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 is to indicate how these site characteristics have influenced plant design and operating criteria and to show the adequacy of the site characteristics from a safety viewpoint.

Identify the applicable regulatory requirements and discuss how these requirements are met for the site characteristics specified below. Identify the regulatory guidance followed and explain and justify any deviations from this guidance. Provide justification for any alternative methods that are used. 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 <u>Site Location and Description</u>

C.I.2.1.1.1 *Specification of Location*

The location of each reactor at the site should be specified 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 United States Geological Survey (USGS)] to the nearest 100 meters (328 feet). The USGS map index should be consulted 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 man-made 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 the site area of suitable scale (with explanatory text as necessary). This map should clearly show the following attributes:

(1) Plant property lines. The area of the plant property (in acres) should be stated.

(2) Location of the site boundary. If the site boundary lines are the same as the plant property lines, this should be stated.

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

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

(5) Scaled plot plan of the exclusion area [as defined in Title 10, Section 100.3, 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.

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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.

(7) True North.

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

(9) Prominent natural and man-made features in the site area.

C.I.2.1.1.3 ***Boundaries for Establishing Effluent Release Limits***

The site description should define the boundary lines of the restricted area (as defined in 10 CFR 20.1003), and should describe how access to this area is controlled for radiation protection purposes, including how the applicant will be made aware of individuals entering the area and will control such access.

If the applicant proposes to set limits higher than those established by 10 CFR 20.1301 [and related to "as low as reasonably achievable" (ALARA) provisions], this section should also include the information specified in Appendix I 10 CFR Part 50. The site map discussed above may be used to identify this area, or a separate map of the site may be used. Indicate the location of the boundary line with respect to the water's edge of nearby rivers and lakes. Distances from plant effluent release points to the boundary line should be clearly defined.

C.I.2.1.2 **<u>Exclusion Area Authority and Control</u>**

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. The status of mineral rights and easements within this area should also be addressed.

If the applicant has not obtained ownership of all land within the exclusion area, those parcels of land not owned within the area should be clearly described by means of a scaled map of the exclusion area, and the status of proceedings to obtain ownership or the required authority over the land for the life of the plant should be specifically described. Minimum distance to and direction of exclusion area boundaries should be given 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***

Any activities unrelated to plant operation which are to be permitted within the exclusion area (aside from transit through the area) should be described 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. Describe the limitations to be imposed on such activities and the procedure to be followed to ensure 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 the exclusion area is traversed by a highway, railroad, or waterway, 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 there are any public roads traversing the proposed exclusion area which, because of their location, will have to be abandoned or relocated, specific information should be provided regarding authority possessed under State laws to effect abandonment; the procedures that must be followed to achieve abandonment; the identity of the public authorities who will make the final determination; and the status of the proceedings completed to date to obtain abandonment. If a public hearing is required prior to abandonment, the type of hearing (e.g., legislative or adjudicatory) should be specified. If the public road will be relocated rather than abandoned, specific information as described above should be provided with regard to the relocation and the status of obtaining any lands required for relocation.

C.I.2.1.3 Population Distribution

Population data presented should be based on the latest census data. The following sections discuss the information that should be presented 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 km), concentric circles should be drawn, 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 22 ½ -degree segments, with each segment 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 residential population within each area of the map formed by the concentric circles and radial lines. The same table, or separate tables, should be used 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 basis for population projections should be described. The applicant should 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*

A map of suitable scale and appropriately keyed tables should be used in the same manner discussed above 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*

Seasonal and daily variations in population and population distribution resulting from land uses (such as recreational or industrial) should be generally described and appropriately keyed to the areas and population numbers contained on the maps and tables in Sections 2.1.3.1 and 2.1.3.2. If the plant is located in an area where significant population variations attributable to transient land use are expected, additional tables of population distribution should be provided 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***

The low population zone (LPZ, as defined in 10 CFR Part 100) should be specified and determined in accordance with the guidance provided in Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations," Revision 2, dated April 1998. A scaled map of the zone should be provided 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. Facilities and institutions beyond the LPZ which, because of their nature, may require special consideration when evaluating emergency plans, should be identified out to a distance of 5 miles (8.05 km). 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 nearest population center (as defined in 10 CFR Part 100) should be identified and its population, direction, and distance from the reactor specified. 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 bases for the selected boundary should also be provided. Indicate the extent to which the transient population has been considered in establishing the population center. In addition to specifying the distance to the nearest boundary of a population center, 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***

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 five years thereafter. 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 does not exceed 500 persons/mile^2 (200 persons/km^2). Demonstrate that the population density is in accordance with the guidance in Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations."

