance, the Staff found that the Applicant did comply with the regulations and regulatory guidance that were not identified.[9]

21. (RH) As part of its review of meteorological characteristics, the Staff evaluated regional and local climatological information, including climate extremes and severe weather

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[6] §100.20(c)(2) states that the meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design (such as maximum probable wind speed and precipitation) must be identified and characterized.

[7] §100.21(c) states that site atmospheric dispersion characteristics must be evaluated and dispersion parameters established such that (1) radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located offsite and (2) radiological dose consequences of postulated accidents shall meet the criteria set forth in §50.34(a)(1) for the type of facility proposed to be located at the site.

[8] §100.21(d) states that the physical characteristics of the site (including meteorology) must be evaluated and site parameters (e.g., site characteristics) established such that potential threats from such physical characteristics will pose no undue risk to the type of facility to be located at the site.

[9] For example, the Staff found that the Applicant should have identified Appendix I to 10 C.F.R. Part 50 as an applicable regulation regarding long-term (routine release) atmospheric dispersion estimates. Appendix I requires demonstrating compliance with the numerical guides for doses contained in this appendix by characterizing atmospheric transport and diffusion conditions to estimate the radiological consequences of routine releases of materials to the atmosphere. Nonetheless, the Staff found that the Applicant met these regulatory requirements by providing the appropriate atmospheric dispersion and deposition estimates for estimating the radiological consequences of routine releases of materials to the atmosphere. SER 2-50 to 2-51.

The Staff also found that the Applicant should have also identified RG 1.112 with respect to the criteria to be used to identify release points and release characteristics applicable to the extent the Applicant provides release points and release characteristics at the ESP stage. Nonetheless, the Staff found that the Applicant made conservative release characteristic assumptions by treating all releases as ground-level releases.

The Staff also noted that if the ESP site does not remain in compliance with the terms and conditions of the ESP, the Staff would seek to modify the ESP or impose requirements on the site. These meteorological concerns are not documented as COL Action Items or permit conditions because § 52.39 provides for the Staff's modification of the ESP to bring the site back into compliance.

occurrences affecting design and siting. The Staff reviewed information concerning the atmospheric dispersion characteristics of the proposed nuclear power plant site to ensure that radioactive effluents from postulated and operational releases stay within Commission guidelines. The Staff prepared Sections 2.3.1 through 2.3.5 of the SER in accordance with the review procedures and reference materials in RS-002 (Attachment 2), using information presented in Section 2.3 of the site safety analysis report ("SSAR"), and responses to Staff RAIs. SER at 2-18.

Q11: Please describe the Staff's examination of regional climatology.

A11: 22. (RH) The Applicant provided information regarding the regional climate and meteorological phenomena, including averages and extremes, that could affect the design and siting of a reactor (within the PPE) at the proposed site. These data were based on information provided by (1) the U.S. National Weather Service at the Peoria and Springfield, Illinois first-order weather stations, (2) nearby cooperative stations (such as the station in Decatur, Illinois), (3) the National Climatic Data Center (NCDC), (4) the American Society of Civil Engineers (ASCE), (5) the Illinois State Climatologist Office (ISCO), and (6) the Illinois State Water Survey (ISWS). SER at 2-18, 2-19.

23. (RH) The Staff's evaluation of the meteorological information utilized information provided by NCDC, National Severe Storms Laboratory ("NSSL"), ISCO, and ASCE. Additionally, Pacific Northwest National Laboratories ("PNNL") prepared a technical evaluation report assessing the tornado site characteristics of the Clinton ESP site. SER at 2-27, 2-28.

24. (RH) The Staff reviewed the available information and found that the Applicant's analysis of the regional and site meteorological characteristics met the requirements of 10 C.F.R. § 100.20(c)(2) and 10 C.F.R. § 100.21(d). SER at 2-33.

25. (RH) As part of its study of the regional meteorology, the Applicant evaluated the 48-hour probable maximum winter precipitation (PMWP). Based on its analysis, the Applicant found a PMWP value of 16.6 inches of water for the ESP site. This value was determined for a 296 square-mile drainage area surrounding the site. The Staff performed an independent 48-hour PMWP analysis for a smaller (more conservative) 10 square-mile drainage basin and found a PMWP value of 18.2 inches of water. However, the Staff found the Applicant's results to be acceptable. The difference between the results can most likely be attributed to the difference in drainage area evaluated (i.e., 10 square miles versus 296 square miles). The weight of the 48-hour PMWP is combined with the weight of the 100-year snowpack to determine the winter precipitation loads that should be included in the combination of extreme live loads in the design of roofs of safety related SSCs pursuant to the Site Analysis Branch Position on Winter Precipitation Loads (ADAMS Accession No. ML050630277). The Staff believes that combining the weight of the 48-hour PMWP with the 100-year snowpack is a very conservative design assumption and expects that a COL Applicant referencing the 48-hour PMWP site characteristic will satisfactorily demonstrate that the 48-hour PMWP (whether it is 16.6 inches of water or 18.2 inches of water) could neither fall nor remain entirely on top of the antecedent snowpack and/or roofs. The Staff therefore found that its 48-hour PMWP results were compatible with the Applicant's results.

Q12: Please describe the Staff's examination of local meteorology.

A12: 26. (RH) The Applicant provided information on the local meteorological conditions based on data collected by the meteorological monitoring program at the CPS. These data were provided for periods from April 1972–April 1977 (pre-CPS Construction) and January 2000-August 2002 (post-CPS Construction). Since the temperature and humidity data were collected from 1972 to 1977 (pre-CPS) the Staff asked the Applicant whether the

construction of Clinton Lake, which is heated, and the once-through cooling system of the CPS, had any effect on the validity of the data. The Applicant made qualitative comparisons of the 1972 - 1977 and 2000 - 2002 temperature and humidity data sets, and concluded that the two data sets were compatible, with only expected variations.[10] SER at 2-34, 2-35. The Applicant used the more recent 2000-2002 data set to develop the short-term (accident release) and long-term (routine release) atmospheric dispersion site characteristics presented in SER Sections 2.3.4 and 2.3.5. SER at 2-45, 2-49.

27. (RH) The Staff also evaluated the local intense precipitation for the site. The Staff's analysis produced an estimate of 18.15 in/h at the ESP site.[11] The local intense precipitation site characteristic of 18.15 in/h clearly bounds the highest recorded 1-day

[10] Although the Staff has not reviewed the details of the Applicant's 1972-77 and 2000-02 temperature/humidity data set comparison, the Staff accepts the Applicant's conclusion that the data sets are compatible. The heating effects attributable to the heated lake should be minimal since the meteorological tower is located approximately ½ mile from the nearest shoreline which is more than 4 miles downstream of the CPS thermal plume discharge location. Any minimal heating effects would be difficult to discern, given the typical year-to-year variations in temperature and humidity as well as the accuracy of the measurements (e.g., typically ±0.5 °C per RG 1.23).

The minimal effects of a nearby lake (heated or unheated) may be more discernable on the delta- temperature (i.e., vertical temperature difference) measurements used to determine atmospheric stability since delta-temperature measurements are typically five times more sensitive than ambient temperature measurements (e.g., typically ±0.1°C per RG 1.23). It is not unexpected to see a slight shift towards unstable conditions due to the water body's potential influence on the lower delta-temperature measurements 10 meters above ground level. Changes in monitoring equipment (e.g., sensors, data recorders) and data reduction methods that occurred between the 1972-77 and 2000-02 data sets may have also caused a change in the reported stability data.

[11] This value is noted as a Site Characteristic in Section 2.4.2.3 of the SER.

precipitation total of 14.25 inches of rain[12] and will be used to mitigate impacts of local site flooding based on grading and drainage design at the COL stage.

28. (RH) The Staff reviewed the Applicant's description of the local meteorology and determined that it represents the conditions at and near the site. The site characteristics listed in Appendix A.3, which will become part of the ESP if the permit is issued, include the winter site characteristics (100 year snowpack and 48-hour PMWP) that must be used by the Applicant in evaluating roof designs at the COL stage. The Staff also reviewed the expected terrain modifications associated with the development of the ESP facility and the site's attainment status designations with respect to the national ambient air quality standards and concluded that neither the terrain modifications nor site air quality conditions would affect plant design and operation. SER at 2-39. The Staff reviewed the available information and concluded that the Applicant's identification and consideration of the meteorological, air quality, and topographical characteristics of the site and the surrounding area meet the requirements of

[12] The 14.25 inches of rain in one day (May 8, 1961) was recorded at the Clinton Climatic Station, which is located approximately 7 miles from the Clinton ESP site and 1 mile from the town of Clinton, IL. The rainfall event was recorded almost 15 years before the existing Clinton Power Station received its construction permit on February 24, 1976, when neither the man-made Lake Clinton nor the Clinton Power Station were in existence. The U.S. Weather Bureau publication "Storm Data" dated May 1961 (Volume 3 No. 5) described the storm event, noting that the entire event occurred from May 5-8, 1961, involving heavy rain, wind, hail, and lightning in Central and Southern Illinois; 2 persons were killed and 2 injured, with estimated property damage of $5,000,000–$50,000,000, and estimated crop damage of $50,000–$500,000.

The Weather Bureau publication provided further details as follows: Heavy rains accompanied by thunderstorms, high winds and hail overflowed lakes, rivers and streams flooding cities, towns and farmlands in central and southern Illinois. Hundreds of families were evacuated from their homes in the worst flooding since 1943. Heaviest 4 day rainfall totals were generally recorded on a line from East St. Louis to Vincennes, Indiana, where generally 10 to 13 inches occurred. The heaviest 4 day amount occurred at Clinton where 15.77 inches fell. 3 to 6 feet of water flooded streets in Browns, Centralia, Edwardsville, Collinsville, Belleville, Marion, Clinton, Mt. Carmel and other locations. At least 25 major highways were blocked by high water. One man suffered a fatal heart attack as his car plunged into deep water on a highway near Centralia. A New Athens farmer was drowned in an overflowed creek. At Tower Hill, a woman was burned by lightning, which struck and set fire to her home. In Decatur a man was injured by lightning, which blasted an 8 × 10 hole in his house. Golf ball sized hail broke 350 windows in a greenhouse in Milford and caused considerable damage to homes in the area.

10 C.F.R. § 100.20(c)(2) and 10 C.F.R. § 100.21(d) and are sufficient to determine the acceptability of the site. SER at 2-39.

29. (RH) The Staff concluded that the Applicant had presented and substantiated information on local meteorology, air quality, and topographic characteristics of importance to the safe design and operation of a nuclear power unit falling within its PPE that might be constructed on the proposed site.

Q13: Please describe the Staff's review of the onsite meteorological measurements program.

A13: 30. (RH) The Applicant used the existing onsite meteorological measurements program for the CPS facility to collect data for the Clinton ESP site. SER at 2-40. The Staff evaluated the onsite meteorological measurements program by reviewing the program description presented in the SSAR and conducting a site visit. The site visit consisted of reviewing the meteorological monitoring system location and exposure, sensor type and performance specifications, data transmission and recording, data acquisition and reduction, and instrumentation maintenance and calibration procedures. The Staff performed a quality review of the post-CPS construction hourly meteorological database. The Staff's examination of the data revealed generally stable and neutral atmospheric conditions at night and unstable and neutral conditions during the day, which was expected. SER at 2-42, 2-43.

