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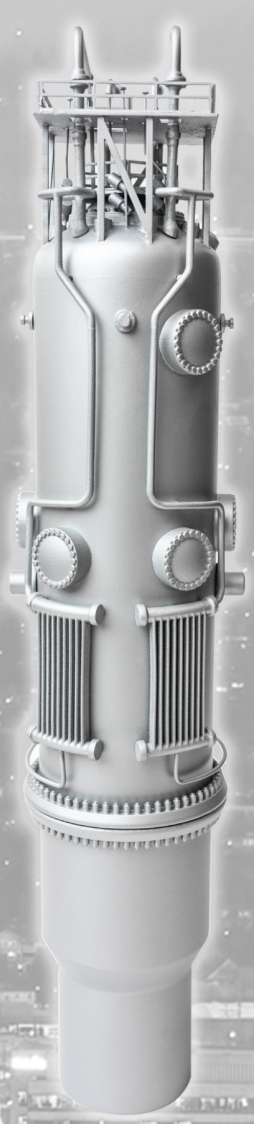
NuScale Standard Plant
Design Certification Application

Chapter Two

Site Characteristics and Site Parameters



PART 2 - TIER 2

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2.0 Site Characteristics and Site Parameters

The NuScale Power Plant design assumes site parameters that are representative of a reasonable number of potential plant site locations in the United States. A summary of these parameters is provided in Table 2.0-1.

COL Item 2.0-1: A COL applicant that references the NuScale Power Plant design certification will demonstrate that site-specific characteristics are bounded by the site parameters specified in Table 2.0-1. If site-specific values are not bounded by the values in Table 2.0-1, the COL applicant will demonstrate the acceptability of the site-specific values in the appropriate sections of its combined license application.

Table 2.0-1: Site Parameters

Site Characteristic	Site Parameter	References to Parameter
Geography and Demography (Section 2.1)		
Minimum exclusion area boundary	400 feet from the closest release point	Sections 2.1 and 2.3.4
Minimum outer boundary of low population zone	400 feet from the closest release point	Sections 2.1 and 2.3.4
Nearby Industrial, Transportation, and Military Facilities (Section 2.2)		
External hazards on plant systems, structures, and components (SSC) (e.g., explosions, fires, release of toxic chemicals and flammable clouds, pressure effects) on plant SSC	No external hazards	Section 2.2
Aircraft hazards on plant SSC	No design basis aircraft hazards	Sections 2.2 and 3.5.1.6
Meteorology (Section 2.3)		
Maximum precipitation rate	19.4 inches per hour 6.3 inches for a 5 minute period	Sections 3.4.2.2 and 3.8.4.3.10
Normal roof snow load	50 psf	Sections 3.4.2.2, 3.8.4.3.10, 3.8.4.3.11, 3.8.4.3.16, 3.8.4.4.1, 3.8.4.4.2, 3.8.4.8, and 3.8.5.5.5
Extreme roof snow load	75 psf	Sections 3.4.2.2, 3.8.4.3.10, 3.8.4.3.12, 3.8.4.3.16, 3.8.4.4.1, 3.8.4.4.2, 3.8.4.8, and 3.8.5.5.5
100-year return period 3-second wind gust speed	145 mph (Exposure Category C) with an importance factor of 1.15 for Reactor Building, Control Building, and Radioactive Waste Building	Sections 3.3.1.1, 3.8.4.3.13, and 3.8.4.8
Design basis tornado maximum wind speed translational speed maximum rotational speed radius of maximum rotational speed pressure drop rate of pressure drop	 230 mph 46 mph 184 mph 150 ft 1.2 psi 0.5 psi/sec	Sections 3.1.1.2, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.8.4.3.14, and 3.8.4.8
Tornado missile spectra	Table 2 of Regulatory Guide 1.76, Revision 1, Region 1	Sections 3.3.2.3, 3.5.1.4, 3.5.2, 3.5.3.1, and 3.5.3.2
Maximum wind speed design basis hurricane	290 mph	Sections 3.1.1.2, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.8.4.3.14, and 3.8.4.8
Hurricane missile spectra	Tables 1 and 2 of Regulatory Guide 1.221, Revision 0	Section 3.5.1.4, 3.3.2.3, 3.5.2, 3.5.3.1, and 3.5.3.2

