C.I.2 Site Characteristics

Chapter 2 of the final safety analysis report (FSAR) should provide information concerning the geological, seismological, hydrological, and meteorological characteristics of the site and vicinity, in conjunction with present and projected population distribution and land use and site activities and controls. The purpose of this information is to demonstrate that the applicant has accurately described the site characteristics and appropriately used them in the plant design and operating criteria.

Combined license (COL) applicants should identify the applicable regulatory requirements and discuss how these requirements are met for the site characteristics specified below. Applicants should identify the regulatory guidance followed and explain and justify any deviations from this guidance. They should also provide justification for any alternative methods that are used. Applicants should clearly describe the data collected, analyses performed, results obtained, and any previous analyses and results cited to justify any of the conclusions presented in the FSAR.

C.I.2.1 Geography and Demography

C.I.2.1.1 *Site Location and Description*

C.I.2.1.1.1 *Specification of Location*

Applicants should specify the location of each reactor at the site by latitude and longitude to the nearest second and by Universal Transverse Mercator Coordinates (zone number, northing, and easting, as found on topographical maps prepared by the U.S. Geological Survey (USGS)) to the nearest 100 meters (328 feet). They should consult the USGS map index for the specific names of the 7½-minute quadrangles that bracket the site area. This section should also identify the State and county (or other political subdivision) in which the site is located, as well as the location of the site with respect to prominent natural features (such as rivers and lakes) and manmade features (such as industrial, military, and transportation facilities).

C.I.2.1.1.2 *Site[1] Area Map*

This section should include a map of suitable scale depicting the site area (with explanatory text as necessary). This map should clearly show the following attributes:

(1) plant property lines, stating the area of the plant property (in acres)

(2) location of the site boundary, stating if the site boundary lines are the same as the plant property lines

(3) location and orientation of principal plant structures within the site area, identified by function (e.g., reactor building, auxiliary building, turbine building)

(4) location of any industrial, military, or transportation facilities and commercial, institutional, recreational, or residential structures within the site area

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[1] "Site" means the contiguous real estate on which nuclear facilities are located and for which one or more licensees has the legal right to control access by individuals and to restrict land use for purposes of limiting potential doses from radiation or radioactive material during normal operation of the facilities.

(5) scaled plot plan of the exclusion area (as defined in Title 10, Section 100.3, “Definitions,” of the *Code of Federal Regulations* (10 CFR 100.3)), which permits distance measurements to the exclusion area boundary in each of the 22½-degree segments centered on the 16 cardinal compass points

(6) scale that permits the measurement of distances with reasonable accuracy

(7) true north

(8) highways, railroads, and waterways that traverse or are adjacent to the site

(9) prominent natural and manmade features in the site area

C.I.2.1.2 *Exclusion Area Authority and Control*

C.I.2.1.2.1 ***Authority***

This section should include a specific description of the applicant’s legal rights with respect to all areas that lie within the designated exclusion area. As specified by 10 CFR 100.21(a), this description should establish that the applicant has the authority to determine all activities, including exclusion and removal of personnel and property from the area. It should also address the status of mineral rights and easements within this area.

If the applicant has not obtained ownership of all land within the exclusion area, it should use a scaled map of the exclusion area to clearly describe those parcels of land not owned within the area. The applicant should also clearly describe the status of proceedings and the schedule to obtain ownership or the required authority over the land for the life of the plant. This section should give the minimum distance to and direction of exclusion area boundaries for both present and proposed ownership. If the exclusion area extends into a body of water, the application should specifically address the bases upon which it has been determined that the applicant holds (or will hold) the authority required by 10 CFR 100.21(a).

C.I.2.1.2.2 ***Control of Activities Unrelated to Plant Operation***

The applicant should describe any activities unrelated to plant operation that will be permitted within the exclusion area (aside from transit through the area) with respect to the nature of such activities, the number of persons engaged in them, and the specific locations within the exclusion area where such activities will be permitted. This section should include a description of the limitations to be imposed on such activities and the procedure(s) for ensuring that the applicant is aware of such activities and has made appropriate arrangements to evacuate persons engaged in such activities in the event of an emergency.

C.I.2.1.2.3 ***Arrangements for Traffic Control***

Where a highway, railroad, or waterway traverses the exclusion area, the application should describe the arrangements made (or to be made) to control traffic in the event of an emergency.

C.I.2.1.2.4 ***Abandonment or Relocation of Roads***

If any public roads traverse the proposed exclusion area that, because of their location, will have to be abandoned or relocated, the applicant should provide specific information regarding the authority possessed under State laws to effect abandonment, the necessary procedures to achieve abandonment, the identities of the public authorities who will make the final determination, and the status of the proceedings completed to date and the schedule to obtain abandonment. If a public hearing is required before abandonment, the applicant should specify the type of hearing (e.g., legislative or adjudicatory). If the public road will be relocated rather than abandoned, this section should provide specific information on the relocation and the status of and schedule for obtaining any lands required for relocation.

C.I.2.1.3 *Population Distribution*

This section should present population data based on the latest census data. The following sections discuss the information that applicants should present on population distribution.

C.I.2.1.3.1 ***Population Within 10 Miles***

On a map of suitable scale that identifies places of significant population grouping (such as cities and towns) within a radius of 10 miles (16.09 kilometers (km)), applicants should draw concentric circles, with the reactor at the center point, at distances of 1, 2, 3, 4, 5, and 10 miles (1.61, 3.22, 4.83, 6.44, 8.05, and 16.09 km). The circles should be divided into 22½-degree sectors, with each sector centered on one of the 16 compass points (e.g., true north, north-northeast, northeast). A table appropriately keyed to the map should provide the current resident population within each area of the map formed by the concentric circles and radial lines. The applicant should use the same table, or separate tables, to provide the projected population within each area (1) for the expected first year of plant operation and (2) by census decade (e.g., 2000) through the projected plant life. The tables should provide population totals for each segment and annular ring and a total for the 0–10-mile (0–16.09-km) enclosed population. The applicant should describe the basis for population projections and provide the methodology and sources used to obtain the population data, including the projection.

C.I.2.1.3.2 ***Population Between 10 and 50 Miles***

The applicant should use a map of suitable scale and appropriately keyed tables in the same manner discussed in Section C.I.2.1.3.1 of this guide to describe the population and its distribution at 10-mile (16.09-km) intervals between the 10- and 50-mile (16.09- and 80.47-km) radii from the reactor.

C.I.2.1.3.3 ***Transient Population***

This section should generally describe seasonal and daily variations in population and population distribution resulting from land uses (such as recreational or industrial) and appropriately key them to the areas and population numbers contained on the maps and tables in Sections 2.1.3.1 and 2.1.3.2 of the FSAR. If the plant is located in an area where significant population variations attributable to transient land use are expected, the applicant should provide additional tables of population distribution to indicate peak seasonal and daily populations. The additional tables should cover projected as well as current populations.

C.I.2.1.3.4 ***Low-Population Zone***

This section should specify the low-population zone (LPZ), as defined in 10 CFR Part 100, "Reactor Site Criteria," which should be determined in accordance with the guidance provided in Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations." The applicant should provide a scaled map of the zone to illustrate topographic features; highways, railroads, waterways, and any other transportation routes that may be used for evacuation purposes; and locations of all facilities and institutions such as schools, hospitals, prisons, beaches, and parks. The applicant should identify, out to a distance of 5 miles (8.05 km), any facilities and institutions beyond the LPZ that, because of their nature, may require special consideration when evaluating emergency plans. A table of population distribution within the LPZ should provide estimates of peak daily, as well as seasonal transient, population within the zone, including estimates of transient population in the identified facilities and institutions. The applicant should determine the LPZ so that appropriate protective measures could be taken on behalf of the enclosed populace in the event of an emergency.

C.I.2.1.3.5 ***Population Center***

The applicant should identify the nearest population center (as defined in 10 CFR Part 100) and specify its population, direction, and distance from the reactor. The distance from the reactor to the nearest boundary of the population center (not necessarily the political boundary) should be related to the LPZ radius to demonstrate compliance with the requirements in 10 CFR Part 100 and the guidance in Regulatory Guide 4.7. The applicant should also provide the bases for the selected boundary, indicating the extent to which it considered the transient population in establishing the population center. In addition to specifying the distance to the nearest boundary of a population center, the applicant should discuss the present and projected population distribution and population density within and adjacent to local population groupings.

C.I.2.1.3.6 ***Population Density***

The applicant should provide a plot out to a distance of at least 20 miles (32.20 km) showing the cumulative resident population (including the weighted transient population) at the time of the projected COL approval and within about 5 years thereafter. The applicant should demonstrate that the resulting uniform population density (defined as the cumulative population at a distance divided by the circular area at that distance) from the cumulative populations averaged over any radial distance out to 20 miles (32.20 km) does not exceed 500 persons/square mile (200 persons/km^2)and demonstrate that the population density is in accordance with the guidance in Regulatory Guide 4.7.

C.I.2.2 Nearby Industrial, Transportation, and Military Facilities

The purpose of this section is to establish (1) whether the effects of potential accidents in the vicinity[2] of the site from present and projected industrial, transportation, and military installations and operations should be used as design-basis events and (2) the design parameters related to the accidents so selected.

COL applicants should identify the applicable regulatory requirements and discuss how these requirements are met for the site characteristics specified below. They should identify the regulatory guidance followed and explain and justify any deviations from this guidance and for any alternative methods that are used. They should also describe the data collected, analyses performed, results obtained, and any previous analyses and results cited to justify any of the conclusions presented in the FSAR.

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2 Applicants should consider all facilities and activities within 5 miles (8.05 km) of the nuclear plant and include facilities and activities at greater distances as appropriate based on their significance.

C.I.2.2.1 *Locations and Routes*

The applicant should provide maps showing the location and distance from the nuclear plant of all significant manufacturing plants; chemical plants; refineries; storage facilities; mining and quarrying operations; military bases; missile sites; transportation routes (air, land, and water); transportation facilities (docks, anchorages, and airports); oil and gas pipelines, drilling operations, and wells; and underground gas storage facilities. Any other facilities that, because of the products manufactured, stored, or transported, may warrant consideration with respect to possible adverse effects on the plant should be shown on the maps. Typically, toxic, flammable, and explosive substances, such as chlorine, ammonia, compressed or liquid hydrogen, liquid oxygen, and propane, may produce adverse effects. As should any military firing or bombing ranges and any nearby aircraft flight, holding, and landing patterns.

The maps should be legible and of suitable scale to enable the easy location of the facilities and routes in relation to the nuclear plant. Applicants should identify in legends or tables all symbols and notations used to depict the locations of facilities and routes. The maps should depict topographic features in sufficient detail to adequately illustrate the information presented.

C.I.2.2.2 *Descriptions*

The descriptions of the nearby industrial, transportation, and military facilities identified in accordance with Section C.I.2.2.1 of this guide should include the information indicated in the following sections.

C.I.2.2.2.1 ***Description of Facilities***

The applicant should provide a concise description, in tabular form, of each facility, including its primary function and major products as well as the number of persons employed.

