2. SITE ENVELOPE

2.2 Nearby Industrial, Transportation, and Military Facilities

2.2.1 Introduction

AP1000 DCD Section 2.2.1 states that the combined license (COL) applicants referencing the AP1000 certified design will provide site-specific information related to the identification of hazards within site vicinity, including an evaluation of potential accidents due to nearby industrial, transportation, and military facilities.

2.2.2 Evaluation

The U.S. Nuclear Regulatory Commission (NRC) staff has prepared SER Section 2.2 in accordance with the review procedures described in the March 2007 revision of NUREG-0800 Section 2.2.1-2.2.2 "Identification of Potential Hazards in Site Vicinity," and Section 2.2.3 "Evaluation of Potential Accidents," using information presented in AP1000 DCD Revision 17. Since the AP1000 design specific standard chemicals were not evaluated for explosion hazard, the staff has requested (request for additional information (RAI)-SRP2.2-RSAC-01) the applicant to provide required information pertaining to explosion hazards of explosive chemicals stored onsite. The applicant responded with proposed changes to incorporate in the next Revision of AP1000 DCD. The staff has reviewed the applicant's response and the proposed changes to be incorporated into AP1000 DCD Revision 18.

2.2.3 Description of Proposed Change

The applicant identified the proposed changes to design certification document (DCD) Section 2.2 based on the RAI-SRP2.2-RSAC-01 Revision 1. These changes included the description and evaluation of AP1000 certified design specific (standard) chemicals stored onsite for the explosion hazard. The applicant presented for each explosive chemical the minimum safe distance from nearest structure, systems, and components that would not result in an overpressure in excess of 1 psi from potential explosions and flammable vapor clouds (delayed ignition). The list of chemicals along with calculated minimum safe distances are presented in proposed AP1000 DCD Table 2.2-1.

2.2.4 Applicable Regulations and Associated Acceptance Criteria

The relevant requirements of the NRC's regulations for these areas of review, and the associated acceptance criteria, are given in Sections 2.2.1, 2.2.2, and 2.2.3 of NUREG-0800, the standard review plan (SRP), and are summarized below. Review interfaces with other SRP sections can be found in Sections 2.2.1, 2.2.2, and 2.2.3 of NUREG-0800.

1. 10 CFR 52.47(a) (1), "Contents of Applications; Technical Information," which requires a DC applicant to provide site parameters postulated for the design. However, DC applications do not provide a general description of site characteristics because this information is site-specific and is not standard

design-specific and therefore is addressed by the COL applicant. There are no postulated site parameters for a design certification related to Sections 2.2.1, 2.2.2, and 2.2.3 of NUREG-0800.

2. This regulatory basis element is provided for information only since it applies to a COL applicant's final safety analysis report (FSAR) Sections 2.2.1 and 2.2.2. 10 CFR 100.20(b), which requires that the nature and proximity of man-related hazards (e.g., airports, dams, transportation routes, military and chemical facilities) be evaluated to establish site parameters for use in determining whether plant design can accommodate commonly occurring hazards, and whether the risk of other hazards is very low (applies to DCD Sections 2.2.1 and 2.2.2 only).

3. This regulatory basis element is provided for information only since it applies to a COL applicant's FSAR Sections 2.2.1, 2.2.2, and 2.2.3. 10 CFR 52.79(a)(1)(iv), as it relates to the factors to be considered in the evaluation of sites, which require the location and description of industrial, military, or transportation facilities and routes, and of 10 CFR 52.79(a)(1)(vi), as it relates to the compliance with 10 CFR Part 100 (applies to DCD Sections 2.2.1, 2.2.2 and 2.2.3).

Acceptance criteria are provided in the NUREG-0800 to meet the above requirements:

1. This acceptance criterion as related to Section 2.2.1-2.2.2 of NUREG-0800 is provided for information only since it applies to a COL applicant's FSAR Section 2.2.1. Data in the SAR adequately describe the locations and distances from the plant of nearby industrial, military, and transportation facilities and that such data are in agreement with data obtained from other sources, when available (applies to DCD Section 2.2.1 only).

2. This acceptance criterion as related to Section 2.2.1-2.2.2 of NUREG-0800 is provided for information only since it applies to a COL applicant's FSAR Section 2.2.2. Descriptions of 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, are adequate to permit identification of the possible hazards cited in Section III of Sections 2.2.1 and 2.2.2 of NUREG-0800 (applies to DCD Section 2.2.2 only).

3. This acceptance criterion as related to Section 2.2.1-2.2.2 of NUREG-0800 is provided for information only since it applies to a COL applicant's FSAR Section 2.2.2. Sufficient statistical data with respect to hazardous materials are provided to establish a basis for evaluating the potential hazards to the plant or plants considered at the site (applies to DCD Section 2.2.2 only).

4. This acceptance criterion as related to Section 2.2.3 of NUREG-0800 is provided for information only since it applies to a COL applicant's FSAR Section 2.2.3. Event Probability: The identification of Design Basis Events (DBEs) resulting from the presence of hazardous materials or activities in the vicinity of the plant

or plants of specified type is acceptable if all postulated types of accidents are included for which the expected rate of occurrence of potential exposures resulting in radiological dose in excess of the 10 CFR 50.34(a)(1) limits as it relates to the requirements of 10 CFR Part 100 is estimated to exceed the NRC staff objective of an order of magnitude of 10^{-7} per year (applies to DCD Section 2.2.3 only).

5. This acceptance criterion as related to Section 2.2.3 of NUREG-008 is provided for information only since it applies to a COL applicant's FSAR Section 2.2.3. DBEs: The effects of DBEs have been adequately considered, in accordance with 10 CFR 100.20(b), if analyses of the effects of those accidents on the safety-related features of the plant or plants of specified type have been performed and measures have been taken (e.g., hardening, fire protection) to mitigate the consequences of such events (applies to DCD Section 2.2.3 only).

2.2.5 Technical Evaluation

The staff reviewed the applicant's response to RAI-SRP2.2-RSAC-01 which included the proposed revision to AP1000 DCD Revision 17 FSAR Section 2.2 pertaining to the description and evaluation of potential explosion hazards of explosive standard AP1000 design specific chemicals stored onsite. The applicant evaluated the accidents involving potential explosions from the explosive chemicals stored onsite. Minimum safe distance not to exceed 1 psi peak incident overpressure to nearest critical plant structure is determined and presented in Table 2.2-1. The applicant concluded in this section that peak incident overpressure of 1 psi is not exceeded at the nearest SSC. The staff performed independent confirmatory analyses with conservative assumptions and using RG 1.91 methodology and found that the results are comparable to those determined by the applicant. Therefore, the staff concludes that the applicant's methodology is reasonable, and the results and conclusions are acceptable. This proposed revision is Confirmatory Item (CI)-SRP2.2-RSAC-01.

2.2.6 Conclusions

The staff reviewed the applicant's response to RAI-SRP2.2-RSAC-01 and proposed revision to AP1000 DCD FSAR Section 2.2 on Docket No.52-006. The results of staff's technical evaluation of the information related to the evaluation of potential explosion hazard of explosive chemicals stored onsite found to be comparable to the results presented by the applicant to be included in AP1000 DCD revision. Therefore, staff concludes that the applicant's analyses reasonable and conclusions acceptable. This proposed revision will remain as confirmatory item 2.2-1 until perusal of this information in AP1000 DCD Revision.18.

As set forth above, the applicant has identified potential explosion hazards of explosive standard AP1000 design specific chemicals stored onsite, and has appropriately determined those that should be considered as design-basis event, and has demonstrated that the AP1000 design is adequately protected to be operated with an acceptable degree of safety with regard to the potential design-basis explosion event due to explosive chemicals stored onsite. The staff has reviewed the proposed information provided that is to be included in next version of AP1000 DCD, and for the reasons specified above, concludes that the applicant has

established that the AP1000 design meets the requirements of 10 CFR 52.47 (a)(1) and also complies with 10 CFR 52.79(a)(1)(iv).

2.3.1 Regional Climatology

Revision 17 to the AP1000 design control document (DCD) changed some of the air temperature site parameters listed in DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1. Table 2.3.1-1 of this safety evaluation report (SER) presents these changes. Revision 17 changes are benchmarked against Revision 15, because Revision 15 is the version of the AP1000 DCD previously approved by the staff of the U.S. Nuclear Regulatory Commission (NRC).

Table 2.3.1-1 Revisions to Air Temperature Site Parameter Values

TIER LEVEL	SITE PARAMETER	DCD REV. 15	DCD REV. 17
Tier 1 & 2	maximum safety dry bulb with coincident wet bulb	115 °F/80 °F (46.1 °C/26.7 ˚C)	115 °F/86.1 °F (46.1°C/30.1 ˚C)
	maximum safety wet bulb (noncoincident)	81 °F (27. 2 ˚C)	86.1 °F (30.1 ˚C)
Tier 2	maximum normal dry bulb with coincident wet bulb	100 °F/77 °F (37.8 ˚C/25.0 ˚C)	101 °F/80.1 °F (38.3 ˚C/26.7 ˚C)
	maximum normal wet bulb (noncoincident)	80 °F (26.7 ˚C)	80.1 °F (26.7 ˚C)

Note that there were no changes in (1) the minimum safety air temperature site parameter value (-40 degrees Fahrenheit (F)) presented in DCD Tier 1, Table 5.0-1, and (2) the minimum normal air temperature site parameter value (-10 degrees F) presented in both DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1.

Revision 17 also made the following changes to the footnotes in DCD Tier 2, Table 2-1:

- Footnote (b) was expanded to clarify that (1) the maximum normal values are 1-percent seasonal exceedance temperatures (June through September in the northern hemisphere), which are approximately equivalent to the annual 0.4-percent exceedance temperatures, and (2) the minimum normal value is the 99-percent seasonal exceedance temperature (December through February in the northern hemisphere) which is approximately equivalent to the annual 99.6-percent exceedance temperature.

- Footnote (g) was added to state that the containment pressure response analysis is based on a conservative set of dry-bulb and wet-bulb temperatures that envelop any conditions where the dry-bulb temperature is 115 degrees F or less and the wet-bulb temperature is less than or equal to 86.1 degrees F.

These revisions relied on the following source documents:

- APP-GW-GLN-108, "AP1000 Site Interface Temperature Limits," Revision 2, September, 2007

- APP-GW-GLE-036, "Impact of a Revision to the Current Wet Bulb Temperature Identified in Table 5.0-1 (Tier 1), and Table 2-1 (Sheet 1 of 3) of the DCD (Revision 16)," Revision 0, June 27, 2008

2.3.1.1 Evaluation

The NRC staff has prepared SER Section 2.3.1 in accordance with the review procedures described in the March 2007 revision of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (hereafter referred to as the SRP), Section 2.3.1, using information presented in DCD Revision 17, APP-GW-GLN-108, APP-GW-GLE-036, and the applicant's responses to the NRC requests for information (RAIs) on APP-GW-GLN-108 and APP-GW-GLE-036. The applicant incorporated the RAI responses in DCD Revision 17; as a result, all the RAIs are closed and the SER does not discuss them.

2.3.1.1.1 General Description

Title 10 of the Code of Federal Regulations (10 CFR) Section 52.47(a)(1) requires in part that the standard design certification (DC) application contain the site parameters postulated for the design, and 10 CFR 52.79(d)(2) requires a combined license (COL) application (final safety analysis report (FSAR)) referencing a standard design to demonstrate that the site characteristics fall within the site parameters specified in the DC. DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, present the list of AP1000 site parameters. If the FSAR does not demonstrate that the site characteristics fall within the site parameters specified in the DC, the COL application must include a request for an exemption or departure, as appropriate, that complies with the requirements of the referenced DC rule and 10 CFR 52.93, "Exemptions and Variances."

SER Section 2.3.1 addresses the climatic site parameters (i.e., air temperature, wind speed, precipitation (snow and ice)) used as design bases for the AP1000. The list of Tier 1 site parameters includes maximum and minimum *safety* air temperature values, which are based on historical data and exceed peaks of less than 2 hours; the list of Tier 2 site parameters includes the same maximum and minimum *safety* air temperature values as well as maximum and minimum *normal* air temperature values, which are 1-percent seasonal exceedance values.

2.3.1.1.2 Description of Proposed Change

SER Table 2.3.1-1 lists the changes in air temperature site parameter values from DCD Revision 15 to DCD Revision 17. SER Table 2.3.1-1 shows that all the revised air temperature site parameter values are greater than before: the maximum safety coincident wet bulb increased 6.1 degrees F (from 80 degrees F to 86.1 degrees F), the maximum safety noncoincident wet bulb increased 5.1 degrees F (from 81 degrees F to 86.1 degrees F), the maximum normal dry bulb increased 1 degree F (from 100 degrees F to 101 degrees F), the maximum normal coincident wet bulb increased 3.1 degrees F (from 77 degrees F to

80.1 degrees F), and the maximum normal noncoincident wet bulb increased 0.1 degrees F (from 80 degrees F to 80.1 degrees F).

The applicant used APP-GW-GLN-108 as its source document for the DCD Revision 16 changes in maximum safety noncoincident wet bulb (from 81 degrees F to 85.5 degrees F), maximum normal coincident wet bulb (from 77 degrees F to 80.1 degrees F), and maximum normal noncoincident wet bulb (from 80 degrees F to 80.1 degrees F). This document states that these modifications to air temperature site parameters better accommodate a broader range of conditions to encompass the potential sites for AP1000 plants. It also provides details on the effects of these changes to air temperature site parameters on a number of structures, systems, and components (SSCs), such as the passive containment cooling system, the normal residual heat removal system, the spent fuel pool cooling system, the service water system, the component cooling water system, and the central chilled water system.

