2. SITE ENVELOPE

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 was 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) that 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) that 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 envelope 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 that should 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 should 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 can be expected 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	None Provided		--
0–2 hours		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	None Provided		--
0–2 hours		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 POINT	RELEASE ELEVATION		HORIZONTAL STRAIGHT-LINE DISTANCE TO RECEPTOR			
			HVAC INTAKE (ELEVATION 19.9 METER(m))		ANNEX BUILDING ACCESS (ELEVATION 1.5 METER(m))	
	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 $1.37x10^{-4}$ m/s (19.4 in./h) to $1.46x10^{-4}$ 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 $x10^{-4}$ 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 is in Table 5.0-1. 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 finds 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 is open item **OI-SRP2.4RHEB-01-01**.

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 among 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 finds 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 is open item **OI-SRP2.4RHEB-01-02**.

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 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, except for the two open issues discussed in the technical evaluation.

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 five main sections of this part of the SER (i.e., Section 2.5) parallel the five main sections included in the applicant's DCD. Each of the five SER sections is 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 any requests for RAIs open items, and any 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 previous 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 design response spectra and 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 these 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 five requirements 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 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 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 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 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 exceeded 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 specific 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 may 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 <u>Regulatory Basis</u>

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 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion"

- 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 0.30g 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.

In response to the RAI, the applicant explained that Figures 3I.1-1 and 3I.1-2 showed hard rock high frequency (HRHF) response spectra resulting from evaluations of hard rock sites, as described in Appendix 3I to the DCD. The applicant also stated that those evaluations showed that the AP1000 was applicable to hard rock sites at which the foundation input response spectra (FIRS) are "less than or equal" to the HRHF response spectra. The applicant further clarified that the response spectra presented in Figures 3I.1-1 and 3I.1-2 of the DCD are not plant design response spectra, but are used for evaluation of a high seismic frequency input.

The applicant then revised Section 2.5.2 of the AP1000 DCD to state that the AP1000 was designed for an earthquake with a PGA of 0.3 g, referring to the AP1000 design earthquake as the AP1000 CSDRS. The applicant also stated that the seismic response spectra given in Figures 3I.1-1 and 3I.1-2 of the DCD were the bounding GMRS with high-frequency content representing a nuclear island founded on a hard rock site. Based on the applicant's response to the RAI, the staff concludes that this revision to the AP1000 DCD is sufficient to clarify the PGA and seismic response spectra requirements for sites referencing the AP1000 standard design. Therefore, 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 RAI 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 Revision 17 of the AP1000 DCD and noted that the revised DCD clearly describes how the site-specific GRMS should be determined, thereby adequately addressing the question described in the RAI. 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 need to be clarified. In RAI-SRP2.5-RGS1-03, the staff asked the applicant to address the following issues:

(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 detailed information regarding acceptance criteria for foundation soil to 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 acceptance criteria and basis are inadequate to show the comparison of the acceptance criteria and the sixth screening requirement. This issue is open item **OI-SRP2.5-RGS1-03**.

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 with conditions that 3-D effects cannot ignore (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, as described in RAI-SRP2.5-RGS1-04, as well as in RAI-TR85-SEB1-07 and 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 believes that the site-specific analysis should consider a 3-D effect for site conditions outside the certified design.
This issue is an open item **OI-SRP2.5-RGS1-04**.

The staff reviewed APP-GW-GLE-004, Revision 0, “Soil and Seismic Parameter Change,” with respect to shear wave velocity, including a case in which the criterion for a soil layer with a low-strain shear wave velocity of greater than or equal to 762 m/s (2,500 fps) was considered, 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 describe and provide the criterion for the case of a soil layer with low-strain shear wave velocity of less than 762 m/s (2,500 fps). In Issue 5 of Question 3 of the same RAI, the staff 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 these responses, especially the justification for deleting the requirement for those cases in which the low-strain shear wave velocity is less than 762 m/s (2,500 fps) because of the unrealistic nature of the tight limits on shear wave velocity variability, as well as the requirement of site-specific evaluations for applicants referencing the AP1000 DCD at a soil site. The staff also confirmed the changes made in Revision 17 to the Tier 1 and Tier 2 tables to reflect the revised criterion for minimum shear wave velocity. Based on the review of the RAI response and the revision of 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 concludes that the applicant provided sufficient information to resolve the geotechnical engineering aspects of both Issues 4 and 5 of Question 3 of RAI-SRP2.5-RGS1-15. Therefore, the staff considers these questions 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) term 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 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 GRMS 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 2.5.