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

The purpose of this section is to establish 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 to establish the design parameters related to the accidents so selected.

Identify the applicable regulatory requirements and discuss how these requirements are met for the site characteristics specified below. Identify the regulatory guidance followed and explain and justify any deviations from this guidance. Provide justification for any alternative methods that are used. 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.2.2.1 Locations and Routes

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, airports); oil and gas pipelines, drilling operations, and wells; and underground gas storage facilities. Show any other facilities that, because of the products manufactured, stored, or transported, may warrant consideration with respect to possible adverse effects on the plant. Typically, adverse effects may be produced by toxic, flammable, and explosive substances. Examples include chlorine, ammonia, compressed or liquid hydrogen, liquid oxygen, and propane. Also, show 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 easy location of the facilities and routes in relation to the nuclear plant. All symbols and notations used to depict the locations of facilities and routes should be identified in legends or tables. Topographic features should be included on the maps 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 Section C.I.2.2.1 should include the information indicated in the following sections.

C.I.2.2.2.1 *Description of Facilities*

A concise description of each facility, including its primary function and major products, as well as the number of persons employed, should be provided in tabular form.

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

A description of the products and materials regularly manufactured, stored, used, or transported in the vicinity of the nuclear plant or onsite should be provided. Emphasis should be placed on the identification and description of any hazardous materials. Statistical data should be provided 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. The applicable toxicity limits

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[2]All facilities and activities within 5 miles (8.05 km) of the nuclear plant should be considered. Facilities and activities at greater distances should be included as appropriate to their significance.

should also be provided for each hazardous material.

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

For pipelines, indicate the pipe size, age, operating pressure, depth of burial, location and type of isolation valves, and type of gas or liquid presently carried. 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 product other than the one presently being carried (e.g., propane instead of natural gas).

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

If the site is located adjacent to a navigable waterway, 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 type of ships and barges using the waterway, and any nearby docks and anchorages.

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

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***

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, provide information regarding 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. Plans for future utilization of the airport, including possible construction of new runways, increased traffic, or utilization by larger aircraft, should also be provided. In addition, provide statistics on aircraft accidents[3] for the following:

(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]

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

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

[3]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 should be provided in Section 3.5 of the FSAR.

[4]"d" is the distance in miles from the site.

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

For each of the above categories, 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**

On the basis of the information provided in Sections 2.2.1 and 2.2.2, determine 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 parameter (e.g., over pressure, missile energies) or physical phenomena (e.g., concentration of flammable or toxic cloud outside building structures).

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. Determination of the probability of occurrence of potential accidents should be 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 accident should be considered a design-basis event, and a detailed analysis of its effects on the plant's safety-related structures and components should be provided. Because of the difficulty of assigning accurate numerical values to the expected rate of low-frequency hazards considered in this guide, judgement 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. The following accident categories should be considered in selecting design-basis events:

(1) Explosions. Accidents involving detonations of high explosives, munitions, chemicals, or liquid and gaseous fuels should be considered for facilities and activities in the vicinity of the plant or onsite, where such materials are processed, stored, used, or transported in quantity. Attention should be given to potential accidental explosions that could produce a blast over pressure on the order of one pound force per square inch (1 psi) or greater at the nuclear plant, using recognized quantity-distance relationships.[5] Missiles generated by the explosion should also be considered, and an analysis should be provided 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). Accidental releases of flammable liquids or vapors that result in formation of unconfined vapor clouds should be considered. Assuming that no immediate explosion occurs, the extent of the cloud and the concentrations of gas that could reach the plant under "worst-case" meteorological conditions should be determined. An

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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," for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

evaluation of the effects on the plant of explosion and deflagration of the vapor cloud should be provided. An analysis of the missiles generated by the explosion should be provided in Section 3.5 of the FSAR.

(3) Toxic Chemicals. Accidents involving the release of toxic chemicals (e.g., chlorine) from onsite storage facilities and nearby mobile and stationary sources should be considered. If toxic chemicals are known or projected to be present onsite or in the vicinity of a nuclear plant, or to be frequently transported in the vicinity of the plant, releases of those chemicals should be evaluated. For each postulated event, a range of concentrations at the site should be determined for a spectrum of meteorological conditions. These toxic chemical concentrations should be used in evaluating control room habitability in Section 6.4 of the FSAR.

