APR1400
DESIGN CONTROL DOCUMENT TIER 2

CHAPTER 2
SITE CHARACTERISTICS

APR1400-K-X-FS-14002-NP

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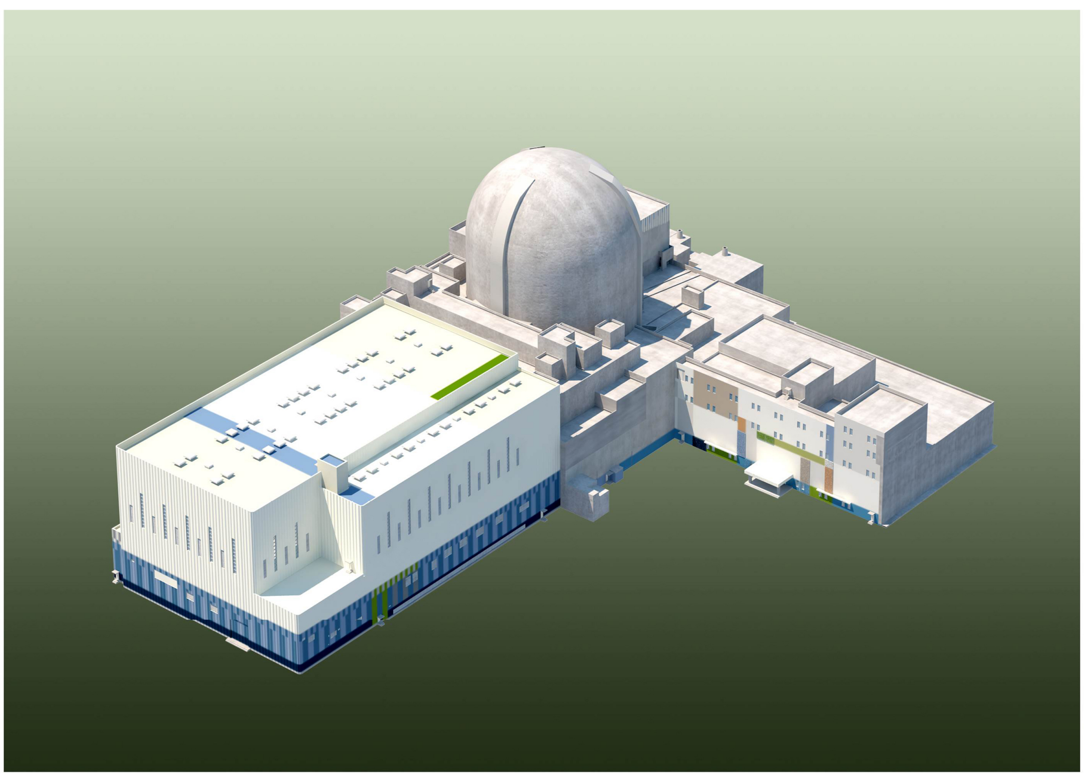

KOREA ELECTRIC POWER CORPORATION

KOREA HYDRO & NUCLEAR POWER CO., LTD

CHAPTER 2 – SITE CHARACTERISTICS

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ACRONYM AND ABBREVIATION LIST

χ/Q	atmospheric dispersion factor
AB	auxiliary building
ADV	atmospheric dump valve
CFR	Code of Federal Regulations
COL	combined license
CSDRS	certified seismic design response spectra
CW	circulating water
CWS	circulating water system
DBE	design basis event
D/Q	relative deposition factor
EAB	exclusion area boundary
EPRI	Electric Power Research Institute
ESWS	essential service water system
FIRS	foundation input response spectra
FS	factor of safety
GMRS	ground motion response spectra
HRHF	hard rock high frequency
HVAC	heating, ventilation, and air conditioning
LPZ	low-population zone
LWR	light water reactor
MCR	main control room
MMI	modified mercalli intensity
NI	nuclear island
NRC	U.S. Nuclear Regulatory Commission
PMF	probable maximum flood
PMP	probable maximum precipitation
PMWP	probable maximum winter precipitation
PSHA	probabilistic seismic hazard analysis
RG	Regulatory Guide

SFG	structural fill granular
SSC	structure, system, or component
SSE	safe shutdown earthquake
UHS	ultimate heat sink
URD	Utility Requirements Document

CHAPTER 2 – SITE CHARACTERISTICS

2.0 Site Characteristics

The APR1400 is designed on the basis of a set of assumed site-related parameters. The parameters were selected to include a range of potential nuclear power plant sites in the United States. A summary of the assumed parameters is provided in Table 2.0-1.

Detailed site-related characteristics will be provided in Chapter 2 of the Final Safety Analysis Report for any applications referencing the APR1400 design. These characteristics are to be reviewed and compared to the site parameters in Table 2.0-1. The combined license (COL) applicant is to demonstrate that the APR1400 design meets the requirements imposed by the site-specific parameters and conforms with all design commitments and acceptance criteria if the characteristics of the site fall outside the assumed site parameters in Table 2.0-1 (COL 2.0(1)).

2.0.1 Combined License Information

COL 2.0(1) The COL applicant is to demonstrate that the APR1400 design meets the requirements imposed by the site-specific parameters and conforms with all design commitments and acceptance criteria if the characteristics of the site fall outside the assumed site parameters in Table 2.0-1.

2.0.2 References

1. Regulatory Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Rev. 1, U.S. Nuclear Regulatory Commission, March 2007.

2. Regulatory Guide 1.221, "Design-Basis Hurricane and Hurricane Missile for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, October 2011.

Table 2.0-1 (1 of 4)

Site Parameters

Parameter Description	Parameter Value
Maximum Elevation of Groundwater	0.61 m (2 ft) below plant grade (1) in the vicinity of the SSCs important to safety
Maximum Flood Elevation	0.30 m (1 ft) below plant grade in the vicinity of the SSCs important to safety
Precipitation	
- Maximum precipitation rate (1 mi^2)	492.7 mm (19.4 in.) over 1 hour 157.5 mm (6.2 in.) in 5 minutes
- 100-year snowpack roof load	2.873 kPa (60 lbf/ft^2)
- Extreme winter precipitation roof load	5.985 kPa (125 lbf/ft^2)
- Depth of 48-hour probable maximum winter precipitation (PMWP)	914.4 mm (36 in.)
HVAC Outdoor Design Temperature (5)	
- 5 % annual exceedance values	
· Maximum	35.0 °C (95 °F) dry bulb and 25.0 °C (77 °F) coincident wet bulb
· Minimum	-20.6 °C (-5 °F) dry bulb
- 1 % annual exceedance values	
· Maximum	37.8 °C (100 °F) dry bulb and 25.0 °C (77 °F) coincident wet bulb
· Minimum	–23.3 °C (–10 °F) dry bulb
- 0 % annual exceedance values (historical limit excluding peaks < 2 hours)	
· Maximum	46.1 °C (115 °F) dry bulb and 26.7 °C (80 °F) coincident wet bulb
· Minimum	–40.0 °C (–40 °F) dry bulb
Ambient Design Temperature for Cooling Tower (5)	
- Ambient 5 % annual exceedance values for circulating water system (CWS)	
· Maximum	26.1 °C (79 °F) non-coincident wet bulb
· Minimum	–20.6 °C (-5 °F) dry bulb

Table 2.0-1 (2 of 4)

Parameter Description	Parameter Value
- Ambient 0 % annual exceedance values for essential service water system (ESWS) (5) (historical limit excluding peaks < 2 hours) · Maximum · Minimum	 27.2 °C (81 °F) non-coincident wet bulb –40.0 °C (–40 °F) dry bulb
Extreme Wind - 50-year 3-second wind gust speed - Importance factor	 64.8 m/s (145 mph); exposure category C 1.15 (2)
Tornado Parameters - Maximum wind speed - Translational speed - Maximum rotational speed - Radius of maximum rotational speed - Pressure drop - Rate of pressure drop - Missile spectrum	 102.8 m/s (230 mph) 20.6 m/s (46 mph) 82.2 m/s (184 mph) 45.7 m (150 ft) 8.274 kPa (1.2 psi) 3.447 kPa/s (0.5 psi/s) Table 2 (Region I) of NRC RG 1.76 (Reference 1 in Subsection 2.0.2)
Hurricane Parameters - Maximum wind speed - Missile spectrum	 116 m/s (260 mph) Table 1 of NRC RG 1.221 (Reference 2 in Subsection 2.0.2)
Accident Release χ/Q Values at exclusion area boundary (EAB) · 0-2 hr	 1.00×10^{-3} s/m^3
Accident Release χ/Q Values at low-population zone (LPZ) · 0-8 hr · 8-24 hr · 24-96 hr · 96-720 hr	 2.20×10^{-4} s/m^3 1.60×10^{-4} s/m^3 1.00×10^{-4} s/m^3 8.00×10^{-5} s/m^3
Annual Average χ/Q Values at Site Boundary · Undepleted/no decay · Undepleted/2.26-day decay · Depleted/8.00-day decay · Relative deposition factor (D/Q)	 2.00×10^{-5} s/m^3 1.99×10^{-5} s/m^3 1.84×10^{-5} s/m^3 2.00×10^{-7} 1/m^2
Control Room, Technical Support Center, and Auxiliary Building Atmospheric Dispersion Factor (χ/Qs)	See Table 2.3-2 through Table 2.3-12

Table 2.0-1 (3 of 4)

Parameter Description	Parameter Value
Inventory of radionuclides that could seep into the groundwater	See Table 11.2-9
Safe Shutdown Earthquake (SSE)	0.3 g peak ground acceleration
Certified Seismic Design Response Spectra (CSDRS) Referencing SSE	See Figures 2.0-1 and 2.0-2
Hard Rock High Frequency (HRHF) Response Spectra (4)	0.46g peak ground acceleration See Figures 2.0-3 and 2.0-4
Tectonic and Non-tectonic Surface Deformation Potential	See Subsection 2.5.3
Allowable Static Bearing Capacity for Seismic Category I Structures (Dead and Live Load)	The allowable static bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum static bearing demand of 957.6 kPa (20 ksf). The allowable static bearing capacity is the value of ultimate bearing capacity divided by 3.0.
Allowable Dynamic Bearing Capacity for seismic Category I Structures (Design Load Combination including SSE Load)	The allowable dynamic bearing capacity, including a factor of safety appropriate for the design load combinations, shall be greater than or equal to the maximum dynamic bearing demand of 2,872.8 kPa (60 ksf). The allowable dynamic bearing capacity is the value of ultimate bearing capacity divided by 2.0.
Minimum Factor of Safety for Slope on Static condition	1.5
Minimum Factor of Safety for Slope on Dynamic condition (SSE)	1.2
Minimum Shear Wave Velocity	304.8 m/s (1,000 ft/s)
Maximum Dip Angle for Soil Uniformity	20 degrees
Liquefaction Potential	See Subsection 2.5.4.8
Maximum Allowable Differential Settlement inside Building	12.7 mm (0.5 in.) per 15.24 m (50 ft) in any direction for all seismic Category I structures under static and seismic load
Maximum Allowable Differential Settlement between Buildings	76.2 mm (3.0 in.) between NI and EDGB, NI and DFOT, EDGB and DFOT under static load.
Minimum Soil Angle of Internal Friction	Greater than or equal to 35 degrees below the footprint of the seismic Category I structures at their excavation depth
Slope Failure Potential (yes/no)	No
Backfill Material Density	2.2 g/cm^3 (137 pcf)

Table 2.0-1 (4 of 4)

Parameter Description	Parameter Value		
Backfill Material Dynamic Poisson's Ratio	0.33		
Backfill Material Dynamic Properties (Normalized Minimum Shear Moduli & Maximum Damping) [6]	Shear Strain (%)	G/G_{max}	Damping (%)
	1.0	0.05	24.0
	0.1	0.22	16.0
	0.01	0.54	6.0
	0.001	0.85	2.0
	0.0001	1.00	1.0
Strain-compatible Minimum Shear-wave Velocity of Backfill	155 m/s (510 fps)		

(1) Plant grade represents the level of ground adjacent to the nuclear island buildings and is established at a plant elevation 98 ft 8 in.

(2) 100-year recurrence interval: Value to be used for design of seismic Category I and II structures only.

(3) Bearing capacity is defined at the foundation level of the seismic Category I structures.

(4) The HRHF response spectra are provided for evaluation of site-specific ground motion response spectra which exceed the CSDRS in the high frequency range at hard rock sites.

(5) Degrees Fahrenheit (°F) are the main units and temperatures in Celsius (°C) are reference values that are converted from main units.

(6) The backfill material dynamic properties are used to calculate the shear-strain-compatible shear wave velocity profiles for the backfill. The strain-compatible damping values of the backfill cannot be greater than 15%.