Table 2.0-1: Site Parameters (Continued)

Site Characteristic	Site Parameter		References to Parameter
Accident release χ/Q values at exclusion area boundary and outer boundary of low population zone			
0-2 hr	6.22E-04 s/m^3		Sections 15.0.3.2 and 15.0.3.3.11; Table 15.0-13
2-8 hr	5.27E-04 s/m^3		
8-24 hr	2.41E-04 s/m^3		
24-96 hr	2.51E-04 s/m^3		
96-720 hr	2.46E-04 s/m^3		
Accident release χ/Q values at main control room/technical support center door and HVAC intake	Door	HVAC Intake	
0-2 hr	6.50E-03 s/m^3	6.50E-03 s/m^3	Section 15.0.3.3.11; Table 15.0-13
2-8 hr	5.34E-03 s/m^3	5.34E-03 s/m^3	
8-24 hr	2.32E-03 s/m^3	2.32E-03 s/m^3	
1-4 day	2.37E-03 s/m^3	2.37E-03 s/m^3	
4-30 day	2.14E-03 s/m^3	2.14E-03 s/m^3	
Routine release χ/Q and D/Q values at restricted area boundary			
undepleted/no decay	1.44E-05 s/m^3		Tables 11.3-5 and 11.3-6
undepleted/2.26-day decay	1.44E-05 s/m^3		
depleted/8.00-day decay	1.44E-05 s/m^3		
D/Q	1.44E-07 1/m^2		
Zero percent exceedance values (historical limit excluding peaks <2 hours)			Sections 3.8.4.3.8, 3.8.4.8, 9.4.1.1, 20.1.1.4, and 20.1.1.5; Table 9.4.1-1
Maximum outdoor design dry bulb temperature	115°F		
Maximum coincident wet bulb temperature	80°F		
Maximum non-coincident wet bulb temperature	81°F		
Minimum outdoor design dry bulb temperature	-40°F		
One percent annual exceedance values			Section 9.2.7.2.1; Tables 9.2.7-1, 9.4.2-1, 9.4.3-1, and 10.4-9
Maximum outdoor design dry bulb temperature	100°F		
Maximum coincident wet bulb temperature	77°F		
Maximum non-coincident wet bulb temperature	80°F		
Minimum outdoor design dry bulb temperature	-10°F		

Table 2.0-1: Site Parameters (Continued)

Site Characteristic	Site Parameter	References to Parameter
Five percent annual exceedance values Maximum outdoor design dry bulb temperature Maximum coincident wet bulb temperature Minimum outdoor design dry bulb temperature	 95°F 77°F -5°F	Table 9.4.4-1
Hydrologic Engineering (Section 2.4)		
Maximum flood elevation Probable maximum flood and coincident wind wave and other effects on max flood level	1 foot below the baseline plant elevation	Sections 2.4.2 and 3.4.2.1; Table 3.8.5-8
Maximum elevation of groundwater	2 feet below the baseline plant elevation	Sections 2.4.12, 3.4.2.1, 3.8.4.3.22.1, and 3.8.4.8; Table 3.8.5-8
Geology, Seismology, and Geotechnical Engineering (Section 2.5)		
Ground motion response spectra /safe shutdown earthquake	See Figures 3.7.1-1 and 3.7.1-2 for horizontal and vertical certified seismic design response spectra (CSDRS) for all Seismic Category I SSC. See Figures 3.7.1-3 and 3.7.1-4 for horizontal and vertical high frequency certified seismic design response spectra (CSDRS-HF) for Reactor Building and Control Building.	Sections 3.7.1.1, 3.8.4.3.16, and 3.8.4.8
Fault displacement potential	No fault displacement potential	Section 2.5.3
Minimum soil bearing capacity (Q_{ult}) beneath safety-related structures	75 ksf	Sections 2.5.4, 3.8.5.6.3, and 3.8.5.6.7
Lateral soil variability	Uniform site (< 20 degree dip)	Section 2.5.4
Minimum soil angle of internal friction	30 degrees	Sections 2.5.4 and 3.8.5.3.1; Table 3.8.5-1
Minimum shear wave velocity	≥ 1000 fps at bottom of foundation	Section 2.5.4
Liquefaction potential	No liquefaction potential	Section 2.5.4
Coefficient of friction (CoF) between concrete foundation and soil	≥ 0.58 where CoF = tan (φ)	Section 2.5.4, 3.8.5.3.1, 3.8.5.4.1.2, 3.8.5.5.2, Table 3.8.5-1, Table 3.8.5-8
Coefficient of friction (CoF) between concrete foundation and soil (CRB nonlinear analysis)	≥ 0.55	Section 2.5.4, 3.8.5.4.1.4, Table 3.8.5-8
Coefficient of friction (CoF) between walls and soil	≥ 0.50	Section 2.5.4, 3.8.5.4.1.2, 3.8.5.4.1.4, Table 3.8.5-1, Table 3.8.5-8