C.I.2.2.2.2 ***Description of Products and Materials***

This section should describe the products and materials regularly manufactured, stored, used, or transported in the vicinity of the nuclear plant or on site. It should emphasize the identification and description of any hazardous materials. The applicant should provide statistical data on the amounts involved, modes of transportation, frequency of shipment, and maximum quantity of hazardous material likely to be processed, stored, or transported at any given time. Applicants should also provide the applicable toxicity limits for each hazardous material.

C.I.2.2.2.3 ***Description of Pipelines***

For pipelines, the applicant should indicate the pipe size, age, operating pressure, depth of burial, location and type of isolation valves, and type of gas or liquid presently carried. The applicant should also indicate whether the pipeline is used for gas storage at higher-than-normal pressure and discuss the possibility that the pipeline may be used in the future to carry a different product (e.g., propane instead of natural gas).

C.I.2.2.2.4 ***Description of Waterways***

If the site is adjacent to a navigable waterway, the applicant should provide information on the location of the intake structure(s) in relation to the shipping channel, the depth of channel, the locations of locks, the types of ships and barges using the waterway, and any nearby docks and anchorages.

C.I.2.2.2.5 ***Description of Highways***

The applicant should describe nearby major highways or other roadways, as appropriate, in terms of the frequency and quantities of hazardous substances that may be transported by truck in the vicinity of the plant site.

C.I.2.2.2.6 ***Description of Railroads***

The applicant should identify nearby railroads and provide information on the frequency and quantities of hazardous materials that may be transported in the vicinity of the plant site.

C.I.2.2.2.7 ***Description of Airports***

For airports, the applicant should provide information regarding the length and orientation of runways, types of aircraft using the facility, number of operations per year by aircraft type, and the flying patterns associated with the airport. This section should also provide plans for future use of the airport, including possible construction of new runways, increased traffic, or use by larger aircraft. In addition, the applicant should provide statistics on aircraft accidents[3] for the following three categories:

(1) all airports within 5 miles (8.05 km) of the nuclear plant

(2) airports with projected operations greater than $500d^2$ movements per year within 10 miles (16.1 km)[4] of the plant

(3) airports with projected operations greater than $1000d^2$ movements per year outside 10 miles (16.1 km)[4] of the plant

Equivalent information describing any other aircraft activities in the vicinity of the plant should be provided. These should include aviation routes, pilot training areas, and landing and approach paths to airports and military facilities.

C.I.2.2.2.8 ***Projections of Industrial Growth***

For each of the categories given in Section C.I.2.2.2.7 of this guide, the applicant should provide projections of the growth of present activities and new types of activities in the vicinity of the nuclear plant that can reasonably be expected based on economic growth projections for the area.

C.I.2.2.3 *Evaluation of Potential Accidents*

The applicant should determine on the basis of the information provided in FSAR Sections 2.2.1 and 2.2.2, the potential accidents to be considered as design-basis events and identify the potential effects of those accidents on the nuclear plant in terms of design parameters (e.g., overpressure, missile energies) or physical phenomena (e.g., concentration of flammable or toxic cloud outside building structures).

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3 The applicant should provide in Section 3.5 of the FSAR an analysis of the probability of an aircraft collision at the nuclear plant and the effects of the collision on the safety-related components of the plant.

4 The variable "d" represents the distance in miles from the site.

C.I.2.2.3.1 ***Determination of Design-Basis Events***

Design-basis events internal and external to the nuclear plant are defined as those accidents that have a probability of occurrence on the order of magnitude of 10^{-7} per year or greater and potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR Part 100 could be exceeded. The probability of occurrence of potential accidents should be determined based on analysis of the available statistical data on the frequency of occurrence for the type of accident under consideration, as well as on the transportation accident rates for the mode of transportation used to carry the hazardous material. If the probability of such an accident is on the order of magnitude of 10^{-7} per year or greater, the applicant should consider it a design-basis event and provide a detailed analysis of its effects on the plant's safety-related structures and components. Because it is difficult to assign accurate numerical values to the expected rate of low-frequency hazards considered in this guide, judgment must be used as to the acceptability of the overall risk presented. Data for low-probability events are often not available to permit accurate calculations. Accordingly, the expected rate of occurrence exceeding the guidelines in 10 CFR Part 100 (on the order of magnitude of 10^{-6} per year) is acceptable if, when combined with reasonable qualitative arguments, the realistic probability can be shown to be lower. Applicants should consider the following accident categories in selecting design-basis events:

(1) Explosions—Applicants should consider accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels for facilities and activities in the vicinity of the plant or on site, where such materials are processed, stored, used, or transported in quantity. Applicants should give particular attention to potential accidental explosions that could produce a blast overpressure on the order of 1 pound force per square inch (1 psi) equivalent of 51.7 mmHg or greater at the nuclear plant, using recognized quantity-distance relationships.[5] If the blast overpressure criterion is not met or if the probability of occurrence of the subject event is greater than 10^{-7}/year, applicants should also consider missiles generated by the explosion and provide an analysis in Section 3.5 of the FSAR. Regulatory Guide 1.91, "Evaluations of Explosions Postulated To Occur on Transportation Routes Near Nuclear Power Plants," provides guidance for evaluating postulated explosions on transportation routes near nuclear facilities.

(2) Flammable vapor clouds (delayed ignition)—Applicants should consider the accidental releases of flammable liquids or vapors that result in the formation of unconfined vapor clouds. Assuming that no immediate explosion occurs, applicants should determine the extent of the cloud and the concentrations of gas that could reach the plant under worst-case meteorological conditions. Applicants should provide an evaluation of the effects on the plant of explosion and deflagration of the vapor cloud. If the probability of occurrence of the subject event is greater than 10^{-7}/year, Section 3.5 of the FSAR should provide an analysis of the missiles generated by the explosion.

(3) Toxic chemicals—Applicants should consider accidents involving the release of toxic chemicals (e.g., chlorine) from onsite storage facilities and nearby mobile and stationary sources. If toxic chemicals are known or projected to be present on site or in the vicinity of a nuclear plant, or to be frequently transported in the vicinity of the plant, applicants should evaluate releases of those chemicals. For each postulated event, applicants should determine a range of concentrations at the site for a spectrum of meteorological conditions. Applicants should use these toxic chemical concentrations to evaluate control room habitability in Section 6.4 of the FSAR.

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[5] One acceptable reference is the U.S. Department of the Army Technical Manual TM 5-1300, "Structures to Resist the Effects of Accidental Explosions," Revision 1, issued 1990, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

(4) Fires—Applicants should consider accidents leading to high heat fluxes or smoke and nonflammable gas- or chemical-bearing clouds from the release of materials as the consequence of fires in the vicinity of the plant. They should evaluate fires in adjacent industrial and chemical plants and storage facilities and in oil and gas pipelines, brush and forest fires, and fires from transportation accidents as events that could lead to high heat fluxes or to the formation of such clouds. The dispersal analysis should include a spectrum of meteorological conditions for determining the concentrations of nonflammable material that could reach the site. Applicants should use these concentrations in Section 6.4 of the FSAR to evaluate control room habitability and in Section 9.5 of the FSAR to evaluate the operability of diesels and other equipment.

(5) Collisions with intake structure—For nuclear power plant sites located on navigable waterways, the evaluation should consider the probability and potential effects of impact on the plant cooling water intake structure and enclosed pumps by the various sizes, weights, and types of barges or ships that normally pass the site, including any explosions incident to the collision. Applicants should use this analysis in Section 9.2.5 of the FSAR to determine whether an additional source of cooling water is required.

(6) Liquid spills—Applicants should consider the accidental release of oil or liquids that may be corrosive, cryogenic, or coagulant to determine the potential for such liquids to be drawn into the plant's intake structure and circulating water system or otherwise to affect the plant's safe operation.

C.I.2.2.3.2 ***Effects of Design-Basis Events***

Applicants should provide an analysis of the effects of the design-basis events identified in Section 2.2.3.1 of the FSAR on the safety-related components of the nuclear plant and discuss the steps taken to mitigate the consequences of those accidents, including such things as the addition of engineered safety feature equipment and the reinforcing of plant structures as well as the provisions made to lessen the likelihood and severity of the accidents.

C.I.2.3 *Meteorology*

This section should provide a meteorological description of the site and its surrounding areas. It should include sufficient data to permit an independent evaluation by the staff.

C.I.2.3.1 Regional Climatology

C.I.2.3.1.1 *General Climate*

This section should describe the general climate of the region with respect to types of air masses, synoptic features (high- and low-pressure systems and frontal systems), general airflow patterns (wind direction and speed), temperature and humidity, precipitation (rain, snow, sleet, and freezing rain), potential influences from regional topography, and relationships between synoptic-scale atmospheric processes and local (site) meteorological conditions. It should Identify the state climatic division of the site also and provide Provide references that indicate the climatic atlases and regional climatic summaries used.

C.I.2.3.1.2 *Regional Meteorological Conditions for Design and Operating Bases*

In this section, the applicant should provide annual (and seasonal, if available) frequencies of severe weather phenomena, including hurricanes, tornadoes and waterspouts, thunderstorms, severe wind events, lightning, hail (including probable maximum size), and high air pollution potential. The probable maximum annual frequency of occurrence, amount, and time duration of freezing rain (ice storms) and dust (sand) storms where applicable should also be provided us this section. A description of the site's air quality, including identification of the site's Interstate Air Quality Control Region and its attainment designation with respect to State and national air quality standards should also be provided.

All regional meteorological and air quality conditions, including those listed below, that should be classified as climatic site characteristics for consideration in evaluating the design and operation of the proposed facility should be identified and be included. Should references to other applicable sections of the FSAR in which these conditions are used provide:

(1) The applicant should provide estimates of the weight of the 100-year return period snowpack and the weight of the 48-hour probable maximum winter precipitation for the site vicinity for use in determining the weight of snow and ice on the roof of each safety-related structure;

(2) the meteorological data used to evaluate the performance of the ultimate heat sink with respect to maximum evaporation and drift loss, minimum water cooling, and if applicable, the potential for water freezing in the ultimate heat sink water-storage facility (See Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."). Identification of the period of record examined and a description of and justification for the bases and procedures used to select the critical meteorological data;

(3) site-characteristic tornado parameters, including translational speed, rotational speed, and maximum pressure differential with its associated time interval. Regulatory Guide 1.76, "Design Basis Tornado and Tornado Missiles for Nuclear Power Plants," contains guidance on appropriate site-characteristic tornado parameters any deviations from the guidance in Regulatory Guide 1.76 should be identified and justified;

(4) the 100-year return period 3-second gust wind speed

(5) ambient temperature and humidity statistics (e.g., 2-percent and 1-percent annual exceedance and 100-year maximum dry bulb temperature and coincident wet bulb temperature; 2-percent and 1-percent annual exceedance and 100-year maximum wet bulb temperature (non-coincident); 98-percent and 99-percent annual exceedance and 100-year minimum dry bulb temperature) for use in establishing heat loads for the design of plant heat sink systems and plant heating, ventilation, and air conditioning systems.