31. (RH) The Staff reviewed available information relative to the meteorological measurements program and the data collected by the program. On the basis of its review, the Staff concluded that the system provides data adequate to represent site atmospheric dispersion conditions, as required by 10 C.F.R. § 100.21(c). The onsite data provided an acceptable basis for making estimates of atmospheric dispersion for design-basis accident and

routine releases from a nuclear unit falling within the Applicant's PPE, and for meeting the requirements of 10 C.F.R. Part 100 and Appendix I to 10 C.F.R. Part 50.

Q14: Please describe the Staff's examination of short-term diffusion estimates.

A14: 32. (RH) The Applicant generated its atmospheric diffusion estimates for postulated accidental airborne releases of radioactive effluents to the EAB and LPZ using the Staff-endorsed computer code PAVAN[13]. The Staff evaluated the applicability of the PAVAN model and concluded that no unique topographic features preclude the use of the PAVAN model for the Clinton ESP site. The Staff also reviewed the Applicant's input to the PAVAN computer code, including the assumptions used concerning plant configuration and release characteristics and the appropriateness of the meteorological data input. The Staff found that the Applicant had made conservative assumptions by ignoring building wake effects and treating all releases as ground-level releases. SER at 2-47.

33. (RH) The Staff independently evaluated the resulting atmospheric diffusion estimates by running the PAVAN computer model, and it obtained PAVAN results similar to those of the Applicant. SER at 2-47, 2-48. The Staff concluded that the Applicant had made conservative assessments of post-accident atmospheric dispersion conditions using its meteorological data and appropriate diffusion models. The Staff reviewed the Applicant's proposed atmospheric dispersion site characteristics for inclusion in an ESP for the Applicant's site, should one be issued, and found these characteristics acceptable. Therefore, the Staff

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[13] The PAVAN computer code used by the Applicant to estimate short-term (accident release) atmospheric dispersion site characteristics for the EAB and LPZ implements the methodology outlined in RG 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." RG 1.145 states that the atmospheric dispersion factor selected for the EAB and LPZ should be the maximum sector X/Q value (i.e., the highest of each of the 16 sector values that are exceeded 0.5 percent of the total hours) or the 5 percent overall site X/Q value, whichever is higher. The intent of this methodology is to allow consideration of the directional variability of wind flow and diffusion conditions as well as EAB and LPZ distances. The technical basis for this methodology is documented in NUREG/CR-2260, "Technical Basis for Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants."

concluded that the Applicant's short-term atmospheric dispersion estimates are appropriate for the assessment of consequences from radioactive releases for postulated (design-basis) accidents, in accordance with 10 C.F.R. § 100.21(c)(2). SER at 2-48, 2-49.

Q15: Please describe the Staff's examination of long-term diffusion estimates.

A15: 34. (RH) The Applicant generated its atmospheric diffusion estimates for routine airborne releases of radioactive effluents to the site boundary, EAB, LPZ, and special receptors of interest using the MIDAS software subprogram XDCALC. The Applicant stated that the XDCALC model is consistent with the guidance in RG 1.111. SER at 2-49. The Staff reviewed the Applicant's input assumptions to the XDCALC computer code concerning plant configuration and release characteristics and found these assumptions to be appropriate. SER at 2-52. The Staff independently evaluated the Applicant's resulting atmospheric diffusion estimates by executing the Staff computer code XOQDOQ and obtaining results similar to those obtained by the Applicant. SER at 2-52. The Staff concluded that the Applicant had used an appropriate atmospheric model and adequate meteorological data to calculate relative concentration and relative disposition at appropriate distances from postulated release points for evaluation of routine airborne releases of radioactive material. SER at 2-52.

35. (RH) The Staff concluded that the Applicant had provided the information necessary to address the requirements of 10 C.F.R. § 100.21(c)(1) and that the Applicant's characterization of long-term atmospheric transport and diffusion conditions is appropriate for use in demonstrating compliance with the numerical guides for doses in Appendix I to 10 C.F.R. Part 50.[14] SER at 2-55.

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[14] The Staff believes it may be helpful to clarify the meanings of the headings in Table 2.3.5-1, which presents the Applicant's long-term diffusion estimates. **Undepleted/No Decay** χ/Q values are atmospheric dispersion factors used to evaluate ground level concentrations of long-lived noble gases, tritium, and carbon 14. The plume is assumed to travel downwind without undergoing dry deposition or radioactive decay. **Undepleted/2.26-Day Decay** χ/Q values are atmospheric dispersion factors used to

(continued...)

Section 2.4, Hydrology

Q16: Discuss how the Staff evaluated the Applicant's hydrologic analysis of the ESP site, beginning with the general hydrologic description.

A16: 36. (GB) The Applicant indicated that the safety-related structures associated with the ultimate heat sink ("UHS"), if the reactor design selected requires a UHS, are the intake structures, the essential service water cooling towers, and other structures that will be located within the ESP facility powerblock area. SER at 2-59.

37. (GB) The Staff conducted a site visit in accordance with the guidance in Section 2.4.1 of RS-002, Attachment 2; used information from the site visit, digital maps, and streamflow data from the USGS; and independently verified the hydrologic description in SSAR Section 2.4.1. SER at 2-63. 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. SER at 2-63.

38. (GB) The Staff determined that a COL or CP applicant would need to ensure that the ESP facility intake piping is installed with adequate clearance from the CPS facility piping, and that such an applicant should provide the detailed design of the UHS system, if a UHS is required. SER at 2-66, 2-68. Specifically, the Staff found that 50 feet of horizontal clearance and 6.6 ft of vertical clearance would be required between CPS and EPS piping.[15]

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[14](...continued)
evaluate ground level concentrations of short-lived noble gases. The plume is assumed to travel downwind without undergoing dry deposition but is depleted assuming a half-life of 2.26 days, based on the half-life of Xe-133m. **Depleted/8.00-Day Decay** χ/Q values are atmospheric dispersion factors used to evaluate ground level concentrations of radioiodine and particulates for the inhalation pathway. The plume is assumed to travel downwind with dry deposition and is depleted assuming a half-life of 8.00 days, based on the half-life of I-131. Finally, **D/Q Values** are deposition factors used to evaluate dry deposition of radioiodine and particulates for the ground plane exposure and food pathways.

[15] The Staff used 6.6 ft of vertical clearance because it is about 3 times the diameter of the largest existing buried pipe and would therefore provide adequate separation for construction activity at the ESP site.

The Staff concluded that, by conforming to Section 2.4.1 of RS-002, Attachment 2, the Applicant met the requirements for general hydrologic descriptions with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-70.

Q17: Please describe the Staff's analysis with respect to floods.

A17: 39. (GB) In Revision 4 of the SSAR, the Applicant revised the maximum rainfall site characteristic to reflect information in Hydrometeorological Report (HMR) 52. SER at 2-73. The revised maximum rate for the 1-hour probable maximum precipitation ("PMP") is 18.15 in and for the 5-min PMP is 6.08 in. SER at 2-73. The Staff noted that a COL or CP applicant should design the ESP intake structures to withstand the combined effects of Probable Maximum Flood ("PMF"), coincident wind wave activity, and wind setup. With respect to site drainage, the local intense precipitation of 18.15 inches during one hour has been identified as a site characteristic; the Applicant should demonstrate that the local intense precipitation flooding can be discharged into Clinton Lake without relying on any active drainage systems, which may become blocked. SER at 2-78, 2-79. The Staff concluded that, by conforming to Section 2.4.2 of RS-002, Attachment 2, the Applicant complied with the flood requirements of 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-80.

Q18: Please describe the Staff's analysis with respect to the probable maximum flood on streams and rivers.

A18: 40. (GB) 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). SER at 2-82. 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. SER at 2-84. The Staff

concluded that the Applicant provided sufficient information and evaluation of PMFs on streams and rivers at the site, and that, by conforming to Section 2.4.3. of RS-002, Attachment 2, the Applicant met the requirements to identify and evaluate PMFs on streams and rivers at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-94.

Q19: Please describe the Staff's analysis with respect to potential dam failures.

A19: 41. (GB) In SSAR Section 2.2.4, the Applicant stated that no dams exist either upstream or downstream of the Clinton Dam. The Applicant also indicated that failure of Clinton Dam, which is not a safety-related structure, would not result in a loss of water from the submerged UHS pond; the water in the UHS pond would still be available for safe shutdown of the proposed reactor. SER at 2-94

42. (GB) The Staff consulted maps published by the USGS to independently verify the Applicant's statement that no dams exist upstream of the Clinton Dam. SER at 2-96. The Staff identified a small impoundment called Dawson Lake. SER at 2-96. The Applicant revised SSAR Section 2.4.1.2 to include the information on Dawson Lake, and stated that there were no existing reservoirs or dams upstream or downstream of Clinton Lake that are large enough to affect the availability of water to Clinton Lake. SER at 2-96, 2-97. The Applicant identified four recreational reservoirs, two upstream and two downstream, one of the upstream reservoirs being Dawson Lake. SER at 2-97. The staff determined, using a set of conservative assumptions, that a postulated dam breach upstream of Lake Clinton would only increase the normal Clinton Lake water level elevation, 690 ft MSL, by 3.1 ft. SER at 2-97.

43. (GB) The Staff stated it would include 716.5 ft MSL as a site characteristic for the combined effects maximum water surface elevation in any ESP that might be issued for this application and noted that even if the maximum water elevation were to be augmented by 3.1 ft because of a breech 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. SER at 2-97. The Staff concluded that, by conforming to Section 2.4.4 of RS-002, Attachment 2, the Applicant met the requirements for potential dam failures with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c).[16] SER at 2-97, 2-99.

44. (GB) The Staff also verified the Applicant's claim that the ESP facility requires no changes to the Clinton Dam spillways. There are two spillways on the Clinton Dam. The service spillway, with a crest elevation of 690 ft MSL, is designed to pass the 100-year flood with the water surface elevation in Clinton Lake at 697 ft MSL. The auxiliary spillway, with a crest elevation of 700 ft MSL, is designed to pass floods greater than the 100-year flood. According to the Staff's independent calculations, the maximum water surface elevation in Clinton Lake during the PMF event was 710.6 ft MSL, 1.2 ft below the top elevation of the Clinton Dam. Since the hydrostatic water surface elevation in Clinton Lake did not rise above the top elevation of the dam, the Staff concluded that the auxiliary spillway does not require any modifications to safely pass the PMF.

Q20: Please describe the Staff's analysis with respect to probable maximum surge and seiche flooding.

A20: 45. (GB) 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 its approach to provide a higher level of conservatism, and the maximum storm surge at the site was stated as 0.3 ft. SER at 2-99.

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[16] The PMF value provided in section 2.4.10.3 of the FSER, 721.7 ft, is incorrect. The correct value is 716.5 ft.

46. (GB) The Staff conducted an independent evaluation to estimate seiche effects, and it determined that meteorologically forced resonance is not likely and that seismically induced seiche is not likely in Clinton Lake because of the large difference between the period of oscillation resulting from seiche (6.8 minutes) and that of seismically induced vibrations (less than 1 sec). SER at 2-102. The Staff concluded that, by conforming to Section 2.4.5 of RS-002, Attachment 2, the Applicant met the ESP-specific requirements to identify and evaluate probable maximum surge and seiche flooding at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-104.

Q21: Please describe the Staff's analysis with respect to probable maximum tsunami flooding.

