# 2. SITE CHARACTERISTICS

This chapter discusses the envelope of site-related design parameters that the economic simplified boiling-water reactor (ESBWR) standard plant is designed to accommodate, focusing on potential nearby hazards, meteorology, hydrology, geology, seismology, and geotechnical parameters. An applicant for a combined license (COL) referencing the ESBWR design control document (DCD) will establish the actual site characteristics with respect to these areas when it applies for a COL, or it will reference an early site permit (ESP) that reflects such characteristics. In either case, the COL applicant must show that the site parameters postulated for and considered in the ESBWR design bound the actual site characteristics. Should the postulated ESBWR site design parameters not encompass the actual site characteristics, the COL applicant must demonstrate by some other means that the proposed facility is acceptable at the proposed site. This applicant might do this by reanalyzing or redesigning the proposed facility.

The staff of the U.S. Nuclear Regulatory Commission (NRC) based its evaluation of the ESBWR envelope of site-related design parameters on a review of Chapter 2, "Site Characteristics," of the EBSWR DCD, Tier 2, along with the applicant's responses to the staff's requests for additional information (RAIs).

The applicant stated that it met the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 52.47(a)(1)(iii) by providing postulated site parameters for the ESBWR design and demonstrating that the standard design meets the required design criteria. The applicant presented in DCD, Tier 2, Chapter 2, the envelope of site-related parameters that the ESBWR standard plant is designed to accommodate. DCD, Tier 2, Table 2.0-2, lists the site design parameters. DCD, Tier 2, Table 2.0-2, also defines the limits imposed on the acceptance criteria in Section II of the various sections in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (hereafter referred to as the SRP), as (1) the envelope of site-related parameters that the ESBWR plant is designed to accommodate and (2) the site-related assumptions, both implicit and explicit, used in the evaluation of the ESBWR design.

## 2.1 Geography and Demography

The applicant, GE Hitachi Nuclear Energy (GEH), stated that a COL applicant referencing the ESBWR DCD must demonstrate that the site characteristics for a given site conform to the ESBWR DCD site design parameter values. The COL applicant should follow the applicable NRC guidance for preparing the COL application, depending on whether or not the COL applicant references an ESP. DCD, Tier 2, Table 2.0-2, provides by reference the SRP

information related to the NRC guidance. The pertinent sections of the SRP include Sections 2.1.1, "Site Location and Description," 2.1.2, "Exclusion Area Authority and Control," and 2.1.3, "Population Distribution."

## 2.1.1 Site Location and Description

### 2.1.1.1 *Regulatory Criteria*

Acceptance criteria regarding site location and description are based on meeting the relevant requirements of 10 CFR 100.20(b) and 10 CFR 100.21, "Non-seismic Site Criteria," which require information about the population density and use characteristics of the site environs, including the exclusion area, low-population zone (LPZ), and population center distance to be considered in determining the acceptability of a site for a power reactor.

SRP Section 2.1.1 addresses the specific criteria for meeting the relevant requirements. Typically, the staff reviews the following:

- reactor location with respect to (1) latitude and longitude and the Universal Transverse Mercator coordinate system, (2) political subdivisions, and (3) prominent natural and manmade features of the area for use in independent evaluations of the exclusion area authority and control (SRP Section 2.1.2), the surrounding population (SRP Section 2.1.3), and nearby manmade hazards (SRP Section 2.2.3, "Evaluation of Potential Accidents")

- the site area map containing the reactor and associated principal plant structures to determine (1) the distance from the reactor to the boundary lines of the exclusion area, including the direction and distance from the reactor to the nearest exclusion area boundary (EAB) line, and (2) the location, distance, and orientation of plant structures with respect to highways, railroads, and waterways that traverse or lie adjacent to the exclusion area to ensure that such descriptions are adequate to permit analyses of the possible effects on the plant of accidents along these transportation routes (SRP Section 2.2.3)

Design certification (DC) applications do not contain this type of site specific information, however the COL application will provide such data.

### 2.1.1.2 *Summary of Technical Information*

GEH specified in DCD, Tier 2, Table 2.0-2, that the COL applicant will supply site specific information in accordance with SRP Section 2.1.1.

### 2.1.1.3 *Staff Evaluation*

The information regarding site location and description is site specific. GEH stated in DCD, Tier 2, Table 2.0-2, that the COL applicant is to supply such information, in accordance with SRP Section 2.1.1. This was identified as COL Information Item 2.0-2-A. The staff finds this acceptable.

### 2.1.1.4 ***Conclusion***

No postulated site parameters for a DC relate to site location and description. Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.1.2 Exclusion Area Authority and Control

#### 2.1.2.1 *Regulatory Criteria*

Acceptance criteria regarding exclusion area authority and control are based on meeting the relevant requirements of the following NRC regulations:

- 10 CFR 100.21(a), which states that every site must have an exclusion area as defined in 10 CFR 100.3, "Definitions"

- 10 CFR 100.3, which defines the exclusion area as the area surrounding the reactor, in which the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property from the area

SRP Section 2.1.2 addresses the specific criteria for meeting the relevant requirements. Typically, the staff reviews (1) the applicant's legal authority to determine all activities within the designated exclusion area, (2) the applicant's authority and control in excluding or removing personnel and property in the event of an emergency, and (3) proposed or permitted activities in the exclusion area unrelated to operation of the reactor to ensure that they do not or will not result in a significant hazard to public health and safety.

DC applications do not contain this type of site specific information, however, the COL application will provide such data.

#### 2.1.2.2 *Summary of Technical Information*

The applicant specified in DCD, Tier 2, Table 2.0-2, that the COL applicant is to supply site specific information, in accordance with SRP Section 2.1.2.

#### 2.1.2.3 *Staff Evaluation*

The information regarding exclusion area authority and control is site specific. GEH stated in DCD, Tier 2, Table 2.0-2, that the COL applicant is to supply such information, in accordance with SRP Section 2.1.2. This was identified as COL Information Item 2.0-3-A. The staff finds this acceptable.

#### 2.1.2.4 *Conclusion*

No postulated site parameters for a DC relate to exclusion area authority and control. Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the

design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.1.3 Population Distribution

#### 2.1.3.1 *Regulatory Criteria*

Acceptance criteria regarding population distribution in the site vicinity are based on meeting the relevant requirements of the following NRC regulations:

(1) 10 CFR 100.21(a), which states that every site must have an exclusion area and an LPZ, as defined in 10 CFR 100.3

(2) 10 CFR 100.21(b), which states that the population center distance, as defined in 10 CFR 100.3, must be at least 1⅓ times the distance from the reactor to the outer boundary of the LPZ

(3) 10 CFR 100.3, which defines the following:

- the exclusion area as the area surrounding the reactor, in which the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property from the area
- the LPZ as the area immediately surrounding the exclusion area which contains residents, the total number and density of which are such that there is a reasonable probability that appropriate protective measures could be taken on their behalf in the event of a serious accident
- the population center distance as the distance from the reactor to the nearest boundary of a densely populated center containing more than about 25,000 residents

SRP Section 2.1.3 addresses the specific criteria for meeting the relevant requirements. Typically, the staff reviews the following:

- data about the population in the site vicinity
- the population in the exclusion area
- the LPZ to determine whether appropriate protective measures could be taken on behalf of the populace in that zone in the event of a serious accident
- the nearest boundary of the closest population center containing 25,000 or more residents to determine whether this boundary is at least 1⅓ times the distance from the reactor to the outer boundary of the LPZ
- the population density in the site vicinity, including weighted transient population at the time of initial site approval and within 5 years thereafter, to determine whether the

density exceeds 500 persons per square mile averaged over any radial distance out to 20 miles

DC applications do not contain this type of site specific information, however COL applications will provide such data.

#### 2.1.3.2 *Summary of Technical Information*

The applicant specified in DCD, Tier 2, Table 2.0-2, that the COL applicant is to describe the population distribution, in accordance with SRP Section 2.1.3.

#### 2.1.3.3 *Staff Evaluation*

The information regarding population distribution in the site vicinity is site specific. GEH stated in DCD, Tier 2, Table 2.0-2, that the COL applicant is to supply such information, in accordance with SRP Section 2.1.3. This was identified as COL Information Item 2.0-4-A. The staff finds this acceptable.

#### 2.1.3.4 *Conclusion*

No postulated site parameters for a DC relate to population distribution. Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The information provided should be sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.2 Nearby Industrial, Transportation, and Military Facilities

DCD, Tier 2, Table 2.0-2, provides by reference the SRP information related to the NRC guidance. The pertinent sections of the SRP include Sections 2.2.1-2.2.2, "Identification of Potential Hazards in Site Vicinity," and 2.2.3.

### 2.2.1-2.2.2 Identification of Potential Hazards in Site Vicinity

#### 2.2.1.1-2.2.2.1 *Regulatory Criteria*

Acceptance criteria regarding the identification of potential hazards in the site vicinity are based on meeting the relevant requirements of the following NRC regulations:

- 10 CFR 100.20(b), which states that the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, military and chemical facilities) must be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards and whether the risk of other hazards is very low

- 10 CFR 100.21(e), which states that potential hazards associated with nearby transportation routes and industrial and military facilities must be evaluated and site parameters established such that potential hazards from such routes and facilities will pose no undue risk to the type of facility proposed to be located at the site

SRP Section 2.2.1-2.2.2 addresses the specific criteria for meeting the relevant requirements. Typically, the staff reviews the following:

- the locations and distances of industrial, military, and transportation facilities in the vicinity of the plant
- the nature and extent of activities conducted at the site and in its vicinity, including the products and materials likely to be processed, stored, used, or transported, in order to identify possible hazards
- statistical data with respect to hazardous materials to establish a basis for evaluating the potential hazard to the plant proposed to be located at the site

#### 2.2.1.2-2.2.2.2 *Summary of Technical Information*

GEH specified in DCD, Tier 2, Table 2.0-2, that the COL applicant must identify and evaluate potential hazards in the site vicinity, in accordance with SRP Section 2.2.1-2.2.2. Potential hazards include manufacturing plants, chemical plants, refineries, storage facilities, mining and quarrying operations, military bases, missile sites, transportation routes (air, land, and water), transportation facilities (docks, anchorages, airports), oil and gas pipelines, drilling operations and wells, and underground gas storage facilities.

#### 2.2.1.3-2.2.2.3 *Staff Evaluation*

The information regarding potential hazards in the vicinity of the site is site specific. GEH stated in DCD, Tier 2, Table 2.0-2, that the COL applicant is to supply such information, in accordance with SRP Section 2.2.1-2.2.2. This was identified as COL Information Item 2.0-5-A. The staff finds this acceptable.

#### 2.2.1.4-2.2.2.4 *Conclusion*

No postulated site parameters for a DC relate to the identification of potential hazards in the site vicinity. Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.2.3 Evaluation of Potential Accidents

#### 2.2.3.1 *Regulatory Criteria*

Acceptance criteria regarding evaluation of potential accidents in the vicinity of the plant are based on meeting the relevant requirements of the following NRC regulations:

- 10 CFR 100.20(b), which states that the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, military and chemical facilities) must be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards and whether the risk of other hazards is very low

- 10 CFR 100.21(e), which states that potential hazards associated with nearby transportation routes and industrial and military facilities must be evaluated and site parameters established such that potential hazards from such routes and facilities will pose no undue risk to the type of facility proposed to be located at the site

SRP Section 2.2.3 addresses the specific criteria for meeting the relevant requirements. Typically, the staff reviews the event probability for which the expected rate of occurrence of potential exposure in excess of the guideline in 10 CFR Part 100, "Reactor Site Criteria," is estimated to exceed $10^{-7}$ per year.

#### 2.2.3.2 *Summary of Technical Information*

Both DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, specify the site parameters used in the ESBWR standard plant design. The standard plant site design parameters specified as Tier 1 are the same as those specified as Tier 2. The following standard plant site design parameters in DCD, Tier 1, Table 5.1-1, and Tier 2, Table 2.0-1, relate to potential accident situations in the vicinity of the plant:

- The probability that site proximity missiles and aircraft accidents will impact the plant is less than $10^{-7}$ per year.

- The maximum toxic gas concentrations at the main control room (CR) and technical support center (TSC) do not exceed toxicity limits.

- There is no volcanic activity.

GEH specified in DCD, Tier 2, Table 2.0-2, that the COL applicant must identify and evaluate potential accidents emanating from those potential hazards listed in SRP Section 2.2.1-2.2.2 that have a probability of occurrence greater than $10^{-7}$ per year and that involve the following:

- missiles more energetic than the tornado missile spectra
- pressure effects in excess of the design-basis tornado
- explosions
- fires
- aircraft impacts
- release of flammable vapor clouds
- release of toxic chemicals

#### 2.2.3.3 *Staff Evaluation*

The applicant has not classified any potential accidents in the vicinity of the plant as design-basis events. The information regarding potential accidents in the vicinity of the site is site specific. GEH stated in DCD, Tier 2, Table 2.0-2, that the COL applicant is to supply site specific information in accordance with SRP Section 2.2.3. This was identified as COL Information Item 2.0-6-A. The staff finds this acceptable.

#### 2.2.3.4 *Conclusion*

The applicant has not classified any potential accidents in the vicinity of the plant as design-basis events. Because this information is site specific, the COL applicant will address it and the staff will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.3 Meteorology

Pursuant to 10 CFR 52.47(a)(1), a DC applicant must provide site parameters postulated for the design. According to 10 CFR 52.1(a), site parameters are the postulated physical, environmental, and demographic features of an assumed site specified in a standard DC. As stated in 10 CFR 52.79(c)(1), if a COL application references an approved standard design, the COL final safety analysis report must contain information sufficient to demonstrate that the characteristics of the site fall within the site parameters specified in the approved design.

To ensure that the design of a nuclear power plant complies with the Commission's regulations, the NRC staff evaluates the site parameters postulated for the design, including the site parameters related to climate extremes and severe weather occurrences, as well as the atmospheric dispersion parameters, to determine whether they are representative of a reasonable number of sites that may be considered within a COL application. The NRC staff has prepared Sections 2.3.1 through 2.3.5 of this report in accordance with the review procedures described in the March 2007 revision of the SRP, using information presented in Revision 6 to the DCD and responses to NRC staff RAIs.

### 2.3.1 Regional Climatology

#### 2.3.1.1 *Regulatory Criteria*

Acceptance criteria regarding regional climatology are based on meeting the relevant requirements of the following NRC regulations:

- General Design Criterion (GDC) 2, "Design Bases for Protection against Natural Phenomena," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires, in part, that structures, systems, and components (SSCs) important to safety be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions. The design bases for these SSCs must reflect, in part, appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which historical

data have been accumulated.

- GDC 4, “Environmental and Dynamic Effects Design Bases,” requires, in part, that SSCs important to safety be protected against the effects of missiles resulting from events and conditions outside the plant.

- 10 CFR 52.47(a)(1) requires a DC applicant to provide site parameters postulated for the design.

Section 2.3.1 of the March 2007 revision to the SRP states that the climatic conditions identified as site parameters for DC applications should include the following:

- the 100-year return period (straight-line) 3-second gust wind speed to be used in establishing wind loading on plant structures

- the tornado parameters (including maximum wind speed, translational speed, rotational speed, and maximum pressure differential with the associated time interval) to be used in establishing pressure and tornado missile loadings on SSCs important to safety

- the weight of the 100-year return period snowpack and the weight of the 48-hour probable maximum winter precipitation (PMWP) for use in determining the weight of snow and ice on the roofs of safety-related structures

- ambient temperature and humidity statistics for use in establishing heat loads for the design of normal plant heat sink systems, post-accident containment heat removal systems, and plant heating, ventilation, and air-conditioning systems

- the ultimate heat sink (UHS) meteorological conditions resulting in the maximum evaporation and drift loss of water, minimum water cooling, and, if applicable, the potential for water freezing in the UHS water storage facility

Section 2.3.1 of the SRP also states that the postulated site parameters should be representative of a reasonable number of sites that may be considered within a COL application, and a basis should be provided for each of the site parameters.

Subsequent to publication of SRP Section 2.3.1, the staff issued proposed interim staff guidance document DC/COL-ISG-7, “Interim Staff Guidance on Assessment of Normal and Extreme Winter Precipitation Loads on the Roofs of Seismic Category I Structures,” for public comment on August 22, 2008 (page 49712, Volume 73, of the *Federal Register* (FR) (73 FR 49712)), to clarify the staff’s position on identifying winter precipitation events as site characteristics and site parameters for determining normal and extreme winter precipitation loads on the roofs of seismic Category I structures. The final version of DC/COL-ISG-7 was issued on July 1, 2009 (74 FR 31470), (Agencywide Documents Access and Management System (ADAMS) Accession No. ML091490565).

The regional climatic site parameters are selected to ensure that the facility is being designed so that potential threats from the physical characteristics of a potential site (e.g., regional climatic extremes and severe weather) will not pose an undue risk to the facility. As an example, Regulatory Guide (RG) 1.76, Revision 1, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," issued March 2007, provides guidance for selecting the design-basis tornado and design-basis tornado-generated missiles that a nuclear power plant should be designed to withstand to prevent undue risk to the health and safety of the public.

#### 2.3.1.2 *Summary of Technical Information*

The list of ESBWR site parameters presented in DCD, Tier 1, Table 5.1-1, and Tier 2, Table 2.0-1, include regional climatic site parameters related to extreme wind, tornado, precipitation (for roof design), and ambient design temperature. The regional climatic site parameters listed in DCD, Tier 1, Table 5.1-1, are the same as those values listed in DCD, Tier 2, Table 2.0-1, except for the three ambient design temperature site parameters related to the control room habitability area (CRHA) heat-up analysis which are designated as Tier 2* material in DCD, Tier 2, Table 2.0-1 (i.e., the maximum average dry bulb temperature for zero-percent exceedance maximum temperature day, the minimum average dry bulb temperature for zero-percent exceedance minimum temperature day, and the maximum high humidity average wet bulb globe temperature index for zero-percent exceedance maximum wet bulb temperature day).

No ESBWR site parameters are associated with the UHS. DCD, Tier 2, Section 3.1.4.15, states that the ESBWR UHS is the isolation condenser/passive containment cooling system (IC/PCCS) pool. In the event of a design-basis accident, heat is transferred to the IC/PCCS pool(s) through the isolation condenser system (ICS) and the PCCS. The water in the IC/PCCS pool(s) is allowed to boil, and the resulting steam is vented to the environment. Since the UHS in the ESBWR design is the atmosphere, with boiling water in the IC/PCCS pool(s) providing the heat transfer mechanism, information on limiting meteorological conditions for the design of the UHS is not required.