Table 2.0-1: Site Parameters (Continued)

Site Characteristic	Site Parameter	References to Parameter
Maximum settlement for the Reactor Building, Control Building, and Radioactive Waste Building:		
• total settlement	4 inches	Sections 2.5.4, 3.8.5.6.1, and 3.8.5.6.2
• tilt settlement	Maximum of 0.5 inch per 50 feet of building length or 1 inch total in any direction at any point in these structures	Sections 2.5.4, 3.8.5.6.1, 3.8.5.6.2, and 3.8.5.6.4
• differential settlement (between Reactor Building and Control Building, and between Reactor Building and Radioactive Waste Building)	0.5 inch	Section 3.8.5.6.4
Slope failure potential	No slope failure potential	Section 2.5.5

2.1 Geography and Demography

The certified design assumes that the Exclusion Area Boundary and Low Population Zone outer boundary are as close as 400 feet from the nearest release point. This is a key site parameter and included in Table 2.0-1.

COL Item 2.1-1: A COL applicant that references the NuScale Power Plant design certification will describe the site geographic and demographic characteristics.

2.2 Nearby Industrial, Transportation, and Military Facilities

The NuScale Power Plant certified design does not postulate any hazards from nearby industrial, transportation or military facilities.

COL Item 2.2-1: A COL applicant that references the NuScale Power Plant design certification will describe nearby industrial, transportation, and military facilities. The COL applicant will demonstrate that the design is acceptable for each of these potential hazards, or provide site-specific design alternatives.

2.3 Meteorology

The NuScale Power Plant is designed using meteorological parameters that are representative of a reasonable number of potential plant site locations in the United States. These parameters are discussed below and presented in Table 2.0-1.

COL Item 2.3-1: A COL applicant that references the NuScale Power Plant design certification will describe the site-specific meteorological characteristics for Section 2.3.1 through Section 2.3.5, as applicable.

2.3.1 Regional Climatology

The design maximum precipitation rate is 19.4 inches per hour and 6.3 inches for a 5 minute period. These values come from NWS HMR #52 (Reference 2.3-1) and address the majority of locations in the contiguous United States.

The design normal roof snow load is 50 psf. For the extreme roof snow load, a value of 150 percent of the normal roof snow load, or 75 psf was selected.

The design basis severe wind is a 3-second gust at 33 ft above ground for exposure category C. The wind speed (W) is 145 mph. The wind speed is increased by an importance factor of 1.15 for the design of the site independent structures. These design parameters are based upon ASCE/SEI 7-05 (Reference 2.3-4).

The parameters provided in Table 2.0-1 for the design basis tornado and tornado missiles are the most severe tornado parameters postulated for the contiguous United States as identified in RG 1.76, Rev. 1. Similarly, the parameters for the design basis hurricane and hurricane missiles are the most severe parameters postulated in RG 1.221, Rev 0.