A21: 47. (GB) The Applicant stated in Revision 0 of SSAR Section 2.4.6 that the site would 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. SER at 1-104.

48. (GB) In 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 near the earthquake's epicenter. SER at 2-107. 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. SER at 2-107. The Staff found that by conforming to Section 2.4.6 of RS-002, Attachment 2, the Applicant met the ESP-specific

requirements to identify and evaluate tsunami flooding with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-107.

Q22: Please describe the Staff's analysis with respect to ice effects.

A22: 49. (GB) The Applicant used the USGS streamflow data measured at the Rowell gauge to identify ice formation in streams. The Applicant stated that low-flow conditions resulting from ice jams on streams upstream of the EPS site would not affect the UHS because of its submerged conditions. The Applicant revised the SSAR and added a new section (Section 2.4.7.1), in which it stated that frazil ice and anchor ice can cause blockages of intake water systems. The Applicant stated in SSAR Revision 2 that an ice sheet equal in thickness to the maximum estimated 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 of 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. An opening of this size would be adequate for the intake water requirements of the ESP plant. SER at 2-108, 2-109, 2-111.

50. (GB) 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. Once of these jams was the February 11, 1959, ice jam reported by the Applicant. This ice jam resulted in a maximum gauge height of 24.84 ft. The Staff found that the mean daily discharge in Salt Creek near Rowell on this day was 6800 cfs and the peak discharge was 7500 cfs. 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. Using this relationship, the Staff estimated a stage of 22.9 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. SER at 2-114.

51. (GB) The Staff independently estimated the likely thickness of surface ice that might form near the intake structures, using Assur's method (Chow, 1964) to estimate a maximum ice thickness of 31.4 in. SER at 2-115. The Staff determined that it is possible for an ice sheet to form for extended periods in Clinton Lake. SER at 2-115. Since the ESP facility intake structure is safety related and the potential for ice formation is a site-induced condition, the Staff noted that a 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. SER at 2-116. Based on e-mail communication with the U.S. Army Corps of Engineers ("USACE") Cold Regions Research and Engineering Laboratory, the Staff determined that a 2002 USACE standard is the currently accepted standard for design ice engineering. SER at 2-118. Thus, the Staff determined that the 2002 USACE equation is acceptable for estimating the ice thickness in Clinton Lake and proposes to use a maximum ice thickness of 27.0 in as a site characteristic in any ESP that may be issued for the site. SER at 2-118, 2-122. The Staff noted that a COL applicant would have to design the ESP facility's UHS intake, if one is required, to maintain a minimum water temperature of 40 °F at all times to preclude formation of frazil and anchor ice on the intake inlet. SER at 2-124. The Staff also noted that a COL applicant should ensure that the ice sheet formed on Clinton Lake will not constrain the intake, predicated on the ESP facility's UHS intake's being located at an elevation of 668 ft MSL. SER at 2-125.

52. (GB) The Staff found that by conforming to RS-002, Attachment 2, Section 2.4.7, the Applicant met the requirements to identify and evaluate ice effects at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c), except as noted in the applicable COL Action Items. SER at 2-127.

Q23: Please describe the Staff's analysis with respect to cooling water canals and reservoirs.

A23: 53. (GB) 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, which would use cooling towers 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 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. SER at 2-127, 2-129. The Applicant calculated the amount of cooling water required for the ESP site using the LAKET model. This model captures only one-dimensional (longitudinal) variations in water temperature throughout the lake. This depth-averaged temperature model may lead to a decreased estimate of heat transfer from the water's surface to the atmosphere. While this model may be conservative at estimating the temperature in the lake, it may not be conservative when used to compute the volume of water evaporated. Therefore, lake water levels computed with the LAKET model may be higher than expected; a depth-averaged model may not be conservative in terms of volumetric analysis during periods of relative drought.

54. (GB) The Staff visually inspected the site during the site safety analysis visit. SER at 2-136. The Staff determined that the SSAR accurately describes the intakes, discharge

canals, outfalls, and reservoirs near the ESP site. SER at 2-136. The Staff determined that it is possible that the ESP facility may require a water-cooled UHS. SER at 2-137. The Staff noted that although the actual design of the NHS and UHS is beyond the scope of the ESP review, site characteristics that govern and may limit the design of the NHS and UHS must be established at the COL stage; thus, a COL or CP applicant should conclusively establish that any water-cooled UHS that may be required by a reactor selected for the ESP facility will be designed to a maximum 30-day makeup water requirement not exceeding 87 ac-ft, and also that the ESP facility's NHS is designed such that there is no over-reliance on the UHS for frequent plant shutdowns.[17] SER at 2-137. The Staff also noted that a COL or CP applicant should ensure the monitoring and any required dredging of the submerged UHS pond. SER at 2-143. The Staff concluded that by conforming to SRP Section 2.4.8, the Applicant met the requirements for cooling water canals and reservoirs at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c)(3), except as noted in the applicable COL Action Items. SER at 2-143.

Q24: Please describe the Staff's analysis with respect to channel diversions.

A24: 55. (GB) The Applicant stated in SSAR Section 2.4.9 that there is no existing historical evidence of channel diversion in Salt Creek or in the North Fork of Salt Creek upstream of the Clinton Dam. SER at 2-144. The Staff developed a basic understanding of the geomorphology of the region during its site visit of May 11, 2004. 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 Center stated in an email to the Staff that no channel diversion studies had been carried out on these streams. SER at 2-145.

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[17] The NHS (Clinton Lake) and the UHS are separate systems; the design of the NHS does not affect the functioning of the UHS and vice-versa. Regardless of the cooling system selected by the COL applicant, Clinton Lake will remain the source of the NHS, the failure of which would require the use of the UHS to safely shut the plant down.

56. (GB) The Staff concluded that by conforming to Section 2.4.9 of RS-002, Attachment 2, the Applicant met the requirement to identify and evaluate channel diversion at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-146.

Q25: Please describe the Staff's analysis with respect to flooding protection requirements.

A25: 57. (GB) SSAR Section 2.4.3.6 estimated the design-basis flood elevation at the ESP site as 713.8 ft MSL. The Applicant stated that the flooding effects of local PMP are design related and would be considered at the COL stage. SER at 2-146, 2-147. The Staff noted that a COL or CP applicant would need to design the ESP facility's intake structures to withstand the combined effects of PMF, coincident wave activity, and wind setup. SER at 2-148. The Staff concluded that by conforming to SRP Section 2.4.10 the Applicant met the requirements of flooding protection at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c)(3), except as noted in the applicable COL Action Item. SER at 2-148.

Q26: Please describe the Staff's analysis with respect to low water considerations.

A26: 58. (GB) The ESP site is adjacent to Clinton Lake, which provides cooling water for CPS Unit 1 and would provide cooling water for the proposed ESP facility. The submerged UHS pond would provide 30-day emergency cooling makeup water for the ESP facility's UHS system. SER at 2-149. 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. SER at 2-149. The Applicant stated that a drawndown analysis of Clinton Lake for the original planned CPS (two 992 MWe units at 70% 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 original 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 CPS Unit 1. The Applicant stated that the previous forced-evaporation rate estimate was based on heat rejection from the 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[18] 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 head load caused by the power uprate of the existing CPS Unit 1. SER at 2-149.

59. (GB) The Staff performed an analysis to assess the maximum rate at which the lake water surface elevation could be expected to drop, which resulted in a conservative estimate of a maximum drop of 4.85 ft/mo. SER at 2-155. The Staff determined that the drop would be gradual enough for the operators to react and safely shut down the EPS facility before the minimum operating threshold was reached. The Staff noted that if the reactor type selected for the ESP facility requires a UHS, a COL applicant would need to develop a plant shutdown protocol when the water surface elevation in Clinton Like falls to 677 ft MSL. SER at 2-156. The Staff concluded that, by conforming to Section 2.4.11 of RS-002, Attachment 2, the

[18] The 0.7 factor is used to correct for the 70% load factor used in the Applicant's original analysis. The use of this factor adjusts the estimate to 100% load factor, which is the value assumed for the existing CPS and the proposed ESP facility for lake drawdown calculations during droughts. This is a conservative estimate, because there is some downtime for all nuclear power plants (i.e., no plant operates at 100% load factor).

Applicant met the requirements for low-water conditions with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c) except with respect to the applicable COL Action Item. SER at 2-156.

Q27: Please describe the Staff's analysis with respect to ground water.

A27: 60. (GB) In Section 2.4.133, the Applicant provided a description of regional and site hydrogeology and ground water conditions. 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 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. SER at 2-157.

61. (GB) Based on its review of a USGS document (Lloyd and Lyke,1995), the Staff determined that the Applicant's description of regional hydrogeological conditions is accurate. SER at 2-160. The Staff further determined that the SSAR accurately describes onsite and offsite ground water use. SER at 2-160. The Staff determined that the normal and safety-related requirements for the ESP facility depend on the selected reactor type; therefore, it concluded 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. SER at 2-160.

62. (GB) The Applicant's description of the effluent-holding facility, which is associated with the type of reactor selected, presumed(see SER Sections 2.4.13.1 and 2.4.13.3) that no scenario exists in which liquid radioactive effluent could be accidentally released above the ambient ground water table. The Staff agreed that under these assumptions accidental release of liquid effluent to ambient ground water could be precluded. SER at 2-162. 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 in which recovery of groundwater occurs to near its dewatering elevation; as a result, the Staff identified Permit Condition 3. SER at 2-162. In an open item from the DSER, 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; the Staff reviewed the Applicant's response to the open item and determined that the Applicant had not provided data to verify the conservatism of the ground water hydraulic gradient or that of soil properties. SER at 2-161, 2-163. Consequently, the Staff noted that a COL or CP applicant would need to undertake additional characterization to establish conservative ground water flow velocities and conservative soil properties representative of the hydrogeologic conditions at the ESP site, i.e., that a hydraulic gradient be maintained in a direction away from Clinton Lake. SER at 2-161, 2-162, 2-163.

63. (GB) The Staff concluded that, except with respect to the applicable COL Action Items and Permit Condition 3, the Applicant, by conforming to Section 2.4.12 of RS-002, Attachment 2, met the requirements to identify and evaluate ground water characteristics at the site with respect to 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-164.

Q28: Please describe the Staff's analysis with respect to accidental releases of liquid effluent.

A28: 64. (GB) 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. SER at 2-164.

65. (GB) 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 grand water table. SER at 2-167. The Staff agreed that, under these assumptions, release of liquid radioactive effluent to ambient ground water could be precluded. SER at 2-167. However, the Staff noted that a 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. SER at 2-167. Further, as per Permit Condition 3, a 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 condition. SER at 2-167. 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 pathway is necessary; as a result, the Staff identified Permit Condition 4. SER at 2-167. The Staff also identified Permit Condition 5, which would provide that the requirements of Condition 3 be kept in place and/or in operation for the life of the facility, including its decommissioning. SER at 2-168.

66. (GB) The Staff concluded that, by conforming to Section 2.4.13 of RS-002, Attachment 2, the Applicant 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 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c), except as noted in Section 2.4.13.3 of the SER. SER at 2-169.

Q29: Please describe the Staff's analysis with respect to thermal discharges.