(4) Fires. 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 should be considered. 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 should be evaluated as events that could lead to high heat fluxes or to the formation of such clouds. A spectrum of meteorological conditions should be included in the dispersal analysis when determining the concentrations of nonflammable material that could reach the site. These concentrations should be used 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. This analysis should be used in Section 9.2.5 of the FSAR to determine whether an additional source of cooling water is required.

(6) Liquid Spills. The accidental release of oil or liquids that may be corrosive, cryogenic, or coagulant should be considered to determine if the potential exists 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*

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 reinforcing of plant structures, as well as the provisions made to lessen the likelihood and severity of the accidents themselves.

C.I.2.3 *Meteorology*

This section should provide a meteorological description of the site and its surrounding areas. Sufficient data should be included to permit an independent evaluation by the staff.

C.I.2.3.1 <u>Regional Climatology</u>

C.I.2.3.1.1 *General Climate*

The general climate of the region should be described 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. Identify the state climatic division of the site. 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*

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. Provide the probable maximum annual frequency of occurrence and time duration of freezing rain (ice storms) and dust (sand) storms where applicable. Describe the site's air quality, including identifying the site's Interstate Air Quality Control Region and its attainment designation with respect to state and national air quality standards.

Identify all the 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. Include references to FSAR in which these conditions are used.

(1) 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) Provide the meteorological data used to evaluate the performance of the ultimate heat sink with respect to (1) maximum evaporation and drift loss, (2) minimum water cooling, and (3) 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"). The period of record examined should be identified, and the bases and procedures used to select of the critical meteorological data should be provided and justified.

(3) Provide site characteristic tornado parameters, including translational speed, rotational speed, and maximum pressure differential with its associated time interval. Guidance on appropriate site characteristic tornado parameters is presented in Regulatory Guide 1.76, "Design-Basis Tornado for Nuclear Power Plants." Identify and justify any deviations from guidance provided in Regulatory Guide 1.76.

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

(5) Provide ambient temperature and humidity statistics (e.g., 0.4 percent, 2 percent, 99 percent and 99.6 percent annual exceedance dry-bulb temperatures; 0.4 percent annual exceedance wet-bulb temperature; 100-year return period maximum dry-bulb and wet-bulb temperatures; 100-year return period 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*

Provide monthly and annual summaries [based on both long-term data from nearby reasonably representative locations (e.g., within 80 km (50 miles)) 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, "Onsite Meteorological Programs," 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 dewpoint temperature summaries, including averages, measured extremes, and diurnal range.

(3) Monthly and annual extremes of atmospheric water vapor (e.g., relative humidity) including averages, measured extremes, and diurnal range.

(4) Monthly and annual summaries of precipitation, including averages and measured extremes, number of hours with precipitation, rainfall rate distribution, (i.e., maximum 1-hr, 2-hr, … 24-hr) and monthly precipitation wind roses with precipitation rate classes.

(5) Monthly and annual summaries of fog (and smog), including expected values and extremes of frequency and duration.

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

(7) Monthly mixing height data, including frequency and duration (persistence) of inversion conditions.

(8) Annual joint frequency distributions of wind speed and wind direction by atmospheric stability for all measurement levels.

This information should be fully documented and substantiated as to the validity of its representation of conditions at and near the site. For example, deviations from regional to local meteorological conditions caused by local topography, nearby bodies of water, or other unique site characteristics should be identified. References should be provided to the National Oceanic and Atmospheric Administration (NOAA), National Weather Service, station summaries from nearby locations and to 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*

Discuss and provide an evaluation of the potential modification of the normal and extreme values of meteorological parameters described in Section C.I.2.3.2.1 of the FSAR as a result of the presence and operation of the plant (e.g., the influence of cooling towers or water impoundment features on meteorological conditions). Provide a map showing the detailed topographic features (as modified by the plant) within a 5-mile (8 km) radius of the plant. Also 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 sixteen 22½ -degree compass point sectors (centered on true North, North-Northeast, Northeast, etc.) 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*

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. References should be included to FSAR sections in which these conditions are used.