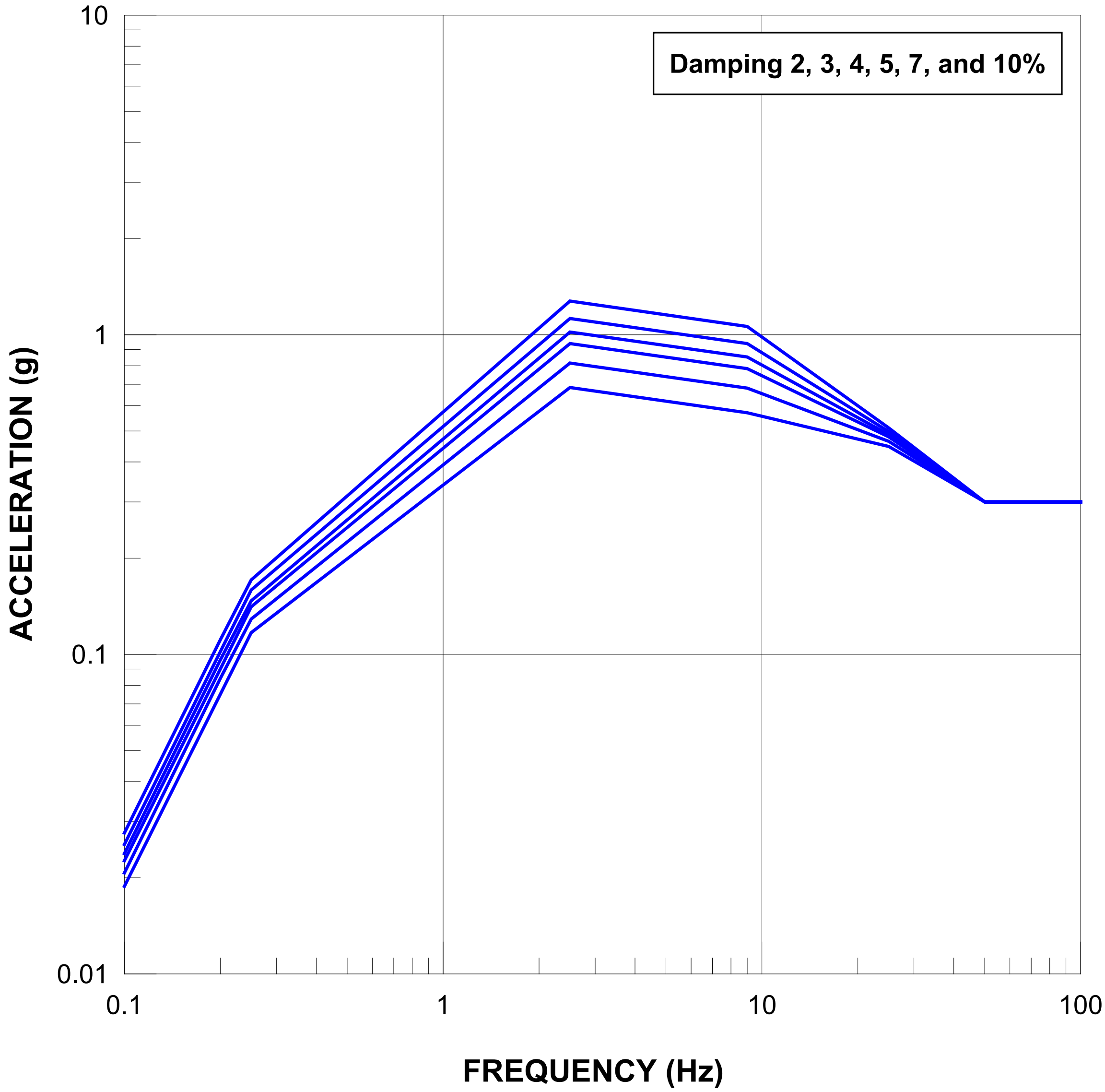

Figure 2.0-1 Horizontal Certified Seismic Design Response Spectra

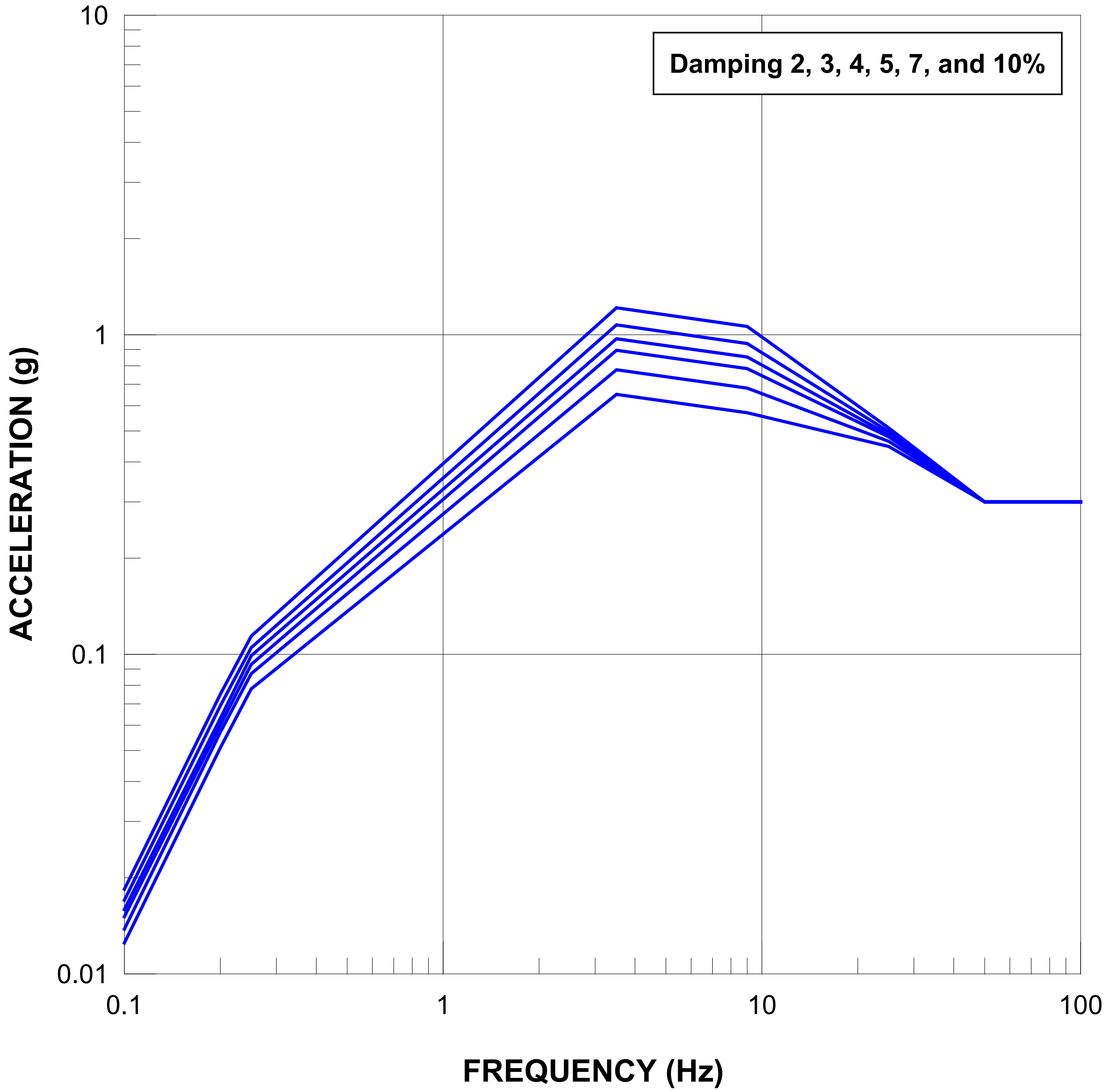

Figure 2.0-2 Vertical Certified Seismic Design Response Spectra

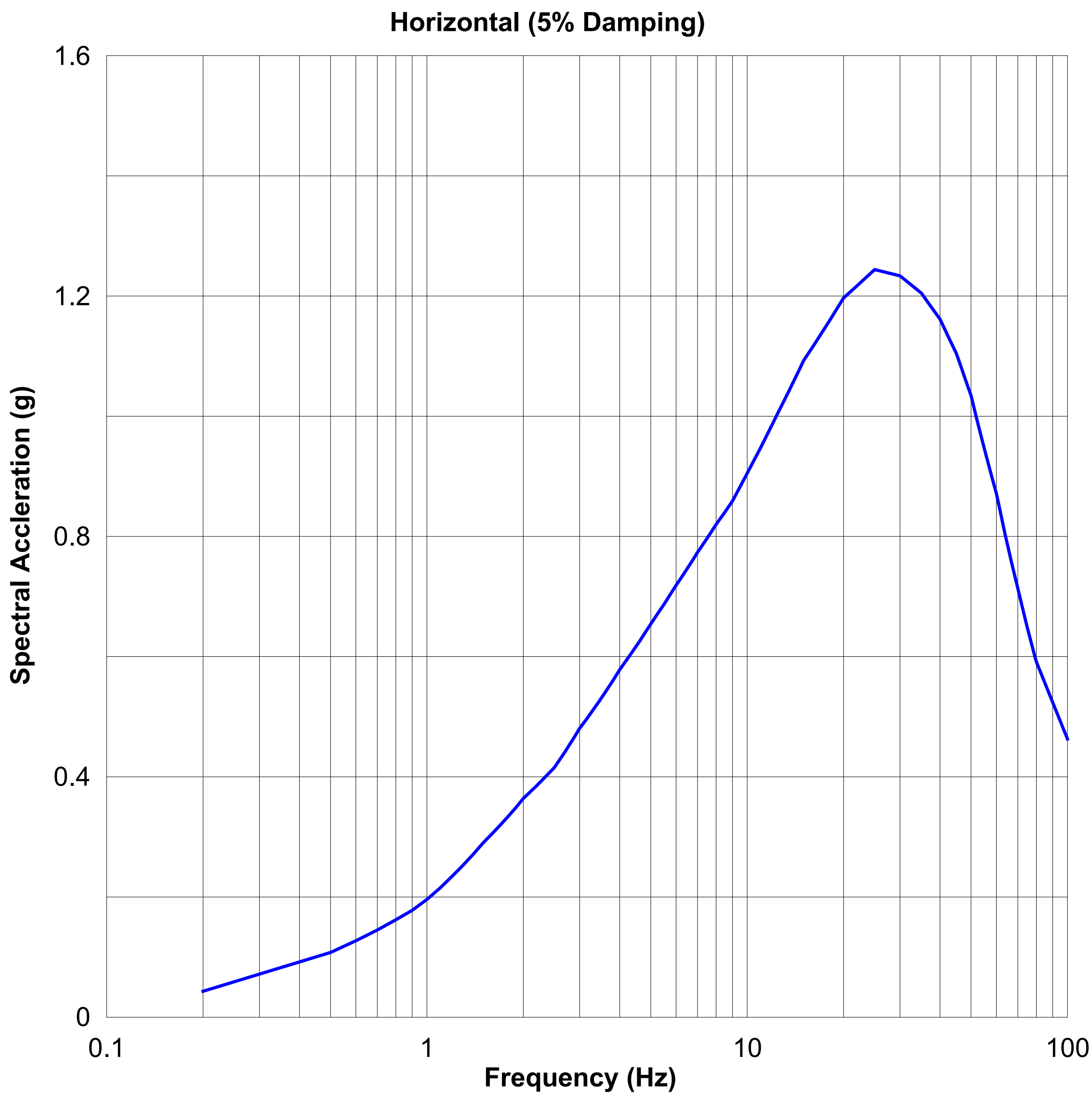

Figure 2.0-3 Horizontal HRHF Response Spectra

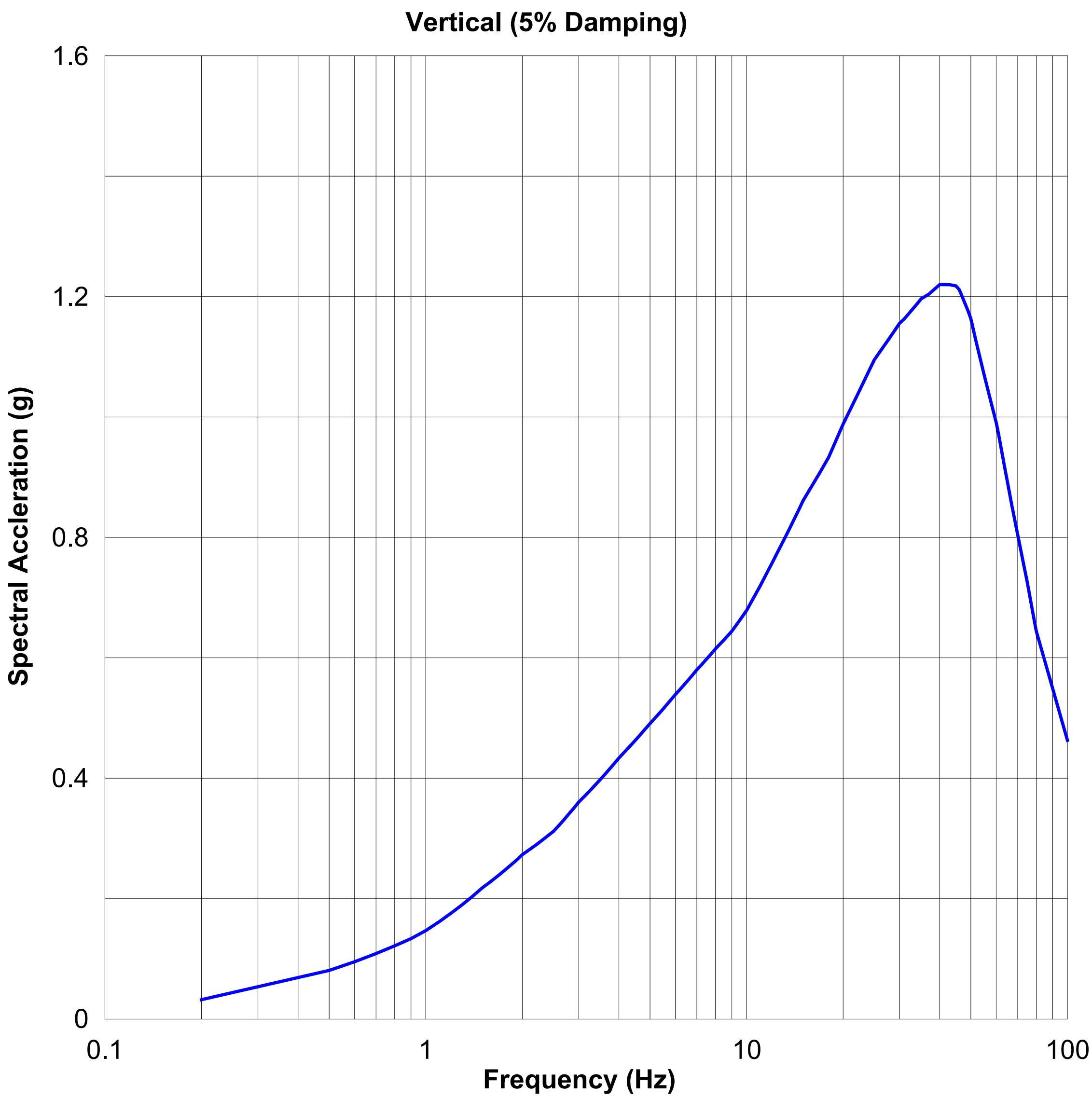

Figure 2.0-4 Vertical HRHF Response Spectra

2.1 Geography and Demography

The COL applicant is to provide site-specific information on the site location and a description of the site, exclusion authority and control, and population distribution, as stated in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.206 (Reference 1) and described in the following subsections (COL 2.1(1)).

2.1.1 Site Location and Description

This subsection describes site-specific information on the site location and a description of the site, including:

a. The boundaries of the site

b. The proposed general location of each facility on the site

c. The location and description of any industrial, military, or transportation facilities and routes

d. Prominent natural and manmade features in the site area

2.1.2 Exclusion Area Authority and Control

The owner of the plant has the legal authority to control and determine the activities to be permitted in the land within the exclusion area boundary (EAB), including the exclusion and removal of personnel and property from the area.

A highway, railroad, or waterway may traverse the exclusion area but is not close enough to the facility to interfere with normal operations. In addition, the appropriate and effective arrangements are made to control traffic on the highway, railroad, or waterway in the case of an emergency. Residences within the exclusion area are normally prohibited. People who live within the EAB are subject to removal, if necessary. Activities unrelated to operation of the reactor that do not result in a significant hazard to public health and safety may be permitted in the EAB as described in Reference 2.

2.1.3 Population Distribution

This subsection addresses site-specific information regarding population distribution, population center, and population density as stated in NRC RG 1.206 (Reference 1).

Population distribution is based on the latest census data. Population center as defined in 10 CFR 100.3 (Reference 3) is described in this subsection and includes population, direction, and distance from the reactor. The description includes the distance to the nearest boundary of a population center and the present and projected population distribution and population density within and adjacent to local population groupings.

2.1.4 Combined License Information

COL 2.1(1) The COL applicant is to provide site-specific information on the site location and description of the site, exclusion authority and control, and population distribution as stated in NRC RG 1.206.

2.1.5 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," U.S. Nuclear Regulatory Commission, June 2007.

2. NUREG-0800, Standard Review Plan, Section 2.1.2, "Exclusion Area Authority and Control," Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

3. 10 CFR 100.3, "Definitions," U.S. Nuclear Regulatory Commission.

2.2 Nearby Industrial, Transportation, and Military Facilities

The COL applicant is to provide site-specific information on nearby industrial, transportation, and military facilities as required in NRC RG 1.206 (Reference 1) (COL 2.2(1)).

The COL applicant is to identify the design basis event (DBE) caused by nearby industrial, transportation, and military facilities and determine its design parameters as outlined below (COL 2.2(2)).

2.2.1 Locations and Routes

Site-specific maps, including the location and distance from the site of all significant facilities, are provided in this subsection.

2.2.2 Descriptions

Site-specific information on nearby industrial, transportation, and military facilities is described. The information on each facility includes the primary function; major products; number of employees; materials regularly manufactured, stored, used, or transported in the vicinity of the site; and the hazards that could result from accidents at the facilities.

2.2.3 Evaluation of Potential Accidents

Potential accidents in the vicinity of the plant, including human-caused hazards, are evaluated by analyzing the accident occurrence rate, which includes taking into account site-specific information. A design basis event is defined as an event with a probability of occurrence on the order of magnitude of 10^{-7} per year or greater and with severe consequences. Because of the low probability of the events under consideration, valid statistical data are often not available to permit accurate quantitative calculation of probabilities. Accordingly, a conservative calculation showing that the probability of occurrence is approximately of 10^{-6} per year is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower.

If potential accidents having unacceptable probability of severe consequences are identified, description of site-specific steps taken to mitigate the consequences is included. Examples of mitigation are adding engineered safety feature equipment, reinforcing plant structures, and provisions to reduce the likelihood and severity of the accidents.

2.2.4 Combined License Information

COL 2.2(1) The COL applicant is to provide site-specific information on nearby industrial, transportation, and military facilities as required in NRC RG 1.206.

COL 2.2(2) The COL applicant is to identify the DBE caused by nearby industrial, transportation, and military facilities and determine its design parameters.

2.2.5 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," U.S. Nuclear Regulatory Commission, June 2007.

2.3 Meteorology

The COL applicant is to provide site-specific information on meteorology including regional climatology, local meteorology, the onsite meteorological measurement program, estimated short-term atmospheric dispersion for accident release, and long-term atmospheric dispersion estimates for routine release as addressed in NRC RG 1.206 (Reference 1) (COL 2.3(1)).

The COL applicant is to perform the radiological consequence analysis and demonstrate that the related dose limits specified in 10 CFR 50.34 (Reference 2) and 10 CFR Part 50, Appendix I (Reference 3) are not exceeded, if the site-specific χ/Q values exceed the bounding values used in this section (COL 2.3(2)).