C.I.2.3.2 <u>Local Meteorology</u>

C.I.2.3.2.1 ***Normal and Extreme Values of Meteorological Parameters***

The applicant should provide monthly and annual summaries based on both long-term data from nearby reasonably representative locations (e.g., within 50 miles (80 km)) and shorter-term onsite data for the following parameters:

(1) monthly and annual wind roses using the wind speed classes provided in Regulatory Guide 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants," and wind direction persistence summaries at all heights at which wind characteristics data are applicable or have been measured

(2) monthly and annual air temperature and atmospheric water vapor (e.g., wet bulb temperature, dewpoint temperature, or relative humidity) summaries, including averages, measured extremes, and diurnal range

(3) monthly and annual summaries of precipitation, including averages and measured extremes, number of hours with precipitation, rainfall rate distribution (i.e., maximum distributions for

1-hour intervals up to 24 hours), and monthly precipitation wind roses with precipitation rate classes

(4) monthly and annual summaries of fog (and smog), including expected values and extremes of frequency and duration

(5) monthly and annual summaries of atmospheric stability defined by vertical temperature gradient or other well-documented parameters that have been substantiated by diffusion data

(6) monthly mixing height data, including frequency and duration (persistence) of inversion conditions

(7) annual joint frequency distributions of wind speed and wind direction by atmospheric stability for all measurement levels

The applicant should fully document and substantiate that this information validly represents conditions at and near the site. For example, the applicant should identify deviations from regional to local meteorological conditions caused by local topography, nearby bodies of water, or other unique site characteristics. This information should include references to the National Oceanic and Atmospheric Administration (NOAA), National Weather Service, station summaries from nearby locations, and other meteorological data that were used to describe site characteristics.

C.I.2.3.2.2 ***Potential Influence of the Plant and Its Facilities on Local Meteorology***

The applicant should discuss and provide an evaluation of the potential modification of the normal and extreme values of meteorological parameters described in Section 2.3.2.1 of the FSAR as a result of the presence and operation of the plant (e.g., the influence of plant structures, terrain modifications, and cooling towers or water impoundment features on meteorological conditions) and provide a map showing the detailed topographic features (as modified by the plant) within a 5-mile (8 km) radius of the plant. In addition, the applicant should provide a smaller scale map showing topography within a 50-mile (80-km) radius of the plant, as well as a plot of maximum elevation versus distance from the center of the plant in each of the 22½-degree sectors centered on one of the 16 compass points (e.g., true north, north-northeast, northeast) radiating from the plant to a distance of 50 miles (80 km).

C.I.2.3.2.3 ***Local Meteorological Conditions for Design and Operating Bases***

The applicant should provide all local meteorological and air quality conditions used for design- and operating-basis considerations and their bases, except for those conditions addressed in Sections C.I.2.3.4 and C.I.2.3.5 of this guide. The applicant should include references to the FSAR sections in which these conditions are used.

C.I.2.3.3 **Onsite Meteorological Measurements Program**

This section should describe the preoperational and operational programs for meteorological measurements at the site, including offsite satellite facilities. This description should include a site map showing tower location with respect to manmade structures, topographic features, and other site features that may influence site meteorological measurements and should indicate distances to nearby obstructions to flow in each downwind sector. The description should also include measurements made; elevations of measurements; exposure of instruments; descriptions of instruments used; instrument performance specifications; calibration and maintenance procedures; data output and recording systems and locations; and data processing, archiving, and analysis procedures. This section should similarly identify, in as much detail as possible, additional sources of meteorological data for consideration in the description of airflow trajectories from the site to a distance of 50 miles (80 km), particularly measurements made, locations and elevations of measurements, exposure of instruments, descriptions of instruments used, and instrument performance specifications. These additional sources of meteorological data may include National Weather Service stations and other meteorological programs that are well-maintained and well-exposed (e.g., other nuclear facilities and university and private meteorological programs). (Regulatory Guide 1.23 contains guidance on acceptable onsite meteorological programs and any deviations from the guidance provided in Regulatory Guide 1.23 should be identified and justified.)

In a supplemental submittal to the application, the applicant should provide an electronic copy of (1) the joint frequency distributions of wind speed and direction by atmospheric stability class based on appropriate meteorological measurement heights and data reporting periods, in the format described in Regulatory Guide 1.23, and (2) an hour-by-hour listing of the hourly averaged onsite meteorological database in the format shown in Regulatory Guide 1.23.

The applicant should provide meteorological data from at least two consecutive annual cycles (and preferably 3 or more entire years), including the most recent 1-year period, at the time of application submittal. If 2 years of onsite data are not available at the time the application is submitted, the applicant should provide at least one annual cycle of meteorological data collected on site with the application. The applicant should use these data to calculate (1) the short-term atmospheric dispersion estimates for accident releases discussed in Section 2.3.4 of the FSAR and (2) the long-term atmospheric dispersion estimates for routine releases discussed in Section 2.3.5 of the FSAR. The applicant should continue to monitor the data and submit the complete 2-year data set when it has been collected. The supplemental submittal should also include a reanalysis of the Section 2.3.4 and 2.3.5 atmospheric dispersion estimates based on the complete 2-year data set.

The applicant should provide evidence to show how well these data represent long-term conditions at the site.

C.I.2.3.4 <u>Short-Term Atmospheric Dispersion Estimates for Accident Releases</u>

C.I.2.3.4.1 *Objective*

The COL applicant should provide, for appropriate time periods up to 30 days after an accident, conservative estimates of atmospheric dispersion factors (χ/Q values) at the site boundary (exclusion area), at the outer boundary of the LPZ, and at the control room for postulated accidental radioactive airborne releases. The applicant should also describe any atmospheric dispersion modeling used in Section 2.2.3 or Section 6.4 of the FSAR to evaluate potential design-basis events resulting from the onsite and/or offsite airborne releases of hazardous materials (e.g., flammable vapor clouds, toxic chemicals, and smoke from fires).

C.I.2.3.4.2 *Calculations*

The applicant should base dispersion estimates on the most representative (preferably onsite) meteorological data and present evidence showing how well these dispersion estimates represent conditions that would be estimated from anticipated long-term conditions at the site. This section should discuss the effects of topography and nearby bodies of water on short-term dispersion estimates. The information provided should be sufficient to allow the staff to perform its own confirmatory calculations.

(1) For postulated accidental radioactive releases, the applicant should provide the following estimates:

(a) Offsite dispersion estimates—Provide hourly cumulative frequency distributions of χ/Q values, using onsite data at appropriate distances from the effluent release point(s), such as the minimum site boundary distance (exclusion area). Report the χ/Q values from each of these distributions that are exceeded 5 percent of the time. For the outer boundary of the LPZ, provide cumulative frequency of χ/Q estimates for (1) the 8-hour time period from 0 to 8 hours; (2) the 16-hour period from 8 to 24 hours; (3) the 3-day period from 1 to 4 days; and (4) the 26-day period from 4 to 30 days. Report the worst condition and the 5-percent probability level conditions. Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," provides guidance on appropriate dispersion models for estimating offsite χ/Q values. Any deviations from the guidance provided in Regulatory Guide 1.145 should be identified and justified.

(b) Control room dispersion estimates—Provide control room χ/Q values that are not exceeded more than 5 percent of the time for all potential accident release points. For the purposes of control room radiological habitability analyses, provide a site plan showing true north and indicating locations of all potential accident release pathways and control room intake and unfiltered in-leakage pathways. Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants," contains guidance on appropriate dispersion models for estimating control room χ/Q values. Any deviations from the guidance provided in Regulatory Guide 1.194 should be identified and justified.

(2) For hazardous material releases, provide a description of the atmospheric dispersion modeling used in evaluating potential design-basis events to calculate concentrations of hazardous materials (e.g., flammable or toxic clouds) outside building structures resulting from the onsite and/or offsite airborne releases of such materials and should justify the appropriateness of the use of the models with regard to release characteristics, plant configuration, plume density, meteorological conditions, and site topography. Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," provides guidance on hazardous chemical dispersion modeling. Any deviations from the guidance provided in Regulatory Guide 1.78 should be identified and justified.

C.I.2.3.5 Long-Term Atmospheric Dispersion Estimates for Routine Releases

C.I.2.3.5.1 *Objective*

The COL applicant should provide realistic estimates of annual average atmospheric dispersion (χ/Q values) and deposition (D/Q values) to a distance of 50 miles (80 km) from the plant for annual average release limit calculations and person-rem estimates.

C.I.2.3.5.2 *Calculations*

The applicant should provide a detailed description of the model used to calculate realistic annual average χ/Q and D/Q values and should discuss the accuracy and validity of the model, including the suitability of input parameters, source configuration, and topography. The meteorological data (onsite and regional) used as input to the models should be provided. Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," contains guidance on acceptable atmospheric transport and dispersion models. Any deviations from the guidance provided in Regulatory Guide 1.111 should be identified and justified. The information provided should be sufficient to allow the staff to perform its own confirmatory calculations.

For each venting release point, the applicant should use appropriate meteorological data to provide a calculation of the annual average χ/Q and D/Q values at appropriate locations (e.g., site boundary, nearest vegetable garden, nearest residence, nearest milk animal, and nearest meat cow in each 22½-degree direction sector within a 5-mile radius of the site) for use in Chapter 11 of the FSAR to estimate the dose to a hypothetical maximally exposed member of the public from gaseous effluents in accordance with Appendix I to 10 CFR Part 50. The calculations provided should also include estimates of annual average χ/Q and D/Q values for 16 radial sectors to a distance of 50 miles (80 km) from the plant using appropriate meteorological data.

The applicant should provide evidence to show how well these estimates represent conditions that would be estimated from climatologically representative data.

C.I.2.4 *Hydrologic Engineering*

The applicant should provide sufficient information to permit an independent hydrologic engineering review of all hydrologically related site characteristics, performance requirements, and bases for operation of structures, systems, and components important to safety, considering the following phenomena or conditions:

(1) probable maximum precipitation, on site and on the contributing drainage area

(2) runoff floods for streams, reservoirs, adjacent drainage areas, and site drainage, and flood waves resulting from dam failures induced by runoff floods

(3) surges, seiches, and wave action

(4) tsunami

(5) nonrunoff-induced flood waves attributable to dam failures or landslides, and floods attributable to failure of onsite or near-site water control structures

(6) blockage of cooling water sources by natural events

(7) ice jam flooding

(8) combinations of flood types

(9) low water and/or drought effects (including setdown resulting from surges, seiches, frazil and anchor ice, or tsunami) on safety-related cooling water supplies and their dependability

(10) channel diversions of safety-related cooling water sources

(11) capacity requirements for safety-related cooling water sources

(12) dilution and dispersion of severe accidental releases to the hydrosphere relating to existing and potential future users of surface water and ground water resources

The level of analysis that this section should present may range from very conservative, based on simplifying assumptions, to detailed analytical estimates of each facet of the bases being studied. The staff suggests the former approach for evaluating phenomena that do not influence the selection of site characteristics, or where the adoption of very conservative site characteristics does not adversely affect plant design.

C.I.2.4.1 <u>Hydrologic Description</u>

C.I.2.4.1.1 *Site and Facilities*

The applicant should describe the site and all safety-related elevations, structures, exterior accesses, equipment, and systems from the standpoint of hydrologic considerations (both surface and subsurface) and provide a topographic map of the site that shows any proposed changes to natural drainage features.