The design basis dry-bulb and wet bulb temperatures are based on the EPRI Utility Requirements Document (Reference 2.3-2). Pertinent zero percent, and one and five percent annual exceedance values assumed in the design are provided in Table 2.0-1. The coincident wet-bulb temperature value represents the overall maximum wet bulb temperature that is coincident with the indicated dry-bulb temperature.

Regional climatology is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.3-1.

2.3.2 Local Meteorology

Local meteorology is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.3-1.

2.3.3 Onsite Meteorological Measurements Programs

Onsite meteorological measurement programs are site-specific and are addressed by the COL applicant as part of the response to COL Item 2.3-1.

2.3.4 Short-Term Atmospheric Dispersion Estimates for Accident Releases

Accidental Radioactive Releases

Topical Report TR-0915-17565-P-A, Revision 4, (Reference 2.3-3) describes the methodology used for establishing source terms and calculating the atmospheric dispersion factors used to determine accident radiological consequences at the technical support center (TSC), main control room (MCR) and offsite locations for the NuScale Power Plant certified design.

Atmospheric dispersion factors (χ/Q values) are determined at the exclusion area boundary (EAB) and the low population zone (LPZ) outer boundary, which may be as close as 400 feet from the closest release point. These χ/Q values as well as the χ/Q values for the MCR were determined for various sites in the United States using a meteorological database that included multiple years of data across all regions of the United States. This approach determined that the meteorological dataset for Sacramento, California, between 1984-1986, is representative of the bounding 80th to 90th percentile of potential NuScale Power Plant construction sites in the United States. This meteorological data set was used to calculate the χ/Q values for the certified design.

The χ/Q values at the EAB and the LPZ outer boundary are listed in Table 2.0-1. These χ/Q values are based on the source location and path shown in Figure 2.3-1.

The χ/Q values used for evaluation of doses in the MCR and TSC are determined at the Control Building doors and HVAC inlet and are listed in Table 2.0-1. Figure 2.3-2 and Figure 2.3-3 show the path and distances from the Reactor Building release point to MCR door and HVAC inlet. The two source locations shown in Figure 2.3-2 and Figure 2.3-3 are the limiting source locations because they are the closest source locations to the main control room personnel doors and main control room HVAC intake. Assumptions for release point characteristics used for the χ/Q calculations are listed in Table 15.0-20.

The χ/Q values for the TSC are the same as the MCR because the TSC is located directly above the MCR and shares the same HVAC inlet and outside doors.

The COL applicant will determine site specific χ/Q values for the EAB, LPZ outer boundary, MCR and present that information as part of the response to COL item 2.3-1.

Hazardous Material Releases

As stated in Section 2.2, the NuScale Power Plant certified design does not postulate any hazards from on-site sources or nearby industrial, transportation, or military facilities.

The COL applicant will provide discussion of site specific hazardous material releases as part of the response to COL item 2.3-1.

2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

Routine release atmospheric dispersion factors (χ/Q values) and relative deposition factor (D/Q) values at the restricted area boundary provided in Table 2.0-1 are conservatively

estimated and used to calculate release concentrations for comparison to the activity release limits in 10 CFR 20, as discussed in Section 11.3.

Routine release atmospheric dispersion factors (χ/Q values) and deposition factor (D/Q) values in unrestricted areas and at locations of interest are site-specific and are developed by the COL applicant as part of the response to COL Item 2.3-1.

2.3.6 References

2.3-1 National Oceanic and Atmospheric Administration, "Application of Probable Maximum Precipitation Estimates- United States East of the 105th Meridian," Hydrometeorological Report Number 52, Washington DC, August 1982.

2.3-2 Electrical Power Research Institute, "Advanced Nuclear Technology: Advanced Light Water Reactor Utility Requirements Document," Revision 13, EPRI, Palo Alto, CA, 2014.

2.3-3 NuScale Power, LLC, "Accident Source Term Methodology," TR-0915-17565-P-A Revision 4.

2.3-4 American Society of Civil Engineers/Structural Engineering Institute, "Minimum Design Loads for Buildings and Other Structures," ASCE/SEI 7-05, Reston, VA.