2.3.1 Regional Climatology

Site-specific information on the climate in the region includes types of air masses, synoptic features, general airflow patterns, temperature and humidity, precipitation, potential influences from regional topography, and relationships between synoptic-scale atmospheric processes, and regional meteorological conditions including severe weather phenomena (hurricanes, tornadoes, waterspouts, thunderstorms, severe wind events, lightning, hail, and high air pollution potential) as stated in NRC RG 1.206 (Reference 1). Meteorological data used to evaluate the performance of the ultimate heat sink (UHS), with respect to maximum evaporation, drift loss, and minimum water for cooling, are also provided.

All meteorological conditions are classified as climatic site characteristics for consideration in evaluating the design and operation of the proposed facility. The APR1400 is designed based on the meteorological parameters (precipitation, temperature, extreme wind, tornado parameters, hurricane parameters) specified in Table 2.0-1.

2.3.2 Local Meteorology

Local meteorology information includes a local meteorological and topographic description of the site area, both before construction and during the operation of a plant that may be constructed on the proposed site, as required by NRC RG 1.206 (Reference 1). The information includes normal and extreme values for meteorological parameters, potential influence of the plant and its facilities on local meteorology, and local meteorological conditions for design and operating bases.

2.3.3 Onsite Meteorological Measurements Program

Preoperational and operational programs for measuring meteorological conditions at the site, including offsite satellite facilities, are provided in this subsection in accordance with NRC RG 1.23 (Reference 4). A meteorological tower and instrumentation for onsite meteorological measurements are described in these programs.

2.3.4 Short-Term Atmospheric Dispersion Estimates for Accident Releases

The short-term atmospheric dispersion factors (χ/Qs) for offsite locations, such as the exclusion area boundary (EAB) and the outer boundary of the low-population zone (LPZ), and onsite locations such as the main control room (MCR) and technical support center (TSC), and auxiliary building (AB) air intakes, are conservatively determined as follows:

a. The offsite χ/Qs used for the APR1400 design are listed in Table 2.3-1. In particular, the 2-hour EAB χ/Q of 1.0×10^{-3} sec/m^3 is the conservative value recommended in the Electric Power Research Institute (EPRI) Utility Requirements Document (URD) (Reference 5) for enveloping U.S. sites. The χ/Qs for the outer boundary of the LPZ are also selected to be conservative values applicable to U.S. sites.

b. Onsite χ/Qs for the APR1400 are calculated using the guidance in NRC RG 1.194 (Reference 6), NRC-approved ARCON96 computer code (Reference 7), and representative meteorological data selected from the publicly available meteorological data for some U.S. sites. The results from these analyses were used to establish the χ/Qs for the APR1400 design.

c. The 95th percentile onsite χ/Qs for the MCR and TSC, and auxiliary building normal air intakes due to post-accident releases from various potential post-accident release locations are summarized in Tables 2.3-2 through 2.3-12. The input variables including post-accident gaseous vent and intake locations used in calculating the accident χ/Qs are shown in Table 2.3-13 and Figure 2.3-1, respectively.

2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

The annual average atmospheric dispersion factor (χ/Q) and relative deposition factor (D/Q) can be calculated using site-specific meteorological data. However, because the plant site for the APR1400 in the United States has not been determined in this stage of the Design Certification, there are no site meteorological data. Therefore, for the APR1400 DC application, the bounding conservative χ/Q and D/Q values are reviewed from the U.S. sites.

For conservative estimates of radioactive decay, a half-life of 2.26 days (Xe-133m) is acceptable for short-lived noble gases, and a half-life of 8 days (I-131) for all iodine released to the atmosphere is acceptable, as addressed in NRC RG 1.111 (Reference 8). Therefore, the annual χ/Qs for undepleted/2.26-day decay and depleted/8-day decay are derived from these half-lives and the typical travel time between the release and the receptor points.

The annual average χ/Q values at the site boundary are listed in Table 2.0-1, including the annual average χ/Q for undepleted/no decay, χ/Q for undepleted/2.26 days decay, χ/Q for depleted/8 days decay, and the relative D/Q values.

2.3.6 Combined License Information

COL 2.3(1) The COL applicant is to provide site-specific information on meteorology including regional climatology, local meteorology, onsite meteorological measurement program, estimated short-term atmospheric dispersion for accident release, and long-term atmospheric dispersion estimates for routine release as addressed in NRC RG 1.206.

COL 2.3(2) The COL applicant is to perform the radiological consequence analysis and demonstrate that the related dose limits specified in 10 CFR 50.34 and 10 CFR Part 50, Appendix I are not exceeded, if the site-specific χ/Q values exceed the bounding values described in Tables 2.3-1 to 2.3-12.

2.3.7 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," U.S. Nuclear Regulatory Commission, June 2007.

2. 10 CFR 50.34, "Contents of Applications, Technical Information," U.S. Nuclear Regulatory Commission.

3. 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," U.S. Nuclear Regulatory Commission.

4. Regulatory Guide 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants (LWR Edition)," Rev. 1, U.S. Nuclear Regulatory Commission, March 2007.

5. EPRI ALWR Utility Requirements Document, Volume II, Electric Power Research Institute, 2008.

6. Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, June 2003.

7. NUREG/CR-6331, PNNL-10521, "Atmospheric Relative Concentrations in Building Wakes," Rev. 1, U.S. Nuclear Regulatory Commission, May 1997.

8. Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases From Light-Water-Cooled Reactors," Rev. 2, U.S. Nuclear Regulatory Commission, April 1977.