C.I.2.4.1.2 ***Hydrosphere***

The applicant should describe the location, size, shape, and other hydrologic characteristics of streams, lakes, shore regions, and ground water environments influencing plant siting and should include a description of existing and proposed water control structures, both upstream and downstream, that may influence conditions at the site. For these structures, the applicant should perform the following tasks:

(1) tabulate contributing drainage areas

(2) describe types of structures, all appurtenances, ownership, seismic design criteria, and spillway design criteria

(3) provide elevation-area-storage relationships and short-term and long-term storage allocations for pertinent reservoirs

The applicant should provide a regional map showing major hydrologic features. The applicant should list the owner, location, and rate of use of surface water users whose intakes could be adversely affected by accidental release of contaminants. (Section 2.4.13.2 of the FSAR provides a tabulation of ground water users.)

C.I.2.4.2 **Floods**

A "flood" is defined as any abnormally high water stage or overflow in a stream, flood way, lake, or coastal area that results in significantly detrimental effects.

C.I.2.4.2.1 ***Flood History***

The applicant should provide the date, level, peak discharge, and related information for major historical flood events in the site region. Stream floods, surges, seiches, tsunami, dam failures, ice jams, floods induced by landslides, and similar events should be included.

C.I.2.4.2.2 ***Flood Design Considerations***

The applicant should discuss the general capability of safety-related facilities, systems, and equipment to withstand floods and flood waves. It should show how the design flood protection for safety-related components and structures of the plant is based on the highest calculated flood water level elevations and flood wave effects (site-characteristic flood) resulting from analyses of several different hypothetical causes. The applicant should discuss 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.

The applicant should discuss the flood potential from streams, reservoirs, adjacent watersheds, and site drainage, including (1) the probable maximum water level from a stream flood, surge, seiche, combination of surge and stream flood in estuarial areas, wave action, or tsunami (whichever is applicable and/or greatest), and (2) the flood level resulting from the most severe flood wave at the plant site caused by an upstream or downstream landslide, dam failure, or dam breaching resulting from a hydrologic, seismic, or foundation disturbance. It should also discuss the effects of superimposing the coincident wind-generated wave action on the applicable flood level and evaluate the assumed hypothetical conditions both statically and dynamically to determine the design flood protection level. The types of events considered, as well as the controlling event or combination of events should be summarized.

C.I.2.4.2.3 ***Effects of Local Intense Precipitation***

The applicant should describe the effects of local probable maximum precipitation (see Section C.I.2.4.3.1 of this guide) on adjacent drainage areas and site drainage systems, including drainage from the roofs of structures. It should tabulate rainfall intensities for the selected and critically arranged time increments, provide characteristics and descriptions of runoff models, and estimate the resulting water levels. It should summarize the design criteria for site drainage facilities and provide analyses that demonstrate the capability of site drainage facilities to prevent flooding of safety-related facilities resulting from local probable maximum precipitation. The applicant should provide sufficient details concerning the site drainage system to permit the following actions:

(1) independent review of rainfall and runoff effects on safety-related facilities

(2) judgment concerning the adequacy of design criteria

(3) independent review of the potential for blockage of site drainage as a result of ice, debris, or similar material

The applicant should provide a discussion of the effects of ice accumulation on site facilities where such accumulation could coincide with local probable maximum (winter) precipitation and cause flooding or other damage to safety-related facilities.

C.I.2.4.3 **<u>Probable Maximum Flood on Streams and Rivers</u>**

The applicant should describe how the hydrological site characteristics affect any potential hazard to the plant's safety-related facilities as a result of the effect of the probable maximum flood (PMF) on streams and rivers. The locations and associated water levels for which PMF determinations have been made should be summarized.

C.I.2.4.3.1 ***Probable Maximum Precipitation***

The applicant should discuss considerations of storm configuration (orientation of areal distribution), maximized precipitation amounts (including a description of maximization procedures and/or studies available for the area, such as by reference to National Weather Service and U.S. Army Corps of Engineers determinations), time distributions, orographic effects, storm centering, seasonal effects, antecedent storm sequences, antecedent snowpack (depth, moisture content, areal distribution), and any snowmelt model in defining the probable maximum precipitation (PMP). Present the selected maximized storm precipitation distribution (time and space).

C.I.2.4.3.2 ***Precipitation Losses***

The applicant should describe the absorption capability of the basin, including consideration of initial losses, infiltration rates, and antecedent precipitation. Provide verification of these assumptions by reference to regional studies or by presentation of detailed applicable local storm-runoff studies.

C.I.2.4.3.3 ***Runoff and Stream Course Models***

The applicant should describe the hydrologic response characteristics of the watershed to precipitation (such as unit hydrographs), provide verification from historical floods or synthetic procedures, and identify methods adopted to account for nonlinear basin response at high rainfall rates. It should also provide a description of watershed subbasin drainage areas (including a map), their sizes, and topographic features. A tabulation of all drainage areas should be included as should a discussion of the stream course model and its ability to compute floods up to the severity of the PMF. The applicant should present any reservoir and channel routing assumptions and coefficients and their bases with appropriate discussion of initial conditions, outlet works (controlled and uncontrolled), and spillways (controlled and uncontrolled).

C.I.2.4.3.4 ***Probable Maximum Flood Flow***

The applicant should present the controlling PMF runoff hydrograph at the plant site that would result from rainfall (and snowmelt if pertinent). It should discuss how the analysis considered all appropriate positions and distributions of the PMP and the potential influence of existing and proposed upstream and downstream dams and river structures and present analyses and conclusions concerning the ability of any upstream dams that may influence the site to withstand PMF conditions combined with setup, waves, and runup from appropriate coincident winds (see Section C.I.2.4.3.6 of this guide). If failures are likely, the applicant should show the flood hydrographs at the plant site resulting from the most critical combination of such dam failures, including domino-type failures of dams upstream of the plant site. When credit is taken for flood lowering at the plant site as a result of failure of any downstream dam during a PMF, the conclusion that the downstream dam has a very high likelihood of failure should be supported. Finally, the estimated PMF discharge hydrograph at the site and, when available, a similar hydrograph without upstream reservoir effects to allow an evaluation of reservoir effects and a regional comparison of the PMF estimate to be made should be provided.

C.I.2.4.3.5 ***Water Level Determinations***

The applicant describe the translation of the estimated peak PMP discharge to elevation using (when applicable) cross-section and profile data, reconstitution of historical floods (with consideration of high water marks and discharge estimates), standard step methods, transient flow methods, roughness coefficients, bridge and other losses, verification, extrapolation of coefficients for the PMF, estimates of PMF water surface profiles, and flood outlines.

C.I.2.4.3.6 ***Coincident Wind Wave Activity***

The applicant should discuss setup, significant (average height of the maximum 33⅓ percent of all waves) and maximum (average height of the maximum 1 percent of all waves) wave heights, runup, and resultant static and dynamic effects of wave action on each safety-related facility from wind-generated activity that may occur coincidently with the peak PMF water level and provide a map and analysis showing that the most critical fetch has been used to determine wave action.

C.I.2.4.4 **<u>Potential Dam Failures</u>**

The applicant should describe how the hydrological site characteristics consider any potential hazard to the plant's safety-related facilities as a result of the seismically induced failure of upstream and downstream water control structures. It should also describe the worst combination failure (domino or simultaneous) that affects the site with respect to the maximum flood.

C.I.2.4.4.1 ***Dam Failure Permutations***

The applicant should discuss the locations of dams (upstream and downstream), potential modes of failure, and results of seismically induced dam failures that could cause the most critical conditions (floods or low water) with respect to the safety-related facilities for such an event (see Section C.I.2.4.3.4 of this guide). The applicant should also discuss how consideration was given to possible landslides, preseismic-event reservoir levels, and antecedent flood flows coincident with the flood peak (base flow). It should present the determination of the peak flow rate at the site for the worst dam failure (or combination of dam failures) reasonably possible, and should summarize all analyses to show that the presented condition is the worst permutation. Descriptions of all coefficients and methods used and their bases should be included. How consideration was given to the effects on plant safety of other potential concurrent events such as blockage of a stream and waterborne missiles should also be discussed.

C.I.2.4.4.2 ***Unsteady Flow Analysis of Potential Dam Failures***

In determining the effect of dam failures at the site (see Section C.I.2.4.4.1 of this guide), the applicant should describe how the analytical methods presented (1) are applicable to artificially large floods with appropriately acceptable coefficients and (2) consider flood waves through reservoirs downstream of failures. If applicable, a discussion of how the applicant considered domino-type failures resulting from flood waves should be provided. Estimates of coincident flow and other assumptions used to attenuate the dam-failure flood wave downstream should be discussed as should static and dynamic effects of the attenuated wave at the site.

C.I.2.4.4.3 ***Water Level at the Plant Site***

The applicant should describe the backwater, unsteady flow, or other computational method used to estimate the water elevation (see Section C.I.2.4.4.1 of this guide) for the most critical upstream dam failure(s), and discuss its verification and reliability. Wind and wave conditions that may occur simultaneously should be superimposed in a manner similar to that described in Section C.I.2.4.3.6 of this guide.

C.I.2.4.5 **<u>Probable Maximum Surge and Seiche Flooding</u>**

C.I.2.4.5.1 ***Probable Maximum Winds and Associated Meteorological Parameters***

The applicant should present the determination of probable maximum meteorological winds in detail. It should describe the analysis of actual historical storm events in the general region and the modifications and extrapolations of data made to reflect a more severe meteorological wind system than actually recorded, insofar as such are deemed "reasonably possible" to occur on the basis of meteorological reasoning. Where this has been done previously or on a generic basis (e.g., Atlantic and Gulf Coast probable maximum hurricane characteristics reported in NOAA Technical Report NWS 23, "Meteorological Criteria for Standard Project Hurricane and Probable Maximum Hurricane Windfields, Gulf and East Coasts of the United States," 1979), that work should be referenced with a brief description. Sufficient bases and information to ensure that the parameters presented represent the most severe combination should be provided.

C.I.2.4.5.2 ***Surge and Seiche Water Levels***

The applicant should provide historical data related to surges and seiches and discuss considerations of hurricanes, frontal (cyclonic) type windstorms, moving squall lines, and surge mechanisms that are possible and applicable to the site. The antecedent water level (the 10-percent exceedance high tide, including initial rise for coastal locations, or the 100-year recurrence interval high water for lakes), the determination of the controlling storm surge or seiche (with the parameters used in the analysis, such as storm track, wind fields, fetch or direction of wind approach, bottom effects, and verification of historic events), a detailed description of the methods and models used, and the results of the computation of the probable maximum surge hydrograph (graphical presentation) should br provided as should a detailed description of the (1) bottom profile and (2) shoreline protection and safety-related facilities.

C.I.2.4.5.3 ***Wave Action***

The applicant should discuss the wind-generated wave activity that can occur independently or coincidently with a surge or seiche. The should resent estimates of the wave period and the significant (average height of the maximum 33⅓ percent of all waves) and maximum (average height of the maximum 1 percent of all waves) wave heights and elevations with the coincident water level hydrograph. Specific data on the largest breaking wave height, setup, runup, and the effect of overtopping in relation to each safety-related facility should be presented and a discussion of the effects of the water levels on each affected safety-related facility and the protection to be provided against hydrostatic forces and dynamic effects of splash should be included.

C.I.2.4.5.4 ***Resonance***

The applicant should discuss the possibility of oscillations of waves at natural periodicity, such as lake reflection and harbor resonance phenomena, and any resulting effects at the site.