The applicant addressed each item separately in its response. With respect to the first concern, the applicant referred to its response to RAI-SRP2.5-RGS1-02, which reflected the change from SSE to CSDRS when defining free-field ground motion. The applicant addressed the second item by referring to its response to RAI-SRP2.5-RGS1-04, which indicated that the applicant moved the paragraph containing the phrase in question to a different section of the DCD. The applicant responded to the issue of inversions by proposing a revision to the DCD. The applicant also proposed an additional revision to the DCD to address the third concern identified by the staff, referencing the proposed revisions described in RAI-SRP2.5-RGS1-02 and RAI-SRP2.5-RGS1-03, which were already resolved. The applicant addressed the fourth staff concern by making a simple revision to include the phrase “over the entire frequency range,” as suggested by the staff. Finally, 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 finds that the tables in question have been 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.

On the basis of its review of the applicant’s responses to the five issues of Question 6, including the revisions to the DCD and the resolution of the referenced RAI-SRP2.5-RGS1-02, RAI-SRP2.5-RGS1-03, and RAI-SRP2.5-RGS1-04, the staff concludes that, although the applicant provided adequate resolutions to all of the staff’s concerns identified in Issue 6 of Question 3 of RAI-SRP2.5-RGS1-15, the AP1000 DCD, Revision 17, Tier 2, Table 2-1, does not completely reflect the resolution. Therefore, the staff considers RAI-SRP2.5-RGS1-15 unresolved. This issue is open item **OI-SRP2.5-RGS1-15**.

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 clearly state the requirement for a site-specific soil degradation model that is one of the basic inputs of the SSI analysis in the AP1000 DCD. In response to these RAIs, 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 concluded 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 revised Table 3.7.1.4 of the DCD to reflect the strain compatible properties. 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 also 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 address the following issues: (1) define the term "geoscience parameters"; (2) clarify the discrepancy between DCD Section 2.5.2.3, which 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, and Section 3.7.1.1, which 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; and (3) 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 referred to its response to RAI-SRP2.5-RGS1-04, in which the applicant updated DCD Section 2.5.2.3 in Revision 17 of the AP1000 DCD with additional information to address the issues of the RAI. The applicant also referred to additional information related to the acceptability of 2-D analyses, which provided further clarification. The staff considered the reference to RAI-SRP2.5-RGS1-04 and the applicant's referral to DCD Section 2.5.2.3.1. Since the staff identified RAI-SRP2.5-RGS1-04 as unresolved, and it is closely related to the question in RAI-SRP2.5-RGS1-16, the staff considers the issues raised in RAI-SRP2.5-RGS1-16 to be unresolved. The staff previously identified the related issues in open item **OI-SRP2.5-RGS1-04** in Section 2.5.2.4.1 of this SER.

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, negligible fault displacement potential, and 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 the closing of open items identified in previous sections of this SER, for meeting the regulatory requirements of 10CFR 100.23, GDC 2, and 10 CFR 52.47(a)(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 the grade for unclear 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, it refers to Section 3.4.1.1.1.1 for 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 performing site-specific analyses to demonstrate factor of safety appropriate for normal plus safe shutdown earthquake 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 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, the site-specific evaluations 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 at the site within the nuclear island footprint and 12.2 m (40 ft) beyond, up to 36.6 m (120 ft) below grade. 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 on a 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 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 applications. In response to this RAI, the applicant added a requirement for the COL applicant to evaluate the 3-D effect 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 the 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 effect 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, 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” 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 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.

The applicant referred to its response to 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 design that envelops all rock and soil cases; and (2) the prior revision used the results from more conservative equivalent static analyses, while the current version used the result from nonlinear dynamic analyses. The dynamic nonlinear analyses showed much lower bearing reactions (1,331 kPa (27,008 psf) for hard rock) than those from the equivalent static design analyses for the basemat. Using the 2-D ANSYS commercial computer software, 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.

Regarding the factor of safety used for 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.

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 does not consider the RAI resolved until the applicant adequately addresses the structural engineering concerns. This issue is open item **OI- SRP2.5-RGS1-09**.

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 both Questions 1 and 2 of the RAI-SRP2.5-RGS1-15 to be resolved.

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 simply stated the liquefaction potential at the plant site as "NONE." In RAI-SRP2.5-RGS1-11, the staff asked the applicant to clearly define how and where the potential for liquefaction was negligible at a site. In response to this RAI, 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 staff reviewed this RAI response and confirmed that Revision 17 of the AP1000 DCD includes the proposed revisions to the DCD. Therefore, the staff concludes that the applicant clarified the phrase "none" in terms of the liquefaction potential requirement and sufficiently addressed the concerns of the RAI. Accordingly, the staff considers RAI-SRP2.5-RGS1-11 resolved.

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 of potential settlements 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 submittal. Since the applicant removed the content in question 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 the evaluation criteria of 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 definition of uniform in RG 1.132, and concluded that the applicant adequately addressed the concern of variations in uniformity of the site, as 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 again 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, 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 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, 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 foundation static and dynamic bearing capacity requirements, which considered 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 "negligible" liquefaction requirement and the requirement on evaluation of the liquefaction potential at the site meet the requirements of 10 CFR 100.23. The staff finds this acceptable.

(5) 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 open 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).