C.I.2.3.3 Onsite Meteorological Measurements Program

The pre-operational and operational programs for meteorological measurements at the site, including offsite satellite facilities, should be described. This description should include a site map showing tower location with respect to man-made structures, topographic features, and other features that may influence site meteorological measurements. Indicate distances to nearby obstructions to flow in each downwind sectors. In addition, describe 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. Additional sources of meteorological data for consideration in the description of airflow trajectories from the site to a distance of 50 miles (80 km) should be similarly described in as much detail as possible, 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, university and private meteorological programs). Guidance on acceptable onsite meteorological programs is presented in Regulatory Guide 1.23. Identify and justify any deviations from the guidance provided in Regulatory Guide 1.23.

In a supplemental submittal to the application, 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 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.

At least two consecutive annual cycles (and preferably three or more entire years), including the most recent 1-year period, should be provided at docketing.

Evidence should be provided to show how well these data represent long-term conditions at the site.

C.I.2.3.4 Short-Term Atmospheric Dispersion Estimates for Accident Releases

C.I.2.3.4.1 *Objective*

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. 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, smoke from fires).

C.I.2.3.4.2 ***Calculations***

Dispersion estimates should be based on the most representative (preferably onsite) meteorological data. Evidence should be provided to show how well these dispersion estimates represent conditions that would be estimated from anticipated long-term conditions at the site. The effects of topography and nearby bodies of water on short-term dispersion estimates should be discussed. Enough information should be provided to allow the staff to perform its own confirmatory calculations.

(1) Postulated Accidental Radioactive Releases

(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). The χ/Q values from each of these distributions that are exceeded 5 percent of the time should be reported. 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. Guidance on appropriate diffusion models for estimating offsite χ/Q values is presented in Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." Identify and justify any deviations from the guidance provided in Regulatory Guide 1.145.

(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. A site plan showing true North and indicating locations of all potential accident release pathways and control room intake and unfiltered in-leakage pathways should be provided. Guidance on appropriate dispersion models for estimating control room χ/Q values is presented in Regulatory Guide 1.194, "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants." Identify and justify any deviations from the guidance provided in Regulatory Guide 1.194.

(2) 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. Justify the appropriateness of the use of the models with regard to release characteristics, plant configuration, plume density, meteorological conditions, and site topography. Guidance on hazardous chemical atmospheric dispersion modeling is provided in Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release." Identify and justify any deviations from the guidance provided in Regulatory Guide 1.78.

C.I.2.3.5 **<u>Long-Term Atmospheric Dispersion Estimates for Routine Releases</u>**

C.I.2.3.5.1 ***Objective***

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*

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

For each venting release point, 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 Section 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. 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 should also be provided.

Evidence should be provided to show how well these estimates represent conditions that would be estimated from climatologically representative data.

C.I.2.4 *Hydrologic Engineering*

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, onsite 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) non-runoff-induced flood waves attributable to dam failures or landslides, and floods attributable to failure of on- 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 groundwater resources

The level of analysis that should be presented may range from very conservative, based on simplifying assumptions, to detailed analytical estimates of each facet of the bases being studied. The former approach is suggested in 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..2.4.1 <u>Hydrologic Description</u>

C.I.2.4.1.1 *Site and Facilities*

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

C.I.2.4.1.2 *Hydrosphere*

Describe the location, size, shape, and other hydrologic characteristics of streams, lakes, shore regions, and groundwater environments influencing plant siting. Include a description of existing and proposed water control structures, both upstream and downstream, that may influence conditions at the site. For these structures:

(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

Provide a regional map showing major hydrologic features. List the owner, location, and rate of use of surface water users whose intakes could be adversely affected by accidental release of contaminants. Refer to Section 2.4.13.2 of the FSAR for the tabulation of groundwater users.

C.I.2.4.2 <u>Floods</u>

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*

Provide the date, level, peak discharge, and related information for major historical flood events in the site region. Include stream floods, surges, seiches, tsunami, dam failures, ice jams, floods induced by landslides, and similar events.

C.I.2.4.2.2 *Flood Design Considerations*

Discuss the general capability of safety-related facilities, systems, and equipment to withstand floods and flood waves. 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. 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.

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. Discuss the effects of superimposing the coincident wind-generated wave action on the applicable flood level. Evaluate the assumed hypothetical conditions both statically and dynamically to determine the design flood protection level. Summarize the types of events considered, as well as the controlling event or combination of events.