C.I.2.4.5.5 ***Protective Structures***

The applicant should discuss 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.

C.I.2.4.6 **<u>Probable Maximum Tsunami Hazards</u>**

For sites that may be subject to tsunami or tsunami-like waves, the applicant should discuss historical tsunami, either recorded or translated and inferred, that provide information for determining the probable maximum water levels and the geoseismic generating mechanisms available, with appropriate references to Section 2.5 of the FSAR.

C.I.2.4.6.1 ***Probable Maximum Tsunami***

The applicant should present the determination of the probable maximum tsunami, discussing consideration given to the most reasonably severe geoseismic activity possible (resulting from, for example, fractures, faults, landslides, or volcanism) in determining the limiting tsunami-producing mechanism. The geoseismic investigations used to identify potential tsunami sources and mechanisms and the resulting locations and mechanisms that could produce the controlling maximum tsunami at the site (from both local and distant generating mechanisms) should be summarized. The applicant should discuss the orientation of the site relative to the earthquake epicenter or generating mechanism, shape of the coastline, offshore land areas, hydrography, and stability of the coastal area (proneness of sliding) and how the applicant considered these factors in its analysis. Also hill-slope failure-generated tsunami-like waves on inland sites and the potential of an earthquake-induced tsunami on a large body of water, if relevant for the site should be discussed.

C.I.2.4.6.2 ***Historical Tsunami Record***

The applicant should provide local and regional historical tsunami information, including any relevant paleo-tsunami evidence.

C.I.2.4.6.3 ***Source Generator Characteristics***

The applicant should provide detailed geoseismic descriptions of the controlling local and distant tsunami generators, including location, source dimensions, fault orientation (if applicable), and maximum displacement.

C.I.2.4.6.4 ***Tsunami Analysis***

The applicant should provide a complete description of the analysis procedure used to calculate tsunami wave height and period at the site and of all models used in the analysis in detail, including the theoretical bases of the models, their verification, and the conservatism of all input parameters.

C.I.2.4.6.5 ***Tsunami Water Levels***

The applicant should provide estimates of maximum and minimum (low water) tsunami wave heights from both distant and local generators. It should describe the ambient water levels, including tides, sea level anomalies, and wind waves assumed to be coincident with the tsunami.

C.I.2.4.6.6 ***Hydrography and Harbor or Breakwater Influences on Tsunami***

The applicant should present the routing of the controlling tsunami, including breaking wave formation, bore formation, and any resonance effects (natural frequencies and successive wave effects) that result in the estimate of the maximum tsunami runup on each pertinent safety-related facility. A discussion of both the analysis used to translate tsunami waves from offshore generator locations (or in deep water) to the site, and antecedent conditions should be provided. Where possible, verification of the techniques and coefficients used by reconstituting the tsunami of record should be provided.

C.I.2.4.6.7 ***Effects on Safety-Related Facilities***

The applicant should discuss the effects of the controlling tsunami on safety-related facilities and the design criteria for measures to protect against and mitigate the effects of tsunami.

C.I.2.4.7 **<u>Ice Effects</u>**

The applicant should describe potential icing effects and design criteria for protecting safety-related facilities from the most severe ice sheets, ice jam flood, wind-driven ice ridges, or other ice-produced effects and forces that are reasonably possible and could affect safety-related facilities with respect to adjacent water bodies, such as streams or lakes, for both high and low water levels. The location and proximity of such facilities to the ice-generating mechanisms should be included and the regional ice and ice jam formation history with respect to water bodies should be described. The applicant should also describe the potential for formation of frazil and anchor ice at the site and should discuss the effects of ice-induced reduction in capacity of water storage facilities as they affect safety-related structures, systems, and components.

C.I.2.4.8 **<u>Cooling Water Canals and Reservoirs</u>**

The applicant should present the design bases for the capacity and operating plan for safety-related cooling water canals and reservoirs (see Section C.I.2.4.11 of this guide). If the source of water for the ultimate heat sink or other safety-related needs relies on cooling water canals or reservoirs and is dependent on a nearby stream, river, estuary, lake, or ocean, the availability of safety-related cooling water may be affected by low-water conditions caused by low streamflow and low water level resulting from draw-down caused by hurricanes, seiches, and tsunamis. It should discuss and provide bases for protecting the canals and reservoirs against wind waves, flow velocities (including allowance for freeboard), and blockage, and describe (where applicable) the facility's ability to withstand a related event, such as a probable maximum flood or surge.

It should discuss the emergency storage evacuation of reservoirs (low-level outlet and emergency spillway) and describe verified runoff models (e.g., unit hydrographs), flood routing, spillway design, and outlet protection.

C.I.2.4.9 Channel Diversions

The applicant should discuss the potential for upstream diversion or rerouting of the source of cooling water (resulting from, for example, channel migration, river cutoffs, ice jams, or subsidence) with respect to seismic, topographical, geologic, and thermal evidence in the region. The history of flow diversions and realignments in the region should be presented and their potential for adversely affecting safety-related facilities or water supply should be discussed. Available alternative safety-related cooling water sources in the event that diversions are possible should be discribed.

C.I.2.4.10 Flooding Protection Requirements

The applicant should describe the static and dynamic consequences of all types of flooding on each pertinent safety-related facility. It should present the design bases required to ensure that safety-related facilities will be capable of surviving all design flood conditions, and reference appropriate discussions in other sections of the FSAR where the design bases are implemented. The applicant should parious types of flood protection used and the emergency procedures to be implemented (where applicable) should be described. COL applicants may provide a reference to emergency procedures discussed in FSAR Section 13.5, as applicable.

C.I.2.4.11 Low Water Considerations

C.I.2.4.11.1 ***Low Flow in Rivers and Streams***

The applicant should estimate and provide 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, to perform adequately. Considerations of downstream dam failures (see Section C.I.2.4.4 of this guide) should be included. For nonsafety-related water supplies, the supply adequacy of during a 100-year drought should be demonstrated.

C.I.2.4.11.2 ***Low Water Resulting from Surges, Seiches, or Tsunami***

The applicant should determine the surge-, seiche-, or tsunami-caused low water level that could occur from probable maximum meteorological or geoseismic events, if such level could affect the ability of safety-related features to function adequately. A description of the probable maximum meteorological event (its track, associated parameters, and antecedent conditions) and the computed low water level or a description of the applicable tsunami conditions should be included. Where applicable, ice formation or ice jams causing low flow should be considered, since such conditions may affect the safety-related cooling water source.

C.I.2.4.11.3 ***Historical Low Water***

If statistical methods are used to extrapolate flows and/or levels to probable minimum conditions, historical low water flows and levels and their probabilities (unadjusted for historical controls and adjusted for both historical and future controls and uses) should be discussed.

C.I.2.4.11.4 ***Future Controls***

The applicant should provide 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. Any provisions for flow augmentation for plant use. Should be substantiated.

C.I.2.4.11.5 ***Plant Requirements***

The applicant should present 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. The capability of cooling water pumps to supply sufficient water during periods of low water resulting from a 100-year drought should be discussed. Sections 9.2.1, 9.2.5, and 10.4.5 of the FSAR may be referenced where applicable as many institutional restraints on water use.

C.I.2.4.11.6 ***Heat Sink Dependability Requirements***

The applicant should identify all sources of normal and emergency shutdown water supply and related retaining and conveyance systems.

The applicant should identify site characteristics used to compare minimum flow and level estimates with plant requirements, and describe any available low water safety factors (see Sections C.I.2.4.4 and C.I.2.4.6 of this guide). It should describe the design bases (or refer to Section 9.2.5 of the FSAR) for operation and normal or accidental shutdown and cooldown during the following three scenarios:

(1) most severe natural and site-related accident phenomena
(2) reasonable combinations of less severe phenomena
(3) single failures of manmade structural components

The applicant describe the design bases to protect all structures related to the ultimate heat sink during the above events and identify the sources of water and related retaining and conveyance systems that will be designed for each of the above bases or situations.

The applicant describe the facility's ability to provide sufficient warning of impending low flow or low water levels to allow switching to alternative sources where necessary. It should identify conservative estimates of heat dissipation capacity and water losses (such as drift, seepage, and evaporation) and indicate whether and how, if applicable, the guidance in Regulatory Guide 1.27 has been followed; if such guidance has not been followed, the specific alternative approaches used and suitable justification for their use should be provided.

The applicant should identify or refer to descriptions of any other uses of water drawn from the ultimate heat sink, such as fire water or system charging requirements. If interdependent water supply systems (such as an excavated reservoir within a cooling lake or tandem reservoirs) are used, the ability of the principal portion of the system to survive the failure of the secondary portion should be described. The bases for the measures to be taken (dredging or other maintenance) to prevent loss of reservoir capacity as a result of sedimentation should be described and their bases provided.

C.I.2.4.12 Ground Water

Provide all ground water data or cross-reference the ground water data provided in Section 2.5.4 of the FSAR.

C.I.2.4.12.1 *Description and Onsite Use*

The applicant should describe the regional and local ground water aquifers, formations, sources, and sinks, as well as the type of ground water use, wells, pumps, storage facilities, and flow requirements of the plant. If the plant will use ground water as a safety-related source of water, the design-basis protection from natural and accident phenomena should be comparted with Regulatory Guide 1.27 criteria. The applicant should indicate whether and how, if applicable, it followed the guidelines of Regulatory Guide 1.27 and if it did not, it should describe the specific alternative approaches used, including the bases and sources of data.

C.I.2.4.12.2 *Sources*

Describe the present and projected future regional water use. Tabulate existing users (amounts, water levels and elevations, locations, and drawdown). Tabulate or illustrate the history of ground water or piezometric level fluctuations beneath and in the vicinity of the site. Provide ground water or piezometric contour maps of aquifers beneath and in the vicinity of the site to indicate flow directions and gradients. Discuss the seasonal and long-term variations of these aquifers. Indicate the range of values and the method of determination for vertical and horizontal permeability and total and effective porosity (specific yield) for each relevant geologic formation beneath the site. Discuss the potential for reversibility of ground water flow resulting from local areas of pumping for both plant and nonplant use. Describe the effects of present and projected ground water use (wells) on gradients and ground water or piezometric levels beneath the site. Note any potential ground water recharge area, such as lakes or outcrops within the influence of the plant.

C.I.2.4.12.3 *Subsurface Pathways*

Provide a conservative analysis of critical ground water pathways for a liquid effluent release at the site. Evaluate (where applicable) the dispersion, ion-exchange, and dilution capability of the ground water environment with respect to present and projected users. Identify potential pathways of contamination to nearby ground water users and to water bodies such as springs, lakes, or streams. Determine ground water and radionuclide (if necessary) travel time to the nearest downgrading ground water user or surface body of water. Include all methods of calculation, data sources, models, and parameters or coefficients used, such as dispersion coefficients, dispersivity, distribution (adsorption) coefficients, hydraulic gradients, and values of permeability, total and effective porosity, and bulk density along contaminant pathways.

C.I.2.4.12.4 ***Monitoring or Safeguard Requirements***

Provide and discuss plans, procedures, safeguards, and monitoring programs to be used to protect present and projected ground water users.