The applicant used APP-GW-GLE-036 as its source document for the subsequent changes in maximum safety coincident wet bulb (from 80 degrees F to 86.1 degrees F), maximum safety noncoincident wet bulb (from 85.5 degrees F to 86.1 degrees F), and maximum normal dry bulb (from 100 degrees F to 101 degrees F). This document states that these changes encompass more sites in the eastern United States, such as Levy County (Levy) and Turkey Point. It also provides details on the effects of these changes to air temperature site parameters on the SSCs listed above.

2.3.1.1.3 Applicable Regulations and Associated Acceptance Criteria

Acceptance criteria regarding regional climatology site parameters, such as air temperature, are based on meeting the relevant requirements of 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.” GDC 2 states, in part, that SSCs important to safety must be designed to withstand the effects of natural phenomena without losing the ability to perform their safety functions.

GDC 2 also states that the design bases for these SSCs shall 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 the historical data have been accumulated.

SRP Section 2.3.1 states that the DC application should include ambient temperature and humidity statistics for use in establishing heat loads for the design of normal plant heat sink systems; postaccident containment heat removal systems; and plant heating, ventilation, and air conditioning systems. SRP Section 2.3.1 also states that the climatic conditions identified as site parameters for DC applications 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.

2.3.1.1.4 Technical Evaluation

This SER section is limited to reviewing the appropriateness of the values chosen as air temperature site parameters; other SER sections (e.g., 5.4.7, 6.2.2, 9.1.3, 9.2.1, 9.2.2, and 9.2.7) review the effects of these changes to air temperature site parameters on SSCs.

To determine if the applicant's revised air temperature site parameters are representative of a reasonable number of potential COL sites, the NRC staff reviewed dry-bulb and wet-bulb data from the Weather Data Viewer database of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). This database, which is discussed in Chapter 28 of the 2005 ASHRAE Handbook—Fundamentals, contains climatic design information for approximately 700 weather stations in the continental United States. The ASHRAE database includes statistics for each weather station, such as extreme wet-bulb, 0.4-percent annual exceedance wet-bulb, and 0.4-percent annual exceedance dry-bulb temperatures.

The ASHRAE extreme wet-bulb data represent hourly data (e.g., the highest of the values measured once each hour), whereas the AP1000 maximum safety coincident and noncoincident wet-bulb site parameter values of 86.1 degrees F exclude peaks of less than 2 hours. Consequently, the NRC staff examined the ASHRAE database to identify those weather stations that had extreme wet-bulb data exceeding 87.1 degrees F, assuming such occurrences would be equivalent to a 2-hour peak exceeding 86.1 degrees F. The NRC staff found that approximately 15 percent (97 out of 660) of the weather stations located throughout the continental United States had an extreme wet-bulb value exceeding 87.1 degrees F. Because only a small number (i.e., 15 percent) of weather stations had an extreme wet-bulb value that exceeded 87.1 degrees F, the NRC staff concludes that the AP1000 maximum safety coincident and noncoincident wet-bulb air temperature site parameter values of 86.1 degrees F can be expected to bound a reasonable number of sites that have been or may be considered for a COL application.

The NRC staff also examined the ASHRAE database to identify the number of weather stations that exceeded a 0.4-percent annual exceedance wet-bulb value of 80.1 degrees F. The AP1000 maximum normal coincident and noncoincident wet-bulb site parameter values of 80.1 degrees F are 1-percent seasonal exceedance values, which are likely to be about the same as a 0.4-percent annual exceedance wet-bulb value of 80.1 degrees F. The NRC staff found that approximately 11 percent (75 out of 660) of the weather stations had a 0.4-percent wet-bulb value exceeding 80.1 degrees F. Because only a small number (i.e., 11 percent) of weather stations had a 0.4-percent wet-bulb value that exceeded 80.1 degrees F, the NRC staff concludes that the AP1000 maximum normal coincident and noncoincident wet-bulb air temperature site parameter values of 80.1 degrees F can be expected to bound a reasonable number of sites that have been or may be considered for a COL application.

The NRC staff also examined the ASHRAE database to identify the number of weather stations where the 0.4-percent annual exceedance dry-bulb value exceeded 101 degrees F. The AP1000 maximum normal dry-bulb site parameter value of 101 degrees F is a 1-percent seasonal exceedance value that is likely to be about the same as a 0.4-percent annual exceedance dry-bulb value of 101 degrees F. The NRC staff found that approximately 5 percent (38 out of 700) of the weather stations had a 0.4-percent dry-bulb value exceeding 101 degrees F. Because only a small number (i.e., 5 percent) of weather stations had a 0.4-percent

dry-bulb value that exceeded 101 degrees F, the NRC staff concludes that the AP1000 maximum normal dry-bulb air temperature site parameter of 101 degrees F which is likely to bound a reasonable number of sites that have been or may be considered for a COL application.

2.3.1.1.6 Technical Conclusions

The applicant has selected a revised set of air temperature site parameters referenced above for plant design inputs, and the NRC staff agrees that these revised site parameters can be expected to be representative of a reasonable number of sites that have been or may be considered for a COL application. This will ensure that GDC 2 is met, in that SSCs important to safety will be designed to withstand the effects of natural phenomena (e.g., extreme air temperatures) without losing the ability to perform their safety functions and will reduce the number of requests for exemptions or departures in future COL applications, which could occur if the FSAR cannot demonstrate that the design of the facility falls within the characteristics of the site.

AP1000 COL Information Item 2.3-1 states that COL applicants referencing the AP1000 design will address site-specific information related to regional climatology. The COL applicant will also need to demonstrate that the characteristics of the selected site fall within the site parameters specified in the design approval, pursuant to 10 CFR 52.79(c)(1). For a selected site with any of the air temperature site characteristics in excess of the corresponding AP1000 site parameters, the COL applicant will need to address how the SSCs important to safety will be able to withstand the effects of the natural phenomena without losing the ability to perform their safety functions in accordance with GDC 2.

In determining site characteristic values for comparison with the AP1000 maximum safety site parameter values, a COL applicant should select the higher of either (1) the most severe value that has been historically reported for the site and surrounding area, or (2) the 100-year return period value. Regulations in 10 CFR 52.79(a)(1)(iii) state, in part, that the COL FSAR shall include the meteorological characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and time in which the historical data have been accumulated. To comply with 10 CFR 52.79(a)(1)(iii), the maximum safety ambient temperature site-specific characteristic values identified by the COL applicant should be based on the higher of either (1) the historic maximum values recorded in the site vicinity or (2) the 100-year return period values. Temperatures based on a 100-year return period are considered to provide sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, as required by the regulation.

APP-GW-GLE-036 states that the revisions to the maximum safety coincident and noncoincident wet-bulb temperatures were implemented to encompass more sites in the eastern United States, such as Levy and Turkey Point. APP-GW-GLE-036 further states that Progress Energy chose the revised wet-bulb temperature values to support the COL application for the Levy site, to avoid any departures from the AP1000 design. The NRC staff's acceptance of the revised AP1000 maximum safety coincident and noncoincident wet-bulb temperature values as being expected to bound a reasonable number of sites does not imply that the NRC staff finds that these revised values bound the corresponding site characteristic values for the

Levy site. The NRC staff will assess the maximum safety coincident and noncoincident wet-bulb temperature site characteristic values as part of its review of the Levy COL application.

2.3.1.2 Conclusion

The NRC staff has reviewed the information presented by the applicant and concludes that the changes in air temperature site parameters are acceptable, because they meet the requirements of GDC 2 in Appendix A to 10 CFR Part 50 and 10 CFR 52.63(a)(1), as well as the associated acceptance criteria specified in SRP Section 2.3.1.

2.3.4 Short-Term (Accident) Atmospheric Relative Concentration

Revision 17 to the AP1000 Design Control Document (DCD) made changes to some of the control room (CR) atmospheric dispersion factors (also known as atmospheric relative concentration or χ/Q) presented in DCD Revision 15. Staff of the U.S. Nuclear Regulatory Commission (NRC) benchmarked the Revision 17 changes against Revision 15, which is the previously staff-approved version of the AP1000 DCD. The applicant made the following changes:

(1) The applicant revised the CR χ/Q values presented in DCD Tier 1, Table 5.0-1, and DCD Tier 2, Tables 2-1 and 15A-6, for plant vent or passive containment cooling system (PCS) air diffuser and ground-level containment releases to the CR heating, ventilation, and air conditioning (HVAC) intake and annex building door. Table 2.3.4-1 of this safety evaluation report (SER) lists these revisions.
(2) The applicant added CR χ/Q values for condenser air removal stack releases to the HVAC intake and annex building door to DCD Tier 1, Table 5.0-1, and DCD Tier 2, Tables 2-1 and 15A-6. SER Table 2.3.4-1 presents a list of these revisions.
(3) The applicant revised some of the CR source and receptor data provided in DCD Tier 2, Table 15A-7, for determining CR atmospheric dispersion factors. SER Table 2.3.4-2 lists these revisions.

The following served as source documents for these revisions:

- AP1000 Document No. APP-GW-GLE-001 Revision 0, March 7, 2008, “Impact of Annex Building Expansion and Condenser Air Removal Stack Location on the Control Room Atmospheric Dispersion Factors”
- AP1000 Document No. APP-GW-GLN-122 Revision 0, July 2007, “Offsite and Control Room Dose Changes”

2.3.4.1 Evaluation

The NRC staff prepared SER Section 2.3.4 in accordance with the review procedures described in the March 2007 revision of the Standard Review Plan (SRP), Section 2.3.4, using information presented in Revision 17 of the DCD, APP-GW-GLE-001, APP-GW-GLN-122, and the applicant’s responses to NRC requests for additional information (RAIs) on APP-GW-GLE-001 and APP-GW-GLN-122. Where appropriate, the applicant has incorporated the RAI responses in Revision 17 of the DCD; as a result, the staff considers all RAIs related to the DCD to be closed. Therefore, this SER does not discuss these RAIs.

2.3.4.1.1 General Description

Section 2.3.4 addresses, among other items, the χ/Q estimates at the CR for postulated design-basis accidental radioactive airborne releases. In lieu of site-specific meteorological data, the applicant provided a set of hypothetical, short-term CR χ/Q values to evaluate the AP1000 design. The set of AP1000 site parameters listed in DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, includes these CR χ/Q values. DCD Tier 2, Section 2.3.4, states that the applicant derived the short-term χ/Q site parameters from a study performed to determine the short-term χ/Q values that would envelop most current plant sites. The CR radiological consequence analyses presented in DCD Tier 2, Sections 6.4 and 15.6.5, use the resulting CR short-term χ/Q values.

2.3.4.1.2 Description of Proposed Changes

(1) Changes in Plant Vent or PCS Air Diffuser and Ground-Level Containment Release χ/Q Values

SER Table 2.3.4-1 lists the applicant's changes to the CR χ/Q values from DCD Revision 15 to DCD Revision 17 for plant vent or PCS air diffuser and ground-level containment releases to the HVAC intake and annex building door. SER Table 2.3.4-1 shows that all plant vent or PCS air diffuser and ground-level containment release CR χ/Q values increased in DCD Revision 17. The extent of this increase ranged from 36 percent to over 400 percent.

The CR habitability analyses used the HVAC intake χ/Q values for (a) evaluating the time period preceding the isolation of the main CR and actuation of the emergency habitability system, (b) evaluating the time period after 72 hours when the compressed air supply in the emergency habitability system would be exhausted and outside air would be drawn into the main CR, and (c) determining CR doses when the nonsafety ventilation system is assumed to remain operable such that the emergency habitability system is not actuated. The analyses used the annex building door χ/Q values when the emergency habitability system is in operation and the only pathway for contaminated air entering the CR is assumed to be the result of ingress or egress. The applicant's source document for these revisions in atmospheric dispersion factors is APP-GW-GLN-122. Revision 0 to this document described three changes implemented in DCD Revision 16 that reduced some of the calculated radiological doses off site and in the main CR for design-basis accidents. These three changes were (a) directing the main CR emergency habitability system discharge airflow into the entry vestibule to provide a continuous vestibule purge, (b) increasing the decay time in Technical Specification 3.9.7, "Decay Time, Refueling Operations," from 24 hours to 48 hours to provide increased radioactive decay of short-lived fission products before irradiated fuel assemblies are handled, and (c) revising the calculation of radioactivity released for the postulated loss-of-coolant accident (LOCA) to take credit for aerosol impaction removal in the containment leakage pathway. The staff approved the first two changes but did not approve the last change; nonetheless, the first two changes allowed the CR atmospheric dispersion site parameter values shown in SER Table 2.3.4-1 to be increased to accommodate sites with higher χ/Q values than those originally specified in DCD Revision 15. Larger χ/Q values are associated with less dilution capability, resulting in higher 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 those required by the reactor design.

(2) New Condenser Air Removal Stack Release χ/Q Values

SER Table 2.3.4-1 lists the new condenser air removal stack release χ/Q values presented in DCD Revision 17. DCD Revision 15 did not present CR χ/Q values for this release pathway. The applicant's source document for these new χ/Q values is APP-GW-GLE-001. This report addresses concerns associated with a correction made to the location of the condenser air removal stack, as shown in DCD Tier 2, Table 15A-7 and Figure 15A-1. The corrected location decreased the distance between the condenser air removal stack and the annex building access door. Footnote 5 in Revision 15 of DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, stated that the listed χ/Q values for the power-operated relief valve (PORV) and safety valve releases bound the dispersion factors for releases from the condenser air removal stack. With the revised location of the condenser air removal stack, the applicant was concerned that this statement may no longer be valid. Consequently, in APP-GW-GLE-001, the applicant (a) modified Footnote 5 to eliminate the assertion that the listed χ/Q values for the PORV and safety valve releases bound the dispersion factors for releases from the condenser air removal stack, (b) added atmospheric dispersion factors specifically for the condenser air removal stack release point, and (c) added Footnote 7 to DCD Tier 1, Table 5.0-1, and DCD Tier 2, Tables 2-1 and 15A-6, which states that the condenser air removal stack release point was included for information only as a potential activity release point and none of the design-basis accident radiological consequence analyses model releases from this release point.