Table 2.3-1

Short-Term Atmospheric Dispersion Factors

Receptor Location	Time Interval (hr)	χ/Q (s/m^3)
EAB	0–2	1.00E-03
LPZ	0–8	2.20E-04
	8–24	1.60E-04
	24–96	1.00E-04
	96–720	8.00E-05

Table 2.3-2

Onsite χ/Q for Reactor Containment Building Release
to MCR and TSC North and South Intakes, and Roof Centerline

Time Interval (hr)	Onsite χ/Q (s/m^3)		
	Containment Building to		
	MCR and TSC North Intake	MCR and TSC South Intake	MCR Roof Centerline
0–2	1.78E-04	1.53E-04	3.60E-03
2–8	1.42E-04	9.28E-05	2.79E-03
8–24	6.19E-05	4.16E-05	1.19E-03
24–96	4.73E-05	2.96E-05	8.48E-04
96–720	3.77E-05	1.97E-05	6.48E-04

Table 2.3-3

Effective Onsite χ/Q for Reactor Containment Building Release to Auxiliary Building Intakes

Time Interval (hr)	Effective Onsite χ/Q [(1)] (s/m^3)
0–2	4.73E-03
2–8	3.58E-03
8–24	1.56E-03
24–96	1.12E-03
96–720	8.29E-04

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-4

Onsite χ/Q for North and South Main Steam Valve Room
Direct and Cross Releases to MCR and TSC North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)			
	North Main Steam Valve Room to		South Main Steam Valve Room to	
	MCR and TSC North Intake	MCR and TSC South Intake	MCR and TSC North Intake	MCR and TSC South Intake
0–2	1.26E-03	1.88E-04	2.27E-04	1.18E-03
2–8	9.81E-04	9.71E-05	1.85E-04	9.21E-04
8–24	4.29E-04	4.24E-05	8.31E-05	4.05E-04
24–96	2.98E-04	2.98E-05	5.34E-05	2.68E-04
96–720	2.31E-04	2.21E-05	4.16E-05	2.12E-04

Table 2.3-5

Effective Onsite χ/Q for North and South Main Steam Valve Room Releases to Auxiliary Building Intakes

Time Interval (hr)	Effective Onsite χ/Q(1) (s/m^3)	
	North Main Steam Valve Room to to Auxiliary Building Intake	South Main Steam Valve Room to to Auxiliary Building Intake
0–2	6.26E-03	7.39E-03
2–8	3.89E-03	6.10E-03
8–24	1.73E-03	2.76E-03
24–96	1.18E-03	1.86E-03
96–720	8.87E-04	1.46E-03

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-6

Onsite χ/Q for North and South Atmospheric Dump Valve
Direct and Cross Releases to MCR and TSC North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)			
	North Atmospheric Dump Valve to		South Atmospheric Dump Valve to	
	MCR and TSC North Intake	MCR and TSC South Intake	MCR and TSC North Intake	MCR and TSC South Intake
0–2	6.83E-04	1.62E-04	1.95E-04	6.17E-04
2–8	5.48E-04	8.40E-05	1.66E-04	4.99E-04
8–24	2.36E-04	3.81E-05	7.35E-05	2.18E-04
24–96	1.66E-04	2.72E-05	4.84E-05	1.43E-04
96–720	1.30E-04	1.95E-05	3.75E-05	1.13E-04

Table 2.3-7

Onsite χ/Q for North and South Main Steam Safety Valve
Direct and Cross Releases to MCR and TSC North and South Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)			
	North Main Steam Safety Valve to		South Main Steam Safety Valve to	
	MCR and TSC North Intake	MCR and TSC South Intake	MCR and TSC North Intake	MCR and TSC South Intake
0–2	6.30E-04	1.57E-04	1.89E-04	6.00E-04
2–8	5.06E-04	8.16E-05	1.59E-04	4.59E-04
8–24	2.19E-04	3.69E-05	7.16E-05	2.03E-04
24–96	1.54E-04	2.63E-05	4.71E-05	1.34E-04
96–720	1.20E-04	1.89E-05	3.62E-05	1.06E-04

Table 2.3-8

Effective Onsite χ/Q for North and South Atmospheric Dump Valve Releases to Auxiliary Building Intakes

Time Interval (hr)	Effective Onsite χ/Q [(1)] (s/m^3)	
	North Atmospheric Dump Valve to Auxiliary Building Intake	South Atmospheric Dump Valve to to Auxiliary Building Intake
0–2	4.02E-03	4.67E-03
2–8	2.74E-03	3.90E-03
8–24	1.21E-03	1.75E-03
24–96	8.15E-04	1.20E-03
96–720	6.24E-04	9.32E-04

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-9

Effective Onsite χ/Q for North and South Main Steam Safety Valve Releases to Auxiliary Building Intakes

Time Interval (hr)	Effective Onsite χ/Q (1) (s/m^3)	
	North Main Steam Safety Valve to Auxiliary Building Intake	South Main Steam Safety Valve to Auxiliary Building Intake
0–2	3.74E-03	4.36E-03
2–8	2.58E-03	3.62E-03
8–24	1.13E-03	1.63E-03
24–96	7.67E-04	1.11E-03
96–720	5.84E-04	8.69E-04

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-10

Effective Onsite χ/Q for Auxiliary Building North and South Exhaust Release to MCR and TSC Intakes

Time Interval (hr)	Effective Onsite χ/Q (1) (s/m^3)	
	North Auxiliary Building Exhaust to MCR and TSC Intake	South Auxiliary Building Exhaust to MCR and TSC Intake
0–2	7.39E-04	7.88E-04
2–8	5.74E-04	6.71E-04
8–24	2.51E-04	2.99E-04
24–96	1.66E-04	1.95E-04
96–720	1.29E-04	1.54E-04

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-11

Effective Onsite χ/Q for Auxiliary Building North and South Exhaust Release to Auxiliary Building Intakes

Time Interval (hr)	Effective Onsite χ/Q (1) (s/m^3)	
	North Auxiliary Building Exhaust to Auxiliary Building Intakes	South Auxiliary Building Exhaust to Auxiliary Building Intakes
0–2	8.45E-04	9.30E-04
2–8	6.78E-04	8.31E-04
8–24	2.90E-04	3.70E-04
24–96	1.93E-04	2.44E-04
96–720	1.50E-04	1.90E-04

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-12

(Effective) Onsite χ/Q for Fuel Handling Area Exhaust Release to MCR and TSC North and South Intakes, and Auxiliary Building Intakes

Time Interval (hr)	Onsite χ/Q (s/m^3)		Effective Onsite χ/Q (1) (s/m^3)
	Fuel Handling Area Exhaust to		
	MCR and TSC North Intake	MCR and TSC South Intake	Auxiliary Building Intakes
0–2	1.26E-04	1.63E-04	1.51E-03
2–8	1.09E-04	1.28E-04	1.16E-03
8–24	5.01E-05	5.63E-05	5.09E-04
24–96	3.36E-05	3.73E-05	3.44E-04
96–720	2.64E-05	2.87E-05	2.66E-04

(1) The effective χ/Q value is calculated based on the two χ/Q values in same time interval in the same wind direction window per NRC RG 1.194, Section 3.3.2.1, Equation 5a.

Table 2.3-13 (1 of 6)

Design Input for ARCON96 Calculation

Parameter		Value
Meteorological Data		Bounding data for six U.S. sites (1)
Source Release Category		
< From >	< To >	< Source Type >
Reactor Containment Building	MCR and TSC Intakes MCR Roof Centerline Auxiliary Building Intakes	Diffuse area source Diffuse area source Diffuse area source
North and South Main Steam Valve Room	MCR and TSC Intakes Auxiliary Building Intakes	Ground level point sources Ground level point sources
North and South Atmospheric Dump Valves	MCR and TSC Intakes Auxiliary Building Intakes	Ground level point sources Ground level point sources
North and South Main Steam Valves	MCR and TSC Intakes Auxiliary Building Intakes	Ground level point sources Ground level point sources
North and South Auxiliary Building Exhaust	MCR and TSC Intakes Auxiliary Building Intakes	Ground level point sources Ground level point sources
Fuel Handling Area	MCR and TSC Intakes Auxiliary Building Intakes	Ground level point sources Ground level point sources
MCR and TSC Intake (Receptor)		
Characteristics MCR and TSC intakes MCR roof centerline Auxiliary building intakes (infiltration path way) Reduction of χ/Qs MCR and TSC intakes		 Dual MCR and TSC intakes Single point at roof center Dual AB intakes Factor of 8*
* Except for the case of north and south auxiliary building exhaust release to MCR and TSC intakes		

Table 2.3-13 (2 of 6)

Parameter		Value
Source – Receptor Horizontal (or Slant) Distance		
< From >	< To >	< Distance (m) >
Reactor Containment Building	MCR and TSC North Intake	41.9
	MCR and TSC South Intake	41.9
	MCR Roof Centerline	31.4
	Auxiliary Building North Intake	25.2
	Auxiliary Building South Intake	25.2
North Main Steam Valve Room	MCR and TSC North Intakes	29.1
South Main Steam Valve Room	MCR and TSC South Intakes	29.1
North Main Steam Valve Room	MCR and TSC South Intakes	71.5
South Main Steam Valve Room	MCR and TSC North Intakes	71.5
North Main Steam Valve Room	Auxiliary Building North Intakes	28.1
South Main Steam Valve Room	Auxiliary Building South Intakes	28.1
North Main Steam Valve Room	Auxiliary Building South Intakes	44.9
South Main Steam Valve Room	Auxiliary Building North Intakes	44.9
North Atmospheric Dump Valves	MCR and TSC North Intakes	40.1
South Atmospheric Dump Valves	MCR and TSC South Intakes	40.1
North Atmospheric Dump Valves	MCR and TSC South Intakes	77.0
South Atmospheric Dump Valves	MCR and TSC North Intakes	77.0
North Main Steam Safety Valves	MCR and TSC North Intakes	41.7
South Main Steam Safety Valves	MCR and TSC South Intakes	41.7
North Main Steam Safety Valves	MCR and TSC South Intakes	78.4
South Main Steam Safety Valves	MCR and TSC North Intakes	78.4
North Atmospheric Dump Valves	Auxiliary Building North Intakes	37.5
South Atmospheric Dump Valves	Auxiliary Building South Intakes	37.5
North Atmospheric Dump Valves	Auxiliary Building South Intakes	51.7
South Atmospheric Dump Valves	Auxiliary Building North Intakes	51.7
North Main Steam Safety Valves	Auxiliary Building North Intakes	39.2
South Main Steam Safety Valves	Auxiliary Building South Intakes	39.2
North Main Steam Safety Valves	Auxiliary Building South Intakes	53.2
South Main Steam Safety Valves	Auxiliary Building North Intakes	53.2
North Auxiliary Building	MCR and TSC North Intakes	97.6
South Auxiliary Building	MCR and TSC South Intakes	97.8
North Auxiliary Building	MCR and TSC South Intakes	120.7
South Auxiliary Building	MCR and TSC North Intakes	117.7
North Auxiliary Building	Auxiliary Building North Intakes	94.0
South Auxiliary Building	Auxiliary Building South Intakes	92.9
North Auxiliary Building	Auxiliary Building South Intakes	101.6
South Auxiliary Building	Auxiliary Building North Intakes	99.3
Fuel Handling Area	MCR and TSC North Intakes	97.2
Fuel Handling Area	MCR and TSC South Intakes	82.2
Fuel Handling Area	Auxiliary Building North Intakes	79.1
Fuel Handling Area	Auxiliary Building South Intakes	74.3

Table 2.3-13 (3 of 6)

Parameter		Value
Source – Receptor Direction		
< From >	< To >	< Degree (°) >
Reactor Containment Building	MCR and TSC North Intake MCR and TSC South Intake MCR Roof Centerline Auxiliary Building North Intake Auxiliary Building South Intake	131 49 90 106 74
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	96 84 24 156
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	53 127 30 150
North Atmospheric Dump Valves South Atmospheric Dump Valves North Atmospheric Dump Valves South Atmospheric Dump Valves	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	101 80 31 149
North Main Steam Safety Valves South Main Steam Safety Valves North Main Steam Safety Valves South Main Steam Safety Valves	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	99 81 32 148
North Atmospheric Dump Valves South Atmospheric Dump Valves North Atmospheric Dump Valves South Atmospheric Dump Valves	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	62 118 40 140
North Main Steam Safety Valves South Main Steam Safety Valves North Main Steam Safety Valves South Main Steam Safety Valves	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	63 117 41 139
North Auxiliary Building South Auxiliary Building North Auxiliary Building South Auxiliary Building	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	91 86 54 124
North Auxiliary Building South Auxiliary Building North Auxiliary Building South Auxiliary Building	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	76 101 64 113
Fuel Handling Area Fuel Handling Area Fuel Handling Area Fuel Handling Area	MCR and TSC North Intakes MCR and TSC South Intakes Auxiliary Building North Intakes Auxiliary Building South Intakes	124 77 111 97

Table 2.3-13 (4 of 6)