A29: 67. (GB) The ESP site is adjacent to Clinton Lake, which provides cooling water for CPS Unit 1. The Normal Plant Heat Sink ("NPHS") water supply for the ESP facility would be obtained from Clinton Lake, and normal operation of the ESP facility would use a cooling tower(s) operated with water drawn from a cooling tower basin(s). SER at 2-169. 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. SER at 2-171. The Staff's analysis of the information provided by the Applicant led the Staff to conclude that the NPHS would be likely to perform its function consistent with the maximum thermal discharge assumed in the PPE 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. SER at 2-172.

Q30: Please describe the Staff's analysis with respect to the ultimate heat sink.

A30: 68. (GB) At the ESP stage, because a specific reactor type is not identified, it is not known whether a UHS will be required for the ESP facility. If 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. SER at 2-174. As discussed in SER Section 2.4.8.3, the Staff determined that the submerged UHS pond has an excess capacity of approximately 318 ac-ft. SER at 2-174. The Staff found that the Applicant provided sufficient information pertaining to the NPHS to determine that the consequences of NPHS operation on the UHS are acceptable. Therefore, the Staff concluded that the Applicant met the requirements of 10 C.F.R. § 52.17(a) and 10 C.F.R. § 100.20(c). SER at 2-175.

Section 2.5, Geology, Seismology, and Geotechnical Engineering

Q31: How did the Staff evaluate the Application with respect to the geological, seismological, and geotechnical engineering properties of the ESP site?

A31: 69. (CM) The Staff's analysis focused on a review of the basic geological and seismological site and regional data, the vibratory ground motion of the site, and the safe-shutdown earthquake ("SSE") ground motion. The Staff's analysis is summarized in Sections 2.5.1 through 2.5.6 of the SER. SER at 2-177.

Q32: Please describe the Staff's health and safety analysis with respect to site and regional geology.

A32: 70. (CM) SSAR Sections 2.5.1.1, "Regional Geology," and 2.5.1.2, "Site Geology," describe the geology of the site and the surrounding region. The Staff's evaluation of the Applicant's submission was based on four areas designated in RG 1.165, corresponding to areas 320km, 40km, 8km, and 1km from the site. SER at 2-195. In order to ensure a thorough review of the Applicant's submission, the Staff obtained the assistance of the U.S. Geological Survey ("USGS"). SER at 2-195. The interpretations, assumptions, and conclusions presented by the Applicant were confirmed by the Staff and USGS advisors through a visit to the ESP site. SER at 2-196. The Staff review of Section 2.5.1 focused on (1) the tectonic or seismic information, (2) the nontectonic deformation information, and (3) the conditions caused by human activities, with respect to both the regional geology and site geology. SER at 2-195, 2-196.

71. (CM) The Staff review of the regional geology evaluated the structural geology, seismology, paleoseismology, physiography, geomorphology, stratigraphy, and geologic history, within 200 miles (320km) of the site. SER at 2-196. The Applicant concluded that the ESP site is one of the most geologically stable areas in the United States, and that the geologic

conditions at the ESP site are the same as those at the CPS site. SER at 2-196. The Staff, after reviewing SSAR Section 2.5.1.1, concluded that the Applicant provided a thorough and accurate description of the geologic features and characteristics of the site. SER at 2-196.

72. (CM) The Staff review of the site geology, presented in SER Section 2.5.1.2, evaluated the site-related geologic features and structure, as well as conditions caused by human activities. SER at 2-199. In the application, the Applicant described the site physiography, stratigraphy, structural geology, ground water conditions, and other geologic conditions. SER at 2-199. The Applicant concluded that the site is located in a tectonically stable area of North America and that there is no evidence of surface faulting at the site. SER 2-200. The Staff found that the Applicant's analysis described readily observable local geologic features and provided an adequate description of the local site conditions, and the Staff concluded that the Applicant provided a thorough and accurate description of the local geology in support of the ESP application. SER at 2-199, 2-200.

73. (CM) After reviewing the geological and seismological information submitted by the Applicant in SSAR Section 2.5.1, the Staff concluded that the Applicant provided a thorough characterization of the geological and seismological characteristics of the site, as required by 10 C.F.R. § 100.23. SER 2-200. The Staff found that no capable tectonic sources that have the potential to cause near-surface fault displacement exist in the site area. SER at 2-200. In addition, the Staff concluded that the Applicant had identified and appropriately characterized the seismic sources significant to determining the SSE for the ESP site, in accordance with RG 1.165 and SRP Section 2.5.1. SER at 2-200. By identifying and classifying the seismic sources significant to determining the SSE for the ESP site, the Staff found that the Applicant satisfied the necessary requirements of 10 C.F.R. § 100.23(c) and GDC 2. SER at 2-200. Based on the Applicant's geological investigations of the site vicinity and the site area, the Staff concluded that the Applicant had properly characterized the site lithology, stratigraphy, geologic

history, and structural geology. SER at 2-200. The Staff also concluded that there is no potential for the effects of human activities (i.e., ground water withdrawal or mining activity) to compromise the safety of the site. SER at 2-200. Therefore, the Staff concluded that the proposed ESP site is acceptable from a geological and seismological standpoint and meets the requirements of 10 C.F.R. § 100.23. SER at 2-200.

Q33: Please describe the Staff's health and safety analysis with respect to vibratory ground motions.

A33: 74. (CM) SSAR Section 2.5.2, "Vibratory Ground Motion," describes the Applicant's determination of the SSE ground motion at the ESP site from possible earthquakes in the site area and region. SER at 2-200. The SSE is based upon a detailed evaluation of earthquake potential, taking into account regional and local geology, Quaternary tectonics, seismicity, and specific geotechnical characteristics of the site's subsurface materials. SER at 2-244. To determine the SSE, the Applicant used RG 1.165. SER at 2.244. According to RG 1.165, applicants may develop the SSE using either the Central and Eastern Unites States ("CEUS") seismic source and ground motion models published by Electric Power Research Institute ("EPRI"), issued in 1986, or those from Lawrence Livermore National Laboratory ("LLNL"), published in 1993. SER at 2-245. However, RG 1.165 recommends that applicants perform geological, seismological, and geophysical investigations and evaluate any relevant research to determine whether revisions to the EPRI or LLNL seismic models are necessary. SER at 2-245. As a result, the Staff focused its review on geologic and seismic data published since the late 1980s that could indicate a need for changes to the EPRI or LLNL seismic models. SER at 2-245.

75. (CM) Rather than attempting to characterize the seismic potential of each of the geologic faults and folds in the region surrounding the ESP site, the Applicant defined broad

seismic source zones that encompass these structural features. SER at 2-246. Within a 200-mile radius of the site (or just beyond), the two major sources of potential earthquakes are the New Madrid seismic zone ("NMSZ"), whose northern boundary is generally considered to lie at or just beyond the 200-mile radius, and the Wabash Valley/Southern Illinois seismic zone ("WVSZ"), located in southeastern Illinois and southwestern Indiana. SER at 2-246. In addition to the NMSZ and WVSZ, evidence from recent studies indicates that significant earthquakes have occurred in the central Illinois basin, where there are no obvious geologic faults at the surface. SER at 2-246. Although the size, location, and recurrence of such earthquakes are not well constrained, the Applicant developed a seismic source zone for this region, referred to as the central Illinois basin source zone. SER at 2-246. The Staff concurred with the Applicant's decision to use large areal seismic source zones rather than attempting to characterize the seismic potential of each of the regional structural features. SER at 2-246. Both the LLNL and EPRI seismic models, endorsed by RG 1.165, use this approach.

76. (CM) The Staff focused its review of SSAR Section 2.5.2.3, "Correlation of Earthquake Activity with Geologic Structure or Tectonic Province," on the Applicant's updating of the EPRI seismic source and ground motion models used for its probabilistic seismic hazard analysis ("PSHA") for the ESP site. SER at 2-246. The Applicant based its update on an evaluation of recent geologic and seismological information. SER at 2-246. The specific areas that the Applicant focused on for each of the three major seismic source zones (NMSZ, WVSZ, and central Illinois) are earthquake recurrence rates, maximum earthquake magnitudes, and ground motion attenuation. SER at 2-247.

77. (CM) With respect to earthquake recurrence rates, the Applicant concluded that for the central Illinois and the WVSZ, the earthquake recurrence relationships did not need to be updated. SER at 2-247. However, for the NMSZ, the Applicant found that recent studies provide evidence that large-magnitude earthquakes have occurred more frequently than the

rates specified in the EPRI seismic source models. SER at 2-247. The Applicant updated the rates for the NMSZ using data from recent studies; however, the Staff questioned the Applicant's interpretation of the data. SER at 2-248. The Applicant revised its recurrence model for the NMSZ to address the Staff's concern through the use of a sensitivity analysis. SER at 2-249. However, the Applicant concluded that since the changes were on the order of 10 percent or less, a revision to the ESP Application was not warranted. SER at 2-249. The Staff determined that an update of the NMSZ seismic models is of sufficient importance to justify updating both the PSHA and SSE for the ESP site. SER at 2-249. In response, the Applicant updated its NMSZ seismic source models, PSHA, and SSE. SER at 2-249.

78. (CM) With respect to maximum earthquake magnitude, the Applicant focused on the maximum magnitudes for the NMSZ, WVSZ, and central Illinois seismic source zone, since these three zones are the main contributors to the total seismic hazard at the ESP site. SER at 2-250. For the NMSZ, the applicant concluded that the maximum magnitudes used for the EPRI seismic model, which range from 7.2 to 8.8, are consistent with the more recent maximum magnitude evaluations, which range from 7.4 to 8.2. SER at 2-250. For the WVSZ, the EPRI seismic models have a maximum magnitude that ranges from 5.0 to 8.0, while recently published maximum magnitudes range from 7.0 to 7.8. SER at 2-250. Similarly, for the central Illinois source zone, the EPRI seismic models have a maximum magnitude that ranges from 4.3 to 7.6, while the recently published maximum magnitudes range from 6.0 to 7.0. SER at 2-250. As a result, the Applicant concluded that the maximum magnitude ranges for both the WVSZ and central Illinois source zone need to be increased to reflect the magnitudes implied by recent studies. SER at 2-250. The Staff reviewed the NMSZ, WVSZ, and central Illinois source zone maximum magnitude ranges used by the Applicant for its PSHA for the ESP site. SER at 2-250. The staff concurred with the Applicant's conclusion that the EPRI seismic models for the NMSZ adequately cover the range of magnitudes estimated from

recent geologic investigations. SER at 2-250. For the WVSZ and central Illinois source zone, the staff reviewed the revised maximum magnitude ranges used by the Applicant to verify its consistency with recent geologic studies. SER at 2-250. Based on its review, the Staff concurred with the Applicant's decision to increase the maximum magnitude distributions of the WVSZ and the central Illinois source zone. SER at 2-252.

79. (CM) With respect to seismic ground motion attenuation, the Applicant chose not to use the original EPRI ground motion models. SER at 2-252. Instead, the Applicant used CEUS ground motion models developed in an EPRI 2003 study. SER at 2-252. The ESP applicant for the North Anna, Virginia, site also used the EPRI 2003 ground motion study for its PSHA. SER at 2-254. The Staff's review of the EPRI 2003 ground motion models is described in Section 2.5.2 of the SER for North Anna. SER at 2-254. Based upon its review, the Staff concluded that the ESP applicant for the North Anna, Virginia, site adequately resolved each of the Staff's concerns with regard to the development by EPRI of new ground motion models for the CEUS. SER at 2-254.