##### 2.3.1.2.1 Extreme Wind

The extreme wind standard plant site parameter for seismic Category I, II and radwaste building structures is a 100-year, 3-second gust wind speed of 67.1 meters per second (m/s) (150 miles per hour (mph)) for Exposure Category D. Footnote 13 to DCD, Tier 2, Table 2.0-1, states that this value was selected to comply with expected requirements of southeastern coastal locations. The extreme wind standard plant site parameter for other seismic Category NS structures is a 50-year, 3-second gust wind speed of 58.1 m/s (130 mph).

##### 2.3.1.2.2 Tornado

The tornado standard plant site parameters include a maximum tornado wind speed of 147.5 m/s (330 mph), a maximum rotational speed of 116.2 m/s (260 mph), a translational velocity of 31.3 m/s (70 mph), a radius of 45.7 meters (m) (150 feet (ft)), a maximum pressure differential of 16.6 kilopascals (kPa) (2.4 pounds per square inch ($lbf/in^2$)), and a rate of pressure change of 11.7 kilopascals per second (kPa/s) (1.7 pounds per square inch per second ($lbf/(in^2 \cdot s)$). Footnote 3 to DCD, Tier 2, Table 2.0-1, states that the maximum speed selected is based on the NRC interim position on RG 1.76 as summarized in Attachment 1 to SECY-04-0200, "A

Risk-Informed Approach to Defining the Design Basis Tornado for New Reactor Licensing."

The tornado standard plant site parameters also include the missile spectra I from Revision 2 of SRP Section 3.5.1.4 applied to the full building height. Footnote 7 to Tier 1, Table 5.1-1, and Footnote 3 to DCD, Tier 2, Table 2.0-1, state that the tornado missiles do not apply to seismic Category II buildings and the tornado missiles defined in RG 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Table 2, Class RW-IIa apply for the radwaste building. Footnote 3 to Tier 2, Table 2.0-1, further states that concrete structures designed to resist Spectrum I missiles, as discussed in Revision 2 of SRP Section 3.5.1.4, also resist missiles postulated in RG 1.76, Revision 1.

#### 2.3.1.2.3 Precipitation (for Roof Design)

The precipitation (for roof design) standard plant site parameters include (1) a maximum rainfall rate of 49.3 centimeters per hour (cm/h) (19.4 inches per hour (in/h)), (2) a maximum short-term rate of 15.7 centimeters (cm) (6.2 inches (in.)) in 5 minutes, (3) a maximum ground snow load for normal winter precipitation event of 2,394 pascals (Pa) (50 pounds-force per square foot ($lbf/ft^2$), and (4) a maximum ground snow load for extreme winter precipitation event of 7,757 Pa (162 $lbf/ft^2$). Footnote 4 to DCD, Tier 2, Table 2.0-1, states that the maximum rainfall rates are based on a probable maximum precipitation (PMP) for 1 hour over 2.6 square kilometers ($km^2$) (1 square mile ($mi^2$)) with a ratio of 5 minutes to 1 hour PMP of 0.32, as found in Hydrometeorological Report (HMR) No. 52, "Application of Probable Maximum Precipitation Estimates—United States East of the 105th Meridian," issued August 1982. Footnote 5 to DCD, Tier 2, Table 2.0-1, states that DC/COL-ISG-07 provides the definition of normal winter precipitation and extreme winter precipitation events and the definition maximum ground snow load for extreme winter precipitation event includes the contribution from the normal winter precipitation event.

#### 2.3.1.2.4 Ambient Design Temperature

The ambient temperature standard plant site parameters are as follows:

- The maximum ambient design temperature corresponding to a 2-percent annual exceedance value is 35.6 degrees Celsius (°C) (96 degrees Fahrenheit (°F)) dry bulb with a mean coincident wet bulb temperature of 26.1 °C (79 °F) and 27.2 °C (81 °F) for noncoincident wet bulb temperature. The minimum ambient design temperature corresponding to a 2-percent annual exceedance value is −23.3 °C (−10 °F).

- The maximum ambient design temperature corresponding to a 1-percent annual exceedance value is 37.8 °C (100 °F) dry bulb with a mean coincident wet bulb temperature of 26.1 °C (79 °F) and 27.8 °C (82 °F) for noncoincident wet bulb temperature. The minimum ambient design temperature corresponding to a 1-percent annual exceedance value is −23.3 °C (−10 °F).

- The maximum ambient design temperature corresponding to a zero-percent exceedance value is 47.2 °C (117 °F) dry bulb with a mean coincident wet bulb temperature of 26.7 °C (80 °F) and 31.1 °C (88 °F) for noncoincident wet bulb temperature. The minimum ambient design temperature corresponding to a zero-percent exceedance value is −40 °C (−40 °F). Footnote 6 to DCD, Tier 2, Table 2.0-1, states that the zero-percent exceedance values are based on conservative estimates of historical high and low values for potential sites and represent historical limits exceeding peaks of less than 2 hours.

- The maximum average dry bulb temperature for zero-percent exceedance maximum temperature day is 39.7 °C (103.5 °F). Footnote 17 to DCD, Tier 2, Table 2.0-1, states this site parameter is defined in Appendix 3H Section 3H.3.2.1.1.

- The minimum average dry bulb temperature for zero-percent exceedance minimum temperature day is −32.5 °C (−26.5 °F). Footnote 18 to DCD, Tier 2, Table 2.0-1, states this site parameter is defined in Appendix 3H Section 3H.3.2.1.2.

- The maximum high humidity average wet bulb globe temperature index for zero-percent exceedance maximum wet bulb temperature day 30.3 °C (86.6 °F). Footnote 19 to DCD, Tier 2, Table 2.0-1, states this site parameter is defined in Appendix 3H Section 3H.3.2.1.3.

Footnote 6 to DCD, Tier 2, Table 2.0-1,states that the 1- and 2-percent annual exceedance values presented above were selected to bound the values presented in the Electric Power Research Institute's, "Advanced Light Water Reactor Utility Requirements Document" (known as the URD), and available ESP applications.

#### 2.3.1.2.5 Combined License Information

COL Information Item 2.0-1-A states that a COL applicant referencing the ESBWR DCD demonstrates that site characteristics for a given site fall within the ESBWR DCD site parameter values per 10 CFR 52.79, "Contents of Applications; Technical Information in Final Safety Analysis Report." A number of the site parameters listed in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1 (i.e., extreme wind, tornado, precipitation, ambient design temperature), are related to regional climatology.

COL Information Item 2.0-7-A states that a COL applicant is to supply site specific information, in accordance with SRP Section 2.3.1.

### 2.3.1.3 *Staff Evaluation*

The staff reviewed the DCD in accordance with the guidance provided in SRP Section 2.3.1 by ensuring that (1) pertinent parameters were selected as site parameters, (2) the site parameters are representative of a reasonable number of sites that have been or may be considered within a COL application, and (3) a technical basis has been provided for each site parameter.

#### 2.3.1.3.1 Extreme Wind

Revision 0 of DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, stated (1) the basic speed of extreme winds used for the design of safety-related structures is 62.6 m/s (140 mph), with an importance factor of 1.15, and (2) the basic speed of extreme wind for non-safety-related structures is 49.2 m/s (110 mph), with an importance factor of 1.00. The staff asked the applicant in RAI 2.3-2 to provide the basis for selecting the extreme winds used for the design of safety-related structures, as presented in DCD, Tier 2, Table 2.0-1. The staff also asked the applicant in RAI 14.3-22 to update DCD, Tier 1, Table 5.1-1, to incorporate the response to RAI 2.3-2.

In its response to RAI 2.3-2, dated July 31, 2006, the applicant stated that the selected extreme wind speed of 62.6 m/s (140 mph) is approximately in the middle of wind speeds seen in a Category 4 hurricane and was selected to comply with the expected requirements of southeastern coastal locations. The applicant also stated that it will update DCD, Tier 2, Table 2.0-1, to (1) clarify the basis for the selection of the 62.6 m/s (140 mph) value and (2) state that the COL applicant is to determine the extreme wind design for non-safety-related, nonseismic structures. In its response to RAI 14.3-22, dated July 31, 2006, the applicant also stated that it would update DCD, Tier 1, Table 5.1-1, to incorporate the response to RAI 2.3-2.

The applicant issued Revision 2 of the DCD in November 2006. The applicant revised DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, of Revision 2 to state that the extreme wind site parameters were (1) a 100-year, 3-second gust wind speed of 67.1 m/s (150 mph) for seismic Category I and II structures and (2) a wind speed of 49.2 m/s (110 mph) for nonseismic standard plant structures. Note that designing to a 100-year wind speed of 67.1 m/s (150 mph), as specified in Revision 2 to the DCD, is equivalent to designing to a basic (e.g., 50-year) 62.6 m/s (140 mph) wind speed with an importance factor of 1.15, as specified in Revision 0 of the DCD (see note * to DCD, Tier 2, Table 3G.1-2). Revision 3 of the DCD issued in February 2007 contained the same extreme wind site parameters as Revision 2 to the DCD.

In reviewing the applicant's response to RAIs 2.3-2 and 14.3-22, as well as the subsequent Revision 3 to the DCD, the staff notes the following:

- The applicant stated in its response to RAI 2.3-2 that the selected extreme wind speed value of 62.6 m/s (140 mph) in DCD, Revision 0, is approximately in the middle of wind speeds seen in a Category 4 hurricane. The staff notes that the ESBWR extreme wind site parameter values cannot be compared directly to the Saffir-Simpson hurricane scale. The ESBWR extreme wind site parameter values are based on 3-second wind speed values over land whereas the Saffir-Simpson hurricane scale is based on 1-minute averaging times over open water.

- Contrary to the statements in the applicant's responses to RAIs 2.3-2 and 14.3-22, the updated Revision 3 of DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, did not describe the basis for the selected extreme wind standard plant site parameters.

- It is unclear whether the 49.2 m/s (110 mph) extreme wind standard plant site parameter for nonseismic structures is a 3-second gust wind speed.

Consequently, the staff issued a supplement to RAI 2.3-2 requesting that the applicant revise DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, to provide the basis for selecting the extreme wind standard plant site parameters for seismic Category I and II structures, as well as nonseismic standard plant structures, and to clarify whether the 49.2 m/s (110 mph) extreme wind standard plant site parameter for nonseismic plant structures is a 3-second gust wind speed. In its response, dated May 8, 2007, the applicant stated that it would add a note to DCD, Tier 2, Table 2.0-1, stating that it selected the extreme wind site parameter for seismic Category I and II structures to comply with the expected requirements of southeastern coastal locations. The applicant also stated that the 49.2 m/s (110 mph) extreme wind site parameter for nonseismic plant structures is a 50-year fast-mile-wind value.

The staff issued a second supplement to RAI 2.3-2 regarding the nonseismic standard plant structure extreme wind site parameter. The staff asked the applicant to (1) express this site parameter in the same 3-second gust wind speed units used to present the extreme wind site parameter for seismic Category I and II structures and (2) select a 50-year wind speed value that is consistent with the 100-year wind speed value chosen for the seismic Category I and II structures. In its response to the second supplement to RAI 2.3-2, dated July 19, 2007, the applicant stated that it will change the extreme wind standard plant site parameter for nonseismic plant structures to a 50-year, 3-second gust wind speed of 58.1 m/s (130 mph). Based on the applicant's response, RAI 2.3-2 is resolved. The applicant's incorporation of these changes into a future revision of the DCD was being tracked as a confirmatory item in the SER with open items. The staff confirmed that this change was included in DCD, Tier 2, Revision 4.

To determine whether the ESBWR extreme wind site parameters bound a reasonable number of sites that may be considered within a COL application, the staff compared these values to Figure 6.1 of SEI/ASCE 7-02, which provides a map of the continental United States showing basic wind speeds for design-basis wind-loading purposes. These basic wind speeds are 3-second gust values at 33 ft (10 m) above the ground in Exposure Category C[1] and represent 50-year return periods. The applicant based its extreme wind site parameter of 67.1 m/s (150 mph) for seismic Category I, II, and radwaste building structures on multiplying a 50-year return period value of 62.6 m/s (140 mph) by the square root of the SEI/ASCE 7-02 essential facilities importance factor of 1.15 to account for the 100-year recurrence. Figure 6.1 of SEI/ASCE 7-02 shows that a basic (50-year return period) wind speed value of 62.6 m/s (140 mph) is exceeded only in the southernmost areas of Louisiana and Florida. The ESBWR is also designed for Exposure Category D,[2] which is more conservative than designing for Exposure Category C. Consequently, the staff concludes that applicant's extreme wind site parameter for seismic Category I, II, and radwaste building structures is representative of a reasonable number of sites that may be considered within a COL application.

Figure 6.1 of SEI/ASCE 7-02 also shows that the 50-year return period value of 58.1 m/s (130 mph) used for the extreme wind standard plant site parameter for nonseismic plant structures is exceeded only along the hurricane-prone Gulf Coast, as well as the Georgia, South

[1] SEI/ASCE 7-02 defines Exposure Category C as open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m). This category includes flat open country, grasslands, and all water bodies in hurricane-prone regions.

[2] SEI/ASCE 7-02 defines Exposure Category D as unobstructed areas and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.

Carolina, and North Carolina coasts and southern Florida. Consequently, the chosen extreme wind site parameter for other seismic category NS standard plant structures is also representative of a reasonable number of sites that may be considered within a COL application. COL applicants with sites where this extreme wind parameter is exceeded will need to reevaluate the extreme wind design for other seismic category NS standard plant structures.

#### 2.3.1.3.2 Tornado

The applicant stated that the selected maximum tornado wind speed is based on the NRC interim position on RG 1.76. In fact, all of the applicant's tornado standard plant site parameters (e.g., maximum wind speed, maximum rotational speed, translational velocity, radius, maximum pressure differential, and rate of pressure change) are the same as the Region I design-basis tornado characteristics specified in the NRC interim position on RG 1.76. Region I represents the central portion of the United States where the most severe tornadoes occur. The ESBWR tornado standard plant site parameters are also more severe than the Region I design-basis tornado characteristics specified in the more recently published Revision 1 of RG 1.76. Consequently, the staff finds that the applicant has provided an adequate basis for the tornado standard plant site parameters, and the applicant's tornado standard plant site parameters are representative of a reasonable number of sites that may be considered within a COL application.

Section 3.5.1.4 of this report discusses the staff's evaluation of the applicant's tornado missile standard plant site parameters.

#### 2.3.1.3.3 Precipitation (for Roof Design)

Revision 0 to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, stated that the maximum snow load for roof design is 2,394 Pa (50 lbf/ft$^2$). In RAI 2.3-4, the staff requested the basis for the DCD, Tier 2, Table 2.0-1, maximum roof design snow load. The staff also asked the applicant in RAI 14.3-22 to update DCD, Tier 1, Table 5.1-1, to incorporate the response to RAI 2.3-4.

In its response to RAI 2.3-4, dated July 31, 2006, the applicant stated that it will update DCD, Tier 2, Table 2.0-1, to clarify that the URD is the source of this value. In its response to RAI 14.3-22, dated July 31, 2006, the applicant also stated that it will update DCD, Tier 1, Table 5.1-1, to incorporate the response to RAI 2.3-4. However, Revision 3 of DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, provided a revised maximum precipitation roof load of 2,873 Pa (60 lbf/ft$^2$) and stated that the revised load accommodates snow load and PMWP, as specified in SEI/ASCE 7-02 and HMR-52.

The staff reviewed the revised maximum precipitation roof load in accordance with Section 2.3.1 of the SRP, which states (1) winter precipitation loads to be included in the combination of normal live loads should be based on the weight of the 100-year snowpack or snowfall, whichever is greater, recorded at ground level, and (2) winter precipitation loads to be included in the combination of extreme live loads should be based on the addition of the weight of the 100-year snowpack at ground level plus the weight of the 48-hour PMWP at ground level for the month corresponding to the selected snowpack. Modifications to this procedure are allowed for certain areas where it can be satisfactorily demonstrated that the PMWP could neither fall on, nor remain entirely on top of, the antecedent snowpack or roofs. Consequently, the staff issued

a supplement to RAI 2.3-4 requesting that the applicant update the DCD to provide the design values and bases for winter precipitation loads to be included in the combination of normal live loads and extreme live loads.

In its response to the supplement to RAI 2.3-4, dated May 8, 2007, the applicant stated that the roof design maximum 48-hour winter rainfall standard plant site parameter of 91.4 cm (36 in.) would result in an additional weight of 10 cm (4 in.) of water on the roof because the lower lip of the roof scuppers is 10 cm (4 in.) above the roof. Assuming all primary roof drains are clogged, the applicant stated that the additional weight of 10 cm (4 in.) of water on the roof would be 996 Pa (21 lbf/ft$^2$). The staff issued a second supplement to RAI 2.3-4 asking the applicant to provide an additional roof design 48-hour PMWP standard plant site parameter to account for additional weight if at least part of the 48-hour PMWP were to fall as frozen precipitation (e.g., snow or ice or both) and remain on the roof. RAI 2.3-4 was being tracked as open item in the SER with open items.

In its response to the second supplement to RAI 2.3-4, dated July 19, 2007, the applicant stated that it would include, in DCD, Tier 2, Table 2.0-1, a 100-year recurrence interval maximum ground snow load of 2,394 Pa (50 lbf/ft$^2$) and a maximum 48-hour winter rainfall of 91.4 cm (36 in.) as standard plant site parameters for the roof design.

Footnote 5 to Revision 4 of DCD, Tier 2, Table 2.0-1, stated that the independent design of the roof scuppers and drains limits water accumulation on the roof to no more than 100 millimeters (mm) (4 in.) during PMWP conditions. The staff subsequently asked the applicant in the third supplement to RAI 2.3-4 to provide details regarding the design of the roof scuppers and drains to demonstrate that an antecedent 100-year recurrence interval ground-level snowpack of 2,394 Pa (50 lbf/ft$^2$) would not clog both the roof scuppers and drains and prevent no more than 100 mm (4 in.) of water accumulation on the roof. The applicant provided sketches of a typical roof drain and overflow scupper in its response to the third supplement to RAI 2.3-4, dated March 7, 2008.

The staff subsequently issued proposed DC/COL-ISG-07 to clarify the staff's position on identifying winter precipitation events as site characteristics and site parameters for determining normal and extreme winter precipitation loads on the roofs of seismic Category I structures.