C.I.2.4.12.5 ***Site Characteristics for Subsurface Hydrostatic Loading***

(1) For plants not employing permanent dewatering systems, describe the site characteristics, including the maximum operational ground water level, for ground-water-induced hydrostatic loadings on subsurface portions of safety-related structures, systems, and components. Discuss the development of these site characteristics. Where dewatering during construction is critical to the integrity of safety-related structures, describe the bases for subsurface hydrostatic loadings assumed during construction and the dewatering methods to be employed in achieving these loadings. Where wells are proposed for safety-related purposes, discuss the hydrodynamic design bases for protection against seismically induced pressure waves.

(2) For plants employing permanent dewatering systems—

(a) Provide a description of the proposed dewatering system, including drawings showing the proposed locations of affected structures, components, and features of the system. Provide information related to the hydrologic design of all system components. Where the dewatering system is important to safety, provide a discussion of its expected functional reliability, including comparisons of proposed systems and components with the performance of existing and comparable systems and components for applications under site conditions similar to those proposed.

(b) Provide estimates and their bases for soil and rock permeabilities, total porosity, effective porosity (specific yield), storage coefficient, and other related parameters used in the design of the dewatering system. If available, provide the results of monitoring pumping rates and flow patterns during dewatering for the construction excavation.

(c) Provide analyses and their bases for estimates of ground water flow rates in the various parts of the permanent dewatering system, the area of influence of drawdown, and the shapes of phreatic surfaces expected during operation of the system.

(d) Provide analyses, including their bases, to establish conservative estimates of the time available to mitigate the consequences of the system degradation that could cause ground water levels to exceed design bases. Document the measures the applicant will take to repair the system or to provide an alternative dewatering system that would become operational before the site-characteristic maximum ground water level is exceeded.

(e) Provide both the site-characteristic maximum and normal operation ground water levels for safety-related structures, systems, and components. Describe how the site-characteristic maximum ground water level reflects abnormal and rare events (such as an occurrence of the safe-shutdown earthquake (SSE), failure of a circulating water system pipe, or single failure within the system) that can cause failure or overloading of the permanent dewatering system.

(f) Postulate a single failure of a critical active feature or component during any design-basis event. Unless it can be documented that the potential consequences of the failure will not result in dose guidelines exceeding those in Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste Containing Components of Nuclear Power Plants," and Regulatory Guide 1.29, "Seismic Design Classification," either (1) document by pertinent analyses that ground water level recovery times are sufficient to allow other forms of dewatering to be implemented before the site-characteristic maximum ground water level is exceeded, discuss the measures to be implemented and equipment needed, and identify the amount of time required to accomplish each measure, or (2) show how all system components are designed for all severe phenomena and events.

(g) Where appropriate, document the bases that ensure the ability of the system to withstand various natural and accidental phenomena such as earthquakes, tornadoes, surges, floods, and a single failure of a component feature of the system (such as a failure of any cooling water pipe penetrating, or in close proximity to, the outside walls of safety-related buildings where the ground water level is controlled by the system). Provide an analysis of the consequences of pipe ruptures on the proposed underdrain system, including consideration of postulated breaks in the circulating system pipes at, in, or near the dewatering system building either independently of, or as a result of, the SSE.

(h) State the maximum ground water level the plant structures can tolerate under various significant loading conditions in the absence of the underdrain system.

(i) Provide a description of the proposed ground water level monitoring programs for dewatering during plant construction and for permanent dewatering during plant operation. Provide (1) the general arrangement in plans and profile with approximate elevation of piezometers and observation wells to be installed, (2) intended zone(s) of placement, (3) type(s) of piezometer (closed or open system), (4) screens and filter gradation descriptions, (5) drawings showing typical installations and limits of filter and seals, (6) observation schedules (initial and time intervals for subsequent readings), (7) plans for evaluation of recorded data, and (8) plans for alarm devices to ensure sufficient time for initiation of corrective action. Describe the implementation program, including milestones, for the construction and operational ground water level monitoring programs for dewatering.

(j) Provide information on the outlet flow monitoring program, including (1) the general location and type of flow measurement device(s) and (2) the observation plan and alarm procedure to identify unanticipated high or low flow in the system and the condition of the effluent. Describe the implementation program, including milestones, for the outlet flow monitoring program.

(k) Describe how information gathered during dewatering for construction excavation will be used to implement or substantiate assumed design bases.

(l) Provide a technical specification for periods when the dewatering system may be exposed to sources of water not considered in the design. An example of such a situation would be the excavation of surface seal material for repair of piping such that the underdrain would be exposed to direct surface runoff. In addition, where the permanent dewatering system is safety related, is not completely redundant, or is not designed for all design-basis events, provide the bases for a technical specification with action levels; the remedial work required and the estimated time that it will take to accomplish the work; the sources, types of equipment, and manpower required; and the availability of the above under potentially adverse conditions.

(m) Where wells are proposed for safety-related purposes, discuss the hydrodynamic design bases for protection against seismically induced pressure waves.

C.I.2.4.13 <u>Accidental Releases of Radioactove Liquid Effluent in Ground and Surface Waters</u>

Describe the ability of the ground and surface water environment to delay, disperse, dilute, or concentrate liquid effluents, as related to existing or potential future water users. Discuss the bases used to determine dilution factors, dispersion coefficients, flow velocities, travel times, adsorption, and pathways of liquid contaminants. Refer to the locations and users of surface waters listed in Section 2.4.1.2 of the FSAR, as well as the release points identified in Section 11.2.3 of the FSAR.

C.I.2.4.14 <u>Technical Specification and Emergency Operation Requirements</u>

Describe any emergency protective measures designed to minimize the impact of adverse hydrology-related events on safety-related facilities. Describe the manner in which the applicant will incorporate these requirements into appropriate technical specifications and emergency procedures. Discuss the need for any technical specifications for plant shutdown to minimize the consequences of an accident resulting from hydrologic phenomena such as floods or the degradation of the ultimate heat sink. If the applicant will use emergency procedures to meet safety requirements associated with hydrologic events, identify the event, provide appropriate water levels and lead times available, indicate what type of action would be taken, and discuss the time required to implement each procedure. Develop specific details on (1) controlling hydrological events, as determined in previous hydrology-related sections of the FSAR, to identify bases for emergency actions required during these events; (2) the amount of time available to initiate and complete emergency procedures before onset of conditions during the controlling hydrological events that may prevent such action; and (3) how technical specifications related to all emergency procedures required to ensure adequate plant safety from controlling hydrological events are reviewed by the organization responsible for the review of issues related to technical specifications.

C.I.2.5 *Geology, Seismology, and Geotechnical Engineering*

Provide sufficient information regarding the seismic and geologic characteristics of the site and the region surrounding the site to permit an adequate evaluation of the proposed site, to support evaluations performed to estimate the site-specific ground motion response spectrum (GMRS), and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site. Provide a summary that includes a synopsis of Sections 2.5.1 through 2.5.5 of the FSAR, including a brief description of the site, investigations performed, results of investigations, conclusions, and identification of who did the work.

C.I.2.5.1 <u>Basic Geologic and Seismic Information</u>

The following sections request basic geologic and seismic information to provide a basis for evaluation. In some cases, this information applies to more than one section. The information may appear under this section, under the following sections, or as appendices to this section, provided that the applicant supplies adequate cross-references in the appropriate sections.

Reference information obtained from published reports, maps, private communications, or other sources. Document information from surveys, geophysical investigations, borings, trenches, or other investigations by providing descriptions of techniques, graphic logs, photographs, laboratory results, identification of principal investigators, and other data necessary to assess the adequacy of the information.

C.I.2.5.1.1 ***Regional Geology***

Discuss all geologic, seismic, tectonic, nontectonic, and manmade hazards within the site region. Provide a review of the regional tectonics, with emphasis on the quaternary period, structural geology, seismology, paleoseismology, physiography, geomorphology, stratigraphy, and geologic history within a distance of 200 miles (320 km) from the site (site region). Discuss, document (by appropriate references), and illustrate such hazards as subsidence, cavernous or karst terrain, irregular weathering conditions, and landslide potential by presenting items such as a regional physiographic map, surface and subsurface geologic maps, isopach maps, regional gravity and magnetic maps, stratigraphic sections, tectonic and structure maps, fault maps, a site topographic map, a map showing areas of mineral and hydrocarbon extraction, boring logs, and aerial photographs. Include maps showing superimposed plot plans of the plant facilities.

Discuss the relationship between the regional and the site physiography. Include a regional physiographic map showing the site location. Identify and describe tectonic structures such as folds, faults, basins, and domes underlying the region surrounding the site, and include a discussion of their geologic history. Include a regional tectonic map showing the site location. Provide detailed discussions of the regional tectonic structures of significance to the site. Include detailed analyses of faults to determine their capacity for generating ground motions at the site and to determine the potential for surface faulting in Sections 2.5.2 and 2.5.3 of the FSAR, respectively.

Describe the lithologic, stratigraphic, and structural geologic conditions of the region surrounding the site and their relationship to the site region's geologic history. Provide geologic profiles showing the relationship of the regional and local geology to the site location. Indicate the geologic province within which the site is located and its relationship to other geologic provinces. Include regional geologic maps indicating the site location and showing both surface and bedrock geology.

C.I.2.5.1.2 ***Site Geology***

Provide a description of the site-related geologic features, seismic conditions, and conditions caused by human activities, at appropriate levels of detail within areas approximately defined by radii of 25 miles (40 km), 5 miles (8 km), and 0.6 miles (1 km) around the site. Section 2.5.4 of the FSAR may include cross-references to material on site geology included in this section.

Describe the site physiography and local land forms, and discuss the relationship between the regional and site physiography. Include a site topographic map showing the locations of the principal plant facilities. Describe the configuration of the land forms, and relate the history of geologic changes that have occurred. Evaluate areas that are significant to the site for actual or potential landsliding, surface or subsurface subsidence, uplift, or collapse resulting from natural features, such as tectonic depression and cavernous or karst terrains.

Describe significant historical earthquakes, as well as evidence (or lack of evidence) of paleoseismology. Also describe the local seismicity, including historical and instrumentally recorded earthquakes.

Describe the detailed lithologic and stratigraphic conditions of the site and the relationship to the regional stratigraphy. Describe the thicknesses, physical characteristics, origins, and degree of consolidation of each lithologic unit, including a local stratigraphic column. Furnish summary logs or borings and excavations, such as trenches used in the geologic evaluation. This section may reference boring logs included in Section 2.5.4 of the FSAR.

Provide a detailed discussion of the structural geology in the vicinity of the site. Include the relationship of site structures to regional tectonics, with particular attention to specific structural units of significance to the site, such as folds, faults, synclines, anticlines, domes, and basins. Provide a large-scale structural geology map of the site, showing bedrock surface contours and including the locations of seismic Category I structures. Furnish a large-scale geologic map of the region within 5 miles (8 km) of the site that shows surface geology and includes the locations of major structures of the nuclear power plant, including all seismic Category I structures.

Distinguish areas of bedrock outcrop from which geologic interpretation has been extrapolated from areas in which bedrock is not exposed at the surface. When the interpretation differs substantially from the published geologic literature on the area, note and document the differences for the new conclusions presented. Discuss the geologic history of the site, and relate it to the regional geologic history.