80. (CM) The Staff focused its review of SSAR Section 2.5.2.4, "Maximum Earthquake Potential," on the Applicant's PSHA results for the ESP site. SER at 2-254. Following the guidance provided in RG 1.165, the Applicant determined the low- and high-frequency controlling earthquakes[19] for the ESP site. SER at 2-254. This procedure involves the deaggregation of the PSHA results to determine the controlling earthquakes in terms of a magnitude and source-to-site distance. SER at 2-255. Based on its review of the ESP site controlling earthquakes, the Staff concluded that the Applicant's PSHA adequately characterized the overall seismic hazard of the ESP site. SER at 2-255. The Staff concluded

[19] The controlling earthquake is determined by summing the percentage contribution for each magnitude range and determining an overall value. An example of the determination of a controlling earthquake is provided in Appendix C of RG 1.165.

that the controlling earthquakes for the ESP site are generally consistent with both the historical earthquake record and paleo-earthquake studies in the NMSZ, WVSZ, and central Illinois seismic source zone. SER at 2-255. The Staff also concluded that ground motions developed by the Applicant from the controlling earthquakes are consistent with the most recent CEUS ground motion evaluations. SER at 2-255. Accordingly, the Staff concluded that the Applicant followed the guidance in RG 1.165 for evaluating the regional earthquake potential and determining the ground motion resulting from the controlling earthquakes. SER at 2-255.

81. (CM) The staff focused its review of SSAR Section 2.5.2.4, "Seismic Wave Transmission Characteristics of the Site," on the method used by the Applicant to develop the site free-field ground motion spectrum. SER at 2-255. The seismic hazard curves from the PSHA are defined for generic hard rock conditions. SER at 2-255. According to the Applicant, these hard rock conditions exist at the ESP site at a depth of several thousand feet or more below the ground surface. SER at 2-255. To determine the free-field ground motion, the Applicant performed a site response analysis. SER at 2-255. The Applicant developed 60 different randomized soil/rock columns in order to model the uncertainties in the soil and rock properties. SER at 2-255. The Applicant determined these soil and rock properties through its field explorations and laboratory tests. SER at 2-255. The Staff reviewed the Applicant's analysis to ensure that it accurately incorporated the local site soil and rock properties and conditions as well as their uncertainties. SER at 2-255. Specifically, the Staff reviewed the range of values encompassed by the Applicant's 60 different randomized soil/rock columns to ensure that it adequately characterized the variability in the uppermost soil layers. SER at 2-256. In response to the Staff's questions about the adequacy of the 60 randomized soil/rock columns to cover the variability of the uppermost soil layers, the Applicant stated that these uppermost layers would be removed during plant construction and replaced by engineering fill. SER at 2-256. The Staff accepted this response and closed

Open Item 2.5.2-2. SER at 2-256. Even though the uppermost soil layers will be replaced by compacted fill material, ESP applicants are required to determine the SSE ground motion using the actual site conditions and not anticipated future conditions. Therefore staff should have documented that it accepted the applicant's response to Open Item 2.5.2-2 based on a comparison of the randomized shear wave velocity profiles, shown in FSAR Figures 4.2-11 and 4.2-12 in Appendix B, with the actual shear wave velocity measurements, shown in FSAR Table 5-2 in Appendix A. A comparison by the staff of these 60 shear wave velocity profiles and the table of shear wave velocity results showed that the applicant's randomization process adequately encompassed the range of field measurements. Although staff reached the accurate conclusion on SER page 2-259 that the applicant' site response analysis adequately incorporated the effects of the local site properties and their uncertainties into the determination of the SSE, as required by 10 C.F.R. 100.23, the bases for this conclusion should have been more completely documented in the SER. In addition to the 60 randomized soil/rock columns, the Staff reviewed the applicability of the dynamic soil models used by Applicant to determine the response of the soils to earthquake ground motion. SER at 2-256. Finally, the Staff reviewed the earthquake time histories used by the Applicant to perform its site response analysis and the final site amplification functions. SER at 2-258, 2-259. The Staff concluded that the Applicant's site response analysis adequately incorporated the effects of the local site properties and their uncertainties in the determination of the ESP free-field SSE, as required by 10 C.F.R. 100.23. SER at 2-259.

Q34: With respect to the Staff's health and safety analysis concerning vibratory ground motions, please describe the primary differences between the standard accepted methodology and the "performance based" approach used by the applicant.

A34: 82. (CM) Rather than using the methodology described in RG 1.165[20] to determine the SSE ground motion, the Applicant chose to use a different approach, which is described in the American Society of Civil Engineers ("ASCE") / Structural Engineering Institute ("SEI") Standard 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities and Commentary." SER at 2-220. This new approach is referred to as a "performance-based" approach, which sets a goal or target of a mean annual frequency of 10^{-5} of unacceptable performance of nuclear SSCs as a result of seismically initiated events. SER at 2-220. Specifically, the performance-based approach is intended to achieve a mean 10^{-5} risk per year of core damage caused by seismic initiators. SER at 2-220. This safety performance goal is based on assuming a target 10^{-4} mean annual risk of core damage caused by all accident initiators and on the assumption that seismic initiators contribute about 10 percent of the risk of core damage posed by all accident initiators. SER at 2-220.

83. (CM) As noted previously, this safety performance target, P_{FT}, is based on assuming (1) a target 10^{-4} mean annual risk of core damage from all accident initiators and (2) that seismic initiators contribute about 10 percent of the risk of core damage posed by all accident initiators. SER at 2-259. The basis for the target 10^{-5} annual performance goal is from the results of seismic probabilistic risk analyses (PRAs) of 25 nuclear power plants, which is documented in NUREG-1742, "Perspectives Gained from the IPEEE Program." SER at 2-238.

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[20] In RG 1.165, the NRC Staff recommended basing an SSE for proposed sites on the median annual probability (reference probability) of exceeding the SSE ground motion for a group of 29 operating nuclear power plant sites in the Central and Eastern United States. The reference probability was determined to be 10^{-5}/yr, which implies that new NPP sites in the CEUS should be designed to remain functional during and after an earthquake ground motion level with a medial recurrence interval of 100,000 years.

NUREG-1742 shows that the median value for the mean seismic core damage frequency ("SCDF") for these 25 nuclear power plants is 1.2×10^{-5}/yr. Rather than targeting SCDF, the performance-based approach targets the annual frequency of onset of significant inelastic deformation ("FOSID") for structures, systems, and components ("SSCs"). SER at 2-238. The onset of significant inelastic deformation implies that SSCs remain essentially elastic in their performance or have a limited inelastic response during the seismic event. SER at 2-238. In contrast, core damage due to a seismic event would result from failure (i.e., large inelastic deformations) of SSCs. SER at 2-238. In order to determine the SSE that achieves the annual performance goal of 10^{-5}, this approach scales the site-specific mean 10^{-4} uniform hazard response spectrum ("UHRS"), determined in the pervious section, by a design factor ("DF"). SER at 2-259.

84. (CM) The performance of SSCs in terms of annual probability of exceeding acceptable behavior limits (i.e., FOSID) can be evaluated by convolution of seismic hazard and seismic fragility curves. SER at 2-223. The site seismic hazard characteristics are quantified by the PSHA seismic hazard curves. SER at 2-223. Seismic fragility curves describe the probability of unacceptable performance versus ground motion level and are modeled using a lognormal distribution. SER at 2-225. Combining seismic hazard curves and fragility curves gives the risk integral, which forms the basis for the performance-based approach. SER at 2-230. Solving the risk integral results in a simplified equation for the DF used to determine the performance-based SSE. SER at 2-236.

85. (CM) After extensive review, the Staff found the performance-based approach to be an advancement over the solely hazard-based reference probability approach recommended in RG 1.165. SER at 2-268. The Staff noted that the performance-based approach uses not only the seismic hazard characterization of the site from the PSHA, but also basic seismic fragility modeling in order to obtain an SSE that directly targets a structural performance

frequency value. SER at 2-268. To review the performance-based approach, the Staff examined in detail the derivation of the DF that, when multiplied by the mean 10^{-4} UHRS, achieves an SSE that meets the target performance goal of 10^{-5}. SER at 2-262. In addition, the Staff reviewed the assumptions underlying the performance-based approach. SER at 2-262. To evaluate these assumptions, the Staff requested four PSHA hazard curves from the Applicant. SER at 2-263. The Staff then evaluated the parameter and modeling assumptions by directly convolving the seismic hazard and fragility curves. SER at 2-263. To verify that FOSID is larger than SCDF, the Staff used the four seismic hazard curves to calculate SCDF values for each of the corresponding performance-based SSE values. SER at 2-265. SCDF values for the corresponding performance-based SSE vary from about 1×10^{-6}/yr to 3×10^{-6}/yr. SER at 2-265. As such, the Staff concluded that the Applicant targeted a sufficiently low value (10^{-5}/yr), which it set to be equivalent to FOSID, such that the resulting performance-based SSE achieves an SCDF that is about 10 times smaller (10^{-6}/yr) than the median of the mean SCDF for the 25 nuclear power plants in NUREG-1742. SER at 2-268.

86. (CM) Consequently, after reviewing SSAR Section 2.5.2 and the Applicant's responses to the RAIs, the Staff found that the Applicant provided a thorough characterization of the seismic sources surrounding the site, as required by 10 C.F.R. § 100.23. SER at 2-273. The Staff found that the Applicant had adequately addressed the uncertainties inherent in the characterization of these seismic sources through a PSHA, and that this PSHA follows the guidance provided in RG 1.165. SER at 2-273. The Staff concluded that the controlling earthquakes and associated ground motion derived from the Applicant's PSHA are consistent with the seismogenic region surrounding the ESP site, and that the Applicant's SSE adequately represents the regional and local seismic hazards and accurately includes the effects of the local ESP subsurface properties. SER at 2-273. Therefore, based on its review, including

approval of the performance-based approach used by the Applicant, the Staff concluded that the proposed ESP site is acceptable from a geologic and seismologic standpoint and meets the requirements of 10 C.F.R. § 100.23. SER at 2-273. However, it should be remembered that the Staff has neither accepted nor evaluated the ASCE 43-05 standard in its entirety. The Staff's review has focused only on the portion of ASCE 43-05 that specifies the development of seismic design response spectra. The Staff is currently preparing a new regulatory guide that will describe in detail its recommendations for implementation of the ASCE 43-05 performance-based approach.

Q35: Please describe the Staff's health and safety analysis with respect to surface faulting.

A35: 87. (CM) Section 2.5.3.3 of the SER provides the Staff's evaluation of the seismological, geological, and geophysical investigations carried out by the Applicant to address the potential for surface deformation that could affect the site. SER at 2-275. The technical information presented in the SSAR Section 2.5.3 reflected the Applicant's surface and subsurface investigations, performed in progressively greater detail as they moved closer to the ESP site. SER at 2-275.

88. (CM) In order to thoroughly evaluate the surface faulting investigations performed by the Applicant, the Staff sought the assistance of the USGS. SER at 2-275. The Staff and its USGS advisors visited the ESP site and met with the Applicant to assist in confirming the interpretations, assumptions, and conclusions presented by the Applicant concerning potential surface deformation. SER at 2-275. The Staff concluded that the Applicant performed extensive field investigations and concurred with the Applicant's conclusion that there are no capable faults within the site area. SER at 2-276. Based on its site visit and its review of SSAR Section 2.5.3, the Staff concurred with the Applicant that there are no

capable tectonic sources within 25 miles of the site that would cause surface deformation in the site area. SER at 2-276. The Staff concluded that the Applicant performed its investigations in accordance with 10 C.F.R. § 100.23 and RG 1.165 and provided an adequate basis to establish that no capable tectonic sources exist in the site vicinity that would cause surface deformation in the site area. SER at 2-276. Therefore, the Staff concluded that the site is suitable from the perspective of tectonic surface deformation and meets the requirements of 10 C.F.R. § 100.23. SER at 2-276, 2-277.