DC/COL-ISG-07 states that the normal winter precipitation event, which is used to determine the normal winter precipitation roof load, should be a function of the highest ground-level weight of either the 100-year return period snowpack, the historical maximum snowpack, the 100-year return period snowfall event, or the historical maximum snowfall event. DC/COL-ISG-07 also states that the extreme precipitation roof load is based on the sum of the roof load associated with the normal winter precipitation event plus the roof load associated with the highest weight resulting from either the extreme frozen winter precipitation event or the extreme liquid winter precipitation event. The extreme frozen winter precipitation event is defined as the higher of the ground-level weight of either (1) the 100-year return period snowfall event or (2) the historical maximum snowfall event in the site region. The extreme liquid winter precipitation event is defined as the theoretically greatest depth of precipitation for a 48-hour period that is physically possible over a 25.9-km$^2$ (10-mi$^2$) area at a particular geographical location during those months with the historically highest snowpacks. The extreme frozen winter precipitation event is assumed to accumulate on the roof on top of the antecedent normal winter precipitation event, whereas the extreme liquid precipitation event may or may not accumulate on the roof,

depending on the geometry of the roof and the type of drainage provided. DC/COL-ISG-07 also states that the roof load resulting from extreme winter precipitation events may be considered as an extreme live load and, therefore, may be treated similarly to other extreme environmental loads (e.g., seismic or tornado loads) in loading combinations for seismic Category I structures.

The staff issued a fourth supplement to RAI 2.3-4 asking the applicant to specify and identify the normal and extreme liquid and frozen precipitation events used in the design of the roofs of safety-related structures, in accordance with the proposed DC/COL-ISG-07. In its response to the fourth supplement to RAI 2.3-4, dated December 8, 2008, the applicant stated that the maximum ground snow load site parameter value of 2,394 Pa (50 lbf/ft$^2$) is associated with the normal winter precipitation event and results in a corresponding roof live load of 38.5 lbf/ft$^2$, which is less than the design live load of 2,873 Pa (60 lbf/ft$^2$). The applicant also stated in its response that the extreme winter precipitation roof load is considered as an extreme live load and treated similarly to other extreme environmental loads, such as the safe-shutdown earthquake (SSE) or tornado in loading combinations, in accordance with DC/COL-ISG-07. The applicant also stated that the extreme liquid winter precipitation event would result in an average depth of 4 in. of water on the roof, with a resulting liquid weight of 21 lbf/ft$^2$, because the lower lip of the roof scuppers is 4 in. above the roof. The extreme winter precipitation roof load is therefore 59.5 lbf/ft$^2$, which is the sum of 38.5 lbf/ft$^2$ for the normal winter precipitation event and 21 lbf/ft$^2$ for the extreme liquid winter precipitation event. The applicant further stated that the roof of an ESBWR seismic Category I building is designed to a more severe loading due to an SSE or tornado in the extreme environmental load combination category. For example, the roof is designed to accommodate a tornado pressure drop equal to 16,600 Pa (2.4 lbf/in$^2$ or 345.6 lbf/ft$^2$). Therefore, the applicant concluded that the extreme frozen winter precipitation event is not controlling in the ESBWR design.

Based on the pictorial layout of the roof drain and scuppers provided by the applicant in its response to the third supplement to RAI 2.3-4, the staff could not conclude that the roof scuppers would be available for draining water from the roof in case of rain after an antecedent snowfall. In that case, the combined snowpack and water on the roof may be as high as the height of the solid parapet and may be more critical. Also, while justifying possible roof loads due to frozen precipitation during an extreme winter precipitation event, the applicant compared the roof design for the tornado pressure drop and concluded that the extreme frozen winter precipitation event is not controlling in the ESBWR design. Since the load caused by a tornado pressure drop acts in a direction opposite to the winter precipitation roof live load, and since roof dead load is available to offset the load caused by a tornado pressure drop, the staff did not understand the applicant's direct comparison of the winter precipitation load and the tornado pressure drop load without considering the effect caused by the dead load. Subsequently, the staff asked the applicant in the fifth supplement to RAI 2.3-4 to calculate the value of the extreme frozen winter precipitation roof load and demonstrate how it is enveloped by other load combinations.

In its response to the fifth supplement to RAI 2.3-4, dated May 11, 2009, the applicant identified 38.5 lbf/ft$^2$ as the normal winter precipitation event roof load that should be treated as a normal live load in all loading combinations. The applicant further stated that it will relabel the associated maximum 50 lbf/ft$^2$ ground snow load in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, as the maximum ground snow load site parameter value for the normal winter precipitation event. The applicant also identified the extreme winter precipitation event roof load as 125 lbf/ft$^2$, which should be treated as an extreme live load in the extreme environmental and

abnormal or extreme environmental loading combinations. The extreme winter precipitation event roof load value of 125 lbf/ft$^2$ is based on water accumulating up to the top of the 2-ft high parapet during the extreme winter precipitation event. The applicant further stated that the ground snow load associated with a roof load of 125 lbf/ft$^2$ is 162 lbf/ft$^2$. The applicant committed to adding this value to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, as a maximum ground snow load site parameter for the extreme (frozen) winter precipitation event. The applicant also committed to update DCD, Tier 2, Sections 3.8 and 3G, to document the roof live loads for both normal and extreme winter precipitation events and associated load combinations.

The staff requested in the sixth supplement to RAI 2.3-4 that the applicant clarify its proposed definitions of the winter precipitation event site parameters listed in DCD, Tier 1, Table 5.1-1, and Tier 2, Tables 2.0-1 and 3G.1-2, to avoid potential confusion among COL applicants who will need to develop corresponding site characteristic values for their plant sites. The staff also requested that the applicant revise DCD, Tier 2, Table 3G.1-2, to document the basis for the extreme winter precipitation event roof load of 125 lbf/ft$^2$ (i.e., the 2-ft high parapet and the specific weight of water). The applicant agreed to the DCD changes requested by the staff in its response to the sixth supplement to RAI 2.3-4, dated June 26, 2009. Based on the applicant's response, RAI 2.3-4 is resolved. The applicant subsequently incorporated these changes into Revision 6 of the DCD.

To determine whether the ESBWR normal winter precipitation event maximum ground snow load site parameter value of 2,394 Pa (50 lbf/ft$^2$) bounds a reasonable number of sites that may be considered within a COL application, the staff compared the 50 lbf/ft$^2$ value to the maximum observed ground snow load recorded at 204 NWS locations throughout the contiguous United States, as reported in Table C7-1 of ASCE/SEI 7-05. The staff found that approximately 5 percent of these sites had maximum observed ground snow loads exceeding 50 lbf/ft$^2$. Consequently, the staff finds that the applicant has provided a normal winter precipitation event maximum ground snow load site parameter value that should bound a reasonable number of sites that may be considered within a COL application. By definition, the extreme frozen winter precipitation event snow load will be no higher than the normal winter precipitation event snow load and the sum of the normal winter precipitation event and extreme frozen winter precipitation event maximum ground snow load site parameters is less that the extreme winter precipitation event maximum ground snow load site parameter value of 7,757 Pa (162 lbf/ft$^2$). Therefore, the staff finds the maximum ground snow load site parameter values to be acceptable.

Section 2.4.3 of this report discusses the staff's evaluation of the applicant's maximum rainfall rate standard plant site parameters.

#### 2.3.1.3.4 Ambient Design Temperature

Revision 0 to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, stated that the maximum design ambient temperature corresponding to a 1-percent exceedance value was 37.8 °C (100 °F) dry bulb with a coincident wet bulb temperature of 26.1 °C (79 °F) and 27.8 °C (82 °F) for noncoincident wet bulb temperature. The minimum design temperature corresponding to a 1-percent exceedance value was −23.3 °C (−10 °F). The zero-percent exceedance dry bulb

temperature was 46.1 °C (115 °F) with a coincident wet bulb temperature of 26.7 °C (80°F) and 29.4 °C (85 °F) for noncoincident wet bulb temperature. The minimum design temperature corresponding to a zero-percent exceedance value was −40 °C (−40 °F).

The staff asked the applicant in RAI 2.3-3 to provide a definition of the zero- and 1-percent exceedance design temperatures presented in Revision 0 to DCD, Tier 2, Table 2.0-1. The staff also asked the applicant in RAI 14.3-22 to update DCD, Tier 1, Table 5.1-1, to incorporate the response to RAI 2.3-3.

In its response to RAI 2.3-3, dated July 31, 2006, the applicant stated that the zero-exceedance values are historical high or low values, as stated in DCD, Tier 1, Table 5.1-1. The applicant also stated that the 1-percent exceedance values are also historical values based on a review of the data available in the ESP applications submitted by Dominion, Entergy, and Exelon for the North Anna, Grand Gulf, and Clinton sites, respectively. The applicant stated that it selected a set of parameters that bounds all three ESP sites and the URD as the standard plant site parameters for the ESBWR.

In Revision 2 of the DCD, issued November 2006, the applicant added 2-percent exceedance ambient design temperatures as standard plant site parameters. The maximum design ambient temperature corresponding to a 2-percent exceedance value was 35.6 °C (96 °F) dry bulb with a coincident wet bulb temperature of 26.1C (79 °F) and 27.2 °C (81 °F) for noncoincident wet bulb temperature. The minimum design temperature corresponding to a 2-percent exceedance value was −23.3 °C (−10 °F). Revision 3 of the DCD, issued February 2007, contained the same ambient temperature standard plant site parameter values as those in DCD, Revision 2.

To determine whether the applicant's ambient design temperature standard plant site parameters bound a reasonable number of sites that may be considered within a COL application, the staff compared the applicant's ambient design temperature standard plant site parameters to the ambient air temperature and humidity site characteristics identified in the first three docketed ESP applications (e.g., NUREG-1835, "Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site," issued September 2005; NUREG-1840, "Safety Evaluation of Early Site Permit Application in the Matter of System Energy Resources, Inc., a Subsidiary of Entergy Corporation, for the Grand Gulf Early Site Permit Site," issued April 2006; and NUREG-1844, "Safety Evaluation Report for an Early Site Permit (ESP) at the Exelon Generation Company, LLC (EGC) ESP Site," issued May 2006). In performing this comparison, the staff considered the zero-percent exceedance or historic limit ambient design temperature standard plant site parameters presented in the ESBWR DCD to be equivalent to the 100-year return period ambient air temperature and humidity site characteristic values presented in the first three docketed ESP applications.

The staff found that the ESP 100-year return period maximum dry bulb temperature site characteristic for Clinton (47.2 °C (117 °F)) was higher than the applicant's zero-percent exceedance (historic limit) standard plant site parameter of 46.1 °C (115 °F). Likewise, the staff found that the ESP 100-year return period maximum noncoincident wet bulb temperature site characteristics for North Anna and Clinton, 31.1° degrees C (88°F) and 30.0°C (86° degrees F), respectively) were higher than the applicant's zero-percent exceedance (historic limit) standard plant site parameter of 29.4°C (85°F). Consequently, the applicant's zero-percent exceedance

(historic limit) maximum dry bulb temperature and maximum noncoincident wet bulb temperature standard plant site parameters may not bound a reasonable number of sites that may be considered within a COL application.

The staff issued a supplement to RAI 2.3-3 requesting that the applicant revise the ESBWR zero-percent exceedance (historic limit) maximum dry bulb and maximum noncoincident wet bulb temperature standard plant site parameters to be more inclusive of a number of sites that may be considered within a COL application. In its response, dated May 8, 2007, the applicant stated that it would change its zero-percent exceedance maximum dry bulb temperature and maximum noncoincident wet bulb temperature standard plant site parameters to 47.2 °C (117°F) and 31.1 °C (88 °F), respectively. The incorporation of these changes into a future revision of the DCD was being tracked as Confirmatory Item 2.3-3. Based on the applicant's response, RAI 2.3-3 is resolved. The staff confirmed that these change were included in DCD, Tier 1, Revision 4, Table 5.1-1 and DCD, Tier 2, Revision 4, Table 2.0-1.

The staff issued a second supplement to RAI 2.3-3 requesting clarification on the definition of the ambient design temperature site parameters listed in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1. In its response, dated March 28, 2008, the applicant stated that the 1-percent and 2-percent ambient design temperatures are annual exceedance values, and the coincident wet bulb temperatures are the mean coincident wet bulb temperatures that are expected to occur at the corresponding maximum dry bulb temperatures for the given exceedance value. The applicant stated that these interpretations are consistent with the values typically reported in the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook. In Revision 5 of DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, the applicant incorporated these interpretations into the definitions of the ambient design temperature site parameters. The applicant also expanded Footnote 6 in Revision 5 of DCD, Tier 2, Table 2.0-1, to state that the zero-percent exceedance values represent historical limits exceeding peaks of less than 2 hours.

To provide further assurance that the applicant's revised air temperature site parameters are representative of a reasonable number of potential COL sites, the staff reviewed dry bulb and wet bulb statistics from the ASHRAE Weather Data Viewer database. This database, which is discussed in Chapter 28 of the 2005 ASHRAE Handbook—Fundamentals, contains climatic design information for approximately 660 weather stations located throughout the continental United States. The ASHRAE database includes a variety of statistics for each weather station, such as the 100-year return dry bulb, historic maximum wet bulb, 1-percent and 2-percent exceedance wet bulb, 99-percent exceedance dry bulb, and 1-percent and 2-percent exceedance dry bulb with mean coincident wet bulb temperature. The percentage of weather stations exceeding each of the ESBWR DCD site parameter values is as follows:

| AMBIENT DESIGN TEMPERATURE SITE PARAMETER | ESBWR DCD VALUES | PERCENTAGE OF WEATHER STATIONS EXCEEDING ESBWR DCD SITE PARAMETER VALUES |
|---|---|---|
| 2% annual exceedance | | |
| Max dry bulb | 35.6 °C (96 °F) | 7 |
| Mean coincident wet bulb | 26.1 °C (79 °F) | 0 |
| Max noncoincident wet bulb | 27.2 °C (81 °F) | 0 |
| Min dry bulb | −23.3 °C (−10 °F) | (statistic not available) |
| 1% annual exceedance | | |
| Max dry bulb | 37.8 °C (100 °F) | 4 |
| Mean coincident wet bulb | 26.1 °C (79 °F) | 1 |
| Max noncoincident wet bulb | 27.8 °C (82 °F) | 0 |
| Min dry bulb | −23.3 °C (−10 °F) | 10 |
| 0% annual exceedance | | |
| Max dry bulb | 47.2 °C (117 °F) | 5 |
| Mean coincident wet bulb | 26.7 °C (80 °F) | (statistic not available) |
| Max noncoincident wet bulb | 31.1 °C (88 °F) | 11 |
| Min dry bulb | −40.0 °C (−40 °F) | 13 |

To determine whether the applicant's zero-percent exceedance coincident wet bulb temperature of 80 °F is representative of a reasonable number of potential COL sites, the staff considered temperature and humidity data from National Climatic Data Center's Solar and Meteorological Surface Observational Network for the period 1961–1990. Based on temperature, dew point, and pressure, the staff derived hourly wet bulb temperatures for 75 observation stations located along the Gulf Coast and East Coast of the contiguous United States. The staff primarily considered locations near the coast because these areas typically have the highest atmospheric moisture content, which would result in the highest wet bulb temperatures. For all 75 locations, the staff determined the highest recorded dry bulb temperatures, all of which fell below 117 °F. The coincident wet bulb temperature was derived for the corresponding hour with the highest recorded dry bulb temperatures. The applicant's proposed site parameter of 80 °F was exceeded only at one location (New Orleans, LA).

Because only a small percentage (less than 14 percent) of weather stations in the ASHRAE database exceeded any of the ESBWR DCD ambient design temperature site parameter values discussed above, the staff concludes that these ESBWR ambient design temperature site parameters bound a reasonable number of sites that have been or may be considered within a COL application.

The applicant provided a revised CRHA heat-up analysis in its supplement 2 revision 1 response to RAI 6.4-24 S01 dated February 19, 2010 using a new set of outside air conditions. The applicant proposed adding two new ESBWR site parameter values to DCD, Tier 2, Table 2.0-1 in order to have COL applicants demonstrate that their corresponding site characteristic values fall within the ESBWR site parameter values used in the revised CRHA heat-up analysis. The applicant's two new proposed ESBWR Tier 2* ambient design temperature site parameter values were: (1) a zero-percent exceedance maximum high humidity diurnal swing of 4.4 °C

(8 °F) and (2) a zero-percent exceedance maximum daily temperature range of 15 °C (27 °F). The applicant also proposed a revision to DCD, Tier 2, Appendix 3H which defined these two new site parameters.

Because a COL applicant referencing the ESBWR DCD must demonstrate that site characteristics for a given site fall within the ESBWR DCD site parameter values, the staff asked the applicant in RAI 6.4-24 S02 to clarify the methodology to be used by COL applicants in calculating the CRHA heat-up analysis site characteristics for comparison with the corresponding site parameters. Pursuant to SRP Section 2.3.1, the staff also asked the applicant in RAI 6.4-24 S02 to provide evidence that the values assigned to each of the two new site parameters envelope most potential COL sites in the United States.

In its response to RAI 6.4-24 S02 dated June 4, 2010, the applicant proposed a revised set of three ambient design temperature site parameters related to the CRHA heat-up analysis for DCD, Tier 2, Table 2.0-1. The applicant also proposed revisions to DCD, Tier 2, Appendix 3H Section 3H3.2.1 which defined these new site parameter values. These three new ambient design temperature site parameters are defined as follows:

- maximum average dry bulb temperature for zero-percent exceedance maximum temperature day: 39.7 °C (103.5 °F)

  This parameter is used to evaluate maximum temperature conditions for the CRHA heat-up analysis. It is defined as the average of the zero percent exceedance maximum dry bulb temperature and the dry bulb temperature resulting from a daily temperature range, where the daily temperature range is defined as the dry bulb temperature difference between the zero percent exceedance maximum dry bulb temperature and the dry bulb temperature that corresponds to the higher of the daily lows before and after that maximum.

- minimum average dry bulb temperature for zero-percent exceedance minimum temperature day: −32.5 °C (−26.5 °F)

  This parameter is used to evaluate minimum temperature conditions for the CRHA heat-up analysis. It is defined as the average of the zero percent exceedance minimum dry bulb temperature and the dry bulb temperature resulting from a daily temperature range, where the daily temperature range is defined as the dry bulb temperature difference between the zero percent exceedance minimum dry bulb temperature and the dry bulb temperature that corresponds to the lower of the daily highs before and after that minimum.

- maximum high humidity average web bulb globe temperature index for zero-percent exceedance maximum wet bulb temperature day: 30.3 °C (86.6 °F)

  This parameter is used to evaluate high humidity conditions for the CRHA heat-up analysis. It is defined as the average of the wet bulb globe temperature (WBGT) index values used to determine the high humidity diurnal swing. The high humidity swing is the difference between the *coincident maximum dry bulb temperature* and the *highest daily low dry bulb temperature*. The *coincident maximum dry bulb temperature* is the dry bulb temperature coincident with the zero-percent exceedance wet bulb temperature and

the *highest daily low dry bulb temperature* is the coincident dry bulb temperature for the highest of the three daily low wet bulb temperatures that occurs before and after the zero percent coincident maximum wet bulb temperature. The WBGT index value is defined as the dry bulb temperature multiplied by 0.3 plus the wet bulb temperature multiplied by 0.7.