APP-GW-GLE-001 states that, because the straight-line distances are similar, the applicant chose the same atmospheric dispersion factors for the condenser air removal stack releases to the HVAC intake as those currently defined values used for the release-receptor pair of the fuel-handling area to the HVAC intake. Similarly, APP-GW-GLE-001 states that, because the straight-line distances are similar, the applicant chose the same atmospheric dispersion factors for the condenser air removal stack releases to the annex building entrance as those currently defined values used for the release-receptor pair of PORV and safety values to the HVAC intake.

(3) Revised Control Room Source and Receptor Data

SER Table 2.3.4-2 lists the changes in CR source and receptor data between DCD Revision 15 and DCD Revision 17. SER Table 2.3.4-2 shows that the horizontal straight-line distances from all release points (except for the condenser air removal stack) to the HVAC intake and annex building access receptors increased.

The applicant used APP-GW-GLE-001 as the source document for these source and receptor changes. This report addresses the impact of a relocation of the annex building entrance and HVAC intake on the CR source and receptor data to be used in determining site-specific CR χ/Q values. With an exception for the condenser air removal stack, the relocation of these two CR receptor locations increased the distances between the previously identified release points and these receptors. A correction made to the location of the condenser air removal stack, as

discussed above, decreased the distances between the condenser air removal stack release pathway and the HVAC intake and annex building access receptors.

2.3.4.1.3 Applicable Regulations and Associated Acceptance Criteria

Acceptance criteria regarding the CR χ/Q site parameter values are based on meeting the relevant requirements of General Design Criterion (GDC) 19, "Control Room," in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," which states, in part, that a CR shall be provided from which actions can be taken to maintain the nuclear power unit in a safe condition under accident conditions, including a LOCA. Atmospheric dispersion factors are an important component of the CR radiological habitability analyses used to demonstrate that the CR operator dose criterion in GDC 19 is met.

SRP Section 2.3.4 states that the design certification (DC) application should include CR atmospheric dispersion factors 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 will use to generate CR χ/Q values (e.g., intake heights, release heights, building cross-sectional areas, distance to receptors). Section 2.3.4 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. Regulatory Guide (RG) 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," presents criteria for characterizing atmospheric dispersion conditions for evaluating the consequences of radiological releases to the CR. RG 1.194 states that the ARCON96 atmospheric dispersion model (Revision 1 to NUREG/CR-6331, "Atmospheric Relative Concentrations in Building Wakes") is an acceptable methodology for assessing CR χ/Q values for use in CR design-basis accident radiological analyses, subject to the provisions in RG 1.194.

2.3.4.1.4 Technical Evaluation

This SER section is limited to reviewing the appropriateness of the values chosen as atmospheric dispersion site parameters; other SER sections (e.g., Sections 6.4 and 15.3) review the effects of the implemented χ/Q revisions on the design-basis dose calculations. To confirm that the revised set of plant vent or PCS air diffuser and ground-level containment release CR χ/Q site parameters and the new set of condenser air removal stack release CR χ/Q site parameters presented in Revision 17 to the DCD are representative of a reasonable number of sites that have been or may be considered for a COL application, the staff generated site-specific χ/Q values for the four docketed early site permit (ESP) applications (North Anna, Clinton, Grand Gulf, and Vogtle) using the ARCON96 computer code with (1) the revised source and receptor information presented in DCD Tier 2, Table 15A-7 (assuming the AP1000 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 AP1000 CR χ/Q site parameter values were bounding in all cases. Consequently, the staff finds that the applicant has provided CR atmospheric dispersion site parameter values that bound several sites that may be considered within a COL application and are therefore acceptable. The CR atmospheric dispersion site parameters will help to ensure that the CR operator dose criterion in

GDC 19 is met. APP-GW-GLE-001 revised the CR χ/Q source and receptor data presented in DCD Tier 2, Table 15A-7, based on a correction made to the location of the condenser air removal stack and relocation of the annex building entrance and CR air inlet. In all cases (except for the condenser air removal stack), the distances between the sources and receptors increased. Since χ/Q values generally decrease as downwind travel distances increase, APP-GW-GLE-001 was conservative in that it did not change the CR atmospheric dispersion factors presented in DCD Tier 1, Table 5.0-1, and DCD Tier 2, Tables 2-1 and 15A-6, to reflect the increases in downwind distances. The applicant based the revisions in χ/Q values presented in SER Table 2.3.4-1 on the changes implemented in response to the findings of APP-GW-GLN-122 as discussed previously. Based on the information above the staff finds this acceptable.

2.3.4.1.5 Technical Conclusions

The applicant has selected a revised set of short-term (accident) CR atmospheric dispersion site parameters referenced above for plant design inputs. The staff agrees that these revised CR χ/Q values can be expected to be representative of a reasonable number of sites that have been or may be considered for a COL application. AP1000 COL Information Item 2.3-4 states, in part, that a COL applicant referencing the AP1000 design will address the site-specific CR χ/Q values. For a site selected that exceeds the bounding CR χ/Q values, COL Information Item 2.3-4 further states that the COL applicant will address how the radiological consequences associated with the controlling design-basis accident continue to meet the CR operator dose limits given in GDC 19 using site-specific χ/Q values. The staff concludes that successful completion of COL Information Item 2.3-4 will demonstrate that the short-term (accident) atmospheric dispersion factors for the CR will be acceptable.

2.3.4.2 Conclusion

The staff has reviewed the information presented by the applicant and concludes that the changes in short-term (accident) CR site parameters are acceptable because they meet the requirements of GDC 19 and 10 CFR 52.63(a)(1) and the associated acceptance criteria specified in SRP Section 2.3.4.

Table 2.3.4-1
Revisions to CR Atmospheric Dispersion Factor (χ/Q) Site Parameter Values (s/m^3)

SITE PARAMETER	DCD REVISION 15	DCD REVISION 17	% INCREASE
Plant Vent or PCS Air Diffuser Release to the HVAC Intake			
0–2 hours	2.2E-3	3.0E-3	136%
2–8 hours	1.4E-3	2.5E-3	179%
8–24 hours	6.0E-4	1.0E-3	167%
1–4 days	4.5E-4	8.0E-4	178%
4–30 days	3.6E-4	6.0E-4	167%
Plant Vent or PCS Air Diffuser Release to the Annex Building Door			
0–2 hours	6.6E-4	1.0E-3	152%
2–8 hours	4.8E-4	7.5E-4	156%
8–24 hours	2.1E-4	3.5E-4	167%
1–4 days	1.5E-4	2.8E-4	187%
4–30 days	1.3E-4	2.5E-4	192%
Ground-Level Containment Release to the HVAC Intake			
0–2 hours	2.2E-3	6.0E-3	273%
2–8 hours	1.4E-3	3.6E-3	257%
8–24 hours	6.0E-4	1.4E-3	233%
1–4 days	4.5E-4	1.8E-3	400%
4–30 days	3.6E-4	1.5E-3	417%
Ground-Level Containment Release to the Annex Building Door			
0–2 hours	6.6E-4	1.0E-3	152%
2–8 hours	4.8E-4	7.5E-4	156%
8–24 hours	2.1E-4	3.5E-4	167%
1–4 days	1.5E-4	2.8E-4	187%
4–30 days	1.3E-4	2.5E-4	192%
Condenser Air Removal Stack Release to the HVAC Intake			
0–2 hours	None Provided	6.0E-3	--
2–8 hours		4.0E-3	
8–24 hours		2.0E-3	
1–4 days		1.5E-3	
4–30 days		1.0E-3	
Condenser Air Removal Stack Release to the Annex Building Door			
0–2 hours	None Provided	2.0E-2	--
2–8 hours		1.8E-2	
8–24 hours		7.0E-3	
1–4 days		5.0E-3	
4–30 days		4.5E-3	

Table 2.3.4-2

Revisions to CR Atmospheric Dispersion Factor (χ/Q) Site Parameter Values (s/m^3)

	RELEASE ELEVATION		HORIZONTAL STRAIGHT-LINE DISTANCE TO RECEPTOR			
			HVAC INTAKE (ELEVATION 19.9 METER(m))		ANNEX BUILDING ACCESS (ELEVATION 1.5 METER(m))	
RELEASE POINT	REV. 15	REV. 17	REV. 15	REV. 17	REV. 15	REV. 17
Plant Vent	55.7 m	No Change	39.6 m	44.9 m	76.8 m	115.6 m
PCS Air Diffuser	71.3 m	69.8 m	32.3 m	36.0 m	68.9 m	104.6 m
Fuel Building Blowout Panel	17.4 m	No Change	50.0 m	61.9 m	89.7 m	130.3 m
Fuel Building Rail Bay Door	1.5 m	No Change	52.4 m	66.6 m	92.1 m	132.1 m
Steam Vent	17.1 m	No Change	18.3 m	18.8 m	48.8 m	79.7 m
PORV/Safety Valves	19.2 m	No Change	19.8 m	20.4 m	44.1 m	77.8 m
Condenser Air Removal Stack	7.6 m	38.4 m	63.0 m	60.4 m	59.9 m	17.8 m
Containment Shell	Same as receptor elevation (19.9 m or 1.5 m)	No Change	11.0 m	12.8 m	47.2 m	83.0 m

2.4 Hydrologic Engineering

2.4.1 Hydrological Description

The AP1000 is a standard design with a plant configuration that assumes a normal water level at 0.6 meter (m) (2 feet (ft)) below the grade, and a flood level at the design plant grade of 30.5 m (100 ft). The actual grade level will be a few inches lower to prevent surface water ingress through the doorways. This provision recognizes that the Utility Requirements Document (URD) states that the maximum flood (or tsunami) level site envelope parameter is 0.3 m (1 ft) below grade. Although the AP1000 design flood level of 30.5 m (100 ft) does not meet the URD flood level criterion explicitly, this deviation is considered inconsequential to safety.

The maximum flood level mentioned above is based on a site parameter referred to as the probable maximum flood (PMF). The PMF is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably

possible in a particular drainage area and is generated by a separate parameter called the probable maximum precipitation (PMP). The PMP is the greatest depth (amount) of precipitation, for a given storm duration, that is theoretically possible for a particular area and geographic location. PMP values are typically found in the National Weather Service hydro-meteorological reports (HMRs).

The applicant proposed a change to the PMP parameter value from 1.37×10^{-4} meter/sec (19.4 inches per hour (in./h)) to 1.46×10^{-4} meter/sec (20.7 in./h) in the AP1000 DCD, Revision 17.

2.4.2 Regulatory Basis

The staff considered the following regulatory requirements in reviewing the applicant's submittal:

- 10 CFR 100.20(c)(3), as it relates to the PMF
- 10 CFR 52.47(a)(1), as it relates to the site parameters postulated for the design
- 10 CFR 52.79(a)(1)(iii), as it relates to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated
- GDC 2, "Design Bases for Protection Against Natural Phenomena," which states in part that structures, systems, and components (SSCs) important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without the loss of capability to perform their safety functions

2.4.3 Summary of Technical Information

In Revision 0 of APP-GW-GLE-012, "Probable Maximum Precipitation Value Increase," the applicant proposed to change the PMP value from 1.37×10^{-4} m/s (19.4 in./h) to 1.46×10^{-4} m/s (20.7 in./h). This value is found in Tier 1, Table 5.0-1, "Site Parameters," on page 5.0-2, and in Tier 2, Table 2-1 (Sheet 3 of 4), "Site Parameters," on page 2-21 of the AP1000 DCD, Revision 17.

2.4.4 Technical Evaluation

The applicant has determined a new PMP value of 1.46×10^{-4} m/s (20.7 in./h) based on an interpretation of Figure 24 in HMR-52 from the National Weather Service. The staff, while not agreeing with this interpretation of Figure 24 found in HMR-52, does agree with the applicant's statements made in the associated AP1000 DCD impact document and has no objection to this change in the PMP value for the AP1000 DCD. The NRC staff held a phone conference call with the applicant on August 21, 2008, to discuss technical issues related to the change. As a followup to that phone call, the staff issued RAI-SRP2.4-RHEB-01. The RAI included three surface water and three ground water questions. The first surface water question was associated with Table 3.3-5, Tier 1, inspection, test, analyses, and acceptance criteria (ITAAC)

Design Commitment 2.b related to the tolerance value of ±1.07m (±3.5 ft) between the design plant grade and the site grade. On September 15, 2008, the applicant responded to RAI-SRP2.4-RHEB-01 in a letter, DCP/NRC2264. Specifically, the applicant, in its response to this question, stated that the tolerance of 1.07m (3.5 ft) between design plant grade and site grade in DCD Tier 1, Table 3.3-5, is based on seismic and soil-structure interaction (SSI) considerations for the auxiliary, shield, and containment buildings. Furthermore, this tolerance is not related to hydrology or surface water considerations. The applicant further stated that it is not appropriate to use this tolerance to establish the relationship between the design plant grade and the PMF. Based on this clarification, the NRC staff finds the response acceptable and considers this question resolved.

The second surface water question asked the applicant to specify where on the site the ITAAC Design Commitment 2.b should be met and to which buildings the commitment should be applied. In letter DCP/NRC2264, the applicant stated that the zone of influence of soil characteristics on the structural response of an embedded structure is generally considered to extend horizontally away from the structure the same distance as the depth of the embedment.