Q36: Please describe the Staff's health and safety analysis with respect to the stability of subsurface materials and foundations.

A36: 89. (CM) SSAR Section 2.5.4 presents the Applicant's evaluation of the stability of subsurface materials and foundations at the ESP site. In SSAR Section 1.5, the Applicant stated that it developed the geological, geophysical, and geotechnical information used to evaluate the stability of the subsurface materials in accordance with the requirements of 10 C.F.R. § 100.23. SER at 2-293. The Applicant applied the guidance of RS-002, RG 1.70, DG-1105,[21] RG 1.132, and RG 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." SER at 2-293. The Staff reviewed SSAR Section 2.5.4 for conformance with the regulatory requirements and guidance applicable to the characterization of the stability of subsurface materials. SER at 2-293.

90. (CM) Based on its review of SSAR Section 2.5.4 and the Applicant's responses to the associated RAIs and an earlier open item, the Staff concluded that the Applicant adequately determined the engineering properties of the soil and rock underlying the ESP site through its field and laboratory investigators. SER at 2-306. The Staff concluded that the Applicant performed sufficient field investigations and laboratory testing to determine the overall

[21] This guidance has been superseded by RG 1.198 since the Applicant submitted the SSAR.

subsurface profile, the properties of the soil and rock underlying the site, and the similarity between the CPS and ESP subsurface profiles and properties. SER at 2-306. Specifically, the Staff concluded that the Applicant adequately determined (1) the soil and rock dynamic properties through its field investigations and laboratory tests and (2) the liquefaction potential of the soils. (The Staff noted that the Applicant covered the response of the soil and rock to dynamic loading in SSAR Section 2.5.2. SER at 2-306.)

91. (CM) In SSAR Table 1.4-1, the Applicant identified three subsurface material properties as ESP site characteristic values, the first of which specifies that there is no liquefaction below 60 feet below the ground surface (bgs). SER at 2-307. The Staff found that the Applicant demonstrated, in SSAR Section 2.5.4.8, that any liquefaction at the ESP site would be limited to the upper 60 ft of soil. SER at 2-307. SSAR Table 1.4-1 states that "soils above 60 ft bgs to be replaced or improved." However, in SSAR Section 2.5.4.12 the Applicant stated, "decisions regarding the need for and type of ground improvement will be made during the COL stage." Therefore, the Staff identified Permit Condition 6, an unequivocal commitment by the Applicant to improve or replace and remove the soils above 60 ft below the ground surface. SER at 2-307.

Q37: Please describe the Staff's health and safety analysis with respect to the stability of slopes.

A37: 92. (CM) The Applicant did not carry out slope stability analyses for the ESP application. SER at 2-307. Therefore, the Staff was unable to reach any conclusions regarding the stability of slopes that have not been designed or constructed. SER at 2-308.

Q38: Please describe the Staff's health and safety analysis with respect to embankments and dams.

A38: 93. (CM) SSAR Section 2.5.6 states that the ESP facility will use cooling towers for cooling, with Clinton Lake being used to provide makeup water to the cooling towers. Because the ESP facility will use the CPS UHS to supply makeup water to the cooling towers, the Applicant stated that it would perform evaluations (if appropriate) at the COL stage to assess the performance of the submerged dam forming the UHS under the ESP SSE ground motion. The Staff found the Applicant's decision to delay this evaluation until the COL stage to be acceptable. SER at 2-309.

c. SER, Chapter 3, "Site Safety Assessment"

Q39: How did the Staff conduct its assessment of site safety?

A39: 94. (KC) In Chapter 3 of the SER, the Staff reviewed the Applicant's assessment of aircraft hazards to verify that the risks due to such hazards are sufficiently low for a new nuclear unit that might be constructed on the proposed site. The Staff noted that the four private airstrips in the site vicinity do not have commercial operations and are only available for public use in emergencies. SER at 3-1. Although the Applicant determined, based on the criterion in RG 1.70, that none of the fields has enough flight operations to require a detailed analysis of the risk to a plant at the proposed ESP site, the Staff conducted an independent evaluation of the hazards associated with the Martin RLA Airport because it is within 5 miles of the ESP site. SER at 3-1, 3-3. The Staff concluded that aircraft hazards associated with the Martin RLA Airport do not pose a significant risk to a plant constructed at the Clinton ESP site; an aircraft from the Martin RLA Airport has a probability of about 6×10^{-8} per year of impacting the ESP facility, lower than the 10^{-7} threshold in the acceptance criteria in SRP Section 3.5.1.6. SER at 3-3.

95. (KC) The Applicant found that a detailed evaluation of the hazards of airport flight operations was not necessary because the number of flights per year associated with the area airports (including the closest public airports – the Central Illinois Regional Airport in Bloomington, about 23 miles north of the site; the Decatur Airport, about 23 miles south of the site; and the Rantoul National Aviation Center Airport (Frank Elliott Field), about 37 miles east of the site) does not exceed the threshold specified in Section 3.5.1.6 of RS-002. SER at 3-1. The Staff did an independent review of public airports in the vicinity of the proposed ESP site and identified 10 airports within 50 miles of the site but, on the basis of the distances from the airports to the site and the annual number of operations, it found that the hazards of operations at these airports near the proposed ESP site do not pose a significant risk to safety-related structures that might be built at the site. SER at 3-4.

96. (KC) Four low-altitude airways pass near the ESP site and are sufficiently close to require detailed evaluations of the hazards; the CPS USAR analysis concluded that the probability of an aircraft crash on the CPS site from flights along the four airways is 5.42×10^{-8} per year. The Staff performed an independent assessment of the risks associated with the airways and concluded that the probability of an aircraft crash on the ESP site having radiological consequences greater than the 10 C.F.R. 50.34(a)(1) criteria is less than 5.0×10^{-8}.

97. (KC) Since the cumulative risk from identified aircraft hazards was estimated to be on the order of magnitude of 10^{-7} per year ~~Therefore~~, the Staff concluded that, from the perspective of aircraft hazards, the proposed site is acceptable for siting a plant or plants of the types specified by the Applicant.[22] SER at 3-4.

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[22] The Staff identified two types of sources of potential aircraft impact hazards that could not be dismissed by inspection. First, the Staff did the screening analysis described with respect to the Martin RLA Airport. Second, the Staff also estimated the likelihood of an aircraft crash due to air traffic mishaps on nearby airways. As indicated in Table 3.5.1.6-2 of the SER, the total probability for the four airways was estimated to be about 4.96×10^{-8} per year. Therefore, the Staff estimated the total aircraft crash

(continued...)

d. SER, Chapter 11, "Radioactive Effluent Dose Consequences from Normal Operations"

Q40: How did the Staff conduct its assessment of radioactive effluent dose consequences from normal operation?

A40: 98. (SK) The Staff evaluated the Application in order to determine whether the site characteristics would maintain radiation doses to the public within the regulatory limits. SER at 11-1. The licensee indicated that the proposed facility will be able to handle these radiological effluents and solid waste materials with minimal environmental, public, and personnel exposure during normal plant operation and maintenance; a plant constructed at the ESP site would be able to ensure that radiation levels are as low as reasonable achievable (ALARA). SER at 11-1. The Staff did not independently verify that the applicant's estimated bounding quantities of radioactive gaseous and liquid waste meet the concentration values in Appendix B to 10 C.F.R. Part 20.[23] However, the Staff did perform independent calculations of

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[22](...continued)
probability for the proposed site to be about 1.1×10^{-7}. However, the Staff judged the actual probability to be less than 10^{-7} per year due to the conservatism used in the analysis (e.g., assuming all aircraft using the airways are large).

The Staff also notes that, in the absence of precise data for low probability events, staff review guidance described in Standard Review Plan Section 2.2.3 considers a probability of about 10^{-6} per year to be acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower.

[23] The Staff has not routinely performed independent verification of the source term because of the low risk significance associated with the calculated doses to members of the public from routine radioactive gaseous and liquid effluents. The historical data from licensee radiological effluent release reports and associated dose calculations support the position that doses are well within the NRC's ALARA criteria (Appendix I to 10 C.F.R. Part 50) for power reactors. The ALARA dose criteria in Appendix I to Part 50 are a requirement in each power reactor's license. Additionally, there is also a license condition that uses Appendix B, Table 2 to 10 C.F.R. Part 20 as the basis for limiting the release rate of radionuclides in routine effluent discharges. Thus, the NRC requires dose and concentration controls to maintain routine effluents ALARA. These license conditions are routinely inspected by NRC Regional Inspectors. The inspection examines the licensee's radiological effluent monitoring and release programs to ensure their programs meet NRC requirements. Thus, the data and inspection reports support the conclusion that the existing fleet of nuclear reactors meets NRC's ALARA criteria.

In summary, based on the information described above, the Staff did not independently derive the routine effluent source term.

dose to members of the public, using the applicant's source term data, meteorological data, and liquid dispersion data.

99. (SK) After evaluating bounding effluent, solid waste, and dose estimates provided by the Applicant, the Staff concluded that the Applicant had provided adequate information to give reasonable assurance that it will control, monitor, and maintain radioactive gaseous and liquid effluents from the ESP facility within the regulatory limits specified in 10 C.F.R. Part 20, 10 C.F.R. Part 71, and 49 C.F.R. Part 173. This analysis also indicated that the Applicant would maintain radioactive effluent releases at ALARA levels, in accordance with the effluent design objectives contained in Appendix I to 10 C.F.R. Part 50. SER at 11-3. However, the Staff noted that any COL applicant that references an ESP for the site should verify that the calculated radiological doses to members of the public from radioactive gaseous and liquid effluents for any facility to be built on the site are bounded by the radiological doses included in the SSAR for the ESP application and reviewed by the NRC Staff. SER at 11-3.

100. (SK) For the ESP review, the Staff was asked to review the Applicant's data using a Plant Parameter Envelope (PPE) concept. The PPE does not contain enough detailed information on plant systems and components that will be used to control radioactive material generated and sent to radioactive waste reduction systems for the Staff to verify the Applicant's assumptions. At the COL stage, the Staff will have specific details on the applicant's reactor design, radioactive waste processing systems, locations of effluent release points, and distances to receptors. This detailed information will allow the Staff to perform independent verification and calculations of the radioactive source term and the dose to members of the public; however, the Staff has not yet determined the level of independent verification and calculation that will be performed at the COL application stage.

e. SER Chapter 13, Conduct of Operations

Section 13.3, “Emergency Planning”

Q41: Describe how the Staff evaluated the Applicant’s emergency plan for the ESP site.

A41: 101. (RM) The Staff evaluated the emergency planning aspects of the Early Site Permit (ESP) Application to determine whether the information was acceptable and met the requirements of 10 C.F.R. § 52.17(b)(1), 10 C.F.R. § 52.17(b)(2)(I), 10 C.F.R.§ 52.17(3), and 10 C.F.R. § 52.18. SER at 13-1. An ESP Application, pursuant to 10 C.F.R. § 52.17(b)(1), must identify any physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans. SER at 13-1. Pursuant to 10 C.F.R. § 52.17(b)(3), an ESP Application must also describe the contacts and arrangements that the Applicant has made with Federal, State, and local government agencies with emergency response planning responsibilities. SER at 13-1.