The applicant also stated in its response to RAI 6.4-24 S02 that it provided evidence that its three new ambient design temperature site parameters added to DCD, Tier 2, Table 2.0-1 envelope most potential COL sites. For example, the applicant stated it reviewed temperature data recorded near the South Texas Project COL site, which is one of the warmer COL application sites. The applicant considered a 50-year maximum extreme dry bulb temperature of 39.9 °C (103.9 °F) and a mean daily dry bulb temperature range of 6.3 °C (11.3 °F) for the hottest month of the year to calculate an average dry bulb temperature of 36.8 °C (98.3 °F), which is bounded by the ESBWR maximum average dry bulb temperature site parameter value of 39.7 °C (103.5 °F). The applicant also stated it reviewed temperature data recorded near the Fermi 3 COL site, which is one of the colder COL application sites. The applicant considered a 50-year minimum extreme dry bulb temperature of −31.7 °C (−24.9 °F) and a mean daily dry bulb temperature range of 7.2 °C (12.9 °F) for the coldest month of the year to calculate an average dry bulb temperature of −28.1 °C (−18.5 °F), which is bounded by the ESBWR minimum average dry bulb temperature site parameter value of −32.5 °C (−26.5 °F). The applicant also stated it considered conservative historic climatic data from Pensacola, Florida (a high humidity location) as a basis for establishing the high humidity diurnal swing and the associated maximum high humidity average web bulb globe temperature index.

The applicant's response to RAI 6.4-24 S02 provided a revision to the DCD which presents guidance to COL applicants regarding the appropriate methodology for calculating site characteristic values for comparison with the corresponding ambient design temperature site parameter values related to the CRHA heat-up analysis. The applicant also provided evidence that the values assigned to each of the three new site parameters envelope most potential COL sites in the United States by comparing the ESBWR site parameter values with data from locations that have severe temperature and humidity statistics. Therefore, the staff considers RAI 6.4-24 S02 to be resolved. The staff also concludes that the CRHA heat-up analysis ambient design temperature site parameters should bound a reasonable number of sites that have been or may be considered within a COL application.

#### 2.3.1.4 *Conclusion*

The staff finds the applicant has selected the regional climatic site parameters referenced above for plant design inputs appropriately, and the staff agrees that they should be representative of a reasonable number of sites that have been or may be considered for a COL application. The regional climatology is site specific and will be addressed by the COL applicant. This is COL Information Item 2.0-7-A. This should include the provision of information sufficient to demonstrate that the actual site characteristics specified in a COL application fall within the values of the site parameters specified in the ESBWR DCD.

## 2.3.2 Local Meteorology

### 2.3.2.1 *Regulatory Criteria*

Section 2.3.2 of the SRP typically involves reviewing the following:

- summaries of local meteorological data based on onsite measurements and NWS station summaries or other standard installation summaries from appropriate nearby locations
- a discussion and evaluation of the influence of the plant and its facilities on the local meteorological and air quality conditions, including identifying potential changes in normal and extreme values
- a complete topographical description of the site and environs out to a distance of 80 kilometers (km) (50 miles (mi))

DC applications do not contain this type of site specific information, however, the COL application referencing the ESBWR DC will include such data.

### 2.3.2.2 *Summary of Technical Information*

COL Information Item 2.0-8-A states that the COL applicant is to supply site specific information in accordance with SRP Section 2.3.2.

### 2.3.2.3 *Staff Evaluation*

No postulated site parameters for the ESBWR DCD relate to local meteorology. A description of the anticipated local meteorology conditions and the impacts of a proposed plant and associated facilities on the local meteorological conditions (e.g., effects of plant structures, terrain modification, and heat and moisture sources due to plant operation) are site specific and should be presented by a COL applicant referencing the ESBWR DCD. Thus, the staff finds that COL Information Item 2.0-8-A, which specifies that a COL applicant is to supply site specific information in accordance with SRP Section 2.3.2, is acceptable.

### 2.3.2.4 *Conclusion*

Local meteorological conditions are site specific and will be addressed by a COL applicant referencing the ESBWR DCD. This is COL Information Item 2.0-8-A. This should include the provision of information sufficient to demonstrate that the actual site characteristics specified in a COL application fall within the values of the site parameters specified in the ESBWR DCD.

## 2.3.3 Onsite Meteorological Measurements Program

### 2.3.3.1 *Regulatory Criteria*

SRP Section 2.3.3 typically involves reviewing the following:

- meteorological instrumentation, including siting of sensors, sensor type and performance specifications, methods and equipment for recording sensor output, the quality assurance program for sensors and recorders, data acquisition and reduction procedures, and special considerations for complex terrain sites

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

DC applications do not contain this type of site specific information, however the COL application will provide such data.

#### 2.3.3.2 *Summary of Technical Information*

COL Information Item 2.0-9-A states that the COL applicant is to supply site specific information in accordance with SRP Section 2.3.3.

#### 2.3.3.3 *Staff Evaluation*

No postulated site parameters for the ESBWR DCD relate to onsite meteorological measurement programs. A description of the preoperational and operational programs for meteorological measurements is site specific and should be presented by a COL applicant referencing the ESBWR DCD. Thus, the staff finds COL Information Item 2.0-9-A, which specifies that a COL applicant is to supply site specific information in accordance with SRP Section 2.3.3, to be acceptable.

#### 2.3.3.4 *Conclusion*

The onsite meteorological monitoring program and the resulting data are site specific and will be addressed by the COL applicant referencing the ESBWR DCD. This is COL Information Item 2.0-9-A.

### 2.3.4 Short-Term Atmospheric Dispersion Estimates for Accidental Releases

#### 2.3.4.1 *Regulatory Criteria*

Acceptance criteria regarding short-term dispersion estimates for accidental releases are based on meeting the relevant requirements of the following Commission regulations:

- GDC 19, “Control Room,” with respect to the meteorological considerations used to evaluate the personnel exposures inside the CR during radiological and airborne hazardous material accident conditions

- Paragraph IV.E.8 of Appendix E, “Emergency Planning and Preparedness for Production and Utilization Facilities,” to 10 CFR Part 50, with respect to the meteorological considerations used to evaluate the personnel exposures inside the TSC during an emergency

- 10 CFR 52.47(a)(1), with respect to the postulated site parameters that a DC applicant shall provide for the design

- 10 CFR 52.47(a)(2)(iv), with respect to an assessment of the plant design features intended to mitigate the radiological consequences of accidents, which includes consideration of postulated site meteorology to evaluate the offsite radiological consequences at any point on the EAB and on the outer boundary of the LPZ

Section 2.3.4 of the SRP states that the DC applicant should include EAB, LPZ, and CR atmospheric dispersion factors (χ/Q values) for the appropriate time periods in the list of site parameters. The DC application should also contain figures and tables showing the design features that the COL applicant would use to generate CR χ/Q values (e.g., intake heights, release heights, building cross-sectional areas, distance to receptors). SRP Section 2.3.4 also states that the postulated site parameters should be representative of a reasonable number of sites that may be considered within a COL application and that a basis should be provided for each of the site parameters.

SRP Section 15.0.3, states, in part, that an application meets the TSC radiological habitability requirements discussed in Appendix E to 10 CFR Part 50 if the total calculated radiological consequences for postulated accidents fall within the exposure acceptance criteria specified for the CR.

The EAB and LPZ χ/Q values are used to demonstrate that the offsite radiological consequences of accidents meet radiation dose guidelines for the EAB and LPZ specified in 10 CFR 52.47(a)(2)(iv). RG 1.145, Revision 1, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," issued November 1982, presents criteria for characterizing atmospheric dispersion conditions for evaluating the consequences of radiological releases to the EAB and LPZ.

The CR χ/Q values are used to demonstrate that the CR radiological consequences of accidents meet the radiation dose guidelines specified in GDC 19. The TSC χ/Q values are used to demonstrate that the radiological consequences to the TSC of accidents meet the radiation dose guidelines specified in SRP Section 15.0.3. RG 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," issued June 2003, presents criteria for characterizing atmospheric dispersion conditions to evaluate the consequences of radiological releases to the CR and TSC. RG 1.194 states that the ARCON96 atmospheric dispersion model (NUREG/CR-6331, Revision 1, "Atmospheric Relative Concentrations in Building Wakes," issued May 1997) is an acceptable methodology for assessing CR χ/Q values for use in CR design-basis accident radiological analyses, subject to the provisions specified in RG 1.194.

### 2.3.4.2 *Summary of Technical Information*

#### 2.3.4.2.1 Site Parameters

The list of ESBWR site parameters presented in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, includes meteorological dispersion (χ/Q) site parameters related to the (1) reactor building, PCCS (reactor building roof), reactor blowout panel, turbine building, and fuel building releases to the CR, and (2) reactor building, turbine building, and PCCS (reactor building roof) releases to the TSC. The meteorological dispersion site parameters listed in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1 are the same. The regional climatic site parameters listed in DCD, Tier 2, Table 2.0-1, have also been designated as Tier 2* in that prior NRC approval is required to change these parameters.

The radiological consequence analyses presented in DCD, Tier 2, Section 15.3, for infrequent events, and DCD, Tier 2, Section 15.4, for accidents, used the meteorological dispersion site parameters with one exception. The mislocated and misoriented fuel assembly loading error consequence analyses in DCD, Tier 2, Section 15.3, relied on the fuel-loading error event radiological analysis associated with Global Nuclear Fuel, "GESTAR II Amendment 28 Revision 1, Misloaded Fuel Bundle Event Licensing Basis Change to Comply with Standard Review Plan 15.4.7" (DCD, Tier 2, Reference 15.3-3).

#### 2.3.4.2.2 ARCON96 Source/Receptor Inputs

Appendix 2A to DCD, Tier 2 provides the ARCON96 source/receptor inputs for use by COL applicants in generating site specific CR and TSC χ/Q values. In particular, DCD, Tier 2, Figure 2A-1, depicts the locations of the sources and receptors for the ESBWR CR and TSC χ/Q determinations. DCD, Tier 2, Tables 2A-3 and 2A-4, provide ARCON96 inputs that are specific for the ESBWR. The applicant stated that it determined the ACRON96 inputs in accordance with RG 1.194.

DCD, Tier 2, Section 2A.2, states that the applicant used meteorological data from various nuclear power plant sites to calculate CR χ/Q values for the ESBWR plant layout, and the resulting meteorological dispersion site parameter values were selected to bound the results.

#### 2.3.4.2.3 Combined License Information

COL Information Item 2.0-1-A states that a COL applicant referencing the ESBWR DCD demonstrates that the characteristics for a given site fall within the ESBWR DCD site parameter values per 10 CFR 52.79. A number of the site parameters listed in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, (i.e., meteorological dispersion χ/Q) relate to short-term atmospheric dispersion estimates for accidental releases. Footnote 11 to DCD, Tier 2, Table 2.0-1, states that, if a selected site has a χ/Q value that exceeds the ESBWR reference site values, the COL applicant will address how the radiological consequences associated with the controlling design basis accident continue to meet the dose reference values provided in 10 CFR 52.79(a)(1)(vi) and CR operator dose limits provided in GDC 19 using site specific χ/Q values.

COL Information Item 2.0-10-A states that the COL applicant is to supply site specific information, in accordance with SRP Section 2.3.4, to show that the site meteorological

dispersion values, as calculated in accordance with RGs 1.145 and 1.194, and compared to the dispersion values given in DCD, Tier 2, Chapter 15, result in doses less than stipulated in 10 CFR 52.79(a)(1)(vi) and the applicable portions of SRP Chapters 11 and 15.

COL Information Item 2A.2-1-A states that, when referencing the ESBWR DCD to confirm that site characteristics at a given site are bounded by the ESBWR DCD site parameter values per 10 CFR 52.79, the COL applicant shall perform ARCON96 determinations for all source/receptor pairs listed in DCD, Tier 2, Tables 2A-3 and 2A-4, using site specific meteorological data (as defined in RG 1.23).

COL Information Item 2A.2-2-A states that, if the χ/Q values for a release from any door or personnel air lock on the east side of the reactor building or fuel building have χ/Q values that would result in doses greater than the bounding dose consequences reported for the fuel-handling accident (FHA) (DCD, Tier 2, Table 15.4-4), the affected doors or personnel air locks are administratively controlled to remain closed during movement of irradiated fuel bundles.

#### 2.3.4.3 *Staff Evaluation*

The staff reviewed the DCD, in accordance with the guidance provided in SRP Section 2.3.4, by ensuring that (1) the DCD included EAB, LPZ , and CR χ/Q values in the list of standard plant site parameters, (2) the DCD contained figures and tables describing the design features that the COL applicant would use to generate CR χ/Q values, (3) the EAB, LPZ, and CR standard plant site parameter χ/Q values are representative of a reasonable number of sites that may be considered within a COL application, and (4) a basis has been provided for each of the EAB, LPZ, and CR standard plant site parameter χ/Q values. The staff also reviewed the radiological consequence analyses presented in DCD, Tier 2, Sections 15.3 and 15.4; the fuel-loading error radiological consequence analysis presented in GESTAR II Amendment 28; the control building habitability systems description presented in DCD, Tier 2, Section 6.4; and the applicant's responses to RAIs 2.3-8, 2.3-9, 15.3-1, and 15.3-2 to determine whether the assumed fission product transport to the environment for each infrequent event and accident was compatible with the χ/Q values used to model the release pathway.

DCD, Tier 2, Revision 3, Reference 15.3-3, cited an August 2004 version of the GESTAR II Amendment 28 report that the applicant had submitted to the staff for review. The staff asked the applicant in RAI 15.3-1 to update DCD, Tier 2, Reference 15.3-3, to cite a revised version of the GESTAR II Amendment 28 report reflecting NRC staff approval. In its response to RAI 15.3-1, dated July 31, 2006, the applicant stated that it would update DCD, Tier 2, Reference 15.3-3, as soon as the staff completed the safety evaluation for GESTAR II Amendment 28. The final reference will be the GESTAR revision (accepted version) that implements Amendment 28 and includes the safety evaluation. This was being tracked as Confirmatory Item 15.3-1.

The staff issued its final safety evaluation for GESTAR II Amendment 28 on March 8, 2007 (ADAMS Accession No. ML0704700550), and GEH subsequently listed this final safety evaluation as Reference 15.3-11 in Revision 4 to the DCD. Based on the applicant's response, RAI 15.3-1 is resolved.

#### 2.3.4.3.1 Offsite χ/Q Values

SRP Section 2.3.4 states that the DC applicant should include in the list of site parameters EAB and LPZ χ/Q values for the appropriate time periods. Revision 0 to the DCD did not identify the EAB and LPZ χ/Q values used in the Chapter 15 radiological consequence analyses as standard plant site parameters. In RAI 2.3-8, the staff asked GEH to identify the EAB and LPZ χ/Q values as standard plant site parameters in DCD, Tier 2, Table 2.0-1. The staff also asked the applicant in RAI 14.3-24 to update DCD, Tier 1, Table 5.1-1, to include LPZ χ/Q values.

In its response to RAI 2.3-8, dated October 20, 2006, GEH agreed to provide the requested EAB and LPZ χ/Q values as standard plant site parameters in DCD, Tier 2, Chapter 2. In its response to RAI 14.3-24, dated October 20, 2006, GEH also agreed to list LPZ χ/Q values in DCD, Tier 1, Table 5.1-1. In its response to RAI 2.3-8, the applicant also stated that it would take the requested EAB and LPZ χ/Q values from GE Energy Report NEDE-33279P, "ESBWR Containment Fission Product Removal Evaluation Model," issued October 2006. This GE Energy report summarizes the methodology GEH used to evaluate the potential dose consequences resulting from a loss-of-coolant accident (LOCA). Chapter 5 of NEDE-33279P states that the EAB and LPZ χ/Q values were "back calculated" to determine the bounding values that would result in doses just under regulatory limits. GEH included the EAB and LPZ χ/Q values from NEDE-33279P as site parameters in Revision 2 to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1. The staff finds that the applicant provided an acceptable basis for its offsite χ/Q site parameter values.

In reviewing Revision 3 to DCD, Tier 2, Sections 2, 15.3, and 15.4, the staff noted that DCD, Tier 2, Tables 15.4-14 and 15-4.21, indicate that the applicant used a χ/Q value of $1.00\times10^{-3}$ seconds per cubic meter ($s/m^3$) to calculate doses at the EAB for the feedwater line break and the reactor water cleanup/shutdown cooling system (RWCU/SDC) line break accidents, respectively. RAI 2.3-8 asked the applicant to explain why the EAB χ/Q value used in these radiological consequence analyses differed from the EAB χ/Q value of $2.00\times10^{-3}$ $s/m^3$ listed as a standard plant site parameter in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1. The use of a lower EAB χ/Q value in these DCD radiological consequence analyses results in lower calculated doses for the EAB. This RAI was being tracked as an open item in the SER with open items. In its response, dated January 25, 2008, the applicant stated that it would revise DCD, Tier 2, Tables 15.4-14 and 15.4-21, to show that the revised analyses for the feedwater line break and the RWCU/SDC line break accidents used an EAB χ/Q value of $2.00\times10^{-3}$ $s/m^3$. In Revision 5 to the DCD, the applicant revised DCD, Tier 2, Tables 15.4-14 and 15-4.21, to indicate that the revised analyses for the feedwater line break and the RWCU/SDC line break accidents used an EAB χ/Q value of $2.00\times10^{-3}$ $s/m^3$. Based on the applicant's response, RAI 2.3-8 is resolved.

The staff asked the applicant, in RAI 2.3-9, to identify postulated release locations to the environment. In its response to RAI 2.3-9, dated November 13, 2006, GEH described the assumed release pathways to the environment for several infrequent events and accidents. One of the release pathways discussed was the main plant stack, which was not part of the ESBWR standard plant design. Because the main plant stack was not part of the ESBWR standard plant design, the staff issued a supplement to RAI 2.3-9 noting that the DCD should explicitly state that the COL applicant should confirm at the COL stage whether the main plant

stack EAB and LPZ χ/Q site characteristic values are less than or equal to the ESBWR EAB and LPZ χ/Q standard plant site parameters. This was being tracked as an open item in the SER with open items.