For the AP1000, this distance is approximately 12.2m (40 ft) from the auxiliary and shield buildings. Additionally, the applicant stated that other evaluations and analyses address the effects of buildings founded at grade adjacent to the nuclear island on the seismic interaction. The applicant also stated that ITAAC Commitment 2.b in DCD Tier 1, Section 3.3, does not apply to site surface water flooding. Based on this information, the NRC staff considers the applicant's response to be acceptable, and the issue is resolved.

The third surface water question asked the applicant to describe the expected vertical distance and tolerance between (1) the design plant grade, (2) the to-be-built site grade, and (3) the maximum surface water elevation associated with a flood (see Table 5.0-1, DCD Tier 1) and to identify to which building these distances and tolerances apply. In letter DCP/NRC2264, the applicant stated that Table 5.0-1 includes the COL information specifying the compliance of the site PMF level with the plant site design parameters. This table defines the distance between the design plant grade of elevation 30.5m (100 ft) and the maximum surface water elevation. The applicant also stated that ITAAC Commitment 2.b in DCD Tier 1, Section 3.3, does not define the distance between the design plant grade of elevation 100 ft and the maximum surface water elevation. The NRC staff finds this response acceptable and considers this issue resolved.

The first ground water question in RAI-SRP2.4RHEB-01 asked the applicant to clarify its definition of normal ground water elevation in Tier 2 of the DCD. In letter DCP/NRC2264, the applicant stated that Table 5.0-1 of DCD Tier 1 defines the maximum ground level as plant elevation 98 ft and the maximum flood level as plant elevation 30.5m (100 ft.) The applicant also stated that the reference to normal ground water is applicable at all times except when there is surface water flooding. The NRC staff found this response to be unacceptable because the applicant did not specify the maximum ground water level, but instead allowed an exception to the ground water level under certain conditions. This issue was open item **OI-SRP2.4RHEB-01-01**. In letter DCP/NRC2629, the applicant retracted the statement referencing normal ground water levels except under conditions of surfacing water flooding and made clear there are no exceptions to the normal ground water elevation. With this exception

removed, this response is acceptable to the staff, and open item OI-SRP2.4RHEB-01-01 is resolved.

The second ground water question in RAI-SRP2.4RHEB-01 asked the applicant to specify to which buildings in Table 5.0-1, DCD Tier 1, the maximum ground water level elevations should be applied. The applicant replied in letter DCP/NRC2264 that the DCD Tier 1, Table 5.0-1, specification of maximum flood level at plant elevation 30.5m (100 ft) (design-grade elevation) is specifically applicable to the safety-related nuclear island. Furthermore, the buildings adjacent to the nuclear island are founded at grade and use the same reference elevation designation as the auxiliary building and the containment building. The applicant also stated that differences in actual elevation between the nuclear island and the adjacent buildings conform to standard construction tolerances and are independent of site grade variation.

The applicant further stated that the site grading, including local slope to encourage run off away from the doorways of the buildings included in the certified design, is site specific. Based on the information, the NRC staff finds this response acceptable, and the issue is resolved.

The third ground water question in RAI-SRP2.4RHEB-01 asked the applicant to specify the maximum allowed water table elevation and the maximum time this elevation can be sustained without an increase in safety risk. The applicant responded to this question in letter DCP/NRC2264, stating that the normal water table elevation is expected to be exceeded only during surface water flooding events. In addition, while surface water flooding may impede access to the AP1000, the AP1000 is designed to cope with impeded access for a period of 7 days. The NRC staff found this response unacceptable because the applicant failed to specify the maximum allowed water table and the time this elevation can be sustained without an increase in safety risk. This issue was open item **OI-SRP2.4RHEB-01-02**. In letter DCP/NRC2629, the applicant retracted the statement referencing normal ground water levels except under conditions of surface water flooding and made clear there are no exceptions to the normal ground water elevation. With the removal of this exception, this response is acceptable to the staff and OI-SRP2.4RHEB-01-02 is resolved.

2.4.5 Conclusion

The applicant has presented information relative to the PMP value found in DCD Tier1, Table 5.0-1, and in DCD Tier 2, Table 2-1 (Sheet 3 of 4). The staff reviewed the information provided and considers all RAI's and Open Items to be resolved. Additionally, the staff concludes that this portion of the application meets the requirements of GDC 2, 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," and 10 CFR Part 100, "Reactor Site Criteria," relating to hydrologic characteristics.

2.5 Geological, Seismological, and Geotechnical Engineering

In Section 2.5, "Geology, Seismology, and Geotechnical Engineering," of Revision 17 of the AP1000 DCD, Tier 2, the applicant described geologic, seismic, and geotechnical engineering properties required for a COL applicant referencing this standard design. DCD Section 2.5.1, "Basic Geologic and Seismic Information," presents geologic and seismic characteristics of the

site and region that COL applicants referencing the AP1000 DCD need to address. DCD Section 2.5.2, "Vibratory Ground Motion," identifies the vibratory ground motion assessment, including the safe-shutdown earthquake (SSE) and design response for the COL applicant to follow. DCD Section 2.5.3, "Surface Faulting Combined License Information," describes the requirements for the COL applicant to address regarding the potential for surface tectonic and nontectonic deformation. DCD Sections 2.5.4, "Stability and Uniformity of Subsurface Materials and Foundations," and 2.5.5, "Combined License Information for Stability and Uniformity of Slopes," describe the foundation and subsurface material stability criteria to be met by COL applicants. DCD Section 2.5.6, "Combined License Information for Embankments and Dams," discusses requirements for stability of embankments and dams near the COL site.

The six main sections of this part of the SER (i.e., Section 2.5) parallel the six main sections included in the applicant's DCD. Except for the sections where the applicant made no changes from Revision 15 of the AP1000 DCD, the SER sections are divided into six subsections: (1) the "Introduction" section, which briefly describes the contents of each main DCD section, (2) the "Technical Information in the Application" section, which describes the technical content of the DCD, (3) the "Regulatory Basis" section, which summarizes the regulations and NRC regulatory guides used by the staff to review the DCD, (4) the "Technical Evaluation" section, which describes the staff's evaluation of what the applicant did, including requests for RAIs and open items, and confirmatory analyses performed by the NRC staff, if applicable, (5) the "Post Combined License Activities" section, which identifies related post-COL activities, and (6) the "Conclusions" section, which provides the staff's conclusions and documents whether the applicant provided sufficient and adequate information to meet all relevant regulatory requirements.

The staff also reviewed the AP1000 DCD Tier 1 information that is related to DCD Tier 2, Section 2.5, and incorporated the Tier 1 information review into the appropriate subsections of the Tier 2 DCD review discussed in this SER section. The SER focuses on the changes the applicant made in Revision 17 of the AP1000 DCD as compared to the previously certified revision of the DCD.

2.5.1 Basic Geologic and Seismic Information

The applicant made no changes or additions to DCD Section 2.5.1 from Revision 15 of the AP1000 DCD. Therefore, the staff did not reevaluate any of the previously certified information included in this section.

2.5.2 Vibratory Ground Motion

2.5.2.1 Introduction

DCD Section 2.5.2 states that the AP1000 certified seismic design response spectra (CSDRS) were developed using the response spectra of RG 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," as the base. The applicant then modified the base spectra to include additional high-frequency amplification at a control point at 25 Hertz (Hz) with equal peak ground acceleration (PGA) in the horizontal and the vertical directions, as presented in Figures 3.7.1-1 and 3.7.1-2 in the DCD. The applicant also stated that for a site at which the

nuclear island is founded on hard rock, the design response spectra specified in Appendix 3I to the DCD and Figures 3I.1-1 and 3I.1-2 can be used in place of the CSDRS.

2.5.2.2 Technical Information in the Application

2.5.2.2.1 Combined License Seismic and Tectonic Characteristics Information

AP1000 DCD, Section 2.5.2.1, "Combined License Seismic and Tectonic Characteristics Information," states that the site-specific ground motion response spectra (GMRS) would be defined at the ground surface in the free-field and compared to the CSDRS. For sites with soil layers that will be completely excavated to expose competent material (in situ material with a shear wave velocity of 305 meter per second (m/s) (1000 feet per second (fps)) or higher), the applicant stated that the GMRS will be specified on an outcrop or a hypothetical outcrop that would exist after excavation. The applicant further clarified that the motions at the hypothetical outcrop are developed as a free-surface motion, not as an in-column motion with no soil above the outcrop.

In addition, the applicant described seven requirements in DCD Subsection 2.5.2.1 for the COL applicant to address in order to demonstrate that a selected site was suitable for the AP1000 standard design. The applicant updated the following five requirements in Revision 17 of the DCD:

(1) For a site at which the nuclear island is founded on hard rock with a shear wave velocity greater than 2,440 m/s (8,000 fps), the site-specific GMRS can be defined at the foundation level and may be shown to be less than or equal to the CSDRS.

(2) For a site at which the nuclear island is directly founded on hard rock, the site-specific PGA and spectra should be developed for the top of competent rock and shown to be less than or equal to those values given in DCD Figures 3I.1-1 and 3I.1-2 at the foundation level and over the entire frequency range.

(3) Layers of the soil beneath the foundation are approximately horizontal, sloping less than 20 degrees, and the minimum estimate of the low-strain shear wave velocity of the soil underneath the nuclear island foundation is greater than or equal to 305 m/s (1,000 fps).

(4) For sites at which the nuclear island is founded on soil, the median estimate of the strain-compatible soil shear modulus and hysteretic damping is compared to the values used in the AP1000 generic analyses shown in DCD Table 3.7.1-4 and Figure 3.7.1-17. Properties of soil layers within a depth of 36.6 m (120 ft) below finished grade are compared to those in the generic soil site analyses (soft soil, soft-to-medium soil, and upper bound soft-to-medium soil). The shear wave velocity should also increase with depth, and the average low-strain shear wave velocity should not be less than 80 percent of the average shear wave velocity at a higher elevation.

(5) A site-specific evaluation, as described in DCD Section 2.5.2.3, may be performed in lieu of the other requirements.

DCD Tier 1, Table 5.0-1, specifies the site parameter for the SSE as follows:

> SSE free-field peak ground acceleration of 0.30 g with modified Regulatory Guide 1.60 response spectra (See Figures 5.0-1 and 5.0-2). Seismic input is defined at finished grade except for sites where the nuclear island is founded on hard rock. If the site-specific spectra exceed the response spectra in Figures 5.0-1 and 5.0-2 at any frequency, or if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed. This evaluation will consist of a site-specific dynamic analysis and generation of in-structure response spectra at key locations to be compared with the floor response spectra of the certified design at 5-percent damping. The site is acceptable if the floor response spectra from the site-specific evaluation do not exceed the AP1000 spectra for each of the locations or the exceedances are justified.
>
> The hard rock high frequency (HRHF) ground motion response spectra (GMRS) are shown in Figure 5.0-3 and Figure 5.0-4 defined at the foundation level for 5% damping. The HRHF GMRS provides an alternative set of spectra for evaluation of the site-specific GMRS. A site is acceptable if its site-specific GMRS falls within the AP1000 HRHF GMRS.

Revision 17 of the DCD added Figures 5.0-1 and 5.0-2 in Tier 1, Section 5.0, accordingly.

DCD Tier 1, Table 5.0-1, also states that there should be no potential for fault motion in the site area.

2.5.2.2.2 Site-Specific Seismic Evaluation

In DCD Tier 2, Section 2.5.2.3, "Site-Specific Seismic Evaluation," the applicant revised the requirements to clarify that, if the site-specific spectra at foundation level exceed the response spectra in Figures 3.7.1-1 and 3.7.1-2 at any frequency, or if soil conditions were outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed. For sites at which the response spectra exceed the CSDRS, or at which the soil parameters are outside those specified in the DCD, the applicant concluded that either a two-dimensional (2-D) or three-dimensional (3-D) site-specific analysis can be used to demonstrate site suitability.

Two-Dimensional Analyses

The applicant stated that for those features that were not within the site parameters, a site-specific SSI analysis may be performed following the guidance in Appendix 3G to the AP1000 DCD. The applicant stated that the results of such an analysis would need to be compared with the results of the 2-D SASSI analyses described in Appendix 3G and should demonstrate that local features are within the bounds established in the DCD. If the 2-D results are not clearly enveloped at significant frequencies of response, the applicant concluded that a 3-D analysis might be required.

Three-Dimensional Analyses

The applicant described the 3-D analyses that may be required if the 2-D results are inconclusive. The 3-D analyses would consist of a site-specific dynamic analysis and generation of in-structure response spectra at six key locations. Upon completion of the analysis, the COL applicant will need to compare the results with the floor response spectra of the certified design at 5-percent damping. The applicant specified that the CSDRS should be used to develop the floor response spectra, and they should be applied at the foundation level for the hard rock site and at finished grade for a soil site. The applicant concluded that the site would be acceptable if the floor response spectra from the site-specific evaluation did not exceed the AP1000 spectra for each of the following locations: containment internal structures at elevation of reactor vessel support, containment operating floor, auxiliary building at northeast corner elevation of 35.5 m (116.5 ft), shield building at fuel building roof, shield building roof, and the steel containment vessel at polar crane support.