102. (RM) In addition, under 10 C.F.R. § 52.17(b)(2), the Applicant chose to seek approval of the major features of its emergency plans. This option is described in NRC Review Standard RS-002, “Processing Applications for Early Site permits,” issued May 2004, and Supplement 2 to NUREG-0654/FEMA-REP-1, Revision 1, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants—Criteria for Emergency Planning in an Early Site Permit Application—Draft Report for Comment” (hereafter referred to as Supplement 2), issued April 1996. SER at 13-12. In its review, the Staff also applied the requirements of 10 C.F.R. § 52.18, “Standards for Review of Applications,” that establish “acceptable” as the standard of review for proposed major features of emergency plans as opposed to the “reasonable assurance” standard established for complete and integrated plans. The Staff evaluated the information that the Applicant provided and concluded that it was consistent with the guidance

in RS-002 and Supplement 2 and therefore was acceptable and met the requirements of 10 C.F.R. § 52.18. SER at 13-14.

103. (RM) In addition to this review, the Staff will review the complete and integrated emergency plan submitted as part of a COL or OL application to ensure compliance with the requirements of Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," to 10 C.F.R. Part 50, "Domestic Licensing of Production and Utilization Facilities," and 10 C.F.R. § 50.47, "Emergency Plans." SER at 13-2.

104. (RM) The Applicant stated that the evacuation time estimate ("ETE") analysis performed in 1993 for the CPS plume exposure pathway served as the basis for its ETE analysis. SER at 13-2. The Applicant further stated that the 1993 ETE analysis assessed the relative feasibility of an evacuation for the 10-mile (mi) EPZ plume exposure pathway. The Applicant found that the assumptions used for the 1993 ETE analysis are still valid for the area surrounding the ESP site. SER at 13-2, 13-3. The Applicant used the NETVAC computer simulation model,[24] evacuation preparation and departure time distributions, and population and vehicle demand distribution data to simulate a variety of evacuation scenarios.[25] SER at 13-3.

105. (RM) Because the ESP site is adjacent to Clinton Power Station, an operating nuclear power plant with integrated onsite and offsite radiological emergency plans, it can be

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[24] According to the Applicant's 1993 ETE analysis, the NETVAC model was developed to provide evacuation time estimates for emergency response planning and has been used at over 30 nuclear facilities in the United States. This code meets the requirements of NUREG-0654/FEMA-REP-1, Rev. 1 and has been accepted by FEMA (now the Department of Homeland Security) and been used by the NRC at several ASLB hearings. The code provides a "reasonably sophisticated" model of evacuation time estimates during an emergency situation.

[25] For example, the 1993 ETE study assumed that it would take up to one hour to assemble transportation for local students. The Staff, based on information provided by the Applicant and an NRC contractor with extensive expertise in the area of evacuation time estimates, believes that the results of the 1993 study still provide a valid projection of the evacuation timetable for the local schools. The evacuation plans for the local schools will not impact the evacuation plans for the Apple and Pork Festival. Since the Festival is held on the last full weekend of September, and school is not in session on the weekends, the buses that would be used for school children during the week would be available to evacuate the Festival.

presumed that no significant impediments exist to the development of emergency plans for the ESP site. SER at 13-13. The Staff also found that the Applicant adequately identified physical characteristics unique to the proposed site by performing a preliminary analysis of the time required to evacuate the transient and permanent population from various sectors and distances within the plume exposure pathway EPZ. The NRC and Department of Homeland Security Staffs' examination of the Applicant's analysis did not find any significant impediments to the development of emergency plans for the ESP site. SER at 13-13. The Staff determined that the Application's ETE analysis includes an estimate of the number of people to be evacuated, using the latest population census numbers and the most recent local conditions. SER at 13-13. Therefore, with respect to impediments to emergency plan development, the Staff concluded that the information the Applicant provided is consistent with the guidance in RS-002 and Supplement 2 and meets the requirements of 10 C.F.R. § 52.17(b)(1) and 10 C.F.R. § 52.18. SER at 13-14.

106. (RM) The Staff found that the Applicant provided an acceptable description of contacts and arrangements made with Federal, State, and local governmental agencies with emergency planning responsibilities. This description included the name and location of the organizations contacted, the title of the persons contacted, and the role of the organization in emergency planning. Therefore, the Staff concluded that the Application is consistent with the guidelines in RS-002 and Supplement 2 and meets the requirements of 10 C.F.R. § 52.17(b)(3). SER at 13-17.

107. (RM) With respect to emergency planning zones, the Application stated that the EPZ boundary of the Clinton ESP site is identical to the CPS EPZ boundary. The CPS EPZ boundary was defined in 1985 following a detailed review of the demography, topography, land characteristics, access routes, and jurisdictional boundaries in the area surrounding the power facility. SER at 13-17. The Staff thus found that the Applicant proposed a plume exposure

pathway EPZ of approximately a 10-mile radius and an ingestion pathway EPZ of approximately a 50-mile radius, both of which reflect local emergency response needs and capabilities. SER at 13-18. The Staff concluded that the size and configuration of the EPZs is consistent with the guidance in RS-002 and Supplement 2, thereby meeting the requirements of 10 C.F.R. § 50.33(g), 10 C.F.R. § 50.47(c)(2), 10 C.F.R. § 52.17(b)(2)(I), 10 C.F.R. § 52.18, and Sections I, III, and IV of Appendix E to 10 C.F.R. Part 50. SER at 13-18.

108. (RM) The Applicant also sought NRC acceptance of 14 major features of its emergency plan. The Staff evaluated the Application with respect to each of these major features, and concluded that 13 of the proposed features (Major Features A-G, I-L, O & P) were consistent with the guidance in RS-002 and Supplement 2, thereby meeting the requirements of 10 C.F.R. § 52.17(b)(2)(I), 10 C.F.R. § 52.18, and the appropriate sections of Appendix E to 10 C.F.R. Part 50, to the extent those requirements apply to the proposed features. SER at 13-22, 13-25, 13-27 to 13-28, 13-29, 13-31, 13-35, 13-38, 13-45, 13-63 to 13-64, 13-70, 13-72, 13-75, 13-79 to 13-80. These features, which the Staff found acceptable, included assignment of responsibility (organization control); onsite emergency organizations; emergency response support and resources; emergency classification system; notification measures; emergency communications; public education and information; accident assessment; protective response; radiological exposure control; medical and public health support; radiological emergency response training; and responsibility for the planning effort (development, periodic review, and distribution of emergency plans). *Id.*

109. (RM) With respect to Major Feature H (related to emergency facilities and equipment), the Staff found that the Applicant had not described in sufficient detail the emergency facilities and related equipment for the operational and technical support centers ("OSC" and "TSC" respectively) as specified in RS-002 and Supplement 2. Therefore, the Staff concluded that proposed Major Feature H was unacceptable. SER at 13-43. However, the

Staff will determine the acceptability of Planning Standard H (since there is no Major Features option at the COL stage) at the COL or OL stage based on the emergency response facility guidance in NUREG-0696. Because the review of Planning Standard H will take place at the later COL or OL stage and is an integral part of a complete and integrated plan that will be required at that stage, it is unnecessary to track this issue in the ESP.

Q42: In reaching its conclusions with respect to emergency planning, did the Staff take into account any lessons learned from the response to Hurricane Katrina?

A42: 110. (RM) No, lessons learned from Hurricane Katrina were not included in the Staff's SER analysis because the hurricane occurred after the issuance of the Draft SER. However, a study has been funded by the NRC to analyze the response to Katrina, and the results of the study will be considered in the future. At this time, the Department of Homeland Security has not directed state, tribal and local governments to take any emergency preparedness actions in response to lessons learned from Katrina.

Section 13.6, Industrial Security

Q43: Describe how the Staff evaluated the Applicant's assessment of the site characteristics in regard to physical security plans for the ESP site.

A43: 111. (AT) The Staff, employing the criteria in 10 C.F.R. 100.21(f), reviewed the physical security sections of the ESP application, the Applicant's RAI response, and conducted a site visit in order to ensure that the site characteristics will allow the development of adequate security plans and measures. SER at 13-80 to 13-81. Specifically, the Staff considered pedestrian land approaches, vehicular land approaches, railroad approaches, water approaches, potential high-ground adversary advantage areas, nearby road transportation routes, nearby hazardous materials facilities, nearby pipelines, and culverts that could provide a pathway into the protected area. SER at 13-81. With respect to pedestrian and water

approaches, the Staff concluded that the distance from possible locations of vital equipment and structures (which might be located anywhere in the identified PPE site footprint) to the owner controlled area ("OCA") boundary is sufficiently large to locate barriers, detection equipment, and isolation zones on the site as required by RG 4.7. SER at 13-81.

112. (AT) The Staff also found that the existing roads, railroad line and spur, and site terrain features, when considered with the size of the OCA, do not preclude the establishment of adequate vehicle control plans or security plans or measures. SER at 13-81, 13-82. Furthermore, hazardous materials facilities and pipelines, and those hazardous materials identified as associated with them, were sufficiently distant from the ESP site areas to preclude any impediment to the development of adequate security plans or measures. SER at 13-82. Based on this evaluation, the Staff concluded that the Clinton ESP site characteristics would allow a COL or CP applicant to develop adequate security plans and measures for a new unit on the ESP site. SER at 13-82.

Q44: Describe how the Staff evaluated the Applicant's assessment of the site characteristics in regard to physical security plans for the ESP site.

A44: 113. (AT) The Staff, employing the criteria in 10 C.F.R. 100.21(f), reviewed the physical security sections of the ESP application, the Applicant's RAI response, and conducted a site visit in order to ensure that the site characteristics will allow the development of adequate security plans and measures. SER at 13-80 to 13-81. Specifically, the Staff considered pedestrian land approaches, vehicular land approaches, railroad approaches, water approaches, potential high-ground adversary advantage areas, nearby road transportation routes, nearby hazardous materials facilities, nearby pipelines, and culverts that could provide a pathway into the protected area. SER at 13-81. With respect to pedestrian and water approaches, the Staff concluded that the distance from possible locations of vital equipment

and structures (which might be located anywhere in the identified PPE site footprint) to the owner controlled area ("OCA") boundary is sufficiently large to locate barriers, detection equipment, and isolation zones on the site as required by RG 4.7. SER at 13-81.

114. (AT) The Staff also found that the existing roads, railroad line and spur, and site terrain features, when considered with the size of the OCA, do not preclude the establishment of adequate vehicle control plans or security plans or measures. SER at 13-81, 13-82. Furthermore, hazardous materials facilities and pipelines, and those hazardous materials identified as associated with them, were sufficiently distant from the ESP site areas to preclude any impediment to the development of adequate security plans or measures. SER at 13-82. Based on this evaluation, the Staff concluded that the Clinton ESP site characteristics would allow a COL or CP applicant to develop adequate security plans and measures for a new unit on the ESP site. SER at 13-82.

f. SER, Chapter 15, "Postulated Accidents and Accident Dose Consequences"

Q45: Describe how the Staff evaluated the Application with respect to postulated accidents and accident dose consequences.