In its response, dated April 18, 2008, the applicant stated that a subsequent ESBWR design change removed the main plant stack and replaced it with three ventilation stacks. The applicant subsequently added Appendix 2A to Revision 5 of DCD, Tier 2, which contains the design information required to perform atmospheric dispersion modeling for the three new ventilation stacks. Because the three ventilation stacks are now part of the ESBWR standard plant design and the COL applicant must confirm that the site specific χ/Q values for the three ventilation stacks fall with the corresponding site parameter values in DCD, Tier 1, Table 5.1-1, and Tier 2, Table 2.0-1, in accordance with COL Information Items 2.0-1-A and 2A.2-1-A, GEH stated that the reason for including an explicit statement about confirming the main plant stack EAB and LPZ χ/Q site characteristic values is precluded. The staff concurs with this assessment. Based on the applicant's response, this part of RAI 2.3-9 is resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 4.

To determine whether the ESBWR EAB and LPZ χ/Q standard plant site parameters bound a reasonable number of sites that may be considered within a COL application, the staff compared the ESBWR EAB and LPZ χ/Q standard plant site parameters to the EAB and LPZ χ/Q site characteristics identified in the first four docketed ESP applications (i.e., North Anna, Grand Gulf, Clinton, and Vogtle). The EAB and LPZ χ/Q values presented in these ESP applications were developed in accordance with current regulatory guidance. The staff found that the ESBWR EAB and LPZ χ/Q standard plant site parameters were higher than the EAB and LPZ χ/Q site characteristics presented in the four ESP applications.[3] Consequently, the staff finds that the applicant has provided EAB and LPZ χ/Q site parameter values that should bound a reasonable number of sites that may be considered within a COL application and, therefore, these site parameter values are acceptable.

GESTAR II Amendment 28 provides the offsite radiological analysis for the mislocated and misoriented fuel assembly loading error events. A bounding EAB and LPZ χ/Q value of $5.04\times10^{-3}$ s/m$^3$ was back-calculated using the alternative source term (AST) regulatory dose criteria for the EAB and LPZ. This means that fuel-loading error at any site with EAB and LPZ χ/Q site characteristics of less than $5.04\times10^{-3}$ s/m$^3$ will result in doses less than the regulatory criteria. Since the GESTAR II Amendment 28 EAB and LPZ χ/Q value of $5.04\times10^{-3}$ s/m$^3$ is greater than any of the ESBWR standard plant site parameter EAB and LPZ χ/Q values listed in DCD, Tier 1, Table 5.1-1, and Tier 2, Table 2.0-1, the ESBWR standard plant site parameter EAB and LPZ χ/Q values are more limiting.

#### 2.3.4.3.2 Control Room χ/Q Values

SRP Section 2.3.4 states that the DC applicant should include in the list of site parameters CR χ/Q values for the appropriate time periods. Revision 0 to the DCD did not identify the CR χ/Q values used in the Chapter 15 radiological consequence analyses as standard plant site

[3] Smaller χ/Q values are associated with greater dilution capability, resulting in lower radiological doses. When comparing a site parameter χ/Q value and a site characteristic χ/Q value, the site is acceptable for the design if the site characteristic χ/Q value is smaller than the site parameter χ/Q value. Such a comparison shows that the site has better dispersion characteristics than that required by the reactor design.

parameters. In RAI 2.3-8, the staff asked GEH to provide CR χ/Q values as site parameters in DCD, Tier 2, Table 2.0-1. The staff also asked the applicant in RAI 14.3-24 to update DCD, Tier 1, Table 5.1-1, to include CR χ/Q values.

In its response to RAI 2.3-8, dated October 20, 2006, GEH agreed to provide the requested CR χ/Q values as site parameters in DCD, Tier 2, Chapter 2. In its response to RAI 14.3-24, dated October 20, 2006, GEH also agreed to list CR χ/Q values in DCD, Tier 1, Table 5.1-1. In its response to RAI 2.3-8, the applicant also stated that it will take the requested CR χ/Q values from GE Energy Report NEDE-33279P. The GE Energy report presents CR χ/Q values for three release pathways—(1) containment leakage through the east wall of the reactor building, (2) PCCS leakage that is assumed to be ducted to the top of the reactor building, and (3) main steam isolation valve leakage from the main condenser in the turbine building. Chapter 5 of NEDE-33279P states that these CR χ/Q values were chosen based on the ESBWR design and the worst alignment for the assumed plant layout.

Revision 2 to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, included the CR χ/Q values from NEDE-33279P as site parameters. Neither NEDE-33279P nor Revision 2 to the DCD indicated whether the provided CR χ/Q values were to be used for the filtered air intake, unfiltered inleakage, or both.

In Revision 3 to the DCD, GEH revised the CR χ/Q values listed as standard plant site parameters in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1. The applicant provided two sets of CR χ/Q values for the reactor building, PCCS/reactor building roof, and turbine building release pathways—one set for unfiltered inleakage and another set for the filtered air intake.

SRP Section 2.3.4 states that the DC application should contain figures and tables showing the design features that the COL applicant would use to generate CR χ/Q values (e.g., intake heights, release heights, building cross-sectional areas, distance to receptors). Revision 0 to the DCD did not contain figures and tables showing the design features that the COL applicant would need to generate site specific CR χ/Q values at the COL stage. In RAI 2.3-9, the staff asked GEH to provide figures showing CR intake, unfiltered inleakage, and postulated design-basis accident release locations to the environment. These figures should provide a basis for determining the distances and directions between potential accident release pathways and intake and inleakage pathways to the CR necessary to execute the ARCON96 atmospheric dispersion computer code using the guidance provided in RG 1.194. The COL applicant will need to execute the ARCON96 model at the COL stage using site specific meteorological data to generate site-specific CR χ/Q values to compare to the ESBWR CR χ/Q standard plant site parameters.

In its response to RAI 2.3-9, dated November 13, 2006, GEH described (1) the location of the CR air intake, (2) three locations as potential unfiltered inleakage locations, and (3) several release locations depending on the design-basis accident being analyzed. The applicant's response also provided figures showing the CR intake and unfiltered inleakage locations and release locations and a table containing some of the inputs required to execute the ARCON96 atmospheric dispersion model for each source/receptor combination. The applicant stated that it was not going to revise the DCD to incorporate the information on source and release locations provided in response to RAI 2.3.9.

In reviewing the applicant's response to RAI 2.3-9 and the subsequent Revision 3 to DCD, Tier 2, Sections 2, 15.3, and 15.4, the staff developed a set of questions which it issued as Supplement 1 to RAI 2.3-9. These questions were tracked as an open item in the SER with open items. Highlights of the applicant's responses and the resulting changes to Revision 5 to the DCD include the following:

- The applicant added Appendix 2A to Revision 2 to DCD, Revision 5 which provided the ARCON96 source/receptor inputs required by COL applicants to derive the site specific CR and TSC χ/Q values for comparison with the ESBWR site parameter values presented in DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1. The information in Appendix 2A includes (1) a scaled drawing showing all potential release pathways and receptors used in the CR dose consequence evaluations, (2) the direction from each receptor to each source in degrees from the ESBWR plant north, (3) the building vertical cross-sectional area perpendicular to the wind for each source/receptor combination, and (4) the heights and widths of all diffuse sources. The applicant also added COL Information Item 2A.2-1-A which states that, when referencing the ESBWR DCD to confirm that site characteristics at a given site are bounded by the ESBWR DCD site parameter values per 10 CFR 52.79, the COL applicant shall perform ARCON96 determinations for all source/receptor pairs listed in DCD, Tier 2, Tables 2A-3 and 2A-4, using site specific meteorological data (as defined in RG 1.23).

- The applicant clarified that releases from the condenser/turbine pathway are assumed to be ground-level releases from turbine building leakage when the turbine building is treated as a diffuse source. The applicant also identified the turbine building truck doors as a potential release point to be modeled by COL applicants, but GEH stated that it expects the turbine building leakage pathway to be bounding.

  The ESBWR design-basis LOCA considers the combined effects of a LOCA and an SSE. The main steamlines, main steam drainlines, and condensers are designed to meet the SSE criteria, whereas the turbine building was not originally designed to meet SSE criteria. Consequently, the staff asked the applicant as part of a second supplement to RAI 2.3.9 to justify why the CR χ/Q values used to model LOCA releases from the main condenser were modeled as a diffuse release when the turbine building was assumed to remain intact.

  In its response, dated November 19, 2008, the applicant stated that it reclassified the turbine building as a seismic Category II structure, thus justifying the decision to model the condenser/turbine pathway as turbine building leakage from a diffuse source. The staff notes that DCD, Tier 2, Section 3.2.1, states that, although seismic Category II SSCs perform no safety-related functions, they are designed to structurally withstand the effects of an SSE. The staff finds this acceptable.

- Because ESBWR Technical Specification 3.6.3.1 does not require the reactor building to be operable during Mode 6 (refueling), COL Information Item 2A.2-2-A was added. This COL information item originally stated that, if the χ/Q values for a release from any door on the east side of the reactor building or fuel building are not bounded by the ESBWR χ/Q values for a release in the reactor building, the doors must be administratively controlled before and during the movement of irradiated fuel bundles. The administrative controls must allow the doors and personnel air locks on the east side of

the reactor building or fuel building to be promptly closed under conditions indicative of an FHA.

Footnote 3 to Section 5.3 of Appendix B to RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," states that radiological analyses should generally not credit manual isolation of the containment (e.g., ESBWR reactor building and fuel building). Consequently, the staff asked the applicant, as part of the second supplement to RAI 2.3.9, to justify why it chose to use reactor building and fuel building diffuse area source models to evaluate the FHA, given that COL Information Item 2A.2-2-A requires that manual action be used to close the reactor building and fuel building doors. In its response, dated November 19, 2008, the applicant stated that it agreed that the ability to promptly close the doors on the east side of the reactor building or fuel building did not comply with Footnote 3 under Section 5.3 of Appendix B to RG 1.183. To ensure that the reactor building and fuel building $\chi/Q$ values comply with RG 1.183, Appendix B, Footnote 3, the applicant modified COL Information Item 2A.2-2-A to state that if the $\chi/Q$ values for a release from any door or personnel air lock on the east side of the reactor building or fuel building have $\chi/Q$ values resulting in doses greater than the bounding dose consequences reported for the FHA (DCD, Tier 2, Table 15.4-4), the affected doors or personnel air locks would be administratively controlled to remain closed during movement of irradiated fuel bundles. The staff finds this acceptable because manual isolation of the containment is no longer needed in the event of a fuel handling accident.

- The applicant modeled each of the three CR air intakes (i.e., the normal air intake on the south face of the control building (CR-N), the emergency air intake on the east face of the control building near the north end (CR-EN), and the emergency air intake on the east face of the control building near the south end (CR-ES)) as separate receptors. In addition, the applicant considered the control building louvers (CBLs) to be the dominant CR inleakage pathway for all releases and modeled them as a separate receptor.

- The applicant also modeled each of the two TSC intakes (i.e., the intake on the north face of the electrical building near the west end (TSC-W) and the intake on the north face of the electrical building near the east end (TSC-E)) as separate receptors.

- The applicant revised the CR accident $\chi/Q$ standard plant site parameters listed in Revision 5 to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, to include unfiltered inleakage and air intake values for releases from the reactor building, PCCS vent, reactor building roof blowout panels, turbine building, and fuel building. Similarly, the applicant added accident $\chi/Q$ standard plant site parameters for the TSC to DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, for releases from the reactor building, PCCS vent, and turbine building. The applicant stated in DCD, Tier 2, Appendix 2A, that it derived the CR $\chi/Q$ standard plant site parameters as bounding values from a set of $\chi/Q$ values which were generated by executing the ARCON96 computer code using the ESBWR plant layout and available meteorological data from various nuclear power plant sites.

The staff reviewed the changes to the DCD resulting from RAI 2.3-9 and found them acceptable. The staff also reviewed the inputs to the ARCON96 atmospheric dispersion model presented in Revision 5 to DCD, Tier 2, Appendix 2A, and found them to be consistent with site

configuration drawings and the guidance provided in RG 1.194. Therefore, RAI 2.3-9 is resolved.

To confirm that the revised set of ESBWR CR and TSC χ/Q site parameters in Revision 5 to the DCD are representative of a reasonable number of sites that have been or may be considered within a COL application, the staff generated site specific χ/Q values for the four docketed ESP applications (North Anna, Clinton, Grand Gulf, and Vogtle) using the ARCON96 computer code with (1) the source/receptor information presented in DCD, Tier 2, Appendix 2A (assuming the ESBWR plant north was aligned to true north at each site), and (2) the site specific hourly meteorology data sets provided in support of each ESP application. The staff found that the ESBWR χ/Q values were bounding in all cases. Consequently, the staff finds that the applicant has provided CR and TSC χ/Q site parameter values that should bound a reasonable number of sites that may be considered within a COL application. Therefore, these values are acceptable.

GESTAR II Amendment 28 provides the CR radiological analysis for the mislocated and misoriented fuel assembly loading error events. A bounding CR χ/Q value of $1.25\times10^{-2}$ s/m$^3$ was back-calculated using the AST regulatory dose criteria for the CR. This means that a fuel-loading error at any site with CR χ/Q site characteristics of less than $1.25\times10^{-2}$ s/m$^3$ will result in doses less than the regulatory criteria. Since the GESTAR II Amendment 28 control χ/Q value of $1.25\times10^{-2}$ s/m$^3$ is greater than any of the ESBWR standard plant site parameter CR χ/Q values listed DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1, the ESBWR standard plant site parameter CR χ/Q values are more limiting.

#### 2.3.4.3 *Conclusion*

The staff finds the applicant has selected the short-term (postaccident) standard plant site parameters referenced above for plant design inputs appropriately, and the staff agrees that they should be representative of a reasonable number of sites that have been or may be considered for a COL application. The short-term atmospheric dispersion characteristics for accidental releases are site specific and will be addressed by the COL applicant. This is COL Information Item 2.0-10-A. This should include the provision of information sufficient to demonstrate that the actual site characteristics fall within the values of the site parameters specified in the ESBWR DCD.

### 2.3.5 Long-Term Dispersion Estimates for Routine Releases

#### 2.3.5.1 *Regulatory Criteria*

Acceptance criteria regarding long-term dispersion estimates for routine releases are based on meeting the relevant requirements of the following Commission regulations:

- Subpart D, "Radiation Dose Limits for Individual Members of the Public," of 10 CFR Part 20, "Standards for Protection against Radiation," with respect to the postulated atmospheric dispersion site parameters used in demonstrating compliance with dose limits for individual members of the public

- 10 CFR 50.34a, "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents—Nuclear Power Reactors," and Sections II.B, II.C, and II.D of Appendix I, "Numerical Guides for Design Objectives and Limited Conditions for

Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, with respect to the postulated atmospheric dispersion site parameters used in demonstrating that the numerical guides for design objectives and limiting conditions for operation meet the requirement that radioactive material in effluents released to unrestricted areas be kept as low as is reasonably achievable

- 10 CFR 52.47(a)(1), with respect to the postulated site parameters that a DC applicant shall provide for the design

Section 2.3.5 of the SRP, Revision 3, states that the DC applicant should include the maximum annual average site boundary atmospheric dispersion factors (χ/Q values) and deposition factors (D/Q values) in the list of site parameters. SRP Section 2.3.5 also states that the postulated site parameters should be representative of a reasonable number of sites that may be considered within a COL application, and a basis should be provided for each of the site parameters.

The annual average atmospheric dispersion and deposition factors are used in the calculation of offsite concentrations and dose consequences of postulated routine airborne radioactive releases to demonstrate compliance with 10 CFR Part 20 and Appendix I to 10 CFR Part 50. RG 1.111, Revision 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," issued July 1977, presents criteria for characterizing atmospheric dispersion and deposition conditions for evaluating the consequences of routine releases.

### 2.3.5.2 *Summary of Technical Information*

#### 2.3.5.2.1 Site Parameters

The ESBWR list of standard plant site parameters presented in DCD, Tier 2, Table 2.0-1, includes long-term (annual average) dispersion estimate χ/Q and D/Q values. The long term dispersion estimate site parameters listed in DCD, Tier 2, Table 2.0-1, have been designated as Tier 2* in that prior NRC approval is required to change these parameters. No DCD, Tier 1 standard plant site parameters relate to long-term dispersion estimates. GEH used the DCD, Tier 2 long-term dispersion standard plant site parameters to calculate (1) annual average site boundary airborne concentrations to demonstrate compliance with Subpart D of 10 CFR Part 20 and (2) doses from routine airborne releases to demonstrate compliance with Appendix I to 10 CFR Part 50. DCD, Tier 2, Section 12.2, describes these calculations.

DCD, Tier 2, Section 12.2.2.1, discusses the generation of the ESBWR long-term χ/Q and D/Q standard plant site parameters. The ESBWR standard design employs three ventilation stacks (airborne release points) that service the ventilation flows from (1) the reactor/fuel buildings (RB/FB-VS), (2) the turbine building (TB-VS), and (3) the radwaste building (RWB-VS). The applicant developed separate long-term χ/Q and D/Q standard plant site parameters for each of the three ventilation stacks. The applicant stated the long-term χ/Q and D/Q site parameter values yield a maximum organ dose just below Appendix I to 10 CFR Part 50 criterion.

#### 2.3.5.2.2 Ventilation Stack Pathway Information for Long-Term χ/Q Values

Appendix 2B to DCD, Tier 2 provides the release pathway information for each of the three ventilation stacks for use by COL applicants in generating site specific annual average χ/Q and D/Q values. In particular, DCD, Tier 2, Table 2B-1, provides ventilation stack parameters that are specific for the ESBWR. Note that DCD, Tier 2, Figure 2A-1, shows the location for each ventilation stack.

#### 2.3.5.2.3 Combined License Information

COL Information Item 2.0-1-A states that a COL applicant referencing the ESBWR DCD demonstrates that the site characteristics for a given site fall within the ESBWR DCD site parameter values. A number of the site parameters listed in DCD, Tier 2, Table 2.0-1 (i.e., long-term dispersion estimates) relate to the long-term dispersion estimates for routine releases. Footnote 12 to DCD, Tier 2, Table 2.0-1, states that per DCD, Tier 2, Section 12.2.2.2, the COL applicant is responsible for ensuring that offsite dose (using site-specific generated χ/Q and D/Q values) due to radioactive airborne effluents complies with the regulatory dose limits in Sections II.B and II.C of Appendix I to 10 CFR Part 50.

COL Information Item 2.0-11-A states that a COL applicant is to supply site-specific information, in accordance with SRP Section 2.3.5.

### 2.3.5.3 *Staff Evaluation*

The staff reviewed the DCD in accordance with the guidance provided in SRP Section 2.3.5 by ensuring that (1) the list of standard plant site parameters in the DCD included long-term dispersion estimate χ/Q and D/Q values, (2) the long-term dispersion estimate χ/Q and D/Q site parameter values were representative of a reasonable number of sites that may be considered within a COL application, and (3) the applicant provided a basis for each of the long-term dispersion estimate χ/Q and D/Q site parameter values.