2.5.2.3 Regulatory Basis

The NRC staff relied on the following applicable regulatory requirements and guidance in reviewing the applicant's discussion of vibratory ground motion:

- 10 CFR 52.47, "Contents of applications; technical information" with respect to requiring COL applicant to provide site parameters postulated for the design and an analysis and evaluation of the design in terms of those site parameters

- 10 CFR Part 50, Appendix A, General Design Criterion (GDC2), "Design Bases for Protection against Natural Phenomena," as it relates to 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

- 10 CFR 100.23, "Geologic and Seismic Siting Criteria," with respect to obtaining geologic and seismic information necessary to determine site suitability and ascertain that any new information derived from site-specific investigations would not impact the GMRS derived by a probabilistic seismic hazard analysis

- RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants"

- RG 1.206, "Combined License Applications for Nuclear Power Plants—LWR Edition"

- RG 1.208, "A Performance-Based Approach to Define Site-Specific Earthquake Ground Motion"

2.5.2.4 Technical Evaluation

The applicant stated in Section 2.5.2 that "the AP1000 is also evaluated for a safe shutdown earthquake defined by a peak ground acceleration of 0.30 g and the design response spectra

specified in Appendix 3I and Figures 3I.1-1 and 3I.1-2. These design response spectra are applicable to certain east coast rock sites." After examining DCD Figures 3I.1-1 and 3I.1-2, the staff asked the applicant, in RAI-SRP2.5-RGS1-01, to clarify what kind of response spectra the figures presented: GMRS or CSDRS, and to explain why the figures showed a PGA of 0.25 g.

In response to the RAI, the applicant revised the DCD text to clarify that Figures 3I.1-1 and 3I.1-2 showed hard rock high frequency (HRHF) response spectra resulting from the applicant's evaluations of hard rock sites, as described in Appendix 3I to the DCD. The applicant clarified that HRHF is not the design spectra, but it is the response spectra that can be used to evaluate the hard rock sites when the site-specific GMRS exceed the CSDRS shown in DCD Figures 3.7.1-1 and 3.7.1-2. The applicant stated that if the site-specific spectra are enveloped by the HRHF, it is non-damaging, and that AP1000 CSDRS control the AP1000 design. The details of the staff's evaluation of the applicant's process to determine the HRHF spectra is described in SER 3.7.1.

The applicant also revised Section 2.5.2 of the AP1000 DCD in response to this RAI to state that the AP1000 was designed for an earthquake with a PGA of 0.30 g, referring to the AP1000 CSDRS. In its response the applicant explained that the PGA of 0.25 g addressed in staff's question RAI-SRP2.5-RGS1-01 is not that of the CSDRS, but it is the PGA of the HRHF spectra described above. The staff considers this response adequate as it clarifies the differences between the AP1000 CSDRS and the HRHF shown in DCD Figures 3I.1-1 and 3I.1-2 and the differences between the PGA values of the CSRDS and the HRHF spectra. Since the applicant revised the DCD to clarify the roles of CSDRS and HFRS, the staff considers RAI-SRP2.5-RGS1-01 resolved.

2.5.2.4.1 Combined License Seismic and Tectonics Characteristics Information

The staff considered the guidance in the SRP while reviewing the use of backfill soil to support the Seismic Category I structures. In RA-SRP2.5 -RGS1-02, the staff asked the applicant to clarify how the GMRS would be calculated when backfill soil was involved. In response to this RAI, the applicant revised the DCD to clarify that no soil or backfill layers may exist above the outcrop when determining a site-specific GMRS. The staff reviewed this update in Revision 17 of the AP1000 DCD and noted that the revised DCD clearly describes how the site-specific GRMS should be determined. Since the revised DCD text clearly states that GMRS calculations will not include an overlying soil column, the staff concludes that the applicant's revised DCD satisfies the regulatory requirements; thereby the staff considers RAI-SRP2.5-RGS1-02 resolved.

The staff found that, in general, requiring the COL applicant to demonstrate that the proposed site satisfies the seven requirements as described in the DCD meets the SRP guidelines; however, some issues needed to be clarified. In RAI-SRP2.5-RGS1-03, the staff asked the applicant to address the following issues of concern:

(1) Define "thin soil layer" and "soft soil layer" referred to in Requirement 4.

(2) Replace the phrase "median estimate" with the phrase "minimum estimate" in Requirement 5.

(3) Provide acceptance criteria and a basis to show the comparison to be acceptable in Requirement 6.

In response to this RAI, the applicant revised DCD Section 2.5.2.1 by eliminating the sentence containing "thin soil layer" and "soft soil layer" and replacing "median estimate" with "minimum estimate." The applicant also referred to detailed information regarding acceptance criteria for foundation soil in Section 3.7.1.4 of the DCD. After review of these revisions to the DCD, as well as the acceptance criteria for foundation soils found in Section 3.7.1.4 of the DCD, the staff concludes that this information is insufficient to resolve the issues identified in RAI-SRP2.5-RGS1-03 because the information does not satisfy the sixth screening requirement. The staff tracked this as Open Item **OI-SRP2.5-RGS1-03**.

To resolve the issues identified in **OI-SRP2.5-RGS1-03**, the applicant submitted a revised response on November 9, 2009 (DCP_NRC_002684). In its response, the applicant proposed a revision to the DCD that would make the site acceptance criteria and the six screening criteria described in AP1000 DCD Tier 1 Section 2.5 consistent with those used in site response analyses, seismic system analyses, and SSI analyses. The most important site parameter is the shear wave velocity of the generic site soil profiles. The proposed DCD revision requires the shear wave velocities of the three generic soil profiles (soft soil (SS), soft-to-medium soil (SM), and upper bound soft-to-medium soil (UBSM)) to be within the lower and upper bounds of the shear wave velocities of the individual layers constituting the site-specific soil profiles. The lower bound and upper bound shear wave velocities correspond to Gmax/1.5 and 1.5*Gmax, respectively, where Gmax is the low-strain maximum shear modulus. The minimum shear wave velocity, however, will still be greater than or equal to 1000 fps. Since the applicant adequately addressed the concerns of the staff by making the site acceptance criteria consistent with the rest of the DCD, and committed to revise the DCD, this open item is now Confirmatory Item **CI-SRP2.5-RGS1-03**. CI-**SRP2.5-RGS1-03** will be closed once the revised AP1000 DCD Tier 2, Section 2.5.2.1, Item 6 incorporates all proposed changes.

In Section 2.5.2.1 of the DCD, the applicant stated that, when site-specific parameters were not enveloped by the AP1000 standard design, a COL applicant might perform site-specific SSI analyses based on 2-D SASSI models and compare the results with those documented in Appendix 3G to DCD Section 3 to determine the adequacy of the standard design for the site. However, in Section 2.5.2.3 of DCD Revision 15, the applicant stated that site-specific SSI analyses should be performed using the 3-D SASSI models described in Appendix 3G. The staff asked the applicant, in RAI-SRP2.5-RGS1-04, to clarify the inconsistency and explain why the AP1000 DCD does not require the COL applicant to perform 3-D SSI analysis for a site at which 3-D effects cannot be ignored (such as a site with sloping excavation). In response to this RAI, the applicant (1) moved the entire paragraph relating to the COL applicant's performance of site-specific SSI analysis from this section to DCD Section 2.5.2.3 and changed the section title from "Sites with Geoscience Parameters outside the Certified Design" to "Site Specific Evaluation." The applicant also explained that a COL applicant would perform a site-specific SSI analysis based on actual site conditions, and if a 2-D analysis was adequate the 3-D analysis would be unnecessary, as discussed in response to RAI-TR85-SEB1-07 and RAI-TR03-015. Furthermore, the applicant added Sections 2.5.2.3.1, "2-D Analyses," and 2.5.2.3.2, "3-D Analyses," to Revision 17 of the DCD. The staff considered these revisions of

the AP1000 DCD and finds that, although the revised DCD added two separate sections to define when a 2-D or 3-D analysis would be required, it did not fully address the concerns of the staff described in RAI-SRP2.5-RGS1-04, RAI-TR85-SEB1-07 and in RAI-TR03-015, about the adequacy of a 2-D SSI analysis for an AP1000 structure where loads are not evenly applied on its foundation. The staff was concerned that the site-specific analysis should consider a 3-D effect for site conditions outside the certified design. This issue was tracked as open item **OI-SRP2.5-RGS1-04**.

The applicant provided a response (dated December 9, 2009, DCP_NRC_002712) to address the staff's concerns described in **OI-SRP2.5-RGS1-04**. In its response, the applicant agreed to modify the DCD by adding a requirement that site-specific analysis should consider 3-D effects for cases where site parameters fall outside the certified design and loads are not evenly applied throughout the AP1000 foundation. The staff reviewed the response and concluded that the proposed revision of the AP1000 DCD provides adequate criteria for a site where the site parameters do not meet the certified design. Performing site-specific analyses with consideration of 3-D effects will ensure the stability of structures and foundations, and therefore this open item is now Confirmatory Item **CI-SRP2.5-RGS1-04. CI-SRP2.5-RGS1-04** will be closed once the revised AP1000 DCD Tier 2, Subsection 2.5.2.3 incorporates all proposed changes.

The staff reviewed APP-GW-GLE-004, Revision 0, "Soil and Seismic Parameter Change," with respect to shear wave velocity conditions and the statement made regarding minimum shear wave velocity. In RAI-SRP2.5-RGS1-15, Question 3, Issue 4, the staff asked the applicant to provide the criterion for the case of a soil layer with low-strain shear wave velocities of less than 762 m/s (2,500 fps). In Issue 5 of Question 3 of the same RAI, the staff also asked the applicant to revise the statement made regarding minimum shear wave velocity from "greater than or equal to 1000 fps based on low-strain, best estimate soil properties over the footprint of the nuclear island at its excavation depth" to "greater than or equal to 305 m/s (1000 fps) based on low-strain, minimum soil properties at its excavation depth."

In its response to RAI-SRP2.5-RGS1-15, the applicant first explained that Revision 15 of the AP1000 DCD originally included the criterion for the low-strain shear wave velocity of less than 762 m/s (2,500 fps), but the criterion was removed as indicated in APP-GW-GLE-004. The applicant explained that the tight limits of ±10 percent stated in the previous revision of the DCD were found to be unrealistic based on shear wave velocity variability. The applicant concluded that soil sites would require site-specific evaluation rather than following some special case. With respect to Issue 5, the applicant responded by stating that it would revise DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, to reflect the criterion for the minimum shear wave velocity.

The staff reviewed the applicant's responses, and determined that elimination of the criterion for soil layers with seismic velocities less than 762 m/s (2,500 fps) is justifiable, as it is replaced by a more conservative approach which requires a site-specific evaluation when shear wave velocities are less than 762m/s (2500 fps). Hence, the staff considers Issue 4 of Question 3 in RAI-SRP2.5-RGS1-15 resolved.

The staff also confirmed the changes made in Revision 17 to the Tier 1 and Tier 2 tables to address the issue raised in RAI-SRP2.5-RGS1-15 Question 3 Issue 5 regarding the minimum shear wave velocity. Based on the fact that the applicant revised the criterion for the low-strain shear wave velocity in DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, the staff considers Issue 5 of Question 3 in RAI-SRP2.5-RGS1-15 resolved.

The staff also reviewed the applicant's description of the SSE. In Issue 6 of Question 3 of RAI-SRP2.5-RGS1-15, the staff asked the applicant to address the following five concerns related to the SSE: (1) designate the free-field ground motion "CSDRS" instead of "SSE," (2) review the definition of "outside the range evaluated for the AP1000 design certification" because possible shear-wave velocity inversions were not discussed, but may significantly affect the results of site response and SSI analyses, (3) clarify whether HRHF GRMS were defined at foundation level or in the free field, (4) amend the statement regarding acceptability of site-specific GRMS falling within the AP1000 HRHF to reflect acceptability "over the entire frequency range," and (5) update DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, to be in agreement with changes made to Section 2s.5. In addition, in RAI-SRP2.5-RGS1-21 Question 3 the staff asked the applicant to further clarify the term HRHF GMRS and the differences between the AP1000 HRHF GMRS and the AP1000 CDRS.

The applicant addressed each item separately in its response. With respect to the staff's first concern, the applicant referred the staff to response to RAI-SRP2.5-RGS1-02, and stated that "The ground motion response spectra have been revised to the certified seismic design response spectra (CSDRS) instead of the SSE." Since the revised DCD now uses the proper terminology, the staff considers this issue resolved. The applicant addressed the second item in staff's question by referring to its response to RAI-SRP2.5-RGS1-04, and stated that the revised DCD text now states the following: "The shear wave velocity should generally increase with depth. The average low strain shear wave velocity in any layer should not be less than 80 percent of the average shear wave velocity in any layer at higher elevation." Since the applicant clarified the phrase "outside the range evaluated for the AP1000 design certification" as 80% of the velocities of the overlying layers, the staff considers this issue resolved. In response to the third concern identified by the staff, the applicant proposed a revision to the DCD and referred the staff to the proposed revisions described in applicant's responses to RAI-SRP2.5-RGS1-02 and RAI-SRP2.5-RGS1-03. The staff's evaluations of these responses are discussed above. The applicant addressed the fourth staff concern by making a simple revision to include the phrase "over the entire frequency range." Hence, the staff considers this issue resolved. The applicant addressed the fifth item by revising the tables in question and committing to incorporate the revised tables in Revision 17 of the DCD. After reviewing Revision 17 of the AP1000 DCD, the staff determined that the tables in question were revised, but not exactly as specified in the applicant's response to RAI-SRP2.5-RGS1-15. The applicant presented the revision for the site parameter SSE in DCD Tier 1, Table 5.0-1, but not in DCD Tier 2, Table 2-1. Therefore, the staff considered RAI-SRP2.5-RGS1-15 unresolved and tracked this as open item **OI-SRP2.5-RGS1-15**.

To address the staff's concerns described in **OI-SRP2.5-RGS1-15**, the applicant submitted a revised response on October 20, 2009 (DCP_NRC_002668; ADAMS Accession Number ML092960456) and proposed DCD revisions that are consistent with the commitments made by the applicant in its responses to RAI-SRP2.5-RGS1-02, 03, 04 and 15. Therefore, this open

item is now Confirmatory Item **CI-SRP2.5-RGS1-15**, which will be closed once the revised AP1000 DCD incorporates all proposed changes in Tier 1 Table 5.0-1, Tier 2 Table 2-1, and Tier 2 Subsections 3.7.1 and 3.7.1.1.