Figure 2.3-1: Limiting Analytical Distance to EAB and LPZ Outer Boundary

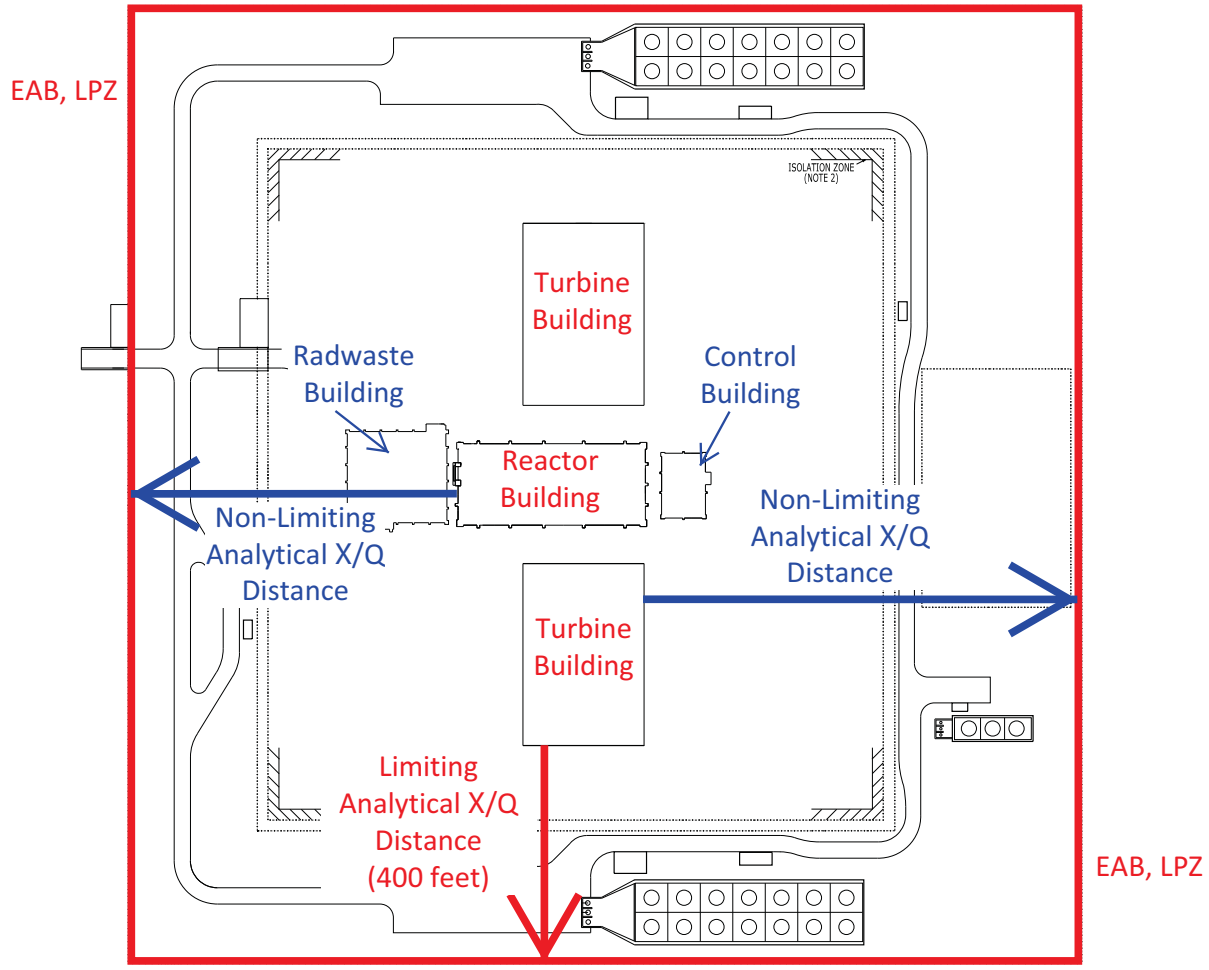

Figure 2.3-2: Source to Control Building Door Distances

{{ Withheld - See Part 9 }}

Figure 2.3-3: Source to Control Building HVAC Intake Distance

{{ Withheld - See Part 9 }}

2.4 Hydrologic Engineering

The NuScale Power Plant design does not rely upon an external water supply for the ultimate heat sink or safety-related makeup water. This design reduces the influence local hydrologic features have on plant safety. Site parameters selected to represent site conditions are presented in Table 2.0-1.