Parameter		Value
Building Wake Area		
< From >	< To >	< Area (m^2) >
Reactor Containment Building	MCR and TSC North Intake MCR and TSC South Intake MCR Roof Centerline Auxiliary Building North Intake Auxiliary Building South Intake	3192 3192 3192 3192 3192
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	869.9 582.5 3192 3192
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	1903 1257 1903 1257
North Atmospheric Dump Valves South Atmospheric Dump Valves North Atmospheric Dump Valves South Atmospheric Dump Valves	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	869.9 582.5 3192 3192
North Main Steam Safety Valves South Main Steam Safety Valves North Main Steam Safety Valves South Main Steam Safety Valves	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	869.9 582.5 3192 3192
North Atmospheric Dump Valves South Atmospheric Dump Valves North Atmospheric Dump Valves South Atmospheric Dump Valves	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	869.9 582.5 3192 3192
North Main Steam Safety Valves South Main Steam Safety Valves North Main Steam Safety Valves South Main Steam Safety Valves	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	869.9 582.5 3192 3192
North Auxiliary Building South Auxiliary Building North Auxiliary Building South Auxiliary Building	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	869.9 582.5 3192 3192
North Auxiliary Building South Auxiliary Building North Auxiliary Building South Auxiliary Building	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	869.9 582.5 3192 3192
Fuel Handling Area Fuel Handling Area Fuel Handling Area Fuel Handling Area	MCR and TSC North Intakes MCR and TSC South Intakes Auxiliary Building North Intakes Auxiliary Building South Intakes	3192 582.5 3192 3192

Table 2.3-13 (5 of 6)

Parameter		Value
Release Height		
< From >	< To >	< Height (m) >
Reactor Containment Building	MCR and TSC North Intake MCR and TSC South Intake MCR Roof Centerline Auxiliary Building North Intake Auxiliary Building South Intake	54.9 54.9 54.9 54.9 54.9
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	25.9 25.9 25.9 25.9
North Main Steam Valve Room South Main Steam Valve Room North Main Steam Valve Room South Main Steam Valve Room	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	25.9 25.9 25.9 25.9
North Atmospheric Dump Valves South Atmospheric Dump Valves North Atmospheric Dump Valves South Atmospheric Dump Valves	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	24.0 24.0 24.0 24.0
North Main Steam Safety Valves South Main Steam Safety Valves North Main Steam Safety Valves South Main Steam Safety Valves	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	24.0 24.0 24.0 24.0
North Atmospheric Dump Valves South Atmospheric Dump Valves North Atmospheric Dump Valves South Atmospheric Dump Valves	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	24.0 24.0 24.0 24.0
North Main Steam Safety Valves South Main Steam Safety Valves North Main Steam Safety Valves South Main Steam Safety Valves	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	24.0 24.0 24.0 24.0
North Auxiliary Building South Auxiliary Building North Auxiliary Building South Auxiliary Building	MCR and TSC North Intakes MCR and TSC South Intakes MCR and TSC South Intakes MCR and TSC North Intakes	5.0 5.0 5.0 5.0
North Auxiliary Building South Auxiliary Building North Auxiliary Building South Auxiliary Building	Auxiliary Building North Intakes Auxiliary Building South Intakes Auxiliary Building South Intakes Auxiliary Building North Intakes	5.0 5.0 5.0 5.0
Fuel Handling Area Fuel Handling Area Fuel Handling Area Fuel Handling Area	MCR and TSC North Intakes MCR and TSC South Intakes Auxiliary Building North Intakes Auxiliary Building South Intakes	17.0 17.0 17.0 17.0

Table 2.3-13 (6 of 6)

Parameter	Value
Intake Height from Ground Level MCR and TSC intakes MCR roof centerline Auxiliary building intakes (infiltration path way)	 27.7 m 29.0 m 33.0 m
Surface Roughness Length	0.2 m
Minimum Wind Speed	0.5 m/s
Average Sector Width Constant	4.3
Lower Measurement Height for Meteorological Data	10.0 m
Intermediate Measurement Height for Meteorological Data	60.0 m
Wind Speed Units for Meteorological Data	Miles per hour (mph)
Vertical Diffusion Area Coefficient (2) (σ_{Z0}) Reactor containment building – MCR and TSC intakes Reactor containment building – MCR roof centerline Reactor containment building – Auxiliary building intakes	 5.44 m 0.0 m 0.0 m
Horizontal Diffusion Area Coefficient (3) (σ_{Y0}) Reactor containment building – MCR and TSC intakes Reactor containment building – MCR roof centerline Reactor containment building – Auxiliary building intakes	 8.08 m 8.08 m 8.08 m

(1) The χ/Q data were derived from an analysis using meteorological data from six U.S. sites: San Onofre (Pacific Ocean), Hope Creek (Delaware River), Prairie Island (Mississippi River), Quad Cities (Mississippi River), Limerick (Schuylkill River), and J.A.FitzPatrick (Lake Ontario). The meteorological data were formatted for an ARCON96 sensitivity analysis with the APR1400 design-specific source-receptor parameters in order to develop a set of conservative input values for the control room habitability analysis. The result of analysis shows that the five year meteorological data from Prairie Island measured during 1993 ~ 1997 bound the other site data when they are used with a margin of 50 percent for the resulting onsite χ/Qs. Therefore, this data is used as design input for the APR1400 ARCON96 calculation.

(2) Height of Diffuse Area × 1/6 : Vertical diffusion area coefficient is calculated based on Reference 6 in Subsection 2.3.7.

(3) Width of Diffuse Area × 1/6 : Horizontal diffusion area coefficient is calculated based on Reference 6 in Subsection 2.3.7.

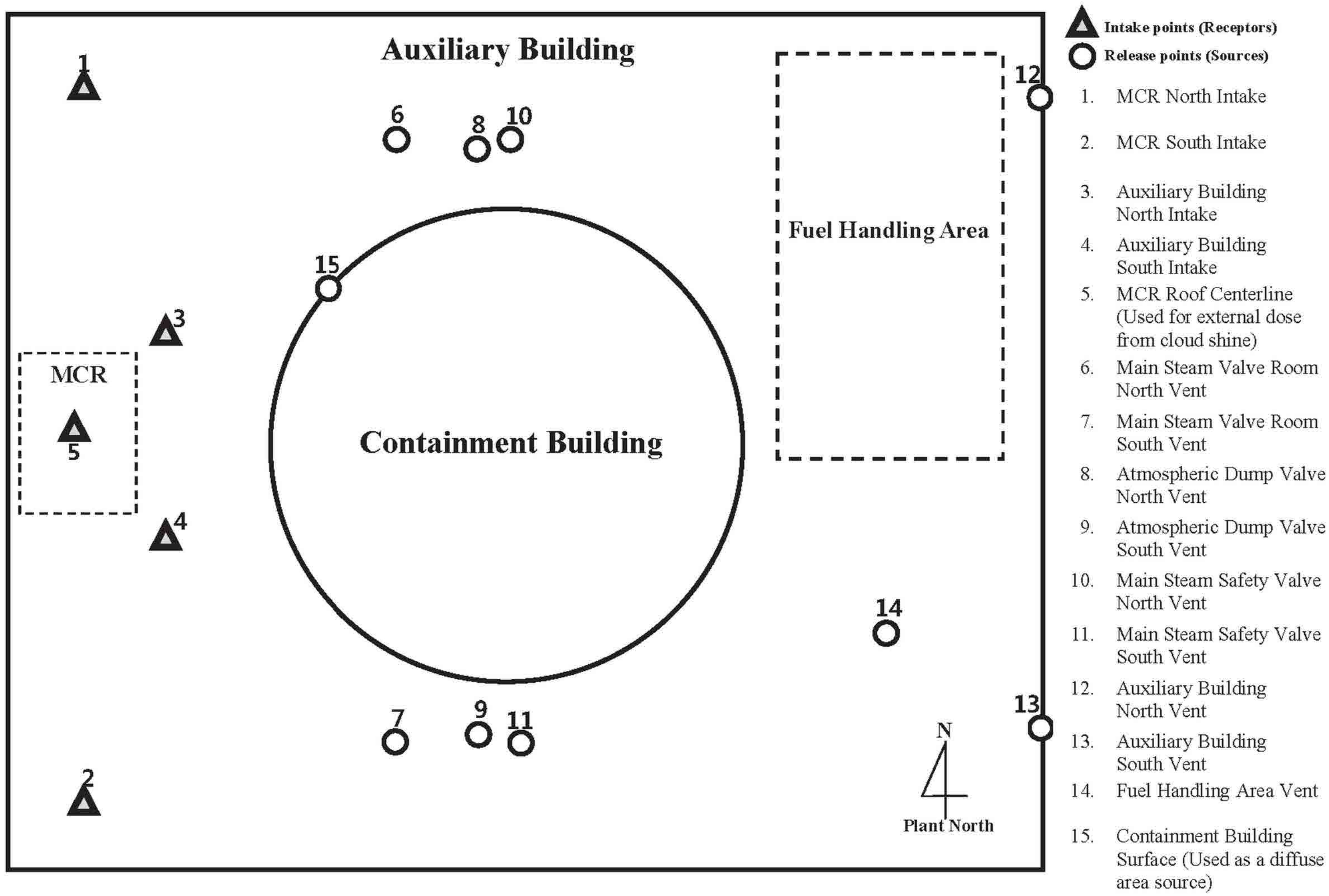

Figure 2.3-1 Locations of Post-accident Gaseous Releases and Intakes

2.4 Hydrologic Engineering

The site grade level is established at least 0.30 m (1 ft) above the maximum flood level. The probable maximum precipitation (PMP) defined as maximum precipitation rate (1-hour, 1-mi^2) in Table 2.0-1 is 492.7 mm (19.4 in.) for a flooding hazard analysis.

The COL applicant is to provide site-specific hydrologic information on PMP, probable maximum flood (PMF) of streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami hazards, ice effects, cooling water canals and reservoirs, channel diversions, flood protection requirements, low water considerations, groundwater, potential accidental release of liquid effluents in ground and surface water, Technical Specifications, and emergency operation requirements in accordance with NRC RG 1.206 (Reference 1), NRC RG 1.59 (Reference 2), and NRC JLD-ISG-2012-06 (Reference 3) (COL 2.4(1)), as described below.

2.4.1 Hydrologic Description

2.4.1.1 Site and Facilities

Hydrologic information about the site and facilities includes all safety-related elevations, structures, exterior accesses, equipment, and systems related to hydrology (both surface and subsurface) and a topographic map of the site that shows any proposed changes to natural drainage features.

2.4.1.2 Hydrosphere

Site-specific hydrospheric-related information includes the location, size, shape, and other hydrologic characteristics of streams, lakes, shore regions, and groundwater environments that influence plant siting and a description of the existing and proposed water control structures, both upstream and downstream, that could influence conditions at the site.

2.4.2 Floods

Site-specific flood-related information includes flood history, flood design considerations, and the effects of local intense precipitation due to PMP.

2.4.2.1 Flood History

Site-specific flood history information includes the date, level, peak discharge, and related information for major historical flood events in the site region.

2.4.2.2 Flood Design Considerations

Site-specific flood-design-related information includes the capability of safety-related facilities, systems, and equipment to withstand floods and flood waves, including the characteristics of how any possible flood condition, up to and including the highest and most critical flood level resulting from any of several different events, affects the basis for the design protection level for safety-related components and structures of the plant.

2.4.2.3 Effects of Local Intense Precipitation

Site-specific information on the effects of local intense precipitation includes the design of adjacent drainage areas and site drainage systems, including drainage from the roofs of structures, to prevent flooding of safety-related facilities.

2.4.3 Probable Maximum Flood on Streams and Rivers

Site-specific information related to the PMF on streams and rivers includes precipitation losses, runoff and stream course models, PMF flow, water level determinations, coincident wind-wave activity, and hydrological site characteristics that pose any potential hazard to the safety-related facilities as a result of the effects of a PMF on streams and rivers.

2.4.3.1 Probable Maximum Precipitation

Site-specific PMF information includes storm configuration, maximized precipitation amounts, time distributions, orographic effects, storm centering, seasonal effects, antecedent storm sequences, antecedent snowpack, and any snowmelt model that is used to determine the PMP.

2.4.3.2 Precipitation Losses

Site-specific precipitation loss information includes the absorption capability of the basin, including initial losses, infiltration rates, and antecedent precipitation.

2.4.3.3 Runoff and Stream Course Models

Site-specific information related to runoff and stream course models includes hydrologic response characteristics of the watershed to precipitation, verification from historical floods or synthetic procedures, and methods adopted to account for nonlinear basin response at high rainfall rates.

2.4.3.4 Probable Maximum Flood Flow

Site-specific PMF flow information includes a controlling PMF runoff hydrograph at the plant site resulting from rainfall (and snowmelt if pertinent).

2.4.3.5 Water Level Determinations

Water level determinations include the translation of the estimated peak PMP discharge to the elevation using cross-sectional and profile data, reconstitution of historical floods, standard step methods, transient flow methods, roughness coefficients, bridge and other losses, extrapolation of coefficients for the PMF, estimates of PMF water surface profiles, and flood outlines.

2.4.3.6 Coincident Wind-Wave Activity

Site-specific information on coincident wind wave activity includes the setup, significant and maximum wave heights, runup, and resultant static and dynamic effects of wave action on each safety-related facility from wind-generated activity that could occur coincidently with the peak PMF water level.