In response to RAI-SRP2.5-RGS1-21 Question 3 the applicant stated that it will replace the term "HRHF GMRS" with "HRHF envelope response spectra" in its next DCD revision. In regard to the issues related to the differences between HRHF and the AP1000 CSDRS, the applicant clarified that the HRHF response spectra are not a second set of CSDRS. The HRHF serves the purpose of determining the acceptability of the site-specific response spectra when there is exceedance in the high-frequency component of the AP1000 CSDRS for a hard rock site. Following further discussions with NRC staff, the applicant agreed to add sentences to the Tier 1 table describing when the HRHF frequency could be applied for a site. The added text would state, "Evaluation of a site for application of the HRHF envelope response spectra includes consideration of the limitation on shear wave velocity identified for use of the HRHF envelope response spectra. This limitation is defined by a shear wave velocity at the bottom of the basemat equal to or higher than 7,500 fps, while maintaining a shear wave velocity equal to or above 8,000 fps at the lower depths."

Since specific shear wave velocities were defined for the soil profile that was used in development of the HRHF envelope response spectra, the applicant stated that it will address the limitation on shear wave velocity in its next DCD revision. The applicant also proposed a DCD revision to reflect the necessary changes. Based on review of the response, the staff finds that (1) The use of "HRHF envelope response spectra" instead of "HRHF GMRS" will eliminate the confusion between design response spectra and GMRS, because the HRHF response spectra are design basis for hard rock site, while the GMRS is obtained from site-specific seismic response analysis; (2) The applicant stated that the HRHF envelope response spectra are not a second set of design spectra but specifically for hard rock sites with higher seismic response spectra in high frequencies. The applicant also specified the shear wave velocity condition for the hard rock sites where the HRHF envelope response spectra may apply; and, (3) the proposed DCD revision will ensure that all necessary changes will be documented in the AP1000 DCD. The staff therefore concludes that the response to Question 3 of the RAI-SRP2.5-RGS1-21 is adequate and is being tracked as Confirmatory Item **CI-SRP2.5-RGS1-21a**. This confirmatory item will be closed once the applicant incorporates all proposed changes in revised AP1000 DCD Tier 1 Section 5.0, Table 5.0-1, Table 5.0-3 and Table 5.0-4; Tier 2 Table 2-1, Subsection 2.5.2, Section 3I.1, Section 3I.2, Figure 3I.1-1 and Figure 3I.1-2.

2.5.2.4.3 Sites with Geoscience Parameters outside the Certified Design

In Section 2.5.2.3, the applicant stated that, if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed. The staff asked the applicant, in RAI-SRP2.5-RGS1-05, to provide acceptance criteria regarding soil properties. In RAI-SRP2.5-RGS1-06 the staff asked the applicant to state the requirements for a site-specific soil degradation model that is one of the basic inputs to the SSI analysis in the AP1000 DCD. In response to these questions, the applicant indicated that (1) it would add the requirement for a site-specific soil degradation model in a later revision of the DCD, and (2) Section 3.7.1.4 of the DCD provides tables and figures illustrating soil properties that were used for the design of the nuclear island. The applicant stated that COL applicants referencing the AP1000 DCD would

generate site-specific soil profile plots and compare them with the design presented in Section 3.7.1.4. The applicant also stated that it revised DCD Table 3.7.1.4 to reflect the strain compatible properties. The staff considers RAI-SRP2.5-RGS1-06 resolved as the applicant implemented the staff's recommendation and revised the DCD to explicitly state that site-specific soil degradation models are a part of the site-specific soil conditions. Since the applicant stated in its response to RAI-SRP2.5-RGS1-05 that Section 3.7.1.4 of the DCD provides tables and plots that can be used by a COL applicant to compare the site soil profile to determine if the soil conditions are outside the range evaluated for AP1000 design certification, the staff concludes that the applicant's response provided adequate description of how a COL applicant would assess whether the soil conditions at a site are outside the range defined by the DCD and considers question RAI-SRP2.5-RGS1-05 resolved. Based on the RAI responses from the applicant and review of Section 3.7.1.4, the staff concludes that the applicant provided adequate information to resolve RAI-SRP2.5-RGS1-05 and RAI-SRP2.5-RGS1-06.

The staff considered the incorporation of APP-GW-CLE-004 into DCD Section 2.5.2.3. In RAI-SRP2.5-RGS1-16, the staff asked the applicant to define the term "geoscience parameters" used in the subtitle of Section 2.5.2.3 "Sites with Geoscience Parameters Outside the Certified Design," In addition, the staff also asked the applicant to clarify the discrepancy between DCD Section 2.5.2.3 and DCD Section 3.7.1.1. DCD Section 2.5.2.3 states that a site-specific evaluation can be performed if the site-specific spectra at foundation level exceed the response spectra at any frequency or if the soil conditions are outside the range evaluated in Section 2.5.2.3. DCD Section 3.7.1.1 states that design response spectra are applied at the foundation level in the free field at hard rock sites and at finished grade in the free field at firm rock and soil sites. The staff also asked the applicant to clarify the statement that the site design response spectra at the foundation level in the free-field were used to develop the floor response spectra, which is inconsistent with DCD Section 3.7.1.1 for soil sites.

In its response, the applicant stated that DCD Subsection 2.5.2.3 was re-written based on the staff's question RAI-SRP2.5-RGS1-04 and referred the staff to its response to RAI-SRP2.5-RGS1-04. In that response the applicant stated that it revised the title of 2.5.2.3 from "Sites with Geoscience Parameters Outside the Certified Design" to "Site Specific Seismic Evaluation". With this revision the staff considers the first issue closed since the applicant revised the title and eliminated the questioned phrase. The applicant also clarified the apparent discrepancy between DCD Section 2.5.2.3 and Section 3.7.1.1 by revising its response to staff's question RAI-SRP2.5-RGS1-04. The applicant revised the DCD to state that "If the site-specific spectra at foundation level at a hard rock site or at grade for other sites exceed the certified seismic design response spectra in Figures 3.7.1-1 and 3.7.1-2 at any frequency, or if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed." With this revision the staff concludes that the apparent discrepancy has been eliminated and the issue resolved. The applicant also modified the DCD to clarify the statement outlined above by staff's question. The revised DCD clarified this third issue. The DCD text now reads "The certified design response spectra in the free-field given in Figures 3.7.1-1 and 3.7.1-2 were used to develop the floor response spectra." With this revision, the staff considers the third issue in the staff's question above resolved.

2.5.2.5 Post Combined License Activities

The staff will identify post-COL activities on a site-by-site basis as part of the review of a COL application referencing the AP1000 DCD.

2.5.2.6 Conclusions

Based on the review of Revision 17 of the AP1000 DCD Tier 2, Section 2.5.2; Tier 1, Table 5.0-1 (and Tier 2, Table 2-1); and APP-GW-GLE-004, the staff finds that the applicant adequately detailed how to determine site-specific GMRS, specified criteria for a site to be suitable for the AP1000 standard design, and provided detailed guidance on performing site-specific seismic evaluation for sites that do not meet the scope of the seven siting requirements described in the DCD. The applicant also provided a set of site parameters related to the geological and seismological basis for the AP1000 standard design, such as requirements on SSE and associated site response spectra, fault displacement potential, and the subsurface material lateral variability requirement. The staff concludes that the geological and seismological related site parameters and requirements presented in the DCD are acceptable, pending closing of the confirmatory items for meeting the regulatory requirements of 10CFR 100.23, GDC 2, and 10 CFR 52.47(a)(1).

2.5.3 Surface Faulting

The applicant changed the site parameter provided in Tier 1, Table 5.0-1 and Tier 2, Table 2-1, for “Fault Displacement Potential” from “None” in Revision 15 to “Negligible” in Revision 17 of AP1000 DCD. The staff, in Question 1 of the RAI-SRP2.5-RGS1-21, asked the applicant to clarify the definition of “negligible.” In its response to this question, the applicant first explained that the reason of making this change is because of the difficulty for a COL applicant to demonstrate that the fault displacement potential for a site is absolutely “None.” Following further discussions with the staff, the applicant subsequently proposed to change this site parameter to “No potential fault displacement considered beneath the seismic Category I and seismic Category II structures and immediate surrounding area. The immediate surrounding area includes the effective soil supporting media associated with the seismic Category I and seismic Category II structures.” The staff considers that no fault displacement potential beneath these structures is a reasonable design basis for representing most existing nuclear power plant sites, as well as the ESP and COL application site. DCD Subsection 2.5.3 describes the information on surface faulting that the COL applicant needs to provide to satisfy the requirement for no surface faulting by completing geological, seismological, and geophysical investigations. Therefore, the staff concludes that this design site parameter is acceptable because it is consistent with the guidance in Regulatory Guide 1.206, and can reasonably ensure that the regulatory requirements of 10 CFR 100.23 will be met. Accordingly, the issue of clearly defining the site parameter for fault displacement potential in Question 1 of the RAI-SRP2.5-RGS1-21 is resolved and now tracked as Confirmatory Item **CI-SRP2.5-RGS1-21b**. This confirmatory item will be closed once the applicant incorporates the proposed changes in revised AP1000 DCD Tier 1 Table 5.0-1and Tier 2 Table 2-1.

2.5.4 Stability and Uniformity of Subsurface Materials and Foundations

2.5.4.1 Introduction

Section 2.5.4, "Stability and Uniformity of Subsurface Materials and Foundations," of the AP1000 DCD presents the requirements related to stability of subsurface materials and foundations for COL applicants referencing the AP1000 standard design. The site-specific information includes excavation, bearing capacity, settlement, and liquefaction potential.

2.5.4.2 Technical Information in the Application

2.5.4.2.1 Excavation

Section 2.5.4.1 of the AP1000 DCD provides the requirements for site excavation. In this section, the applicant stated that, for the nuclear island structures below grade, a COL applicant may use either a sloping excavation or a vertical face. The applicant further stated that, if a COL applicant uses a sloping excavation, an evaluation of the 3-D effects on the site response and site-specific SSI analyses must be performed using a combination of either 2-D or 3-D SASSI models that reflect the sloping excavations. In the event that a vertical face is used, the COL applicant would need to cover the face with a waterproof membrane, as described in DCD Section 3.4.1.1.1.1, or use soil nailing and mechanically stabilized earth (MSE) walls as the outside form for the exterior walls below grade of the nuclear island.

DCD Section 2.5.4.1.1 describes the detailed requirements for using a soil nailing method as an alternative to stabilize vertical faces of undisturbed soil or rock below grade for nuclear island structures. The applicant stated that the soil nailing method produced a vertical surface down to the bottom of the excavation and was used as the outside form for the exterior walls below grade of the nuclear island. The applicant also provided details on soil-retaining wall installation in this section.

DCD Section 2.5.4.1.2 describes the MSE as a flexible retaining wall using strip, grid, or sheet type of tensile reinforcements so that the wall behaves as a retaining wall. The applicant stated that the tensile strength of the reinforcements provides internal stability and the walls could be used in areas where retaining wall soils have been removed or elevation needs to be raised.

DCD Section 2.5.4.1.3 describes the mud mat, including both the upper and lower mats, which will be placed ahead of the placement of reinforcements for the foundation mat structural concrete. The applicant stated that both the lower mud mats would have a compressive strength of 17,236 kilopascal (kPa) (2,500 pound per square inch (psi)) and be a minimum of 15.24 centimeter (cm) (6 inches) thick. Finally, DCD Section 3.4.1.1.1.1 describes waterproofing system alternatives.

2.5.4.2.2 Bearing Capacity

DCD Section 2.5.4.2, "Bearing Capacity," specifies that the maximum bearing reaction is less than 1,676 kPa (35,000 psf) under all combined loads, including the SSE, based on the analyses described in Appendix 3G to the AP1000 DCD and occurs at the western edge of the

shield building. The DCD applicant noted that the COL applicant would need to verify whether the site-specific allowable soil-bearing capacities for static and dynamic loads would exceed this demand with a factor of safety appropriate for the design load combination, including SSE loads.

In DCD Tier 1, Table 5.0-1, and Tier 2, Table 2-1, the applicant listed the site parameters of average allowable bearing capacity. These tables stated the average allowable static soil bearing capacity as greater than or equal to the average bearing demand of 8,900 pounds per square foot (lb/ft^2) over the footprint of the nuclear island at its excavation depth. It also defined the maximum allowable dynamic bearing capacity for normal plus SSE loads as greater than or equal to the maximum bearing demand of 35,000 lb/ft^2 at the edge of the nuclear island at its excavation depth, or by performing site-specific analyses to demonstrate a factor of safety appropriate for normal plus SSE loads.

2.5.4.2.3 Settlement

DCD Section 2.5.4.3, "Settlement," requires the COL applicant to address both short-term (elastic) and long-term (heave and consolidation) settlement for soil sites for the history of loads imposed on the foundation consistent with the construction sequence. The applicant noted that the time-history of settlements should include construction activities and construction of the superstructure. The applicant also stated that the AP1000 design does not rely on SSCs located outside the nuclear island footprint for safety-related functions.

In Revision 17 of the AP1000 DCD, the applicant added Table 2.5-1 that provides guidance to the COL applicant on predictions of absolute and differential settlement that are acceptable without additional evaluation.