COL Item 2.4-1: A COL applicant that references the NuScale Power Plant design certification will investigate and describe the site-specific hydrologic characteristics for Section 2.4.1 through Section 2.4.14, except Section 2.4.8 and Section 2.4.10.

2.4.1 Hydrologic Description

The local hydrology is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.2 Floods

The design assumes that the maximum flood elevation (including wind-induced wave run-up) is one foot below baseline plant elevation. The baseline plant elevation is the top of concrete of the ground floor of the Reactor Building. This maximum flood elevation is a key design parameter.

The potential for flooding is site-specific and is addressed by the COL applicant as part of part of the response to COL Item 2.4-1.

2.4.3 Probable Maximum Flood (PMF) on Streams and Rivers

The probable maximum flood (PMF) is site-specific and is addressed by the COL as part of the response to COL Item 2.4-1.

2.4.4 Potential Dam Failures

The presence of onsite, upstream, and downstream water control structures is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.5 Probable Maximum Surge and Seiche Flooding

The potential for surge or seiche flooding is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.6 Probable Maximum Tsunami Hazards

The potential for tsunamis is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.7 Ice Effects

The design does not rely upon a safety-related intake structure as a makeup source for the reactor pool, which acts as the ultimate heat sink. Therefore, ice effects do not affect safety

related cooling. The potential for ice effects to contribute to flooding is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.8 Cooling Water Canals and Reservoirs

The design does not rely upon safety-related cooling water canals or reservoirs as a makeup source for the reactor pool, which acts as the ultimate heat sink.

2.4.9 Channel Diversions

The design does not rely upon a safety-related makeup water source. Therefore, upstream channel diversions would not adversely affect safety-related cooling. The potential for channel diversions to contribute to flooding is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.10 Flood Protection Requirements

The design assumes that the baseline plant elevation is one foot above the maximum flood level. Therefore there are no flood protection requirements.

2.4.11 Low Water Considerations

The design does not rely upon a safety-related source of makeup water. Low flow from surges, seiches, tsunamis, downstream dam failures, future water controls, ice effects, upstream channel diversions, or other sources of low water would not adversely affect safety-related cooling.

The potential effects of low water levels on nonsafety-related water supplies is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.12 Groundwater

The design does not employ a permanent dewatering system. Groundwater is assumed to be a minimum of two feet below site grade. High groundwater has an adverse effect on stability. This is a key design parameter.

Groundwater is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.4.13 Accidental Releases of Radioactive Liquid Effluents in Groundwater and Surface Waters

Dilution factors, dispersion coefficients, flow velocities, travel times, adsorption, and pathways of liquid contaminants for radioactive liquid effluents from accidental releases into groundwater or surface water is site-specific and is addressed by the COL applicant as part of the response to COL Item 2.4-1. The source term provided in Table 12.2-10 associated with the pool surge control system storage tank is assumed to be contained by the passive and durable mitigative design feature (a metal-lined concrete catch basin) in an analysis to evaluate the effects of an accidental release of radioactive liquid as part of the

response to COL Item 2.4-1 demonstrating the adequacy of the site's hydrogeologic properties.

2.4.14 Technical Specifications and Emergency Operation Requirements

The design does not require emergency protective measures to minimize the impact of adverse hydrology-related events on safety-related facilities.

Site-specific emergency protective measures are addressed by the COL applicant as part of the response to COL Item 2.4-1.

2.5 Geology, Seismology, and Geotechnical Engineering

The NuScale Power Plant is designed using geologic, seismologic, and geotechnical engineering parameters that are representative of a reasonable number of potential plant site locations in the United States. These parameters are presented in Table 2.0-1.

COL Item 2.5-1: A COL applicant that references the NuScale Power Plant design certification will describe the site-specific geology, seismology, and geotechnical characteristics for Section 2.5.1 through Section 2.5.5, below.