Include an evaluation from an engineering-geology standpoint of the local geologic features that affect the plant structures. Describe in detail the geologic conditions underlying all seismic Category I structures, dams, dikes, and pipelines. Describe the dynamic behavior of the site during prior earthquakes. Identify deformational zones such as shears, joints, fractures, and folds, or combinations of these features, and evaluate these zones relative to structural foundations. Describe and evaluate zones of alteration or irregular weathering profiles, zones of structural weakness, unrelieved residual stresses in bedrock, and all rocks or soils that might be unstable because of their mineralogy or unstable physical or chemical properties. Evaluate the effects of human activities in the area, such as withdrawal or addition of subsurface fluids or mineral extraction at the site.

Describe the site's ground water conditions. This section may reference information included in Section 2.4.13 of the FSAR.

C.I.2.5.2 <u>Vibratory Ground Motion</u>

Present the criteria and describe the methodology used to establish the GMRS.

C.I.2.5.2.1 *Seismicity*

Provide a complete list of all historically reported earthquakes that could have reasonably affected the region surrounding the site, including all earthquakes of modified Mercalli intensity greater than or equal to IV or of magnitude greater than or equal to 3.0 that have been reported within 200 miles (320 km) of the site. Also report large earthquakes outside of this area that would impact the GMRS. Present a regional-scale map showing all listed earthquake epicenters, supplemented by a larger-scale map showing earthquake epicenters within 50 miles (80 km) of the site. For each earthquake, provide information, whenever available, on the epicenter coordinates, depth of focus, date, origin time, highest intensity, magnitude, seismic moment, source mechanism, source dimensions, distance from the site, and any strong-motion recordings. Identify the sources of the information. Identify all magnitude designations such as m_b, M_L, M_s, or M_w. In addition, completely describe any earthquake-induced geologic failure such as liquefaction (including paleoseismic evidence of large prehistoric earthquakes), landsliding, land spreading, and lurching, including the estimated level of strong motion that induced failure and the physical properties of the materials.

C.I.2.5.2.2 ***Geologic and Tectonic Characteristics of the Site and Region***

Identify each seismic source, any part of which is within 200 miles (320 km) of the site. For each seismic source, describe the characteristics of the geologic structure, tectonic history, present and past stress regimes, seismicity, recurrence, and maximum magnitudes that distinguish the various seismic sources and the particular areas within those sources where historical earthquakes have occurred. Discuss any alternative regional tectonic models derived from the literature. Augment the discussion in this section of the FSAR with a regional-scale map showing the seismic sources, earthquake epicenters, locations of geologic structures, and other features that characterize the seismic sources. In addition, provide a table of seismic sources that contains maximum magnitudes, recurrence parameters, a range of source-to-site distances, alternative source models (including probability weighting factors), and any notable historical earthquakes or paleoseismic evidence of large prehistoric earthquakes.

C.I.2.5.2.3 ***Correlation of Earthquake Activity with Seismic Sources***

Provide a correlation or association between the earthquakes discussed in Section 2.5.2.1 of the FSAR and the seismic sources identified in Section 2.5.2.2 of the FSAR. Whenever an earthquake hypocenter or concentration of earthquake hypocenters can be reasonably correlated with geologic structures, provide the rationale for the association considering the characteristics of the geologic structure (including geologic and geophysical data, seismicity, and tectonic history) and regional tectonic model. Include a discussion of the method used to locate the earthquake hypocenters, an estimation of their accuracy, and a detailed account that compares and contrasts the geologic structure involved in the earthquake activity with other areas within the seismotectonic province.

C.I.2.5.2.4 ***Probabilistic Seismic Hazard Analysis and Controlling Earthquake***

Describe the probabilistic seismic hazard analysis (PSHA), including the underlying assumptions and methodology, and how they follow or differ from the guidance in NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," dated April 1, 1997. Describe how the results of the site investigations were used to update the seismic source characterizations in the PSHA or to develop additional seismic sources. Provide the rationale for any minimum magnitude or other ground motion parameters (such as cumulative absolute velocity) used in the PSHA. Describe the ground motion attenuation models used in the PSHA, including the rationale for including each model, consideration of uncertainty, model weighting, magnitude conversion, distance measure adjustments, and model parameters for each spectral frequency. Describe and show how logic trees for seismic source parameters (maximum magnitude, recurrence, source geometry) and attenuation models were used to incorporate model uncertainty.

Provide 16^{th}, median, mean, and 84^{th} fractile PSHA hazard curves for 1, 2.5, 5, 10, 25, and 100 Hertz (Hz) frequencies both before and after correcting for local site amplification. Show and explain the relative contributions of each of the main seismic sources to the median and mean hazard curves. Also show and explain the effects of other significant modeling assumptions (source or ground motion attenuation) on the mean and median hazard curves. In addition, provide both the 10^{-4} and 10^{-5} mean and median uniform hazard response spectra (UHRS) derived from the PSHA hazard curves.

If the applicant used the performance-based approach, as described in Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," it should provide the controlling earthquake magnitudes and distances for the mean 10^{-4}, 10^{-5}, and 10^{-6} hazard levels at spectral frequencies of 1 and 2.5 Hz (low frequency) and 5 and 10 Hz (high frequency). If the applicant used the reference probability approach, as described in Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake

Ground Motion," it should provide the controlling earthquake magnitudes and distances for the reference probability hazard level at spectral frequencies of 1, 2.5, 5, and 10 Hz. The applicant describe the methodology used and how it either follows or differs from the procedure outlined in Appendix C to Regulatory Guide 1.165 and provide bar graph plots of both the low- and high-frequency deaggregation results for each of the hazard levels and provide a table showing each of the low- and high-frequency controlling earthquakes.

Compare the controlling earthquake magnitudes and distances for the site with the historical earthquake record, any prehistoric earthquakes based on paleoseismic evidence, and the earthquake potential associated with each seismic source.

C.I.2.5.2.5 ***Seismic Wave Transmission Characteristics of the Site***

The application should include a description of the site response analyses, including the method used to represent the uncertainty and variability across the site, and a presentation of the following material properties for each stratum under the site:

- thickness
- seismic compressional and shear velocities
- bulk densities
- soil index properties and classification
- shear modulus and damping variations with strain level
- water table elevation and its variations

Describe the methods used to determine these properties, including the variability in each of these properties and the methods used to model the variability. Provide the shear modulus and damping relationships, including a comparison between the test results performed on site borings and the modulus and damping curves. Describe the site material properties to the depth that corresponds to the hard rock conditions assumed by the ground motion attenuation models used in the PSHA. In addition, provide the rationale for any assumed nonlinear rock behavior.

Provide the response spectra for each of the controlling earthquakes after scaling the spectra to the appropriate low- or high-frequency spectral acceleration value. Describe the method used, if necessary, to extend the response spectra beyond the range of frequencies defined for the ground motion attenuation models. Provide a description of the method used to develop the time histories for the site response analysis, including the time history database. Provide figures showing the initial time histories and final time histories for which the response spectra have been scaled to the target earthquake response spectra.

Describe the method used to compute the site amplification function for each controlling earthquake. Describe the computer program used to compute the site amplification functions. In addition, provide a figure showing the final site transfer function and a table of the results for frequencies ranging from 0.1 to 100 Hz.

C.I.2.5.2.6 ***Ground Motion Response Spectrum***

Describe the methodology used to determine both the horizontal and vertical GMRS. If the applicant used the performance-based approach, as described in Regulatory Guide 1.208, provide a table with the mean 10^{-4}, 10^{-5} UHRS values, design factors, and horizontal GMRS. If the applicant used the reference-probability approach, as described in Regulatory Guide 1.165, provide figures showing how the horizontal GMRS envelopes the low- and high-frequency controlling earthquake response spectra.

Provide the GMRS ground motion spectrum at a sufficient number of frequencies (at least 25) such that it adequately represents the local and regional seismic hazards. Provide the vertical to horizontal (V/H) response spectral ratios used to determine the vertical GMRS from the horizontal GMRS.

Provide plots of both the horizontal and vertical GMRS. In addition, provide a table with the horizontal GMRS, V/H ratios, and vertical GMRS.

C.I.2.5.3 <u>Surface Faulting</u>

Provide information describing whether a potential for surface deformation exists that could affect the site. Describe the detailed surface and subsurface geological, seismological, and geophysical investigations performed around the site to compile this information.

C.I.2.5.3.1 *Geological, Seismological, and Geophysical Investigations*

Provide a description of the quaternary tectonics, structural geology, stratigraphy, geochronological methods used, paleoseismology, and geological history for the site. Describe the lithologic, stratigraphic, and structural geologic conditions of the site and the area surrounding the site, including its geologic history. Include site and regional maps and profiles constructed at scales adequate to clearly illustrate the surficial and bedrock geology, structural geology, topography, and the relationship of the safety-related foundations of the nuclear power plant to these features.

C.I.2.5.3.2 *Geological Evidence, or Absence of Evidence, for Surface Deformation*

Provide sufficient surface and subsurface information, supported by detailed investigations, to either confirm the absence of surface tectonic deformation (i.e., faulting) or, if surface deformation is present, demonstrate the age of its most recent displacement and ages of previous displacements. If tectonic deformation is present in the site vicinity, define the geometry, amount and sense of displacement, recurrence rate, and age of latest movement. In addition to geologic evidence that may indicate faulting, document linear features interpreted from topographic maps, low- and high-altitude aerial photographs, satellite imagery, and other imagery.

C.I.2.5.3.3 *Correlation of Earthquakes with Capable Tectonic Sources*

Provide an evaluation of all historically reported earthquakes within 25 miles (40 km) of the site with respect to hypocenter accuracy and source origin. Provide an evaluation of the potential for causing surface deformation for all capable tectonic sources that could, based on their orientations, extend to within 5 miles (8 km) of the site. Provide a plot of earthquake epicenters superimposed on a map showing the local capable tectonic structures.

C.I.2.5.3.4 *Ages of Most Recent Deformations*

Present the results of the investigation of identified faults or folds associated with blind faults, any part of which is within 5 miles (8 km) of the site. Provide estimates of the age of the most recent movement, and identify geological evidence for previous displacements, if such evidence exists. Describe the geological and geophysical techniques used, and provide an evaluation of the sensitivity and resolution of the exploratory techniques used for each investigation.

C.I.2.5.3.5 *Relationship of Tectonic Structures in the Site Area to Regional Tectonic Structures*

Discuss the structure and generic relationship between site area faulting or other tectonic deformation and the regional tectonic framework. For regions with active tectonics, discuss any detailed geologic and geophysical investigations conducted to demonstrate the structural relationships of site area faults with regional faults known to be seismically active.

C.I.2.5.3.6 ***Characterization of Capable Tectonic Sources***

For all potential capable tectonic sources such as faults, or folds associated with blind faults, within 5 miles (8 km) of the site, provide the geometry, length, sense of movement, amount of total offset, amount of offset per event, age of latest and any previous displacements, recurrence, and limits of the fault zone.

C.I.2.5.3.7 ***Designation of Zones of Quaternary Deformation in the Site Region***

Demonstrate that the zone requiring detailed faulting investigation is of sufficient length and breadth to include all quaternary deformation significant to the site.

C.I.2.5.3.8 ***Potential for Surface Tectonic Deformation at the Site***

Where the site is located within a zone requiring detailed faulting investigation, provide the details and results of investigations substantiating that no geologic hazards exist that could affect the safety-related facilities of the plant. The information may be in the form of boring logs, detailed geologic maps, geophysical data, maps and logs of trenches, remote sensing data, and seismic refraction and reflection data.