2.5.4.2.4 Liquefaction

In DCD Section 2.5.4.4, the DCD applicant stated that the COL applicant will demonstrate that, for soil sites, the potential for liquefaction is negligible for both the soil underneath the nuclear island foundation and at the side embedment engaged in passive resistance adjacent to the nuclear island. DCD Tier 1, Table 5.0-1, as well as Tier 2, Table 2-1, state that liquefaction potential is negligible at the site.

2.5.4.2.5 Subsurface Uniformity

Section 2.5.4.5 of the DCD states that, although the design and analysis of the AP1000 was based on soil or rock conditions with uniform properties within horizontal layers, provisions and design margins to accommodate many nonuniform sites were also included. The applicant described, in detail, the types of site investigation that would be sufficient for a "uniform" site or a "nonuniform" site. The applicant indicated that the acceptability of a nonuniform site would be based on an individual site evaluation. The applicant concluded that, for uniform sites whose site parameters fall within the site profiles evaluated as part of the DC, no further action will be needed. However, for nonuniform sites, or other sites whose parameters do not fall within the site profiles, a site-specific evaluation will need to be performed. For nonuniform sites, Sections 2.5.1 and 2.5.4.6.1 of the DCD outline the geological investigations for the extended

investigation effort to determine whether the site is acceptable for construction of an AP1000 reactor. In Revision 17 of the DCD, the applicant deleted Sections 2.5.4.5.1 and 2.5.4.5.2 and labeled them as "Not Used."

2.5.4.2.5.1 Site Foundation Material Evaluation Criteria

DCD Section 2.5.4.5.3 states that the COL applicant will demonstrate that the variation of subgrade modulus across the nuclear island footprint will be within the range considered for design of the nuclear island basemat. The DCD also stated that the COL applicant will consider the subsurface conditions within the nuclear island footprint and 12.2 m (40 ft) beyond, and to a depth of 36.6 m (120 ft) below finished grade within the nuclear island footprint. The applicant also noted that a uniform site would be acceptable for the AP1000 design, without additional site-specific analyses, based on the analyses and evaluations performed to support the design certification. The applicant also outlined two criteria for site uniformity.

2.5.4.2.5.2 Site-Specific Subsurface Uniformity Design Basis

DCD Section 2.5.4.5.3.1 states that nonuniform soil conditions may require the evaluation of the AP1000 seismic response, as described in DCD Section 2.5.2.3.

For the rigid basemat evaluation, the applicant stated that if the site variability can be identified without significant variations in the horizontal direction, a 2-D analysis can be used. However, the applicant also stated that sites with variability in the horizontal direction indicate the need for a 3-D analysis. The applicant further stated that the bearing pressure from the site-specific analysis needs to be less than or equal to 120 percent of that for a similar site with uniform soil properties.

For a flexible basemat evaluation, the applicant stated that soils may be represented by soil springs or by a finite element model, depending on the variability identified at the site. The applicant also pointed out that, for a site to be acceptable, the bearing pressures from the site-specific analyses will need to be less than the design bearing strength of each portion of the basemat under both static and dynamic loads.

In DCD Tier 1, Table 5.0-1, the applicant addressed the site parameters for lateral variations by stating that the soils supporting the nuclear island should not have extreme variations in subgrade stiffness. The applicant described the documentation of variations as follows:

(1) Soils supporting the nuclear island are uniform in accordance with RG 1.132 if the geologic and stratigraphic features at depths less than 36.6 m (120 ft) below grade can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units, or

(2) Site-specific assessment of subsurface conditions demonstrates that the bearing pressures below the footprint of the nuclear island do not exceed 120 percent of those from the generic analyses of the nuclear island at a uniform site, or

(3) Site-specific analysis of the nuclear island basemat demonstrates that the site-specific demand is within the capacity of the basemat.

The applicant further stated that as an example of sites that are considered uniform, the variation of shear wave velocity in the material below the foundation to a depth of 36.6 m (120 ft) below finished grade within the nuclear island footprint and 12.2 m (40 ft) beyond the boundaries of the nuclear island footprint meets the criteria in the case outlined below.

Case 1: For a layer with a low-strain shear wave velocity greater than or equal to 2,500 feet per second, the layer should have approximately uniform thickness, should have a dip not greater than 20 degrees, and should have less than 20-percent variation in the shear wave velocity from the average velocity in any layer.

DCD Tier 1, Table 5.0-1, also states that the shear wave velocity should be greater than or equal to 305 m/s (1,000 ft/sec) based on minimum low-strain soil properties over the footprint of the nuclear island at its excavation depth.

2.5.4.2.6 Combined License Information

The applicant made only a few changes to the AP1000 DCD Tier 2, Section 2.5.4.6, “Combined License Information.”

DCD Section 2.5.4.6.3, “Excavation and Backfill,” details excavation and backfill requirements for the COL applicant. For excavation, it requires the COL applicant to provide information concerning the extent of safety-related structure foundation excavations, fills, and slopes. For backfills, the DCD states that the COL applicant needs to provide information on sources, quantities, and engineering properties of borrowing materials; the compaction requirements; results of field compaction tests; and fill material properties. It also provides information requirements on the soil retention system, including the length and size of soil nails or tension reinforcement.

DCD Section 2.5.4.6.11, “Settlement of the Nuclear Island,” states that the COL applicant should address the short-term (elastic) and long-term (heave and consolidation) settlement for soil sites for the history of loads imposed on the nuclear island foundation and adjacent buildings consistent with the construction sequence. This section also specifies that special construction requirements may be needed to meet the settlement requirements, as described in Table 2.5-1.

2.5.4.3 Regulatory Basis

The applicable regulatory requirements and guidance for reviewing the applicant’s discussion of stability of subsurface materials and foundations are as follows:

(1) 10 CFR Part 50, Appendix A, GDC 2, as it relates to 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.

(2) 10 CFR Part 50, Appendix S, "Earthquake Engineering Criteria for Nuclear Power Plants," as it applies to the ability of the design of nuclear power plant structures, systems, and components important to safety to withstand the effects of earthquakes.

(3) 10 CFR 100.23, which provides the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability and identify geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants.

(4) RG 1.132, " Site Investigations for Foundations of Nuclear Power Plants."

(5) RG 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants."

(6) RG 1.206, "Combined License Applications for Nuclear Power Plants – LWR Edition."

2.5.4.4 Technical Evaluation

2.5.4.4.1 Excavation

In DCD Section 2.5.4.1, the applicant stated that if a sloping excavation was used for a site, then the 3-D effect on the SSI analysis should be considered. In RAI-SRP2.5-RGS1-07, the staff asked the applicant to add this statement to the DCD as a requirement for COL applicants. In response to this RAI, the applicant added a requirement for the COL applicant to evaluate the 3-D effects by performing a site-specific SSI analysis using either 2-D or 3-D SASSI models, or both, for sloping excavations. The staff reviewed DCD Revision 17 and confirmed that the applicant had included this updated information. Accordingly, the staff considers the revised DCD to be sufficient to resolve RAI-SRP2.5-RGS1-07, which requested that the applicant include the requirement to evaluate the 3-D effects through site-specific SSI analyses in the DCD.

Since the staff found that at least one COL applicant used precast facing panels to retain the side soil, RAI-SRP2.5-RGS1-08 asked the applicant to clarify whether it would revise the DCD regarding other methods that can be used to retain the vertical excavation face. In response to this RAI, as well as to RAI-TR85-SEB1-040, the applicant stated that it substantially revised Section 2.5.4.1 to address the option of using an MSE wall with precast concrete facing panels to retain the side soil. The staff reviewed the revisions to the DCD, particularly the option to use an MSE wall, and concludes that the additional options to retain side soil are sufficient to resolve the geotechnical engineering aspects of RAI-SRP2.5-RGS1-08. Therefore, the staff considers this RAI resolved.

2.5.4.4.2 Bearing Capacity

Based on its review of Section 2.5.4.2, the staff raised the following concerns in RAI-SRP2.5-RGS1-09:

(1) Since bearing capacity is highly site specific, replace the “bearing capacity” value calculated from seismic analyses with the “bearing demand” value based on the maximum foundation contact pressure.

(2) Justify why Revision 16 states that the maximum allowable dynamic bearing capacity (bearing demand) is greater than or equal to 1,676 kPa (35,000 psf), which is far less than 5,746 kPa (120,000 psf), as listed in the prior revision of DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1.

(3) Define the “factor of safety” for the bearing capacity evaluation.

In response to this RAI, the applicant replaced the term “bearing capacity” with “bearing demand” in DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, and changed average allowable static soil bearing capacity from 421 kPa (8,600 psf) to 426 kPa (8,900 psf) to reflect the enhanced shield building design. Revision 17 of the DCD includes these changes, and the staff considers Issue 1 of Question RAI-SRP2.5-RGS1-09 resolved.

In response to Issue 2 above, the applicant referred the staff to its response to question RAI-TR85-SEB1-03 for an explanation as to why Revision 16 of the AP1000 DCD listed the bearing capacity value of 1,676 kPa (35,000 psf). In responding to the RAI, the applicant stated that this difference resulted from (1) different seismic loads being applied to the foundation dynamic response analysis. The prior revision used a seismic load for hard rock certified design, while the current version used a design that envelops all rock and soil cases; and (2) the prior revision used the results from a more conservative equivalent static analyses, while the current version used the result from a nonlinear dynamic analyses. The dynamic nonlinear analyses showed a much lower bearing reaction (1,331 kPa (27,008 psf) for hard rock) than those from the equivalent static design analyses for the basemat. Using the commercial computer software 2-D ANSYS, the applicant completed nonlinear analyses, which yielded higher bearing pressures (1,652 kPa (34,500 psf)) for a soft-to-medium soil case than those for the hard rock case. Based on the new analysis results, the applicant chose the soil bearing reaction of 1,676 kPa (35,000 psf) to cover both soil and rock sites. The applicant further indicated that the bearing pressures from the ANSYS analyses were conservative because the effect of the side soil was neglected. Since the applicant re-analyzed the bearing capacity calculations using a more realistic non-linear soil model, the staff considers this reduction in bearing capacity value as acceptable since the non-linear model would result in more realistic estimates than the previous equivalent static analyses the applicant conducted. Hence, the staff considers Issue 2 resolved.

Regarding the factor of safety used for the bearing capacity evaluation, the applicant stated that the factor of safety should be site specific and therefore COL applicants will be responsible for defining an appropriate factor of safety for their sites. Since this issue will be addressed by each COL applicant, the staff considers Issue 3 in Question RAI-SRP2.5-RGS1-09 resolved.

After reviewing the applicant's response, including the revision of the DCD, the explanation of the allowable bearing capacity, and the site-specific nature of the factor of safety, the staff concludes that the applicant provided adequate information to address all three areas of concern identified in RAI-SRP 2.5-RGS1-09. However, since RAI-SRP2.5-RGS1-09 also relates to another RAI related to structural engineering (RAI-TR85-SEB1-03), the staff will not consider the RAI resolved until the applicant adequately addresses the structural engineering concerns. This issue was tracked as open item **OI-SRP2.5-RGS1-09**.

To close **OI-SRP2.5-RGS1-09**, the applicant provided a response to RAI-TR85-SEB1-03 (response dated September 18, 2007, DCP/NRC1999). In the response, the applicant provided detailed explanations of the soil model used in the 3D ANSYS finite element model and how it determined the maximum dynamic bearing pressure. In a later response (dated October 20, 2009, DCP_NRC_002666), the applicant also provided a new maximum bearing demand value that is based on a 3-D SASSI analyses. As a result of these new analyses, a more realistic and conservative limit of maximum bearing seismic demand will now be used as a site parameter in the DCD. Based on the review of the applicant's responses to RAI-TR85-SEB1-03 and OI-SRP2.5-RGS1-09, the staff concludes that the analysis model used in the dynamic bearing pressure determination is adequate and that the design parameter specified in the DCD is reasonable. Because the applicant adequately addressed all issues identified in RAI-TR85-SEB1-03, OI-SRP2.5-RGS1-09, and RAI-TR85-SEB1-03 and also because the staff confirmed that the applicant revised related site parameters in AP1000 DCD, **OI-SRP2.5-RGS1-09** is closed.

While reviewing this section, the staff also considered the information provided in APP-GW-GLE-004 and DCD Tier 1, Table 5.0-1. The staff asked the applicant, in Questions 1 and 2 of RAI-SRP2.5-RGS1-15, to clarify the use of the terms, "average allowable static soil bearing capacity," and "average allowable dynamic soil bearing capacity," and justify the use of the phrase "greater than or equal to" for the calculated soil bearing demand values. In its response, the applicant cited the proposed changes to DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, made in response to RAI-SRP2.5-RGS1-09, which include the definitions of average allowable static and dynamic bearing capacity. In response to the second question, the applicant stated that site-specific allowable bearing capacity must be "greater than or equal to" the AP1000 calculated demand values. Since the staff had already determined that the revisions to the two tables were acceptable in RAI-SRP2.5-RGS1-09, the staff concludes that Question 1of RAI-SRP2.5-RGS1-15 is resolved. Furthermore, the staff considered the statement of requiring the site-specific allowable bearing capacity to be greater than or equal to the calculated demand values and concludes that this statement sufficiently addresses the geotechnical engineering concerns of the second question of RAI-SRP2.5-RGS1-15. Accordingly, the staff considers Questions 1 and 2 of the RAI-SRP2.5-RGS1-15 to be resolved.

In RAI-SRP2.5-RGS1-21 Question 2 the staff also requested the applicant redefine the site parameter for dynamic bearing capacity which is labeled as "Maximum Allowable Dynamic Bearing Capacity for Normal Plus Safe Shutdown Earthquake (SSE)" used in AP1000 DCD Rev. 17, Tier 1, Table 5.0-1 and Tier 2, Table 2-1. The staff considered this label to not clearly define the requirement that a site must have the minimum capacity to meet the maximum dynamic bearing demand. Therefore, in Question 2 of RAI-SRP2.5-RGS1-21, the staff asked the applicant to justify the use of "Maximum Allowable" for dynamic bearing capacity parameter.