SRP Section 2.3.5 states that the DC applicant should include in the list of site parameters the maximum annual average site boundary χ/Q and D/Q values. Revision 0 to the DCD did not list the long-term χ/Q and D/Q values used in the Chapter 12 radiological consequence analyses as standard plant site parameters. In RAI 2.3-10, the staff asked GEH to list the long-term χ/Q and D/Q values as site parameters in DCD, Tier 2, Table 2.0-1. In its response to RAI 2.3-10, dated October 20, 2006, GEH agreed to list the requested long-term χ/Q and D/Q values as site parameters in DCD, Tier 2, Table 2.0-1. GEH included the requested long-term χ/Q and D/Q values as site parameters in Revision 2 of DCD, Tier 1, Table 5.1-1, and DCD, Tier 2, Table 2.0-1.

In Revision 2 to the DCD, the applicant assumed that routine releases were releases through the plant vent stack. The plant vent stack was not included as part of the ESBWR standard plant design in Revision 2 to the DCD. To determine whether the long-term χ/Q and D/Q site parameters in Revision 2 of the DCD bound a reasonable number of sites that may be considered within a COL application, the staff compared the Revision 2 long-term χ/Q and D/Q site parameters to the annual average EAB χ/Q and D/Q site characteristics identified in the first three docketed ESP applications (i.e., North Anna, Grand Gulf, and Clinton). This comparison showed that the ESBWR long-term χ/Q and D/Q site parameters did not bound (i.e., they were

lower than) the annual average EAB χ/Q and D/Q site characteristics presented in the three ESP applications.[4]

The staff found that, because the first three docketed ESP applicants used bounding conservative assumptions in generating their site characteristic values (e.g., all three ESP applicants assumed ground-level releases), the three ESP sites have higher long-term χ/Q and D/Q site characteristic values than the ESBWR long-term χ/Q and D/Q site parameters. To confirm this belief, the staff asked the applicant, in a supplement to RAI 2.3-10, to describe the assumptions it used to derive the ESBWR long-term χ/Q and D/Q site parameters. RAI 2.3-10 was being tracked as an open item in the SER with open items.

In its response to the supplement to RAI 2.3-10, dated October 15, 2007, the applicant stated that it is not critical that the ESBWR long-term χ/Q and D/Q site parameters bound the corresponding ESP values because other parameters are inputs to the dose calculation used to demonstrate compliance with dose criteria in 10 CFR Part 50, Appendix I. The staff found this response unsatisfactory and issued a second supplement to RAI 2.3-10 requesting that the applicant identify all release pathways to the atmosphere for each of the annual airborne release source terms provided in DCD, Tier 2, Table 12.2-16, and reiterating its request that the applicant provide the basis for the long-term χ/Q and D/Q values selected as standard plant site parameters.

In its response to the second supplement to RAI 2.3-10, dated April 24, 2008, the applicant stated that it redesigned its ventilation system to employ three ventilation stacks (airborne release points). Individual stacks will service the ventilation flows from the reactor/fuel building, the turbine building, and the radwaste building. The applicant also provided design data associated with each release point (e.g., release height, vent diameter, average effluent exit velocity) and stated that the revised three-stack design was now a standard ESBWR design feature. The applicant also provided a set of long-term χ/Q and D/Q values for each stack, assuming that two of the release points (RB/FB-VS and RWB-VS) were ground-level releases and one of the release points (TB-VS) was a mixed-mode (part-time ground, part-time elevated) release.

To determine whether the long-term χ/Q and D/Q site parameter values identified in Supplement 2 to RAI 2.3-10 bound a reasonable number of sites that may be considered within a COL application, the staff compared these long-term χ/Q and D/Q site parameters to the annual average EAB χ/Q and D/Q site characteristics identified in the first four docketed ESP applications (i.e., North Anna, Grand Gulf, Clinton, and Vogtle). Because all four ESP χ/Q and D/Q site characteristics were derived assuming ground-level releases, the staff compared only the ESBWR ground-level release point (RB/FB-VS and RWB-VS) χ/Q and D/Q site parameter values to the ESP χ/Q and D/Q site characteristic values. This comparison showed that (1) all four ESP site boundary χ/Q site characteristic values exceeded the ESBWR RB/FB-VS χ/Q site parameter value and (2) three of the four ESP site boundary χ/Q site characteristics values exceeded the ESBWR RWB-VS χ/Q site parameter value. Subsequent discussions with GEH

[4] Smaller χ/Q values are associated with greater dilution capability, resulting in lower radiological doses. When comparing site parameter χ/Q and D/Q values with site characteristic χ/Q and D/Q values, the site is acceptable for the design if the site characteristic χ/Q and D/Q values are smaller than the site parameter χ/Q and D/Q values. Such a comparison shows that the site has better dispersion characteristics than that required by the reactor design.

identified an error in the applicant's calculation methodology for the ESBWR χ/Q site parameter values. The applicant subsequently increased the height of the RB/FB-VS to qualify this release pathway as a mixed-mode release and recalculated the long-term χ/Q site parameter values for the RB/RB-VS and RWB-VS release pathways. The applicant included its revised set of long-term χ/Q and D/Q site parameters in Revision 5 to DCD, Tier 2, Table 2.0-1.

To confirm that the revised set of ESBWR long-term atmospheric dispersion χ/Q and D/Q site parameters in Revision 5 to the DCD are representative of a reasonable number of sites that have been or may be considered within a COL application, the staff generated site specific χ/Q and D/Q values for the four docketed ESP applications (North Anna, Clinton, Grand Gulf, and Vogtle) with the XOQDOQ computer code using (1) the release characteristics for each of the three ESBWR ventilation stacks and (2) site-specific meteorology, site boundary distances, and terrain heights. The XOQDOQ computer code (NUREG/CR-2919, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," issued September 1982) implements the methodology outlined in RG 1.111. The staff found that, with one exception (the Vogtle TB-VS χ/Q value), the ESBWR χ/Q and D/Q values were bounding. Because the ESBWR DCD χ/Q and D/Q values found in Revision 5 of the DCD bounded most of the site specific ESP χ/Q and D/Q values, the staff concludes that the ESBWR long-term dispersion χ/Q and D/Q standard plant site parameters listed in DCD, Tier 2, Table 2.0-1, bound a reasonable number of sites that may be considered within a COL application. Therefore, the staff found the long-term atmospheric dispersion χ/Q and D/Q site parameter values in Revision 5 to the DCD to be acceptable.

The staff issued a third supplement to RAI 2.3-10 asking the applicant to update the DCD to include release pathway information (e.g., stack release height above grade and the relationship to adjacent buildings, stack inside diameter, and average flow velocity) for each of the three ventilation stacks. COL applicants will require this information to generate site specific, long-term atmospheric dispersion site characteristics. The staff also asked the applicant to verify that all three ventilation stacks are uncapped and vertically oriented.

In its response to the third supplement to RAI 2.3-10, dated November 10, 2008, the applicant verified that all three ventilation stacks are uncapped and vertically oriented. The applicant also added DCD, Tier 2, Appendix 2B, to Revision 6 of the DCD, to provide the ventilation stack information necessary for executing the XOQDOQ computer code. Based on the applicant's response, RAI 2.3-10 is resolved.

The applicant removed the long-term dispersion estimates as DCD, Tier 1 site parameters in Revision 4 of DCD, Tier 1, Table 5.1-1. In RAI 2.3-11, the staff asked GEH to explain why it removed the long-term dispersion estimates as DCD, Tier 1 site parameters. In its response to RAI 2.3-11, dated March 17, 2008, the applicant responded that the COL holder will be required to comply with 10 CFR Part 50, Appendix I, during normal operations, regardless of whether the COL applicant's long-term dispersion site characteristics are bounded by the long-term dispersion site parameters cited in the DCD. In addition, the ESBWR assumes only one set of χ/Q and D/Q values for all exposure pathways, whereas the COL applicant may have multiple sets of χ/Q and D/Q values that vary with respect to location and pathway (e.g., site boundary; nearest garden, residence, and milk cow). Other parameters, such as release rates, can also be adjusted to demonstrate compliance with 10 CFR Part 50, Appendix I, dose criteria. For these reasons, the staff finds that the applicant's removal of the long-term dispersion estimates

as DCD, Tier 1 site parameters is acceptable. The long-term χ/Q and D/Q values remain as Tier 2* site parameters in DCD, Tier 2, Table 2.0-1.

In its supplemental response to RAI 12.2-28 dated January 19, 2010, the applicant proposed reducing by approximately a factor of two the long-term dispersion χ/Q and D/Q site parameter values presented in Revisions 5 and 6 to the DCD. These reductions in χ/Q and D/Q site parameter values were implemented by the applicant to ensure that 10 CFR Part 50, Appendix I dose limits were not exceeded as a result in an increase in airborne releases to the environment. The staff concludes that this reduction in χ/Q and D/Q site parameter values means that potential COL sites will need to have significantly better dispersion characteristics that what was previously assumed.

The applicant further stated in its supplemental response to RAI 12.2-28 that DCD, Tier 2, Section 12.2.2.1 will be modified to state that the revised χ/Q and D/Q site parameter values were determined by performing a XOQDOQ analysis using available meteorological data from 27 locations assuming an 800-meter site boundary. The applicant stated that it's chosen χ/Q and D/Q site parameter values bounded (were greater than) a significant majority of the maximum generated χ/Q and D/Q values for these 27 locations. However, the staff found that the revised ESBWR χ/Q site parameter values for the two mixed-mode release pathways (the RB/FB-VS and the TB-VS) no longer bounded any of the ESP site specific site boundary χ/Q values. Subsequently, the staff conducted an audit to review the applicant's XOQDOQ computer runs for its 27 locations to determine why the staff's conclusions differed from the applicant's conclusions. The staff reviewed a subset of the applicant's 27 XOQDOQ computer code runs during the audit and identified two inputs to the applicant's model runs which resulted in under prediction of the χ/Q and D/Q values for the two mixed-mode release pathways.

The applicant subsequently issued a revised supplemental response to RAI 12.2-28 on May 26, 2010. The revised supplemental response removed a discussion from the DCD Section 12.2.2.1 regarding the use of meteorological data from 27 locations with an assumed 800-meter site boundary as a basis for determining the ESBWR χ/Q and D/Q site parameter values. Instead, DCD, Tier 2, Section 12.2.2.1 was amended to state the revised χ/Q and D/Q site parameter values, which results in calculations that yield a maximum organ dose just below the 10 CFR Part 50, Appendix I criterion.

To demonstrate that the ESBWR design yields acceptable gaseous effluent doses for a reasonable number of sites that have been or may be considered for a COL application, the applicant performed a dose analysis for three plant sites using the ESBWR design airborne release source term. The applicant used meteorological data from these three sites to calculate site-specific χ/Q and D/Q values. While several χ/Q and D/Q values for these three sites were not bounded by the revised ESBWR χ/Q and D/Q site parameter values, the applicant found that the calculated doses met the 10 CFR Part 50, Appendix I gaseous effluent dose criteria for all three sites. This is because the ESBWR DCD calculates 10 CFR Part 50, Appendix I doses assuming all the receptors of interest (e.g., the nearest site boundary, vegetable garden, and milk and meat animals) are all collocated and therefore have the same χ/Q and D/Q values. In comparison, a COL applicant may have these receptors of interest at different distances, with the result that each type of receptor may have different χ/Q and D/Q values (some lower, some higher) than the ESBWR site parameter values. The staff notes that COL Information

Item 12.2-2-A states that the COL applicant is responsible for ensuring that offsite dose (using site-specific parameters such as χ/Q and D/Q values) due to radioactive airborne effluents complies with the regulatory dose limits in Appendix I to 10 CFR Part 50.

The purpose of certifying a "standard plant design" is to approve a design that can be sited at a reasonable number of sites without having to undergo a design review and/or change. The applicant has met this criterion by demonstrating that the 10 CFR Part 50, Appendix I dose criteria can be met for the three plant sites it evaluated using the ESBWR design airborne release source term and site-specific χ/Q and D/Q values. Therefore, the staff concludes that ESBWR long-term dispersion χ/Q and D/Q standard plant site parameters listed in DCD, Tier 2, Table 2.0-1, are acceptable.

#### 2.3.5.4 *Conclusion*

The staff finds the applicant has selected the long-term (annual average) atmospheric dispersion and deposition site parameters referenced above for plant design inputs and the staff agrees the ESBWR design (with its airborne release source term) should be able to be sited at a reasonable number of sites that have been or may be considered for a COL application. The long-term atmospheric dispersion and deposition characteristics are site specific and will be addressed by the COL applicant. This is COL Information Item 2.0-11-A.

## 2.4 Hydrologic Engineering

In this section of DCD, Tier 2, the applicant provide information to allow an independent hydrologic engineering review to be made of all hydrologically related design bases, performance requirements, and bases for operation of SSCs important to safety. The NRC staff will conduct such a review consistent with the guidance gleaned from the SRP. This safety evaluation is based on the review of Revision 3 of the GEH application dated February 2007. The staff used Table 2.0-2 of Revision 3, which includes COL information items, to determine the adequacy of the application. The review areas include the hydrological description, floods, probable maximum flood on streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami flooding, ice effects, cooling water channels and reservoirs, channel diversion, flooding protection requirements, low water considerations, ground water, accidental release of liquid effluents in ground and surface waters, and technical specification and emergency operation requirements. For the DC review, site specific issues will be deferred to the COL applicant. This section reviews the hydrological parameters that constitute the ESBWR standard plant design bases for siting suitability presented by a COL applicant under 10 CFR Part 52, “Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants,” or included in an application under 10 CFR Part 50.

### 2.4.1 Hydrologic Description

#### 2.4.1.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.1, “Hydrological Description,” using guidance provided in SRP Section 2.4.1, “Hydrological Description.” The staff will consider the applicant’s hydrological description adequate if it meets the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the

following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- GDC 2, "Design Bases for Protection Against National Phenomena," states that SSCs important to safety must be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches, without loss of capability to perform their safety functions.

- GDC 44, "Cooling Water," states that a system to transfer heat from SSCs important to safety to a UHS must be provided. The system safety function must be to transfer the combined heat load of these SSCs under normal operating and accident conditions.

- GDC 60, "Control of Releases of Radioactive Material to the Environment," states that the nuclear power unit design must include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences. Sufficient holdup capacity must be provided for the retention of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment.

- According to 10 CFR 52.79(a) and 10 CFR 100.20(2)(c), consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology.

- According to 10 CFR 100.23(d)(3), in establishing the design-basis flood, seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined.

#### 2.4.1.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum ground-water level considered in the plant design is 0.61 m (2 ft) below grade. DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific hydrologic information to the COL applicant.

#### 2.4.1.3 *Staff Evaluation*

The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100, which form the basis of the hydrologic engineering design. This is identified as COL Information Item 2.0-12-A. DCD, Tier 1, Table 5.1-1, captures this basic design-basis site parameter. The staff finds this acceptable.

#### 2.4.1.4 *Conclusion*

Because the hydrologic description information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.2 Floods

#### 2.4.2.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.2, "Floods," using guidance provided in SRP Section 2.4.2, "Floods." The staff will consider the applicant's flood design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.79(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.20(c)(3), which states that factors important to hydrological radionuclide transport that may affect the consequences of an escape of radioactive material from a plant will be obtained from onsite measurements

- 10 CFR 100.23(d)(3), which states that, in establishing the design-basis flood, seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined

#### 2.4.2.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum flood level considered in the standard plant design is 0.3 m (1 ft) below grade. DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific hydrologic information to the COL applicant.

#### 2.4.2.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.2, in light of the regulatory criteria cited in Section 2.4.2.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that the standard plant design-basis flood is not exceeded. This is identified as COL Information Item 2.0-13-A. DCD, Tier 1, Table 5.1-1, captures this basic design-basis site parameter. The staff finds this acceptable.

#### 2.4.2.4 *Conclusion*

Because the flood information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.3 Probable Maximum Flood on Streams and Rivers

#### 2.4.3.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2 and Section 2.4.3, "Probable Maximum Flood (PMF) on Streams and Rivers," in accordance with SRP Section 2.4.3, "Probable Maximum Flood (PMF) on Streams and Rivers." The staff will consider the applicant's flood design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that the consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.23(d)(3), which states that, in establishing the design-basis flood, seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined

#### 2.4.3.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum flood level considered in the plant design is 0.3 m (1 ft) below grade. DCD, Tier 2, Table 2.0-1, also indicates a maximum rainfall rate of 19.4 in/h and a maximum short-term (5 minute) rainfall rate of 6.2 in/h. DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific hydrologic information to the COL applicant.

#### 2.4.3.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.3, in light of the regulatory criteria cited in Section 2.4.3.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that any flood resulting from the overflow of streams and rivers will not exceed the standard plant design-basis flood. This is identified as COL Information Item 2.0-14-A. DCD, Tier 1, Table 5.1-1, captures this basic design-basis site parameter. The staff finds this acceptable.

Issue 103, as discussed in NUREG-0933, addresses the acceptable methodology for determining the design flood level for a particular plant site. The use of the National Oceanic and Atmospheric Administration (NOAA) procedures for determining the PMP for a site was questioned after a licensee disputed the use of two of NOAA HMRs. The issue was resolved

with the revisions to SRP Sections 2.4.2 and 2.4.3 in 1989, incorporating the PMP procedures and criteria contained in the latest NWS publications. This was documented in Volume 54, page 31268, of the Federal Register (54 FR 31268), issued on July 27, 1989, and GL 89-22, "Potential for Increased Roof and Plant Area Flood Runoff Depth at Licensed Nuclear Power Plants Due to Recent Change in Probable Maximum Precipitation Criteria Developed by the National Weather Service," dated October 19, 1989.

In DCD, Tier 1, Section 5, Table 5.1-1 and Tier 2, Section 2, Table 2.0-1, the applicant stated that the PMP is a site-related parameter; the ESBWR is designed for a PMP of 49.3 cm (19.4 inches) per hour and 15.2 cm (6 inches) in a 5-minute interval. The applicant stated that the COL applicant is responsible for demonstrating that the specific site parameters are within the limits specified for the standard ESBWR design. The specific site is acceptable if the site characteristics are within the ESBWR plant site design parameters detailed in DCD, Tier 2, Table 2.0-1. DCD, Tier 2, Chapter 2, provides additional information on the site interface parameters.

The COL applicant must use site specific environmental data to determine the PMP in accordance with SRP Sections 2.4.2, "Floods," and 2.4.3, "Probable Maximum Flood (PMF) on Streams and Rivers." This is to ensure that the maximum flood level for the ESBWR design specified in both DCD, Tier1 (Table 5.1-1) and Tier 2 (Table 2.0-1) shall not be exceeded by the site specific flood level. Section 2.4 of this report further discusses this issue. This is a COL Action Item.