C.I.2.5.4 **<u>Stability of Subsurface Materials and Foundations</u>**

Present information concerning the properties and stability of all soils and rock that may affect the nuclear power plant facilities, under both static and dynamic conditions, including the vibratory ground motions associated with the GMRS. Demonstrate the stability of these materials as they influence the safety of seismic Category I facilities. Present an evaluation of the site conditions and geologic features that may affect nuclear power plant structures or their foundations. This section should cross-reference, rather than duplicate, any information presented in other chapters of the FSAR.

C.I.2.5.4.1 ***Geologic Features***

Describe geologic features, including the following information:

(1) areas of actual or potential surface or subsurface subsidence, solution activity, uplift, or collapse and the causes of these conditions

(2) zones of alteration or irregular weathering profiles and zones of structural weakness

(3) unrelieved residual stresses in bedrock and their potential for creep and rebound effects

(4) rocks or soils that might be unstable because of their mineralogy, lack of consolidation, water content, or potentially undesirable response to seismic or other events

(5) history of deposition and erosion, including glacial and other preloading influence on soil deposits

(6) estimates of consolidation and preconsolidation pressures and methods used to estimate these values

Provide descriptions, maps, and profiles of the site stratigraphy, lithology, structural geology, geologic history, and engineering geology.

C.I.2.5.4.2 ***Properties of Subsurface Materials***

Describe in detail the properties of underlying materials, including the static and dynamic engineering properties of all soils and rocks in the site area. Discuss the type, quantity, extent, and purpose of all site explorations. Describe the testing techniques used to determine the classification and engineering properties of soils and rocks. Indicate the extent to which the procedures used in field investigations to determine the engineering properties of soil and rock materials conform to Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." Likewise, indicate the extent to which the procedures used in laboratory investigations of soils and rocks conform to Regulatory Guide 1.138, "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants."

Provide summary tables and plots that show the important test results. In addition, provide a detailed discussion of laboratory sample preparation when applicable. For critical laboratory tests, provide a complete description (e.g., how saturation of the sample was determined and maintained during testing and how the pore pressures changed).

Provide a detailed and quantitative discussion of the criteria used to determine that the samples were properly taken and tested in sufficient manner to define all critical soil parameters for the site. For sites underlain by saturated soils and sensitive clays, show that all zones that could become unstable as a result of liquefaction of strain-softening phenomena have been adequately sampled and tested. Describe the relative density of soils at the site. Show that the consolidation behavior of the soils, as well as their static and dynamic strength, have been adequately defined. Explain how the developed data are used in the safety analysis, how the test data are enveloped by the design, and why the design envelope is conservative. Present values of the parameters used in the analyses.

C.I.2.5.4.3 ***Foundation Interfaces***

Provide plot plans that graphically show the location of all site explorations, such as borings, trenches, seismic lines, piezometers, geologic profiles, and excavations, with the locations of the safety-related facilities superimposed thereon. Also provide profiles illustrating the detailed relationship of the foundations of all seismic Category I and other safety-related facilities to the subsurface materials.

Provide logs of all core borings and test pits. Furnish logs and maps of exploratory trenches and geologic maps and photographs of the excavations for the facilities of the nuclear power plant.

C.I.2.5.4.4 ***Geophysical Surveys***

Provide a description of the geophysical investigations performed at the site to determine the dynamic characteristics of the soil or rock and geophysical features of the site. Provide the results of compressional and shear wave velocity surveys performed to evaluate the occurrence and characteristics of the foundation soils and rocks in tables and profiles. Discuss other geophysical methods used to determine foundation conditions.

C.I.2.5.4.5 ***Excavations and Backfill***

Discuss the following data concerning excavation, backfill, and earthwork analyses at the site:

(1) sources and quantities of backfill and borrow, including a description of exploration and laboratory studies and the static and dynamic engineering properties of these materials in the same fashion detailed in Sections C.I.2.5.4.2 and C.I.2.5.4.3 of this guide

(2) extent (horizontally and vertically) of all seismic Category I excavations, fills, and slopes, including the locations and limits of excavations, fills, and backfills on plot plans and geologic sections and profiles

(3) compaction specifications and embankment and foundation designs

(4) dewatering and excavation methods and control of ground water during excavation to preclude degradation of foundation materials, including a discussion of proposed quality control and quality assurance programs related to foundation excavation, and subsequent protection and treatment, and measures to monitor foundation rebound and heave

C.I.2.5.4.6 ***Ground Water Conditions***

Discuss ground water conditions at the site, including the following information:

(1) ground water conditions relative to the foundation stability of the safety-related nuclear power plant facilities

(2) plans for dewatering during construction

(3) plans for analysis and interpretation of seepage and potential piping conditions during construction

(4) records of field and laboratory permeability tests

(5) history of ground water fluctuations, as determined by periodic monitoring of local wells and piezometers, including flood conditions

If the applicant has not completed the analysis of ground water at the site as discussed in this chapter at the time the applicant files a COL application, describe the implementation program, including milestones.

C.I.2.5.4.7 ***Response of Soil and Rock to Dynamic Loading***

Describe the response of soil and rock to dynamic loading, including the following information:

(1) any investigations to determine the effects of prior earthquakes on the soils and rocks in the vicinity of the site, including evidence of liquefaction and sand cone formation

(2) compressional and shear (P and S) wave velocity profiles, as determined from field seismic surveys (surface refraction and reflection and in-hole and cross-hole seismic explorations), including data and interpretation of the data

(3) results of dynamic tests in the laboratory on samples of the soil and rock

Section 2.5.2.5 of the FSAR may cross-reference material concerning site geology included in this chapter.

C.I.2.5.4.8 ***Liquefaction Potential***

If the foundation materials at the site adjacent to and under safety-related structures are saturated soils or soils that have a potential to become saturated and the water table is above bedrock, provide an appropriate state-of-the-art analysis of the potential for liquefaction occurring at the site. Indicate the extent to which the guidance provided in Regulatory Guide 1.198, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites," was followed.

C.I.2.5.4.9 ***Earthquake Site Characteristics***

Provide a brief summary of the derivation of the SSE ground motion, including a reference to Section 2.5.2.6 of the FSAR.

C.I.2.5.4.10 ***Static Stability***

Describe an analysis of the stability of all safety-related facilities for static loading conditions. Describe the analysis of foundation rebound, settlement, differential settlement, and bearing capacity under the dead loads of fills and plant facilities. Include a discussion and evaluation of lateral earth pressures and hydrostatic ground water loads acting on plant facilities. Discuss field and laboratory test results. Discuss and justify the design parameters used in stability analyses. Provide sufficient data and analyses so that the staff may make an independent interpretation and evaluation.

C.I.2.5.4.11 ***Design Criteria***

Provide a brief discussion of the design criteria and methods of design used in the stability studies of all safety-related facilities and how they compare to the geologic and seismic site characteristics. Identify required and computed factors of safety, assumptions, and conservatisms in each analysis. Provide references. Explain and verify computer analyses used.

C.I.2.5.4.12 ***Techniques To Improve Subsurface Conditions***

Discuss and provide specifications for measures to improve foundations, such as grouting, vibroflotation, dental work, rock bolting, and anchors. Discuss a verification program designed to permit a thorough evaluation of the effectiveness of foundation improvement measures. If the applicant has not completed the foundation improvement verification program discussed in this section at the time the applicant files a COL application, describe the implementation program, including milestones.

C.I.2.5.5 **<u>Stability of Slopes</u>**

Present information concerning the static and dynamic stability of all natural and manmade earth or rock slopes (such as cuts, fills, embankments, and dams) for which failure, under any of the conditions to which they could be exposed during the life of the plant, could adversely affect the safety of the nuclear power plant facilities. Include a thorough evaluation of site conditions, geologic features, and the engineering properties of the materials comprising the slope and its foundation. Present the results of slope stability evaluations using classic and contemporary methods of analyses. Include, whenever possible, comparative field performance of similar slopes. All information related to defining site conditions, geologic features, engineering properties of materials, and design criteria should be of the same scope as that discussed in Section 2.5.4 of this guide. The applicant may use cross-references where appropriate. For the stability evaluation of manmade slopes, include summary data and a discussion of construction procedures, record testing, and instrumentation monitoring to ensure high-quality earthwork.

C.I.2.5.5.1 *Slope Characteristics*

Describe and illustrate slopes and related site features in detail. Provide a plan showing the limits of cuts, fills, or natural undisturbed slopes, and show their relation and orientation relative to plant facilities. Clearly identify benches, retaining walls, bulkheads, jetties, and slope protection. Provide detailed cross-sections and profiles of all slopes and their foundations. Discuss exploration programs and local geologic features. Describe the ground water and seepage conditions that exist and those assumed for analysis purposes. Describe the type, quantity, extent, and purpose of exploration, and show the locations of borings, test pits, and trenches on all drawings.

Discuss the sampling methods used. Identify material types and the static and dynamic engineering properties of the soil and rock materials comprising the slopes and their foundations. Identify the presence of any weak zones, such as seams or lenses of clay, mylonites, or potentially liquefiable materials. Discuss and present results of the field and laboratory testing programs, and justify selected design strengths.

C.I.2.5.5.2 *Design Criteria and Analyses*

Describe the criteria for the stability and design of all safety-related and seismic Category I slopes. Present valid static and dynamic analyses to demonstrate the reliable performance of these slopes throughout the lifetime of the plant. Describe the methods used for static and dynamic analyses, and indicate the reasons for selecting them. Indicate assumptions and design cases analyzed with computed factors of safety. Present the results of stability analyses in tables identifying design cases analyzed, strength assumptions for materials, forces acting on the slope and pore pressures acting within the slope, and the type of failure surface. For assumed failure surfaces, show them graphically on cross-sections, and appropriately identify them in both the tables and sections. In addition, describe adverse conditions, such as high water levels attributable to the PMF, sudden drawdown, or steady seepage at various levels. Explain and justify computer analyses, and provide an abstract of computer programs used.

Where liquefaction is possible, present the results of the analysis of major dam foundation slopes and embankments by state-of-the-art finite-element or finite-difference methods of analysis. Where there are liquefiable soils, indicate whether changes in pore pressure attributable to cyclic loading were considered in the analysis to assess the potential for liquefaction, as well as the effect of pore pressure increase on the stress-strain characteristic of the soil and the postearthquake stability of the slopes.

C.I.2.5.5.3 *Logs of Borings*

Present the logs of borings, test pits, and trenches that were completed for the evaluation of slopes, foundations, and borrow materials to be used for slopes. Logs should indicate elevations, depths, soil and rock classification information, ground water levels, exploration and sampling method, recovery, rock quality designation, and blow counts from standard penetration tests. Discuss drilling and sampling procedures, and indicate on the logs where samples were taken.

C.I.2.5.5.4 ***Compacted Fill***

Provide a description of the excavation, backfill, and borrow material planned for any dams, dikes, and embankment slopes. Describe planned construction procedures and control of earthworks. This information should be similar to that outlined in Section C.I.2.5.4.5 of this guide. Discuss the quality control techniques and documentation during and following construction, and reference the applicable quality assurance sections of the FSAR.