2.4.4 Potential Dam Failures

Site-specific information related to potential dam failures includes potential hazards to safety-related facilities due to the failure of upstream and downstream water control structures, dam failure permutations, unsteady flow analysis of potential dam failures, and water level at the plant site.

2.4.4.1 Dam Failure Permutations

Site-specific information related to dam failure permutations includes the locations of dams, potential modes of failure, and results of seismically induced dam failures that could cause the most critical conditions with respect to the safety-related facilities for such a PMF.

2.4.4.2 Unsteady Flow Analysis of Potential Dam Failures

Site-specific information related to the effect of dam failures on the site includes how the analytical methods that are presented are applicable to artificially large floods with appropriately acceptable coefficients and flood waves through reservoirs downstream of failures.

2.4.4.3 Water Level at the Plant Site

Site-specific information related to water level at the plant site includes backwater, unsteady flow, or other computational method used to estimate the water elevation for the most critical upstream dam failures.

2.4.5 Probable Maximum Surge and Seiche Flooding

Site-specific information related to the probable maximum surge and seiche flooding includes the extent to which safety-related plant systems require protection, surge and seiche water levels, wave action, resonance, and protective structures, if applicable.

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

Site-specific information related to probable maximum winds and associated meteorological parameters includes wind speed and pressure drop.

2.4.5.2 Surge and Seiche Water Levels

Site-specific information related to surge and seiche water levels includes historical data on surges, seiches, and hurricanes; frontal (cyclonic) type windstorms; moving squall lines; and surge mechanisms that are possible and applicable to the site.

2.4.5.3 Wave Action

Site-specific information related to wave action includes the wind-generated wave activity that can occur independently or coincidently with a surge or seiche.

2.4.5.4 Resonance

Site-specific information related to resonance includes the possibility of oscillations of waves at natural periodicity, such as lake reflection and harbor resonance phenomena, and any resulting effects at the site.

2.4.5.5 Protective Structures

Site-specific information related to protective structures includes the location of, and design criteria for, any special facilities for the protection of intake, effluent, and other safety-related facilities against surges, seiches, and wave action.

2.4.6 Probable Maximum Tsunami Hazards

Site-specific information related to probable maximum tsunami hazards includes probable maximum tsunami, historical tsunami record, source generator characteristics, tsunami water levels, hydrography, harbor or breakwater influences on tsunamis, and the effects on safety-related facilities.

2.4.6.1 Probable Maximum Tsunami

Site-specific information related to probable maximum tsunami includes the determination of the probable maximum tsunami, including the most reasonably severe geoseismic activity possible in determining the limiting tsunami-producing mechanism; verification of the orientation of the site relative to the earthquake epicenter or generating mechanism; shape of the coastline; offshore land areas; hydrography; the stability of the coastal area; and how these factors are considered in the probable maximum tsunami analysis.

2.4.6.2 Historical Tsunami Record

Site-specific information related to the historical tsunami record includes regional historical tsunami information, including any relevant paleo-tsunami evidence.

2.4.6.3 Source Generator Characteristics

Site-specific information related to source generator characteristics includes detailed geoseismic descriptions of the controlling local and distant tsunami generators, including location, source dimensions, fault orientation (if applicable), and maximum displacement.

2.4.6.4 Tsunami Analysis

Site-specific information related to the tsunami analysis includes a description of the analysis procedure used to calculate tsunami wave height and period at the site and of all models used in the analysis, including the theoretical bases of the models, their verification, and the conservatism of all input parameters.

2.4.6.5 Tsunami Water Level

Site-specific information related to tsunami water level includes estimates of maximum and minimum (low water) tsunami wave heights from both distant and local generators and a description of the ambient water levels, including tides, sea level anomalies, and wind waves assumed to be coincident with the tsunami.

2.4.6.6 Hydrography and Harbor or Breakwater Influences on Tsunamis

Site-specific information related to hydrography and harbor or breakwater influences on tsunamis includes the routing of the controlling tsunami, including breaking wave formation, bore formation, and any resonance effects that result in the estimate of the maximum tsunami runup on each pertinent safety-related facility.

2.4.6.7 Effects on Safety-Related Facilities

Site-specific information related to the effects on safety-related facilities includes the effects of the controlling tsunami on safety-related facilities and the design criteria for measures to protect against and mitigate the effects of tsunamis.

2.4.7 Ice Effects

Site-specific information related to ice effects includes potential icing effects and design criteria for protecting safety-related facilities from the most severe ice sheets, ice jam floods, wind-driven ice ridges, or other ice-produced effects and forces that are reasonably possible and that could affect safety-related facilities with respect to adjacent water bodies such as streams or lakes for both high and low water levels. Additional site-specific information includes the potential for formation of frazil and anchor ice at the site and the effects of an ice-induced reduction in the capacity of water storage facilities as they affect safety-related structures, systems, and components (SSCs).

2.4.8 Cooling Water Canals and Reservoirs

Site-specific information related to cooling water canals and reservoirs includes the design bases for the capacity and operating plan for safety-related cooling water canals and reservoirs. Site characteristics include the emergency storage evacuation of reservoirs, verified runoff models, flood routing, spillway design, and outlet protection if required.

2.4.9 Channel Diversions

Site-specific information related to channel diversions includes the potential for upstream diversion or rerouting of the source of cooling water with respect to seismic, topographical, geologic, and thermal evidence in the region. Alternative safety-related cooling water sources in the event are to be described if available.

2.4.10 Flooding Protection Requirements

Site-specific information related to flooding protection requirements includes the static and dynamic consequences of all types of flooding on each pertinent safety-related facility, including the various types of flood protection used such levees, seawalls, flood walls, revetments or breakwaters or site bulkhead pursuant to NRC RG 1.102 and the emergency procedures to be implemented (where applicable).

2.4.11 Low Water Considerations

Site-specific information related to low water considerations includes low flow in rivers and streams; low water resulting from surges, seiches, or tsunamis; historical low water; future controls; plant requirements; and heat sink dependability requirements.

2.4.11.1 Low Flow in Rivers and Streams

Site-specific information related to low flow in rivers and streams includes the design basis for the flow rate and water level resulting from the most severe drought considered reasonably possible in the region if such conditions could affect the ability of safety-related facilities, particularly the ultimate heat sink (UHS), to perform adequately. Additional information includes non-safety-related water supplies and the supply adequacy during a 100-year drought.

2.4.11.2 Low Water Resulting from Surge, Seiches, or Tsunamis

Site-specific information related to low water resulting from surge, seiches, or tsunamis includes the surge-caused, seiche-caused, or tsunami-caused low water level that could occur from probable maximum meteorological or geoseismic events if such levels could affect the ability of safety-related features to function adequately.

2.4.11.3 Historical Low Water

Site-specific information related to historical low water includes historical low water flows and levels and their probabilities if statistical methods are used to extrapolate flows or levels to probable minimum conditions.

2.4.11.4 Future Controls

Site-specific information related to future controls includes the estimated flow rate, durations, and levels for drought conditions, considering future uses if such conditions could affect the ability of safety-related facilities to function adequately.

2.4.11.5 Plant Requirements

Site-specific information related to plant requirements includes the minimum safety-related cooling water flow, the sump invert elevation and configuration, the minimum design operating level, pump submergence elevations (operating heads), and design bases for effluent submergence, mixing, and dispersion.

2.4.11.6 Heat Sink Dependability Requirements

Site-specific information related to heat sink dependability requirements includes all sources of normal and emergency shutdown water supply and related retaining and conveyance systems, the facility’s ability to provide sufficient warning of impending low-flow or low-water levels to allow switching to alternative sources when necessary and any other uses of water drawn from the UHS such as fire water or system charging requirements.

2.4.12 Groundwater

Site-specific information related to groundwater includes water source, subsurface pathways, monitoring or safeguard requirements, and site characteristics for subsurface hydrostatic loading.

2.4.12.1 Description and Onsite Use

Site-specific information related to the description and onsite use of groundwater includes regional and local groundwater aquifers, formations, sources, and sinks as well as the type of groundwater use, wells, pumps, storage facilities, and flow requirements of the plant.

2.4.12.2 Sources

Site-specific information related to the sources of groundwater includes present and projected future regional water uses such as existing users (amounts, water levels and elevations, locations, and drawdown), the history of groundwater or piezometric level fluctuations and contour maps of aquifers beneath and in the vicinity of the site.

2.4.12.3 Subsurface Pathways

Site-specific information related to subsurface pathways includes a conservative analysis of critical groundwater pathways for a liquid effluent release at the site and an evaluation (where applicable) of the dispersion, ion exchange, and dilution capability of the groundwater environment with respect to present and projected users. Potential pathways of contamination to nearby groundwater users and to water bodies such as springs, lakes, and streams are identified.

2.4.12.4 Monitoring or Safeguard Requirements

Site-specific information related to monitoring or safeguard requirements includes the plans, procedures, safeguards, and monitoring programs to be used to protect present and projected groundwater users.

Site groundwater monitoring systems are designed to support the early detection of leakage and contaminant migration in conformance with NRC RG 4.21 (Reference 4).

2.4.12.5 Site Characteristics for Subsurface Hydrostatic Loading

Site-specific information on subsurface hydrostatic loading includes the maximum operational groundwater level for ground-water-induced hydrostatic loadings on the subsurface portions of safety-related SSCs.

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

Site-specific information related to accidental releases of radioactive liquid effluents in ground and surface waters includes the ability of the groundwater and surface water environments to delay, disperse, dilute, or concentrate liquid effluents, as related to existing or potential future water users.

Additional information includes the bases used to determine dilution factors, dispersion coefficients, flow velocities, travel times, adsorption and pathways of liquid contaminants, and references to the locations, users of surface waters, and release points.

The analysis related to the accidental release of liquid effluents is described in Subsection 11.2.3.2.

2.4.14 Technical Specification and Emergency Operation Requirements

Site-specific information related to Technical Specifications and emergency operation requirements includes any emergency protective measures designed to minimize the impact of adverse hydrology-related events on safety-related facilities. The emergency requirements are incorporated into the appropriate Technical Specifications and emergency procedures, and the need for any Technical Specifications for plant shutdown to minimize the consequences of an accident resulting from hydrologic phenomena such as floods or degradation of the UHS is described.

If emergency procedures are used to meet safety requirements associated with hydrologic events, the event is identified and the appropriate available water levels and lead times are provided.

Details on controlling hydrological events are developed to provide reasonable assurance of plant safety, such as the amount of time needed to initiate and complete emergency procedures and the relevant Technical Specifications, if any.

2.4.15 Combined License Information

COL 2.4(1) The COL applicant is to provide the site-specific hydrologic information on probable maximum precipitation (PMP), probable maximum flood (PMF) of streams and rivers, potential dam failures, probable maximum surge and seiche flooding, probable maximum tsunami hazards, ice effects, cooling water canals and reservoirs, channel diversions, flood protection requirements, low water considerations, groundwater, potential accidental release of liquid effluents in ground and surface water, and Technical Specifications and emergency operation requirements in accordance with NRC RG 1.206, NRC RG 1.59, and NRC JLD-ISG-2012-06.

2.4.16 References

1. Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," U.S. Nuclear Regulatory Commission, June 2007.

2. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," Rev. 2, U.S. Nuclear Regulatory Commission, August 1977.

3. NRC JLD-ISG-2012-06, "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment," U.S. Nuclear Regulatory Commission, November 2012.

4. Regulatory Guide 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," U.S. Nuclear Regulatory Commission, June 2008.

2.5 Geology, Seismology, and Geotechnical Engineering

The COL applicant is to provide site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206 (Reference 1) and described below (COL 2.5(1)). The site-specific information includes the geological, seismological, geophysical, and geotechnical investigation and evaluations procedures to estimate the site-specific ground motion response spectra (GMRS), as well as the geotechnical engineering aspects of the site and slope stability.

2.5.1 Basic Geologic and Seismic Information

Geological, seismological, geophysical, and geotechnical characteristics of the region within 320 km (200 mi) of the site will be described. The details of the investigations are increased as the radius of the investigation decreases. The site characteristics based on the investigation results will be described in accordance with NRC RGs 1.206, 1.132, 1.138, and 1.208 (References 1 through 4, respectively).

2.5.2 Vibratory Ground Motion

Information to determine the site-specific GMRS and to compare the GMRS to the seismic design response spectra for the APR1400 will be described. The site-specific GMRS is developed using the PSHA results based on the performance based approach recommended in NRC RG 1.208 (Reference 4) and is described at the stage of COL application (COL 2.5(1)). The design spectra for the APR1400, referred to as the certified seismic design response spectra (CSDRS), are presented in Figures 3.7-1 and 3.7-2.

The APR1400 is evaluated for hard rock high frequency (HRHF) input using the response spectra specified in Subsection 3.7.1. Both the CSDRS and HRHF response spectra are defined at the surface of the finished grade.