2.5.1 Basic Geologic and Seismic Information

Basic regional and site geologic and seismic information is site-specific and addressed by the COL applicant as part of the response to COL Item 2.5-1.

2.5.2 Vibratory Ground Motion

There are two design basis earthquakes for the evaluation of structures that are included in the certified design: the certified seismic design response spectra (CSDRS) and the certified seismic design response spectra - high frequency (CSDRS-HF). These spectra were developed by reviewing earthquake design data from the U.S. nuclear industry and are intended to bound most of the central and eastern U.S. as well as sites in less seismically active portions of the western U.S.

The CSDRS and CSDRS-HF are discussed in Section 3.7.1. The CSDRS is shown in Figure 3.7.1-1 and Figure 3.7.1-2. The CSDRS-HF is shown in Figure 3.7.1-3 and Figure 3.7.1-4. The CSDRS and CSDRS-HF are key design parameters.

Local vibratory ground motion, including development of a safe shutdown earthquake is site-specific and addressed by the COL applicant as part of the response to COL Item 2.5-1.

2.5.3 Surface Faulting

The design analysis assumes that there is no fault displacement potential under the plant structures. This assumption is a key design parameter.

Detailed surface and subsurface geological, seismological, and geophysical information, including surface faulting, is site-specific and addressed by the COL applicant as part of the response to COL Item 2.5-1.

2.5.4 Stability of Subsurface Materials and Foundations

The design analysis assumes the following parameters:

- The minimum shear wave velocity is 1000 fps. Competent material is generally considered to be in situ material having a minimum shear wave velocity of 1,000 fps.
- The minimum ultimate bearing capacity (Q_{ult}) is 75 ksf. This bearing capacity is sufficient to provide a factor of safety greater than 3.0 for the static bearing pressure

and greater than 2.0 for dynamic bearing pressure. Bearing pressures for the Reactor Building and Control Building are provided in Section 3.8.5.

- The soil column is uniform (i.e., the site layers dip less than 20 degrees). As described in NUREG/CR-0693, the use of horizontal layers for soil-structure interaction analysis is acceptable if the layers dip less than 20 degrees.
- There is no potential for soil liquefaction. This analysis may be performed with the site-specific safe shutdown earthquake.
- The minimum coefficient of static friction at the interfaces between the basemat and the soil is 0.58. The minimum coefficient of friction at the interface between the basemat and the soil for Control Building nonlinear analyses is 0.55. In addition, the minimum coefficient of friction between the walls and soil is 0.50. The friction is defined between concrete and clean gravel, gravel-sand mixture, or coarse sand with a friction angle of 30 degrees (Reference 2.5-1).
- The minimum soil angle of internal friction is 30 degrees.

There are no rigid safety-related connections between the structures and no safety-related connections to other site structures. The maximum allowable total settlement at any foundation node is 4 inches and a maximum allowable differential settlement between the Reactor Building and Control Building, and between the Reactor Building and Radioactive Waste Building is 0.5 inch. A settlement tilt limit of 1 inch total or half an inch per 50 feet has been established. This tilt (< 0.1 degree) is small enough that it does not affect the structural analysis.

The following are key design parameters:

- minimum shear wave velocity
- minimum ultimate bearing capacity
- uniformity of soil layers
- potential for soil liquefaction
- minimum coefficient of static friction
- minimum soil angle of internal friction
- settlement tilt

Characteristics of the subsurface materials are site-specific and are discussed by the COL applicant as part of the response to COL Item 2.5-1.

2.5.5 Stability of Slopes

The standard plant layout assumes a uniform, graded site as shown in Figure 1.2-4. Therefore, no slope failure potential is a key design parameter.

Stability of slopes on or near the site are confirmed by the COL applicant as part of the response to COL Item 2.5-1. This analysis may be performed with the site-specific safe shutdown earthquake.

2.5.6 References

2.5-1 Department of the Navy, "Design Manual 7.2 - Foundation and Earth Structures," NAVFAC DM-7.2, Alexandria, VA, May 1982.