A45: 115. (JL) The Staff evaluated the radiological consequences of design-basis accidents (DBAs) in order to determine whether a new nuclear unit could be built at the ESP site without undue risk to the public health and safety, as required by 10 C.F.R. § 52.17, "Contents of Applications," and 10 C.F.R. Part 100, "Reactor Site Criteria." SER at 15-1. The Applicant, instead of selecting a particular reactor design, used surrogate reactor characteristics to develop a set of reactor DBA source term parameters. SER at 15-1. The Applicant used these parameters and accident-related site specific characteristics to assess the suitability of the proposed ESP site as part of its PPE. SER at 15-1. Seven reactor designs,

five water-cooled reactors and two gas-cooled reactors[26], were reviewed to develop the PPE; the Applicant used the source terms for only two of these designs, the ABWR and the AP1000, as inputs to its DBA analyses.[27] SER at 15-1.

116. (JL) As discussed in RS-002, the Staff considers the PPE approach to be an acceptable method for assessing site suitability. For the purposes of this analysis, the Applicant proposed a fission product release from the ESP footprint to the environment; the Staff reviewed the Applicant's dose evaluation based on this proposed release. SER at 15-4. Using the ABWR and AP1000 source terms and the site-specific χ/Q values, the Applicant performed and provided radiological consequence analyses. SER at 15-1.

117. (JL) The Staff found that the Applicant's PPE values for source terms used as inputs to the radiological consequence analyses were reasonable and that the Applicant's site-specific χ/Q values and dose consequence evaluation methodology were acceptable. Therefore, the Staff concluded that the proposed distances to the EAB and the LPZ outer boundary of the proposed ESP site are adequate to provide reasonable assurance that the radiological consequences of the DBAs would be within the dose consequence evaluation factors set forth in 10 C.F.R. 50.34 (a)(1) for the proposed ESP site. SER at 15-9.

Q46: Describe the Staff's review of the Applicant's selection of DBAs.

A46: 118. (JL) The Staff concluded that the Applicant's DBAs are consistent with the DBA list and analysis presented in the SRP and RG 1.183, "Alternative Radiological Source Terms

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[26] The five light water reactor ("LWR") designs are the Advanced Pressurized Water Reactor 1000 ("AP1000"); the Advanced Boiling Water Reactor ("ABWR"); the Advanced Canada Deuterium Uranium Reactor ("ACR-700"); the Economic Simplified Boiling Water Reactor ("ESBWR"), and the International Reactor Innovative and Secure ("IRIS") Reactor. The two gas-cooled designs are the Gas Turbine Modular Helium Reactor ("GT-MHR") and the Pebble Bed Modular Reactor ("PBMR").

[27] Based on a limited review of the ACR-700 design and the Ft. St. Vrain gas cooled reactor, the Staff believes that any conclusions regarding the site acceptability based on the AP1000 and ABWR designs will be valid for the other designs being considered by the Applicant. Whether or not such designs are in fact bounded, these DBA analyses will be subject to the Staff's review during any COL or CP application related to the ESP site.

for Evaluating Design Basis Accidents at Nuclear Power Plants," issued July 2000. SER at 15-5. The Staff also found that the site acceptability conclusions based on the AP1000 and ABWR designs are likely to be valid for the Applicant's other reactor designs; the Staff will verify the acceptability of these other reactor designs at the COL or CP stage. SER at 15-5. Therefore, the Staff found that the Applicant provided an acceptable DBA selection for evaluating the compliance of the proposed ESP site with the dose consequence evaluation factors specified in 10 C.F.R. § 50.34(a)(1). SER at 15-5.

Q47: Describe the Staff's review with respect to design-specific (postulated) χ/Q values.

A47: 119. (JL) After Westinghouse revised the χ/Q (atmospheric dispersion factor) values for the AP1000 design certification, the Applicant chose to update the ESP application to apply the new values to all DBAs. The Staff verified that the χ/Q values used by the Applicant are the same as those in the AP1000 design certification document (DCD). SER at 15-5. The Applicant used both the site-specific χ/Q and postulated χ/Q values for the AP1000 to obtain its ratios. These ratios were used in conjunction with the radiological consequence doses certified in the AP1000 DCD to demonstrate the compliance of the radiological consequence doses with 10 C.F.R. § 50.34. SER at 15-7. In evaluating the ABWR, the applicant did not use the postulated χ/Q values in the ABWR certified DCD. Instead, the applicant calculated the radiological consequence doses using the postulated activity releases in the ABWR certified DCD, the site-specific χ/Q values and the dose conversion factors in Federal Guidance Reports 11 and 12.[28] SER at 15-6.

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[28] Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion (1988)," U.S. Environmental Protection Agency and Oak Ridge National Laboratory. Federal Guidance Report 12, "External Exposure to Radionuclides in Air, Water, and Soil (1993)," U.S. Environmental Protection Agency and Oak Ridge National Laboratory.

Q48: What are χ/Q values?

A48: 120. (JL) The χ/Q values (atmospheric dispersion factors expressed in seconds per cubic meter) indicate the atmospheric dilution capability. The "χ" is the radioactivity concentration (in curies per cubic meter) and "Q" is the radioactivity release rate (in curies per second). Smaller χ/Q values are associated with greater dilution capability, resulting in lower radiological doses. The radiological consequence doses are directly proportional with the χ/Q values: in other words, as the EAB and LPZ distances from the site increase, the resulting χ/Q values become smaller. The Applicant identified and proposed appropriate EAB and LPZ sizes and distances to demonstrate the compliance of the radiological consequence doses with 10 C.F.R. § 50.34. SER at 15-7.

Q49: How are the radiological doses calculated?

A49: 121. (JL) Total effective dose equivalent (TEDE) as set forth in 10 C.F.R. 50.34 (a)(1) means the sum of the deep-dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposure). The internal exposure is calculated by multiplying the source term, the χ/Q values, the breathing rate provided in Federal Guidance Reports 11, and the dose conversion factors provided in Federal Guidance Reports 12. The external exposure is calculated by multiplying the source term, the χ/Q values, and the dose conversion factors provided in Federal Guidance Reports 11.

Q50: Describe the Staff's review with respect to site-specific χ/Q values.

A50: 122. (JL) The Staff, following the guidance in Section 2.3.4 of RS-002, performed an independent analysis of the Applicant's site specific χ/Q values. After the Applicant revised its χ/Q values to account for additional meteorological data[29] and a new minimum distance of

[29] The Applicant expanded the scope of the data considered from January 2000-August 2002 to January 2000-December 2002.

805 meters to the EAB (the previous calculations used a minimum distance of 1025 meters), the Staff found the Applicant's analysis to be acceptable. SER at 15-6.

Q51: Describe the Staff's review with respect to source terms and radiological consequence evaluations.

A51: 123. (JL) Based on the AP1000 DCD and the design certification rule for the ABWR, the Staff found that the certified ABWR and the proposed AP1000 designs met the radiological consequence evaluation factors identified in 10 C.F.R. § 50.34(a)(1) with their postulated χ/Q values. SER at 15-7. The radiological consequences of the DBAs for the final reactor design, assuming that neither the AP1000 nor ABWR is selected by the COL applicant, are likely to be bounded by the AP1000 and ABWR analysis. For a new reactor design other than the proposed AP1000 and the certified ABWR, the Staff will evaluate, at the COL stage, whether the design of the facility falls within the parameters specified in any ESP issued for the Clinton ESP site. SER at 15-8. The Staff found the PPE source terms to be reasonable and acceptable and noted that the Applicant's dose consequences for the AP1000 and ABWR comply with the dose consequence factors in 10 C.F.R. § 50.34(a)(1). SER at 15-8. The Staff concluded that the proposed distances to the EAB and LPZ outer boundary of the ESP site, when considered with the Applicant's fission product release rates to the environment, provide reasonable assurance that the radiological consequences of the DBAs will be within the dose consequence evaluation factors required by 10 C.F.R. § 50.34(a)(1). SER at 15-9. Therefore, the Staff found that: (1) the Applicant demonstrated the suitability of the proposed ESP site, in terms of risk to the public health and safety, and (2) the Applicant complied with the requirements of 10 C.F.R. § 52.17 and 10 C.F.R. Part 100. SER at 15-10.

g. SER Chapter 17, "Early Site Permit Quality Assurance Measures"

Q52: Describe the Staff's evaluation of the Applicant's quality assurance measures.

A52: 124. (PP) As part of its safety review, the Staff evaluated the Applicant's, and its contractors'[30], ESP quality assurance measures.[31] Even though current NRC regulations do not require ESP applicants to implement a 10 C.F.R. Part 50 Appendix B[32] QA program, applicants are expected to have an equivalent program in place in order to ensure the effective use of ESP data in the formulation of safety SSCs at the COL or CP stage. SER at 17-1. The Applicant is not required to comply with Appendix B at this time because the ESP permit process does not involve Systems, Structures, or Components (SSCs). The focus of the ESP permit process is on design, documentation, personnel qualification, and other applicable quality controls to ensure the reliability of this information in subsequent phases of design and construction. Specifically, the ESP QA program did not include: the Identification and Control of Materials; Parts and Components; Inspection; Inspection, Test and Operating Status; and Nonconforming Materials, Parts, or Components. Therefore, the Staff evaluated the Applicant's ESP QA measures to ensure the integrity and reliability of SSC-related site information. SER at 17-1. The Staff focused its review on the compliance of the Applicant's program with the QA measures described in RS-002 Section 17.1.1. SER at 17-1. The Staff performed much of its inspection in January 2004 and documented the results in a February 2004 Inspection Report. SER at 17-1, 17-2.

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[30] Contractors identified with respect to the QA review included CH2M HILL, Parsons Energy & Chemicals Group, Testing Services Corporation, Geomatrix, GRL Engineers, Inc., Stratigraphics, and the University of Texas.

[31] Some contractors and subcontractors were not audited because they are listed as "approved suppliers." Approved suppliers have already been audited and have provided evidence that they meet the requirements of 10 C.F.R. Part 50 Appendix B.

[32] "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"

125. (PP) The Staff reviewed 18 QA elements and found that each element was either acceptably implemented with respect to ESP application activities, or was not required based on the scope of work for the ESP project. SER 17-2 to 17-40. The elements examined by the Staff included QA organization; the quality assurance program; design control; procurement document control; instructions, procedures, and drawings; document control; control of purchased material, equipment, and services; identification and control of materials, parts, and components; control of special processes; inspection; test control; control of measuring and test equipment; handling, storage, and shipping; inspection, test, and operating status; nonconforming materials, parts, or components; corrective action; quality assurance records; and audits.[33] SER 17-2 to 17-40. As part of the Staff's safety review, two open items from the draft SER were resolved: first, the Staff determined through review of supporting documentation during a follow-up inspection that the Applicant had provided adequate QA measures to authenticate and verify data retrieved from internet web sites; and, second, the Staff determined the applicability of 10 C.F.R. Part 21 to ESP applicants.

126. (PP) Based on its review and evaluation of the Applicant's QA program, the Staff concluded that the program conforms to the guidance in RS-002, Attachment 2, as well as to appropriate industry standards, and that the Applicant and its contractors implemented it for the ESP application activities. SER at 17-40.

[33] The elements the Staff found not to be required based on the scope of work for the ESP project were identification and control of materials, parts, and components; control of special processes; inspection; inspection, test, and operating status; and nonconforming materials, parts, or components. SER at 17-21, 17-23, 17-24, 17-31, and 17-32.