Based on its review of this information, the staff concludes that Issue 103 is resolved for the ESBWR design.

#### 2.4.3.4 *Conclusion*

Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.4 Potential Dam Failures

#### 2.4.4.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.4, "Potential Dam Failures," in accordance with SRP Section 2.4.4, "Potential Dam Failures." The staff will consider the applicant's flood design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.20(c)(3), which states that factors important to hydrological radionuclide transport that may affect the consequences of an escape of radioactive material from a plant will be obtained from onsite measurements

- 10 CFR 100.23(d)(3), which states that, in establishing the design-basis flood, seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined

#### 2.4.4.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum flood level considered in the plant design is 0.3 m (1 ft) below grade, and DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific information to the COL applicant.

#### 2.4.4.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.4, in light of the regulatory criteria cited in Section 2.4.4.1 of this report. The COL applicant will provide the site-specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that any flood resulting from seismic dam failure will not exceed the standard plant design-basis flood. This is identified as COL Information Item 2.0-15-A. The staff finds this acceptable.

#### 2.4.4.4 *Conclusion*

Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.5 Probable Maximum Surge and Seiche Flooding

#### 2.4.5.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.5, "Probable Maximum Surge and Seiche Flooding," in accordance with SRP Section 2.4.5, "Probable Maximum Surge and Seiche Flooding." The staff will consider the applicant's flood design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that the consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.23(d)(3), which states that, in establishing the design-basis flood, seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined

#### 2.4.5.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum flood level considered in the plant design is 0.3 m (1 ft) below grade, and DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific information to the COL applicant.

#### 2.4.5.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.5, in light of the regulatory criteria cited in Section 2.4.5.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that any flood resulting from maximum surge and seiche flooding will not exceed the standard plant design-basis flood. This is identified as COL Information Item 2.0-16-A. The staff finds this acceptable.

#### 2.4.5.4 *Conclusion*

Because the information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.6 Probable Maximum Tsunami Flooding

#### 2.4.6.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.6, "Probable Maximum Tsunami Flooding," in accordance with SRP Section 2.4.6, "Probable Maximum Tsunami Flooding." The staff will consider the applicant's flood design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.23(d)(3), which states that, in establishing the design-basis flood, seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined

#### 2.4.6.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum flood level considered in the plant design is 0.3 m (1 ft) below grade. Because the standard plant design basis is intended to be suitable for varied site conditions and therefore site independent, DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific information to the COL applicant.

#### 2.4.6.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.6, in light of the regulatory criteria cited in Section 2.4.6.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that any flood resulting from tsunami flooding will not exceed the standard plant design-basis flood. This is identified as COL Information Item 2.0-17-A. The staff finds this acceptable.

#### 2.4.6.4 *Conclusion*

Because the information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.7 Ice Effects

#### 2.4.7.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.7, "Ice Effects," in accordance with SRP Section 2.4.7, "Ice Effects." The staff will consider the applicant's design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- GDC 44, which states that a system to transfer heat from SSCs important to safety to a UHS must be provided, and the system's safety function must be to transfer the combined heat load of these SSCs under normal operating and accident conditions

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

#### 2.4.7.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-2, indicates that the specific plant design does not include a safety-related service water system that could be affected by ice flooding or blockage and defers the presentation of site specific information to the COL applicant.

### 2.4.7.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.7, in light of the regulatory criteria cited in Section 2.4.7.1 of this report. Regarding the applicability of the relevant requirements of GDC 44, the staff considered the information in Table 2.0-1 which stated that no safety-related service water systems exist that could be subjected to ice flooding or blockage. The staff issued RAIs 2.4-14 and 2.4-15, which noted that water storage for the ICS, PCCS, and other pools for safety-related use is located near the top of the reactor building. For a plant located in a very cold climate, ice formation caused by freezing in the safety-related pools during an extended outage could reduce the quantity of available liquid water. GEH responded that since the pools' safety function is achieved by boiling, there were no low water considerations regarding ice formation. However, water needed for post-72-hour cooling is stored in fire water tanks and may be subject to freezing depending on site characteristics. The staff issued a supplement to RAI 2.4-14 to address this concern. In response, the applicant stated that freeze protection is provided for the firewater storage tanks and exposed piping and updated DCD, Tier 2 to reflect this feature. Based on the applicant's responses, RAIs 2.4-14 and 2.4-15 are resolved.

If an external water source is used to meet the requirements of GDC 44, the COL applicant will need to provide site specific information to satisfy the requirements of 10 CFR Parts 52 and 100 related to flooding, low water, or ice damage to safety-related SSCs. This is identified as COL Information Item 2.0-18-A.

### 2.4.7.4 *Conclusion*

Because the information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.4.8 Cooling Water Channels and Reservoirs

### 2.4.8.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.8, "Cooling Water Channels and Reservoirs," in accordance with SRP Section 2.4.8, "Cooling Water Channels and Reservoirs." The staff will consider the applicant's design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- GDC 1, "Quality Standards and Records," which states that SSCs important to safety must be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed

- GDC 2, which states that SSCs important to safety must be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches, without loss of capability to perform their safety functions

- GDC 44, which states that a system to transfer heat from SSCs important to safety to a UHS must be provided, and the system's safety function must be to transfer the combined heat load of these SSCs under normal operating and accident conditions

- 10 CFR 52.17(a) and 10 CFR 100.20, which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

#### 2.4.8.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-2, indicates that the plant design does not include a safety-related service water system that requires transport and impoundment of plant cooling water and defers the presentation of site specific information to the COL applicant.

#### 2.4.8.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.8, in light of the regulatory criteria cited in Section 2.4.8.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that the capacities of the cooling water canals and reservoirs are adequate. This information is not available at the DC stage. In view of the relevant requirements of GDC 1, GDC 2, and 10 CFR Part 100, the staff considered the fact that the regulations regarding safety-related service water systems require transport and impoundment of plant cooling water (see Section 4.1 of DCD, Tier 1). This is identified as COL Information Item 2.0-19. The staff finds this acceptable.

#### 2.4.8.4 *Conclusion*

Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.9 Channel Diversion

#### 2.4.9.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.9, "Channel Diversion," in accordance with SRP Section 2.4.9, "Channel Diversion." The staff will consider the applicant's design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- GDC 1, which states that SSCs important to safety must be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed

- GDC 2, which states that SSCs important to safety must be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches, without loss of capability to perform their safety functions

- GDC 44, which states that a system to transfer heat from SSCs important to safety to a UHS must be provided, and that the system's safety function must be to transfer the combined heat load of these SSCs under normal operating and accident conditions

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

#### 2.4.9.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-2, indicates that the plant design does not include a safety-related service water system that could be adversely affected by natural stream channel diversion and defers the presentation of site specific information to the COL applicant.

#### 2.4.9.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.9, in light of the regulatory criteria cited in Section 2.4.9.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate that the capacities of cooling water canals and reservoirs are adequate. This site specific information is not available at the DC stage. In view of the relevant requirements of GDC 1, GDC 2, and GDC 44, the staff considered the fact that the regulations regarding safety-related service water systems require transport of plant cooling water that would be affected by natural stream channel diversion. This is identified as COL Information Item 2.0-20. The staff finds this acceptable.

#### 2.4.9.4 *Conclusion*

Because the information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.10 Flooding Protection Requirements

#### 2.4.10.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.10, "Flooding Protection Requirements," in accordance with SRP Section 2.4.10, "Flooding Protection Requirements." The staff will consider the applicant's flood design basis for safety-related plant features

adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- GDC 1, which states that SSCs important to safety must be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed

- GDC 2, which states that SSCs important to safety must be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches, without loss of capability to perform their safety functions

- GDC 44, which states that a system to transfer heat from SSCs important to safety to a UHS must be provided, and the system's safety function must be to transfer the combined heat load of these SSCs under normal operating and accident conditions

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

#### 2.4.10.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum flood level considered in the plant design is 0.3 m (1 ft) below grade. DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific information to the COL applicant.

#### 2.4.10.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.10, in light of the regulatory criteria cited in Section 2.4.10.1 of this report. The COL applicant will provide the site-specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to demonstrate the topography and geology of the site and their applicability to damage as a result of flooding. Flooding protection requirements for the standard design have two parts—one is based on site specific conditions, and the other is based on the measures taken by the standard plant design features, such as watertight access doors, qualification of equipment that may be subject to inundation caused by external flooding, and flood elevation warning systems, if any. The first part relates to the criteria of GDC 1, GDC 2, and GDC 44, and the applicant has specified its design-basis flood elevation. This is identified as COL Information Item 2.0-21-A.

In RAI 2.4-32, the staff asked the applicant to address potential accidental flooding of safety-related compartments located well below grade resulting from unanticipated defects or other nonmechanistic causes and to identify the provisions in the standard design to detect and mitigate flooding of lower compartments. Section 3.4.1 of this report discusses the GEH response to this RAI. Therefore, RAI 2.4-32 is resolved.

### 2.4.10.4 *Conclusion*

Because this information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.4.11 Low Water Considerations

### 2.4.11.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.11, "Cooling Water Supply," in accordance with SRP Section 2.4.11, "Low Water Considerations." The staff will consider the applicant's design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements of GDC 44, 10 CFR Parts 52, and 100 are met as they relate to identifying and evaluating the hydrologic features of the site:

- GDC 44, which states that a system to transfer heat from SSCs important to safety to a UHS must be provided, and the system's safety function must be to transfer the combined heat load of these SSCs under normal operating and accident conditions

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

### 2.4.11.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-2, indicates that the plant design does not include a safety-related service water system that requires a water supply to operate the plant or maintain safe shutdown under normal and emergency conditions and defers the presentation of site specific information to the COL applicant.

### 2.4.11.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.11, in light of the regulatory criteria cited in Section 2.4.11.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 that are associated with likely land-use changes and changes in water demand that could alter the frequency of low-flow conditions and the related minimum water elevation for the safety-related water use at a plant. In view of the relevant requirements of GDC 44 and view of the information provided in DCD, Tier 1, Section 4.1, the staff considered the fact that the site specific, safety-related service water system will require transport or impoundment of plant cooling water and determined that the COL applicant is responsible for this issue. This is identified as COL Information Item 2.0-22-A. The staff finds this acceptable.

### 2.4.11.4 *Conclusion*

Because the information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.4.12 Ground Water

### 2.4.12.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.12, "Groundwater," in accordance with SRP Section 2.4.12, "Groundwater." The staff will consider the applicant's design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.20(c)(3), which states that factors important to hydrological radionuclide transport that may affect the consequences of an escape of radioactive material from a plant will be obtained from onsite measurements

- 10 CFR 100.23, "Geologic and Seismic Siting Criteria," which requires that siting factors, including the cooling water supply, be evaluated, taking into account information concerning the physical, including hydrological, properties of the materials underlying the site

### 2.4.12.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, indicates that the maximum ground-water level considered in the plant design is 0.61 m (2 ft) below grade, and DCD, Tier 2, Table 2.0-2, defers the presentation of the required site specific hydrologic information to the COL applicant.

### 2.4.12.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.12, in light of the regulatory criteria cited in Section 2.4.12.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100, which include site specific local hydrogeological information and hydraulic parameters that govern contaminant transport. This is identified as COL Information Item 2.0-23-A. The staff finds this acceptable.

### 2.4.12.4 *Conclusion*

Because the information is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.4.13 Accidental Releases of Liquid Effluent in Ground and Surface Water

### 2.4.13.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.13, "Accidental Releases of Liquid Effluent in Ground and Surface Water," in accordance with SRP Section 2.4.13, "Accidental Releases of Liquid Effluent in Ground and Surface Water." The staff will consider the applicant's design basis for safety-related plant features adequate if the features meet the codes, standards, and regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying and evaluating the hydrologic features of the site:

- 10 CFR 52.17(a) and 10 CFR 100.20(c), which state that consideration of the acceptability of a site will include the physical characteristics of the site, including seismology, meteorology, geology, and hydrology

- 10 CFR 100.20(c)(3), which states that factors important to hydrological radionuclide transport that may affect the consequences of an escape of radioactive material from a plant will be obtained from onsite measurements

- 10 CFR 100.21, "Non-seismic Site Criteria," which provides nonseismic siting criteria

- GDC 60, "Control of Releases of Radioactive Material to the Environment," which states that the nuclear power unit design must include a means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences, and that sufficient holdup capacity must be provided for the retention of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment

### 2.4.13.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-2, indicates that the source term to be used in the radionuclide transport analysis (accidental release) can be found in Table 12.2-13a and defers the presentation of site specific information to the COL applicant.

### 2.4.13.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.13, in light of the regulatory criteria cited in Section 2.4.13.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to describe the radionuclide transport characteristic of ground and surface water with respect to existing and future users.

In Revision 3 to DCD, Tier 2, Table 2.0-2, the applicant stated that SRP Section 2.4.13 does not apply to an ESBWR because of its mitigation capabilities. This statement did not conform to the staff guidance in SRP Section 11.2 and Branch Technical Position (BTP) 11-6, "Guidance on the Level of Detail Required for Design Certification Applications under 10 CFR Part 52," issued March 2007. To address SRP Section 2.4.13 for a future site suitability assessment, the applicant needed to add a COL information item for evaluating the effects of an accidental release of radioactive liquid waste on surface and ground water, as necessary. In addition, the applicant needed to provide in the DCD the source term from the single tank (in accordance with the assumptions in BTP 11-6) that the COL applicant would use for a future site evaluation to address SRP Section 2.4.13. This is the postulated inventory to be used for site safety assessments. The staff requested this information from the applicant in RAI 2.4.1-2 and a supplement to RAI 2.4.1-2.

On July 5, 2007, GEH committed to revise its response in MFN Letter 06-226. Specifically, GEH committed that it would (1) add a COL information item for evaluating the effects of an accidental release of radioactive liquid waste on surface and ground water, providing the source term for the postulated single tank failure (Table 12.2-13a), and (2) incorporate steel liners in the liquid waste management system tank cubicles to prevent accidental releases to the environment. Based on the applicant's response, RAI 2.4.1-2 is resolved. This RAI was being tracked as a confirmatory item in the SER with open items. The staff confirmed that GEH added COL Information Item 2.0-24-A in DCD, Tier 2, Revision 5.

#### 2.4.13.4 *Conclusion*

The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

### 2.4.14 Technical Specification and Emergency Operation Requirements

#### 2.4.14.1 *Regulatory Criteria*

The staff reviewed DCD, Tier 2, Table 2.0-2, Section 2.4.14, "Technical Specification and Emergency Operation Requirements," in accordance with SRP Section 2.4.14, "Technical Specification and Emergency Operation Requirements." The staff will consider the applicant's safety analysis report adequate if the features meet the regulatory guidance commensurate with the safety function to be performed. This will ensure that the following relevant requirements are met as they relate to identifying technical specifications and emergency procedures required to implement flood protection for safety-related structures and to ensure an adequate water supply for shutdown and cooldown purposes:

- GDC 2, which states that SSCs important to safety must be designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods,

tsunami, and seiches, without loss of capability to perform their safety functions

- 10 CFR 50.36(c)(ii)(B)(2), which details the lowest functional capability or performance of equipment required for safe operation of the facility

### 2.4.14.2 *Summary of Technical Information*

DCD, Tier 2, Table 2.0-1, and DCD, Tier 1, Table 5.1-1, indicate the basic hydrologic design bases related to the maximum ground-water level considered in the plant design. Since the site specific hazards related to any emergency condition for plant operation or limiting conditions of operation are not available at the DC stage, DCD, Tier 2, Table 2.0-2, defers the presentation of the required site-specific hydrologic information to the COL applicant.

### 2.4.14.3 *Staff Evaluation*

The staff evaluated DCD, Tier 2, Table 2.0-2 and Section 2.4.12, in light of the regulatory criteria cited in Section 2.4.14.1 of this report. The COL applicant will provide the site specific information used to satisfy the requirements of 10 CFR Parts 52 and 100 and to describe the site specific emergency conditions of operation. This is identified as COL Information Item 2.0-25-A. The staff finds this acceptable.

### 2.4.14.4 *Conclusion*

Because information about the emergency operation requirements related to flooding is site specific, the COL applicant will address it and the NRC will review it at the COL stage. The COL applicant should provide information sufficient to demonstrate that the design of the plant falls within the values of the actual site characteristics specified in a COL application. Therefore, the requirement that the COL applicant address these issues is acceptable.

## 2.5 Geological, Seismological, and Geotechnical Engineering

The following regulatory requirements apply to the review of geological, seismological, and geotechnical engineering:

- 10 CFR 52.47, “Contents of Applications,” requires a DCD applicant to provide the technical information required of applicants for construction permits and operating licenses and states that the contents should be technical relevant and not site specific.

- Appendix S, “Earthquake Engineering Criteria for Nuclear Power Plants,” to 10 CFR Part 50 requires each applicant to design nuclear power plant SSCs important to safety to withstand the effects of natural phenomena, such as earthquakes, without losing the ability to perform their safety function.

- 10 CFR 100.23(d) states geologic and seismic siting factors

- GDC 2 states design basis for protection against natural phenomona

### 2.5.1 Summary of Technical Information

DCD, Tier 2, Section 2.0, describes the envelope of site-related geologic, seismologic, and geotechnical parameters that the ESBWR standard plant is designed to accommodate. The applicant stated that these parameters envelop most potential sites in the United States and that both DCD, Tier 1 and DCD, Tier 2, Section 2.0, specify these parameters. DCD, Tier 2, Section 2.0, Table 2.0-1, specifies the following key site parameters:

- Soil properties, including:
    - both static and dynamic bearing capacities, and the relationship between the capacities and demands.
    - minimum shear wave velocity (300 m/s (1,000 feet per second (fps)))
    - liquefaction potential (none under footprint of seismic Category I or II structures)
    - angle of internal friction (greater than 30 degrees)
- Seiemology criteria, including
    - both horizontal and vertical SSE (as shown in DCD, Tier 2, Figures 2.0-1 and 2.0-2)
- Maximum and differential settlement (values specified for various structures)
- Safety factors for slope stability

Notes accompanying DCD, Tier 2, Section 2.0, Table 2.0-1, further clarified that static bearing the pressure is the average pressure and the dynamic bearing pressure is the toe pressure. The maximum static bearing demand is multiplied by a factor of safety appropriate for the design load combination and is compared with the site-specific allowable static bearing pressure. The maximum dynamic bearing demand is multiplied by a factor of safety appropriate for the design load combination and is compared with the site-specific allowable dynamic bearing pressure. The minimum shear wave velocity is the minimum shear wave velocity associated with seismic strains for lower bound soil properties, after taking into account uncertainties, at the foundation level. The SSE design ground response spectra are defined as free-field outcrop spectra at the foundation level of seismic Category I structures. DCD, Tier 2, Section 2.0, Table 2.0-2, includes the additional geologic criterion that the ESBWR design assumes no permanent ground deformation from tectonic or nontectonic faulting.