2.5.2.1 Seismicity

A complete list of historically reported earthquakes is included in the site-specific data. The list includes earthquakes of Modified Mercalli Intensity (MMI) greater than or equal to IV or a magnitude greater than or equal to 3.0 reported within 320 km (200 mi) of the site. Large earthquakes outside the area that could affect the SSE are included.

2.5.2.2 Geologic and Tectonic Characteristics of the Site and Region

The geologic and seismotectonic characteristics of the region that constitute the basis for defining the seismic source zones that potentially contribute to the seismic hazard at the site will be described. The investigation for seismic sources will be performed for the region within a 320 km (200 mi) radius of the site. Other significant sources beyond this radius will be considered if the sources have the potential to affect the seismic hazard at the site.

2.5.2.3 Correlation of Earthquake Activity with Seismic Sources

The possible correlation between earthquake activity records and the geologic structure and regional tectonic model will be described along with site-specific information. Detailed accounts of the rationale for the association will be provided based on the information regarding the geologic and geophysical data, seismicity, and tectonic history.

2.5.2.4 Probabilistic Seismic Hazard Analysis and Controlling Earthquake

The procedures, technical bases of inputs, and results of the probabilistic seismic hazard analysis (PSHA) will be described. Based on the PSHA results, the seismic hazard curves for the site and uniform hazard response spectra for mean annual frequency of exceedance for 10^{-4}, 10^{-5}, and 10^{-6} will be provided. The controlling earthquakes determined from the deaggregation of seismic hazards will also be described.

2.5.2.5 Seismic Wave Transmission Characteristics of the Site

The site response analyses using the site-specific geophysical and geotechnical data for each stratum under the site will be described. The data include thickness, compressional and shear wave velocities, bulk densities, soil index properties and classification, shear modulus and damping variations with strain level, and water table elevation and its variations. The method to account for the uncertainty and variation in velocity profiles and site properties will also be described.

2.5.2.6 Ground Motion Response Spectrum

The site-specific horizontal and vertical GMRS and methodology used to determine the GMRS will be described. For a site with stable surface material, i.e., low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s), the GMRS will be determined in the free field on the ground surface. For a site with low-strain shear wave velocity of less than 304.8 m/s (1,000 ft/s), the submaterials are completely excavated to expose competent material with a low-strain shear wave velocity equal to or greater than 304.8 m/s (1,000 ft/s), and the GMRS are defined as a free-field motion on the hypothetical outcrop after the excavation. For a site where the seismic Category I structures are located on hard rock with a shear wave velocity greater than 2,804 m/s (9,200 ft/s), the site-specific GMRS can be defined at the foundation level. For this case, GMRS could be referred to as foundation input response spectra (FIRS) for the seismic Category I structures. The site-specific GMRS need to be transferred to the foundation elevations of each seismic Category I structure to obtain FIRS of each seismic Category I structure. The COL applicant is to confirm that the site meets the following requirements:

a. For a site with a low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation, the site-specific GMRS at the finished grade are completely enveloped by the APR1400 CSDRS shown in Figures 3.7-1 and 3.7-2. In addition, according to the NRC DC/COL-ISG-017 (Reference 5), the FIRS of each seismic Category I structure are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of each seismic Category I structure shown in Figures 3.7A-9 through 3.7A-11 (COL 2.5(2)).

b. For hard rock sites with a low-strain shear wave velocity of supporting medium for each seismic Category I structure greater than 2,804 m/sec (9,200 ft/s), FIRS of each seismic Category I structure are completely enveloped by the CSDRS (COL 2.5(2)).

c. For soil sites, (i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2,002.3 kg/m^3 (125 lb/ft^3); (ii) the profiles of site-specific soil properties are generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-8 and Figures 3.7A-1 through 3.7A-8; (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it; and (iv) the site-specific best estimate (BE), lower bound (LB), and upper bound (UB) strain-compatible soil shear wave velocity profiles, including backfill, are consistent with one of the APR1400 generic site conditions S1 through S4 and S6 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-8 and Figures 3.7A-1 through 3.7A-8. The lower bound and upper bound shear wave velocity profiles are obtained, as defined in SRP 3.7.2 (Reference 10), from the mean properties plus or minus one standard deviation, maintaining the minimum variation of 1.5GBE for the upper bound range and GBE/1.5 for the lower bound range, where GBE denotes the best estimate low-strain shear modulus. The lower bound low-strain shear wave velocity for the site-specific soil profile is not to be less than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation (COL 2.5(3)).

d. For a HRHF site, the site-specific profile needs to be consistent with the soil profile provided in Table 3.7B-3. The site-specific GMRS determined at the finished grade are completely enveloped by the APR1400 HRHF response spectra shown in Figures 3.7-12 and 3.7-13. In addition, according to the NRC DC/COL-ISG-017 (Reference 5), the FIRS of the seismic Category I structures are completely enveloped by the HRHF-compatible free-field response motions at the bottom elevation of each seismic Category I structure (COL 2.5(4)).

e. If the requirements a, b, and c listed above are not satisfied, a site-specific seismic analysis is performed to develop in-structure response spectra at key locations using the procedure described in Appendix 3.7A. The site-specific strain-compatible properties are to be consistent with the assumptions used in the SSI analyses including embedment and extent of backfill, as described in Appendix 3.7A. The site-specific 5% damped in-structure response spectra developed are compared with the corresponding 5% damped in-structure response spectra provided in Appendix 3.7A. If the site-specific in-structure response spectra are not enveloped by the corresponding CSDRS-based in-structure response spectra, site-specific member forces are calculated and compared with CSDRS-based member forces at key locations to determine whether further site-specific seismic design is required (COL 2.5(5)). In addition, if the item d above is not satisfied, site-specific seismic response analyses are performed using the procedure described in Appendix 3.7B and in the EPRI White Paper, "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions" (Reference 6). Further structural integrity (including member forces) and functionality evaluations are also required for a HRHF site if the site specific in-structure response spectra exceed the HRHF-based in-structure response specta (COL 2.5(6)).

2.5.2.7 Soil Uniformity

The APR1400 is designed for application at a site where the foundation conditions do not have extreme variation within the standard plant structure footprint. The subsurface may consist of layers that dip with respect to the horizontal. If the dip is less than 20 degrees, the generic analysis using horizontal layers is applicable as described in NUREG/CR-0693 (Reference 7). The physical properties of the foundation medium may or may not vary systematically across a horizontal plane. The methodology for checking uniformity is to calculate from the boring logs a series of "best-estimate" planes beneath the standard plant structure footprint that define the top and bottom of each soil or rock layer. These planes should represent and delineate stratigraphic boundaries, lithologic changes, and unconformities, but most important, they should represent boundaries between layers having different shear wave velocities. Shear wave velocity is the primary property used for defining uniformity of a site.

The distribution of bearing reactions under the basemat is a function of the subgrade modulus, which in turn is a function of the shear wave velocity and soil profile. Site-specific data should be provided to evaluate the variation of subgrade modulus or shear wave velocity across the footprint and to demonstrate the site is within the range considered for design of the standard plant structure basemat. The deeper that the non-uniform layer is located below the foundation, the less influence it has on the bearing pressures at the basemat.

The COL applicant is to perform an evaluation of the subsurface conditions within the standard plant structure footprint based on the geologic investigation in accordance with NRC RG 1.132 (COL 2.5(7)). Subsurface conditions may be considered uniform if the geologic and stratigraphic features can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units. An occasional anomaly or a limited number of unexpected lateral variations may occur. If a site can be classified as uniform, it qualifies for the APR1400 based on analyses and evaluations performed to support design certification without additional site-specific analyses.

2.5.3 Surface Faulting

Detailed surface and subsurface geological, seismological, and geophysical investigations performed around the site will be compiled on a site-specific basis. Sufficient surface and subsurface information, supported by detailed investigations, confirms the absence of tectonic surface deformation (i.e., faulting) and nontectonic surface deformation (i.e., subsidence, karst terrain, glaciation or deglaciation, and growth faulting) in accordance with NRC RG 1.208 (Reference 4).

Tectonic surface deformation with capability and non-tectonic deformation with no engineering solution are not considered under the foundations of seismic Category I structures and adjacent seismic Category II structures in the APR 1400.

The COL applicant is to evaluate the potential future surface deformation of tectonic and non-tectonic origin (COL 2.5(8)). If the potential for future surface deformation exists, the COL applicant needs to demonstrate the potential effects of surface deformation are within the design basis of the facility (COL 2.5(9)).

Structure and generic relationship between site area faulting or other tectonic deformation and the regional tectonic framework will be described on a site-specific basis. For regions with active tectonics, any detailed geologic and geophysical investigations will be conducted and described to demonstrate the structural relationships of the site area faults and regional faults known to be seismically active.

2.5.4 Stability of Subsurface Materials and Foundations

Site-specific information will be presented on the properties of soil and rock formations and their stability under static and dynamic conditions based on evaluations of the site conditions and geologic features that may affect the nuclear power structures or their foundations.

Static properties of subsurface material, such as bearing capacity, settlement, and dynamic properties including liquefaction and soil-structure interaction, will also be described.

The foundations for seismic Category I structures of APR1400 can be located on rock and soil.

The acceptability of rock and soil materials for foundations is to be provided to provide reasonable assurance that the assumptions in Subsection 3.7.1 are consistent.

2.5.4.1 Geologic Features

Site-specific geologic features underlying the site, as well as descriptions, maps, and profiles of the site stratigraphy, lithology, structural geology, geologic history, and engineering geology will be described.

2.5.4.2 Properties of Subsurface Materials

The static and dynamic engineering properties of the foundation soil and rock in the site area will be provided. Procedures and methods of site investigations follow NRC RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Laboratory testing follows NRC RG 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants."

Subsurface materials are grouped in terms of origin, geologic stratigraphy, and weathering. The representative values for each group will be determined.

The site-specific engineering properties include the following:

a. Physical properties (e.g., density, deformation modulus, Poisson's Ratio)

b. Mechanical properties (e.g., strength, bearing capacity)

c. Dynamic properties (e.g., P-wave velocity, S-wave velocity, dynamic deformation modulus, dynamic shear modulus, dynamic Poisson's Ratio)

The minimum soil angle of internal friction is 35 degrees as indicated in Table 2.0-1. The friction angle of soil is used for estimating the friction resistance of the foundation. The friction coefficient derived from the soil friction angle was used for evaluating the stability of NI common basemat against sliding as described in Subsection 3.8A.1.4.2.3.2. The COL applicant is to confirm that the soil angle of internal friction below the footprint of the seismic Category I structures at their excavation depth is a minimum of 35 degrees (COL 2.5(10)).

2.5.4.3 Foundation Interfaces

NRC RG 1.132, "Site Investigation for Foundation of Nuclear Power Plant," defines procedures for and the extent of field investigations to determine the engineering properties of soil and rock materials.

The spacing and minimum depth of sounding as defined in NRC RG 1.132 will be followed. The results of investigations will be presented as forms of cross sections and profiles with a proper scale. Piezometers and other monitoring instruments for settlement or tilting, if needed, will be installed at a proper location to represent the site conditions.

2.5.4.4 Geophysical Surveys

A description will be provided of the geophysical investigations performed at the site to determine the dynamic characteristics of the soil or rock, including geophysical methods used to determine foundation conditions. The results of compressional and shear wave velocity surveys and electric resistivity surveys performed to evaluate the occurrence and characteristics of the foundation soils and rocks will be provided in tables and profiles.

2.5.4.5 Excavations and Backfill

Site-specific information will be provided for excavation and backfill, including properties of borrow and backfill materials, extent (horizontally and vertically) of all seismic Category I excavations, compaction specifications, dewatering, excavation methods, and control measures of groundwater during excavation. Minimum requirements of structural fill granular (SFG) for dynamic properties are described in Table 2.0-1. The typical APR1400 site arrangement is shown in Figure 1.2-1 and the typical profile of basemat and SFG is shown in Figure 2.5-1.

Under the basemat of seismic Category I structures a layer of approximately 0.91 m (3 ft) thick lean concrete with a minimum compressive strength of 140 kg/cm^2 (2,000 psi) is backfilled between the bottom of the basemat and the top surface of soil below the excavation.

The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures and the compressive strength of lean concrete under the nuclear island basemat satisfy the SFG requirements provided in Table 2.0-1 and the minimum compressive strength of 140 kg/cm^2 (2,000 psi) for the lean concrete (COL 2.5(11)).

2.5.4.6 Groundwater Conditions

Basic groundwater conditions are described in Section 2.4. In this subsection, the groundwater conditions relative to foundation stability of the safety-related facilities, plans for dewatering during construction, and plans for analysis of seepage and potential piping conditions during construction will be provided. Records of field and laboratory permeability tests and history of groundwater fluctuations will be provided.