In response to this RAI the applicant stated that the modifier "maximum allowable" was not necessary and proposed to eliminate it from the referenced Tables. Based on this proposed change the staff considers Question 2 of RAI-SRP2.5-RGS1-21 resolved. This issue of RAI-SRP2.5-RGS1-21 will be closed once the proposed updates are incorporated in the next revised DCD. This is being tracked as Confirmatory Item **CI-SRP2.5-RGS1-21c.**

2.5.4.4.3 Settlement

DCD Section 2.5.4.3 states that "the settlement under the NI [nuclear island] footprint is represented in the distribution of subgrade stiffness." In RAI-SRP2.5-RGS1-10, the staff asked the applicant to explain how this statement applied to the settlement evaluation. In response to the RAI, the applicant deleted this phrase from the DCD for it is irrelevant to settlement requirements. Since the DCD no longer includes this statement, the staff considers this RAI resolved.

After reviewing the settlement requirements for the AP1000 reactor, as specified in Table 2.5-1 of AP1000 DCD Revision 17, and the assertion that, because of the locations of all safety-related structures on the nuclear island, and differential settlement requirements are defined for adjacent structures to ensure the safe operation of the AP1000, the staff concludes that the applicant has considered adequate settlement criteria and provided detailed settlement requirements for COL applicants referencing the AP1000 DCD. Therefore, the settlement requirements are sufficient and acceptable.

2.5.4.4.4 Liquefaction

During the review of DCD Section 2.5.4.4, the staff noted that both DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, in Revision 15 stated the liquefaction potential at the plant site as "NONE." In Revision 16 of DCD Section 2.5.4.4, the applicant changed 'NONE' to "NEGLIGIBLE." In separate questions, RAI-SRP2.5-RGS1-11 and Question 1 in RAI-SRP2.5-RGS-21, the staff asked the applicant to define how and where the potential for liquefaction was negligible at a site. In response to these RAIs, the applicant revised Section 2.5.4.4 to define that, for a soil site, the COL applicant should demonstrate that the potential for liquefaction was negligible for both the soil underneath the nuclear island foundation and the soil of the side embedment engaged in passive resistance adjacent to the nuclear island. The applicant restated in DCD Revision 17 that for the AP1000 liquefaction beneath the certified design. The applicant further stated:

> The AP1000 design has not been evaluated for a site where there is a liquefaction potential of the soil below the nuclear island. A COL applicant must describe the soil and rock structure beneath the nuclear island in their application. DCD Subsection 2.5.4.6 describes the geotechnical information that should be provided by the COL applicant. Liquefaction potential for the site is evaluated for the site specific SSE ground motion (specific site GMRS). A COL applicant will satisfy the requirement for no liquefaction by providing information concerning the properties and stability of supporting soils and rock consistent with the guidance of Regulatory Guide 1.206.

Regarding the word change from “None” to “Negligible,” the applicant explained that the reason for making this change is because of the difficulty for a COL applicant to demonstrate the liquefaction potential at a site as absolutely “None.” The applicant however recognized that the AP1000 design has not been evaluated for a site where there is a liquefaction potential of the soil below the nuclear island. Following further discussions with the staff, the applicant subsequently proposed to change this site parameter to “No liquefaction considered beneath the seismic Category I and seismic Category II structures and immediate surrounding area. The immediate surrounding area includes the effective soil supporting media associated with the seismic Category I and seismic Category II structures.” The staff considers that no potential liquefaction beneath these structures at a site is a reasonable design basis for representing most of the existing nuclear power plant sites, as well as ESP and COL application sites. DCD Subsection 2.5.4.6 describes the information concerning the properties and stability of supporting soils and rock that the COL applicant needs to provide in order to evaluate the liquefaction potential beneath the nuclear island and to satisfy the requirement of no liquefaction potential. Therefore, the staff concludes that this design site parameter is acceptable because it is consistent with the guidance of RG 1.206, and can reasonably ensure the regulatory requirements of 10 CFR 100.23 are met.

Based on the applicant’s responses and the staff’s confirmation that Revision 17 of the AP1000 DCD includes these revisions, the staff concludes that the applicant clarified the liquefaction potential requirement and sufficiently addressed the concerns of the RAIs. Accordingly, the staff considers RAI-SRP2.5-RGS1-11 and Question 1 of RAI-SRP2.5-RGS-21 resolved provided the proposed changes are incorporated in revised DCD Tier 1 Table 5.0-1and Tier 2 Table 2-1. This is being tracked as Confirmatory Item **CI-SRP2.5-RGS1-21d.**

2.5.4.4.5 Subsurface Uniformity

At the end of Section 2.5.4.5, Revision 15 of the DCD presented a survey of 22 commercial nuclear power plant sites in the United States that focused on site parameters that affect the seismic response. All but one of the 22 sites were uniform sites. In RAI-SRP2.5-RGS1-12, the staff questioned the purpose of this survey and the reasons for its inclusion in the AP1000 DCD. As a response to this RAI, the applicant removed the paragraph referencing the survey, having decided that it was no longer applicable. Since the questionable paragraph has been removed, the staff considers RAI-SRP2.5-RGS1-12 to be resolved.

Regarding the site investigation criteria, in RAI-SRP2.5-RGS1-13, the staff asked the applicant to explain why it addressed issues related to settlement caused by static loads but did not consider the criteria needed to evaluate site response and dynamic SSI issues. In response to this RAI, the applicant revised the DCD to remove Sections 2.5.4.5.1 and 2.5.4.5.2 stating that the site investigation criteria should not be part of the DCD, but should be part of the COL applicant’s submittal. Since the content in question was removed from the DCD, the staff considers this RAI resolved.

In RAI-SRP2.5-RGS1-14, the staff asked the applicant to clarify and provide the basis for evaluation criteria for the site uniformity discussed in APP-GW-GLE-004. The applicant responded by referring to the evaluation criteria given in DCD Section 2.5.4.5, as revised in the technical report. The applicant stated that the AP1000 would be acceptable at uniform sites

without further evaluation based on the definition of uniform given in RG 1.132. The applicant justified the acceptability of relatively smooth variations by citing design analyses of the basemat described in DCD Section 3.8.5, which considered the basemat to be supported by uniform soil springs. Furthermore, the applicant indicated that the AP1000 design included a 20-percent margin above the results of uniform soil springs to accommodate the smooth variations that may occur at a uniform site. Finally, the applicant stated that, although additional evaluation would be required for nonuniform sites, the level of detail would depend on the nonuniformity identified in the site investigations.

The staff considered this response, particularly the 20-percent margin above uniformity of soil springs, as well as the applicant's adoption of the definition of "uniform" as described RG 1.132, and concluded that the applicant adequately addressed the concern of variations in uniformity of the site identified in the RAI. Therefore, the staff considers RAI-SRP2.5-RGS1-14 resolved.

In Question 3 of RAI-SRP2.5-RGS1-15, the staff asked the applicant to (1) clarify the definition of uniform soils in Criterion 1 and address the incorporation of specific criteria on shear wave and compressional wave velocity profiles needed to ensure the adequacy of SSI calculations, (2) clarify how the variability in bearing pressure relates to the corresponding variability of the soil stiffness and shear wave velocity and describe the basis of Criterion 2, and (3) provide the basis for using the phrase "within the NI [nuclear island] footprint" in describing Criterion 3, since the zone of influence under the foundation level would extend beyond the boundary of the nuclear island foundation mat.

The applicant responded to the first issue of Question 3 by stating that, while the uniformity conditions of RG 1.132 were subjective, for sites where uniformity was not clear, the site will be evaluated as nonuniform. The applicant provided more discussion on shear wave velocity profiles in DCD Section 2.5.2. With respect to the second issue, the applicant stated that the AP1000 design included a 20-percent margin above the results of the uniform soil springs analyses to accommodate relatively smooth variation in soil springs at uniform sites. The applicant further stated that the member forces and required reinforcement were conservatively assumed to increase in the same percentage as bearing pressure. With respect to the third issue of Question 3, the applicant reiterated information from Paragraph 3 of DCD Section 2.5.4.5.3 stating that it will add the phrase "and 40 feet [12.2 m] beyond the boundaries of the nuclear island footprint" to both DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1.

The staff reviewed the applicant's response and confirmed that the applicant updated DCD Tier 1, Table 5.0-1, and DCD Tier 2, Table 2-1, in Revision 17 of the DCD with the additions described in the RAI response. The staff concludes that the applicant provided sufficient information to address the concerns of site uniformity, uniform soil springs analyses. and the zone of influence at the nuclear island foundation mat. Accordingly, the staff considers Issues 1 through 3 of Question 3 of RAI-SRP2.5-RGS1-15 resolved.

In RAI-SRP2.5-RGS1-17, the staff asked the applicant to explain the applicability of the survey of nuclear power plant conditions in the United States and how the survey results can be used to justify the site uniformity of a prospective site. In response to this RAI, the applicant pointed out that it had deleted the paragraph regarding the survey of nuclear plant conditions in response to RAI-SRP2.5-RGS1-12. Since RAI-SRP2.5-RGS1-12 is already considered

resolved, the staff concludes that RAI-SRP2.5-RGS1-17 is also resolved.

In RAI-SRP2.5-RGS1-18, the staff asked the applicant to incorporate, in DCD Section 2.5.4.5.1, the potential effects of a lack of uniformity outside the nuclear island footprint in SSI responses. In response to this RAI, the applicant referred to its response to RAI-SRP2.5-RGS1-13, in which the applicant stated that it planned to delete DCD Sections 2.5.4.5.1 and 2.5.4.5.2. Since RAI-SRP2.5-RGS1-13 is resolved, the staff concludes that RAI-SRP2.5-RGS1-18 is also resolved.

In RAI-SRP2.5-RGS1-19, the staff asked the applicant to clarify why it did not discuss faulting criteria. The applicant responded that, although faulting was not discussed as a separate criterion, faulting may result in different soil properties on each side of a fault, and that therefore the difference in properties would be evaluated against the criteria for lateral variability. The staff reviewed this response and finds that an assessment of lateral variability of soils will be an acceptable substitute to faulting criteria because it will address the offset of the fault in the site area. Therefore, the staff concludes that RAI-SRP2.5-RGS1-19 is resolved.

Finally, in RAI-SRP2.5-RGS1-20, the staff asked the applicant to justify the exclusion of site uniformity evaluation criteria for the case of a soil layer with a low-strain shear wave velocity less than 762 m/s (2,500 fps). In its response, the applicant referred to RAI-SRP2.5-RGS1-15 Question 3, Issue 4, which stated that soil sites would require a site-specific evaluation because of the unrealistically tight limit of ±10 percent. The staff resolved this question in its review of the applicant's response to RAI-SRP2.5-RGS1-15. Therefore, the staff concludes that RAI-SRP2.5-RGS1-20 is resolved.

2.5.4.5 Post Combined License Activities

The staff will identify post-COL activities on a site-by-site basis as part of its review of a COL application referencing the AP1000 DCD.

2.5.4.6 Conclusions

Based on its review of Revision 17 of AP1000 DCD, Section 2.5.4; DCD Tier 1, Table 5.0-1, and Tier 2, Table 2-1; and APP-GW-GLE-004, as well as the applicant's responses to RAIs and open items, the staff finds the following:

(1) The applicant clearly described the requirements for site excavation and backfill used for safety-related structure foundations, as well as the requirement for soil retaining structures for COL applicants that reference the AP1000 standard design. The staff finds this acceptable.

(2) The applicant clearly presented the technical basis for establishing proper static and dynamic foundation bearing capacity requirements, which consider the design static and dynamic loadings, including safe shutdown earthquake seismic loading. The staff finds this acceptable.

(3) Based on the previous review and calculation performed by the staff, as well as the

addition of DCD Tier 2, Table 2.5-1, the specification regarding foundation settlement adequately addressed the settlement requirement for the AP1000 nuclear island foundation and adjacent structures. The staff finds this acceptable.

(4) The information provided by the applicant in the DCD on subsurface uniformity is reasonable, and the site investigation and site foundation material evaluation criteria are acceptable because they acknowledge that site parameter information is required to satisfy the design and regulation. The staff finds this acceptable.

In summary, the staff finds that AP1000 DCD Revision 17, Tier 1, Table 5.0-1, and DCD Tier 2, Section 2.5.4, adequately describe the site-specific geotechnical and geophysical information and investigations that a COL applicant referencing the AP1000 DCD must provide to determine the properties and stability of all soils and rock that may affect the safety of nuclear power plant facilities, under both static and dynamic conditions, including the vibratory ground motions associated with the SSE. The staff concludes that, pending the closing of the confirmatory items identified in the previous technical evaluation section of this SER, Revision 17 of DCD Tier 2, Section 2.5.4, and the geological, seismological, and geotechnical engineering-related site parameters presented in Tier 1, Table 5.0-1, as well as in Tier 2, Table 2-1, are acceptable, because they meet the requirements of GDC 2, 10 CFR 52.47(a)(1), and 10 CFR 52.47(a)(2)(iv).

2.5.5 Combined License Information for Stability and Uniformity of Slopes

The applicant made no additions or changes to DCD Section 2.5.5 from the certified design of Revision 15 of the DCD; therefore, the staff did not reevaluate any of the previously certified information in this section.

2.5.6 Combined License Information for Embankments and Dams

The applicant made no additions or changes to DCD Section 2.5.6 from the certified design of Revision 15 of the DCD; therefore, the staff did not reevaluate any of the previously certified information in this section.