### 2.5.2 Staff Evaluation

The staff reviewed the geologic and seismic information presented in DCD, Tier 2, Section 2.0, to ensure that the relevant requirements of 10 CFR 52.47 were met. Accordingly, the staff reviewed DCD, Tier 2, Section 2.0, Table 2.0-1, to ensure that the applicant included the key geological, seismological, and geotechnical engineering parameters for a site. The staff also reviewed the COL information items specified in DCD, Tier 2, Section 2.0, Table 2.0-2, to verify that the table completely describes the information that COL applicants should provide satisfy 10 CFR Part 100.

The ESBWR standard plant design SSE associated with DCD, Tier 2, Table 2.0-1 is actually a combination of two spectra: an RG 1.60 spectrum (see RG 1.60, Revision 1, "Design Response Spectra for Seismic Design of Nuclear Power Plants," issued December 1973) anchored at 0.3g for the lower frequency portion and the North Anna, VA, site-specific SSE for the high frequency portion (above 9 hertz (Hz)). In RAI 2.5-1, the staff asked the applicant to explain the differences between the high-frequency portion (9 Hz and above) of the ESBWR SSE (shown in DCD, Tier 2, Figure 2.0-1) and the North Anna SSE for the ESP site. In particular, the staff noted that the actual North Anna ESP SSE is slightly larger than the high-frequency portion of the ESBWR SSE. In response, the applicant stated that the spectra shown in DCD, Tier 2, Figures 2.0-1 and 2.0-2, are the high-frequency spectra computed exactly as they were for the North Anna ESP SSE but defined at deeper control points corresponding to the ESBWR control building and reactor/fuel building bases. The North Anna ESP SSE spectrum is from a higher control point at the top of competent rock.

Based on the applicant's explanation of the different control points or depths for the North Anna SSE, the staff finds that the slight differences between the North Anna ESP site specific SSE shown in DCD, Tier 2, Figures 2.5-1 and 2.5-2, and the North Anna ESP SSE presented in Dominion's ESP application for North Anna are acceptable. The staff concludes that it is acceptable for the applicant to specify the ESBWR standard plant design response spectrum at the foundation level, which enables an easy comparison to the minimum design requirements for the SSE covered in Appendix S to 10 CFR Part 50. Appendix S to 10 CFR Part 50 states "the horizontal component of the Safe Shutdown Earthquake Ground Motion in the free-field at the foundation level of the structures must be an appropriate response spectrum with a peak ground acceleration of at least 0.1g." COL applicants referencing the ESBWR standard plant design must ensure that the comparison between the site specific SSE and the standard plant design SSE are made at the same control point. The development of the site-specific SSE by COL applicants, in accordance with SRP Section 2.5.2, is identified as COL Information Item 2.0-27-A.

With regard to the minimum shear wave velocity (300 m/s (1,000 fps)) specified in DCD, Tier 2, Section 2.0, Table 2.0-1, the staff asked the applicant in RAI 2.5-5 to indicate whether this minimum shear wave velocity is applicable to each soil layer in the soil profile or whether it is a value that represents some averaged value for the entire soil column. The applicant defined "minimum shear wave velocity: 300 m/s (1,000 fps)" with a footnote that specifies the use of $V_{eq}$ as the shear wave velocity in Table 2.0-1. Specifically, the footnote states the following:

> This is the equivalent uniform shear wave velocity ($V_{eq}$) at seismic strains after the soil property uncertainties have been applied. $V_{eq}$ is calculated to achieve the same wave traveling time over the depth equal to the embedment depth plus 2 times the largest foundation plan dimension below the foundation as follows:
>
> $$V_{eq} = \frac{\sum d_i}{\sum \frac{d_i}{V_i}}$$
>
> where $d_i$ and $V_i$ are the depth and shear wave velocity, respectively, of the ith layer. The ratio of the largest to the smallest shear wave velocity over the mat

foundation width at the foundation level does not exceed 1.7.

The staff notes that this definition allows the shear wave velocity to be averaged over a specified depth (embedment depth plus 2 times the largest foundation plan dimension) below the foundation. Based on this averaging, the shear wave velocity for the materials beneath the foundation depth can be low since a deeper underlying hard rock layer with a larger shear wave velocity can bring the average shear wave velocity above 300 m/s (1,000 fps) for the soil column under consideration. In addition, the criterion, "the ratio of the largest to the smallest shear wave velocity over the mat foundation width at the foundation level does not exceed 1.7," does not provide any constraint on the minimum shear wave velocity of the profile because the ratio is evaluated "over the mat foundation width at the foundation level."

This definition of $V_{eq}$ also deviates from the staff's position indicated in SRP Section 3.7.1, which specifies that the soils immediately below the foundation have a shear wave velocity of at least 300 m/s (1,000 fps). If the minimum shear wave velocity of the supporting foundation material is less than 300 m/s (1,000 fps), additional analysis should be performed that considers the shear wave velocity profile, and its degree of variability, and the potential impact on soil-structure interactions, potential settlements, and design of foundation elements. In RAI 2.5-10, the staff asked the applicant to justify its definition of $V_{eq}$ and to comment on the potential for low-velocity materials directly beneath the foundation and the implications for settlement, soil response, and foundation design. The staff also asked the applicant to clarify whether the ratio of 1.7 between the largest and smallest shear wave velocity is intended to constrain the soil horizontal heterogeneity, and if not, to explain how the ratio 1.7 was derived and why it was defined over the mat foundation width and at the foundation level.

In responding to the staff's concern, the applicant eliminated $V_{eq}$ as the shear wave velocity parameter and modified Footnote 8 as follows: "This is the minimum shear wave velocity, associated with seismic strains for lower bound soil properties after taking into account uncertainties, at the foundation level." The applicant also explained that it added the requirement that the ratio of the largest to the smallest shear wave velocity over the mat foundation width at the foundation level not exceed 1.7 to address the effect of the soil horizontal heterogeneity.

Despite this revision, the staff continued to have concerns since the shear wave velocity footnote only defines the minimum shear wave velocity for the soil at the foundation level and not for the entire soil profile beneath the foundation. The SSE ground motion response spectrum depends on soil properties, such as the shear wave velocity, over the entire soil profile and not just at the foundation level. To ensure the static and dynamic stability of the foundation, as specified in SRP Section 2.5.4, the staff asked the applicant to justify the specification of the

minimum shear wave velocity values only at the foundation level and not for the entire soil profile. In addition, the staff asked the applicant to specify what it meant by the phrase "lower bound soil properties."

In response to RAI 2.5-10, the applicant stated that it would replace the phrase "at the foundation level" with the phrase "of the supporting foundation material." The applicant also explained that regarding the lower bound soil properties, the phrase," after taking into account uncertainties" would be replaced with "minus one sigma from the mean." These modifications addressed the staff's concerns: 1) defining the minimum shear wave velocity for the "foundation supporting material" instead of "at the foundation level" reflects the fact that the entire soil profile needs to be considered regarding soil static and dynamic properties, and 2) the specific uncertainties used are more clear by using the phrase "minus one sigma from the mean" to replace "after taking into account uncertainties." For this reason, the staff concludes that the applicant's revisions with respect to the minimum shear wave velocity parameter are satisfactory. Based on the applicant's response, RAI 2.5-10 is resolved.

In responding to RAI 3.8-96(details regarding this RAI are provided in SER Section 3.8), the applicant made changes regarding the soil parameters in DCD, Tier 2, Revision 6, Table 2.0-1 and Table 5.1-1 (Tier 1 information). Specifically, the applicant redefined soil properties using both maximum static and dynamic bearing demands instead of capacities, and made changes to corresponding soil parameter values. Demand and capacity are two closely associated parameters. The staff considers that capacity should be used in defining the capability to resist any seismic or nonseismic input generically for the foundation supporting materials. While keeping the capacity, it would also maintain the consistency with respect to soil parameters defined in other DCDs. Therefore, the staff asked the applicant in RAI 2.5-11 to update the tables in terms of the minimum bearing capacity (both static and dynamic) and revise the footnotes to indicate the relationship between the capacity and demand. The applicant responded to this RAI by clearly defining the relationship between the capacity and demand in both tables, i.e., the "minimum static bearing capacity" is "greater than or equal to the maximum static bearing demand multiplied by a factor of safety appropriate for the design load combination." The same relationship also was explicitly defined between the minimum dynamic bearing capacity and maximum bearing demand. In responding to RAI 3.8-96, the applicant also explained that all the numerical value changes were supported by the numerical simulations. Because the applicant clearly indicated the relationship between capacity and demand, supported by numerical values in terms of both static and dynamic demands, the staff considers that the revised contents are fundamentally consistent with the concept of defining soil parameters in other DCDs, and future applicants will be able to consistently address this aspect of soil parameters. Further, as noted previously, these parameters are more appropriately defined in terms of capacity. Based on the applicant's response, this RAI is being tracked as a confirmatory item. This **confirmatory item** will be closed once the applicant has incorporated the proposed DCD changes in DCD, Revision 7, Tier 1, Table 5.1-1 and Tier 2, Section 2.0, Table 2.0-1.

In RAI 2.5-6, the staff asked the applicant to clarify its restrictions with regard to soil liquefaction specified in DCD, Tier 2, Table 2.0-1, which state only "no liquefaction potential." In response to RAI 2.5-6, the applicant revised DCD, Tier 2, Table 2.0-1, to read, "None under footprint of seismic Category I or II structures." In addition, the applicant added a paragraph to DCD, Tier 2, Section 2.0, which states the following:

> The site parameters include a requirement that liquefaction not occur underneath seismic Category I and II SSCs resulting from a site specific SSE. In addition, although the ESBWR design is independent of a particular site and takes into consideration the 0.3g RG spectra, the evaluation of each site for liquefaction potential under seismic Category I and II SSCs uses the site specific SSE with acceptance criteria demonstrating adequate margin for no liquefaction.

The staff finds that the applicant's modifications to DCD, Tier 2, Table 2.0-1 are acceptable because they explicitly specify the site-related requirements with respect to liquefaction. In addition, the applicant's revision of DCD, Tier 2, Table 2.0-1, to specify that no liquefaction potential may exist under the footprint of safety-related structures meets the requirements of 10 CFR 100.23(d)(4), which states that liquefaction potential must be evaluated for the design of nuclear power plants. Furthermore, the staff concurs with the applicant's specification that liquefaction potential be evaluated using the site specific SSE rather than the ESBWR standard plant SSE. Based on the applicant's response, RAI 2.5-6 is resolved.

The use of the site specific SSE to evaluate liquefaction potential is consistent with the requirements of GDC 2, which requires that SSCs important to safety be designed to withstand the effects of natural phenomena, such as earthquakes. Furthermore, GDC 2 states that the design bases for these SSCs must reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The requirements in GDC 2 that "the most severe of the natural phenomena that have been historically reported for the site and surrounding area" be considered clearly indicates that the site-specific SSE should be used to evaluate the potential for liquefaction. DCD, Tier 2, Table 2.0-2 specifies that COL applicants describe the static and dynamic stability of the subsurface materials and foundations. This is identified as COL Information Item 2.0-29-A.

In RAI 2.5-7, the staff asked the applicant to clarify its restrictions with regard to soil stability as specified in DCD, Tier 2, Table 2.0-1, which states only "assumes stable slopes." In response to RAI 2.5-7, the applicant revised DCD, Tier 2, Table 2.0-1, to provide a slope stability factor of safety of 1.5 for static (nonseismic) loading and 1.1 for dynamic (seismic) loading. The staff finds the applicant's specification of factors of safety for static and dynamic loading conditions to be an adequate description of slope stability. In particular, the factor of safety values are compatible with the previously accepted values in NUREG-1835). However, slope stability is a site specific parameter, which depends on many factors, such as the distance between a slope and a safety-related structure and the type of analysis used to determine slope stability. Therefore, the staff will evaluate slope stability analyses on a case-by-case basis to ensure that the analysis methodology adequately characterizes the engineering properties of the soil and rock materials comprising the slopes, as well as the static and dynamic loading conditions. This is identified as COL Information Item 2.0-30-A.

RAIs 2.5-2, 2.5-3, and 2.5-4 identified minor errors and inconsistencies in DCD, Tier 2, Section 2.5. Revision 3 of DCD, Tier 2 eliminated Section 2.5 and consolidated all of the relevant ESBWR standard plant site design parameters into Section 2.0. The staff verified that these issues were no longer relevant to the material in Section 2.0. Thus, these three RAIs are resolved.

In summary, the applicant provided fundamental site parameters for geology, seismology, and geotechnical engineering in site characteristics section. In addition, other than the COL items discussed above, the applicant also defined COL information items to require a COL applicant to (1) provide site specific geology and seismology information, identified as COL Information Item 2.0-26-A, and (2) provide tectonic and nontectonic deformation information, identified as COL Information Item 2.0-28-A, through site specific investigations. The staff finds that they are acceptable.

### 2.5.3 Conclusion

Based on its review, the staff concludes that the applicant has imposed basic site parameters from geology, seismology, and geotechnical engineering perspective in Section 2.0 and the associated tables. These site parameters are consistent with the acceptance criteria in SRP Sections 2.5.1 through 2.5.5, which reflect the requirements of 10 CFR 52.47, Appendix S to 10 CFR Part 50, and 10 CFR 100.23(d)(4).

These site parameters for the ESBWR standard design are established as a basic set of requirements to be satisfied or enveloped by site specific parameters through geological, seismological, and geotechnical investigations. There is no assumed acceptability for any specific site regarding those parameters. A COL applicant should provide sufficient information to demonstrate that the design of the plant envelops the values of the actual site characteristics specified in a COL application.

## REFERENCES


**Atlantic Oceanographic and Meteorological Laboratory (AOML)**

— — — — —, "Frequently Asked Questions, Subject: D4) What Does 'Maximum Sustained Wind' Mean? How Does it Relate to Gusts in Tropical Cyclones?" FAQ: Hurricanes, Typhoons, and Tropical Cyclones, April 2006. http://www.aoml.noaa.gov/hrd/tcfaq/D4.html, (February 2007), (Agencywide Documents Access and Management System (ADAMS) Accession No. ML071650549).

**Structural Engineering Institute and American Society of Civil Engineers (SEI/ASCE)**

— — — — —, SEI/ASCE 7-02, "Minimum Design Loads for Buildings and Other Structures." 2002.

**Electric Power Research Institute (EPRI)**

— — — — —, "Advanced Light Water Reactor Utility Requirements Document, Volume III, ALWR Passive Plant." EPRI: Palo Alto, CA. March 1999.

**GE Energy**

— — — — —, NEDE-33279P, "ESBWR Containment Fission Product Removal Evaluation Model," October 2006, (ADAMS Accession No. ML063060042).

**Global Nuclear Fuel (GNF)**

— — — — —, Letter from A.A. Lingenfelter, GNF, to USNRC Document Control Desk, Transmittal of Updated Attachments Supporting GESTAR II Amendment 28 and Associated GESTAR II Sections (TAC NO. MC3559)", June 2006, (ADAMS Accession No. ML061580110).

**National Hurricane Center (NHC)**

— — — — —, "The Saffir-Simpson Hurricane Scale." The Saffir-Simpson Hurricane Scale. June 22, 2006. http://www.nhc.noaa.gov/aboutsshs.shtml, February 2007, (ADAMS Accession No. ML071650547).

**National Oceanic and Atmospheric Administration (NOAA)**

— — — — —, Hydrometeorological Report No. 52, "Application of Probable Maximum Precipitation Estimates—United States East of the 105$^{th}$ Meridian," August 1982.

— — — — —, Hydrometeorological Report No. 53, "Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates, United States East of the 105$^{th}$ Meridian," April 1980.

***U.S. Code of Federal Regulations***

— — — — —, Title 10, Energy, Part 20, "Standards for Protection against Radiation."

— — — — —, Title 10, Energy, Part 50, "Domestic Licensing of Production and Utilization Facilities."

— — — — —, Title 10, Energy, Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."

— — — — —, Title 10, Energy, Part 100, "Reactor Site Criteria."

**U.S. Nuclear Regulatory Commission (NRC)**

Commission Papers

— — — — —, SECY-06-0220, "Final Rule to Update 10 CFR Part 52, 'Licenses, Certifications, and Approvals for Nuclear Power Plants' (RIN AG24)," October 2006.

NUREG-Series Reports

— — — — —, NUREG/CR-2919, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," September 1982.

— — — — —, NUREG/CR-6331, Revision 1, "Atmospheric Relative Concentrations in Building Wakes," May 1997.

— — — — —, NUREG-0800, Revision 3, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," March 2007.

— — — — —, NUREG-1835, "Safety Evaluation Report for an Early Site Permit (ESP) at the North Anna ESP Site," September 2005, (ADAMS Accession No. ML052710305).

— — — — —, NUREG-1840, "Safety Evaluation Report for an Early Site Permit (ESP) at the Grand Gulf Site," April 2006, (ADAMS Accession No. ML061070443).

— — — — —, NUREG-1844, "Safety Evaluation Report for an Early Site Permit (ESP) at the Exelon Generation Company, LLC (EGC) ESP Site," May 2006, (ADAMS Accession No. ML061210203).

Regulatory Guides

— — — — —, Regulatory Guide 1.23, Revision 1, "Meteorological Monitoring Programs for Nuclear Power Plants," March 2007, (ADAMS Accession No. ML070350028).

— — — — —, Regulatory Guide 1.60, Revision 1, "Design Response Spectra for Seismic Design of Nuclear Power Plants," December 1973.

— — — — —, Regulatory Guide 1.76, Revision 1, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants,” March 2007, (ADAMS Accession No. ML070360253).

— — — — —, Regulatory Guide 1.111, Revision 1, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” July 1977, (ADAMS Accession No. ML003740354).

— — — — —, Regulatory Guide 1.145, Revision 1, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants,” November 1982, (ADAMS Accession No. ML003740205).

— — — — —, Regulatory Guide 1.194, “Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants,”, June 2003, (ADAMS Accession No. ML031530505).

NRC Letters

— — — — —, Letter from L.S. Rubinstein, NRC, to E.E. Kintner, “ALWR Design Basis Tornado”, March 1988, (ADAMS Accession No. ML031270370).

Other NRC Documents

— — — — —, Memorandum from H.R. Denton, NRC to R.R. Maccary “Site Analysis Branch Position—Winter Precipitation Loads”, March 1975, (ADAMS Accession No. ML050630277).