2.5.4.7 Response of Soil and Rock to Dynamic Loading

Site-specific information will be provided on the response of soil and rock to dynamic loading, including investigations to determine the effects of prior earthquakes on the soils and rocks, compressional and shear wave velocity profiles determined from field seismic surveys, and the results of dynamic tests in the laboratory on samples of the soil and rock. The methodology of site response analysis is described in Appendix 3.7A.

2.5.4.8 Liquefaction Potential

No liquefaction potential is allowed for the foundation at the site adjacent to and under seismic Category I structures. The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198 (Reference 9). In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level (COL 2.5(12)).

2.5.4.9 Earthquake Site Characteristics

The earthquake site-specific characteristics are described in Subsection 2.5.2.

2.5.4.10 Static Stability

Bearing capacity analysis and settlement computation using stratigraphic conditions, strength, and elastic parameters of the rock mass, building loads, and structural interfaces are provided.

An evaluation of lateral earth pressures and hydrostatic groundwater loads acting on plant facilities will be provided. Foundation information and factor of safety (FOS) of stability on seismic Category I structures are provided in Subsection 3.8.5.

An analysis will be conducted using a two-dimensional or three-dimensional model.

2.5.4.10.1 Bearing Capacity

The maximum bearing pressure under static loading conditions for the foundation basemat beneath the Seismic Category I structure (reactor containment building, auxiliary building, emergency diesel generator building and diesel fuel oil tank) is 937.02 kPa (19,570 lb/ft^2), which includes the dead weight of the structure and components and live load. The maximum bearing pressure under safe shutdown earthquake loads combined with static loads, as described in Subsection 3.8.5, is 2,586.01 kPa (54,010 lb/ft^2) (Reference 8). The maximum bearing pressure is smaller than the allowable bearing capacity specified in Table 2.0-1.

The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5 (COL 2.5(13)).

2.5.4.10.2 Settlement

The safety-related structures of APR1400 are reactor containment building, auxiliary building, emergency diesel generator building, and diesel fuel oil tank. Based on the distributed arrangement of safety-related systems and components, there are some restricted interfaces between systems which communicate between or within buildings. The effect of Total settlement and differential settlement will be considered where these interfaces occur.

Total settlement and differential settlement is dependent on site-specific conditions, construction sequence, loading condition, and excavation plans. It is expected that most of this settlement occurs during civil construction prior to final installation of the equipment. Site-specific considerations for the predicted settlement will be taken into account. Site-specific considerations include the effects of excavation, foundation material preparation, sequence of concrete placement of the basemat, and site specific construction sequence of the superstructure.

The COL applicant will verify whether the predicted settlements within each building and between buildings exceed the maximum differential settlement specified in Table 2.0-1 for site suitability determination. If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant to demonstrate acceptability. The COL applicant will also meet settlement criteria specified in COL 3.8(18) for construction sequence and post construction settlement limits (COL 2.5(14)).

2.5.4.11 Design Criteria

The criteria for the factor of safety (FOS) for the safety analysis of foundation soil and slope that may affect seismic Category I facilities are shown in Table 2.0-1.

The allowable bearing capacity of soil under foundation is the value of ultimate bearing capacity divided by FOS. For bearing capacity, the required FOS is greater than or equal to 3.0 for the static condition and greater than or equal to 2.0 for the dynamic condition including SSE load.

For slope, the required FOS is greater than or equal to 1.5 for static condition and the required FOS is greater than or equal to 1.2 for dynamic condition including SSE load.

2.5.4.12 Techniques to Improve Subsurface Conditions

If necessary to improve subsurface conditions, the plans, summaries of specifications, and methods of quality control will be described in the site-specific information.

2.5.5 Stability of Slopes

The APR1400 standard plant design is based on the premise that there is no site-specific potential for slope failure that could adversely affect the nuclear island.

The COL applicant is to provide site-specific information about the static and dynamic stability of all natural and man-made soil and rock slopes including embankments and dams (COL 2.5(15)).

2.5.6 Combined License Information

COL 2.5(1) The COL applicant is to provide the site-specific information on geology, seismology, and geotechnical engineering as required in NRC RG 1.206. The COL applicant is to conduct the probabilistic seismic hazard analysis (PSHA) and develop the site-specific GMRS using the PSHA results as required in NRC RG 1.208.

COL 2.5(2) The COL applicant is to confirm that the FIRS of each seismic Category I structure are completely enveloped by the CSDRS-compatible free-field response motions at the bottom elevation of each seismic Category I structure for a site with the low-strain shear wave velocity greater than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation. Alternately, the COL applicant is to confirm that the FIRS of each seismic Category I structure are completely enveloped by the CSDRS for a hard rock site with a low-strain shear wave velocity of supporting medium for each seismic Category I structure greater than 2,804 m/s (9,200 ft/s).

COL 2.5(3) The COL applicant is to confirm that (i) the requirement for the site-specific weight densities of subsurface soils is to be no less than 2,002.3 kg/m^3 (125 lb/ft^3); (ii) the profiles of site-specific soil properties are generally increasing with depth from the ground surface in a manner similar to the general profile shapes shown in Tables 3.7A-1 through 3.7A-8 and Figures 3.7A-1 through 3.7A-8; (iii) the site-specific soil profiles have no inverse condition, i.e., the soil properties of a deeper soil layer are less than the properties of the soil layer above it; and (iv) the site-specific best estimate (BE), lower bound (LB), and upper bound (UB) strain-compatible soil shear wave velocity profiles, including backfill, are consistent with one of the APR1400 generic site conditions S1 through S4 and S6 through S9 considered for the standard design as shown in Tables 3.7A-1 through 3.7A-8 and Figures 3.7A-1 through 3.7A-8. The lower bound and upper bound shear wave velocity profiles are obtained, as defined in SRP 3.7.2, from the mean properties plus or minus one standard deviation, maintaining the minimum variation of 1.5GBE for the upper bound range and GBE/1.5 for the lower bound range, where GBE denotes the best estimate low-strain shear modulus. The lower bound low-strain shear wave velocity for the site-specific soil profile is not to be less than 304.8 m/s (1,000 ft/s) up to the structural foundation elevation.

COL 2.5(4) The COL applicant is to confirm that the site-specific profile for a HRHF site is consistent with the soil profile provided in Table 3.7B-3 and the site-specific GMRS determined at the finished grade are completely enveloped by the APR1400 HRHF response spectra shown in Figures 3.7-12 and 3.7-13. In addition, the COL applicant is to confirm that the FIRS of the seismic Category I structures are completely enveloped by the HRHF-compatible free-field response motions at the bottom elevation of each seismic Category I structure.

COL 2.5(5) The COL applicant is to perform a site-specific seismic analysis to develop in-structure response spectra at key locations using the procedure described in Appendix 3.7A if COL 2.5(2) and COL 2.5(3) above are not met. The COL applicant's site-specific strain-compatible properties are to be consistent with the assumptions used in the SSI analyses including embedment and extent of backfill, as described in Appendix 3.7A. The COL applicant is to confirm that the site-specific 5% damped in-structure response spectra so generated are enveloped by the corresponding 5% damped in-structure response spectra provided in Appendix 3.7A. If this requirement is not satisfied, the COL applicant is to calculate the site-specific member forces and compare them with CSDRS member forces at key locations to determine whether further site-specific seismic design is required.

COL 2.5(6) The COL applicant is to perform a site-specific seismic response analysis using the procedure described in Appendix 3.7B and the EPRI White Paper "Seismic Screening of Components Sensitive to High Frequency Vibratory Motions", if COL 2.5(4) is not met. The COL applicant is to develop the site specific in-structure response spectra and compare them with the corresponding HRHF-based in-structure response spectra to determine whether further structural integrity (including member forces) and functionality evaluations are required.

COL 2.5(7) The COL applicant is to perform an evaluation of the subsurface conditions within the standard plant structure footprint based on the geologic investigation in accordance with NRC RG 1.132.

COL 2.5(8) The COL applicant is to evaluate the potential future surface deformation of tectonic and non-tectonic origin.

COL 2.5(9) If the potential for future surface deformation exists, the COL applicant needs to demonstrate the potential effects of surface deformation are within the design basis of the facility.

COL 2.5(10) The COL applicant is to confirm that the soil angle of internal friction below the footprint of the seismic Category I structures at their excavation depth is a minimum of 35 degrees.

COL 2.5(11) The COL applicant is to confirm that the dynamic properties of SFG to be used in construction of the APR1400 seismic Category I structures and the compressive strength of lean concrete under the nuclear island basemat satisfy the SFG requirements provided in Table 2.0-1 and the minimum compressive strength of 140 kg/cm^2 (2,000 psi) for the lean concrete.

COL 2.5(12) The COL applicant is to evaluate the potential for liquefaction occurring at the site adjacent to and under seismic Category I structures in accordance with NRC RG 1.198. In addition, the COL applicant is to evaluate the liquefaction potential for those seismic Category II structure foundations that if failed, could degrade the function of a seismic Category I SSC to an unacceptable safety level.

COL 2.5(13) The COL applicant will evaluate the allowable bearing capacity of the subsurface based on the site-specific properties of the underlying materials, including appropriate laboratory test data to evaluate strength, and considering local site effects, such as fracture spacing, variability in properties, and evidence of shear zones. If the site-specific allowable bearing capacity is less than the maximum bearing demands specified in Table 2.0-1, a site-specific evaluation shall be performed by a COL applicant using the APR1400 basemat model and methodology described in Subsection 3.8.5.

COL 2.5(14) The COL applicant will verify whether the predicted settlements within each building and between buildings exceed the maximum differential settlement specified in Table 2.0-1 for site suitability determination. If the predicted settlement exceeds the maximum value in Table 2.0-1, a detailed site specific evaluation shall be performed by a COL applicant to demonstrate acceptability. The COL applicant will also meet settlement criteria specified in COL 3.8(18) for construction sequence and post construction settlement limits.

COL 2.5(15) The COL applicant is to provide site-specific information about the static and dynamic stability of all natural and man-made soil and rock slopes including embankments and dams.

2.5.7 References

1. Regulatory Guide 1.206, “Combined License Applications for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, June 2007.

2. Regulatory Guide 1.132, “Site Investigations for Foundations of Nuclear Power Plants,” Rev. 2, U.S. Nuclear Regulatory Commission, October 2003.

3. Regulatory Guide 1.138, “Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants,” Rev. 2, U.S. Nuclear Regulatory Commission, December 2003.

4. Regulatory Guide 1.208, “A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion,” U.S. Nuclear Regulatory Commission, March 2007.

5. NRC DC/COL-ISG-017, “Interim Staff Guidance on Ensuring Hazard-Consistent Seismic Input for Site Response and Soil Structure Interaction Analyses,” U.S. Nuclear Regulatory Commission, August 2009.

6. EPRI White Paper, “Seismic Screening of Components Sensitive to High Frequency Vibratory Motions,” Electric Power Research Institute, June 2007.

7. NUREG/CR-0693, “Seismic Input and Soil-Structure Interaction,” U.S. Nuclear Regulatory Commission, February 1979.

8. APR1400-E-S-NR-14006-P, “Stability Check for NI Common Basemat,” Rev. 5, KEPCO & KHNP, May 2018.

9. Regulatory Guide 1.198, “Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites,” U.S. Nuclear Regulatory Commission, November 2003.

10. NUREG-0800, Standard Review Plan, Section 3.7.2, “Seismic System Analysis,” Rev. 4, U.S. Nuclear Regulatory Commission, September 2013.

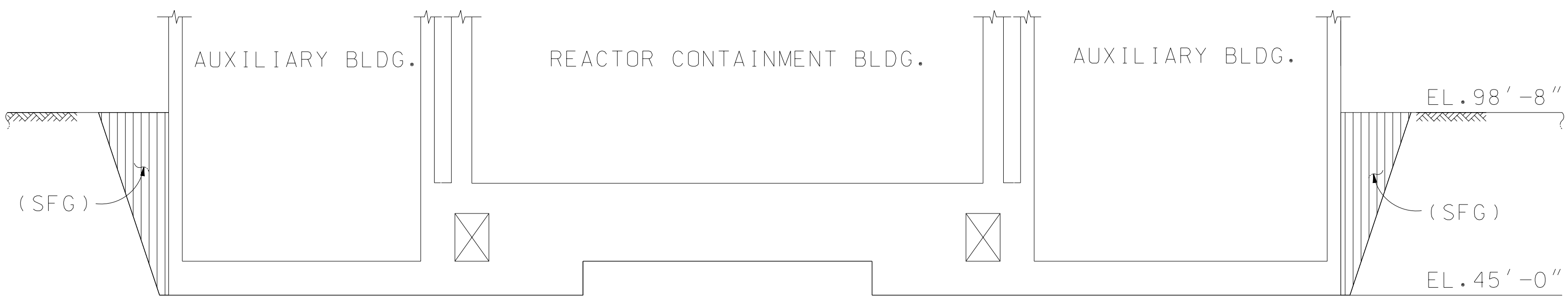

Figure 2.5-1 Typical Profile of Basemat