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

Describe the effects of local probable maximum precipitation (see Section C.I.2.4.3.1of this guide) on adjacent drainage areas and site drainage systems, including drainage from the roofs of structures. Tabulate rainfall intensities for the selected and critically arranged time increments, provide characteristics and descriptions of runoff models, and estimate the resulting water levels. 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. Provide sufficient details concerning the site drainage system to permit:

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

(2) a judgement concerning the adequacy of design criteria

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

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 (PMF) on Streams and Rivers</u>

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 PMF on streams and rivers. Summarize the locations and associated water levels for which PMF determinations have been made.

C.I.2.4.3.1 *Probable Maximum Precipitation (PMP)*

Discuss considerations of storm configuration (orientation of areal distribution), maximized precipitation amounts (include a description of maximization procedures and/or studies available for the area, such as by reference to National Weather Service and 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 PMP. Present the selected maximized storm precipitation distribution (time and space).

C.I.2.4.3.2 *Precipitation Losses*

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 presenting detailed applicable local storm-runoff studies.

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

Describe the hydrologic response characteristics of the watershed to precipitation (such as unit hydro graphs), provide verification from historical floods or synthetic procedures, and identify methods adopted to account for nonlinear basin response at high rainfall rates. Provide a description of watershed sub-basin drainage areas (including a map), their sizes, and topographic features. Include a tabulation of all drainage areas. Discuss the stream course model and its ability to compute floods up to the severity of the PMF. 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*

Present the controlling PMF runoff hydro graph at the plant site that would result from rainfall (and snowmelt if pertinent). 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. 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, show the flood hydro graphs 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, support the conclusion that the downstream dam has a very high likelihood of failure. Finally, provide the estimated PMF discharge hydro graph at the site and, when available, provide a similar hydro graph without upstream reservoir effects to allow an evaluation of reservoir effects and a regional comparison of the PMF estimate to be made.

C.I.2.4.3.5 *Water Level Determinations*

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*

Discuss setup, significant (average height of the maximum 33⅓% of all waves) and maximum (average height of the maximum 1% 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. Provide a map and analysis showing that the most critical fetch has been used to determine wave action.

C.I.2.4.4 Potential Dam Failures, Seismically Induced

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. 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*

Discuss the locations of dams (both 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). Discuss how consideration was given to possible landslides, pre-seismic-event reservoir levels, and antecedent flood flows coincident with the flood peak (base flow). Present the determination of the peak flow rate at the site for the worst dam failure (or combination of dam failures) reasonably possible, and summarize all analyses to show that the presented condition is the worst permutation. Include descriptions of all coefficients and methods used and their bases. Also discuss how consideration was given to the effects on plant safety of other potential concurrent events such as blockage of a stream, waterborne missiles, and so forth.

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), 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, discuss how domino-type failures resulting from flood waves were considered. Discuss estimates of coincident flow and other assumptions used to attenuate the dam-failure flood wave downstream. Discuss static and dynamic effects of the attenuated wave at the site.

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

Describe the backwater, unsteady flow, or other computational method leading to the water elevation estimate (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. Superimpose wind and wave conditions that may occur simultaneously 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*

Present the determination of probable maximum meteorological winds in detail. 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. 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, 1979), reference that work with a brief description. Provide sufficient bases and information to ensure that the parameters presented represent the most severe combination.

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

Provide historical data related to surges and seiches. Discuss considerations of hurricanes, frontal (cyclonic) type windstorms, moving squall lines, and surge mechanisms that are possible and applicable to the site. Include the antecedent water level (the 10% 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 (include 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 hydro graph (graphical presentation). Provide a detailed description of the (1) bottom profile and (2) shoreline protection and safety-related facilities.

C.I.2.4.5.3 *Wave Action*

Discuss the wind-generated wave activity that can occur coincidently with a surge or seiche, or independently. Present estimates of the wave period and the significant (average height of the maximum 33⅓% of all waves) and maximum (average height of the maximum 1% of all waves) wave heights and elevations with the coincident water level hydro graph. Present specific data on the largest breaking wave height, setup, runup, and the effect of overtopping in relation to each safety-related facility. Include 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.

C.I.2.4.5.4 *Resonance*

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*

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 Flooding</u>

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

C.I.2.4.6.1 *Probable Maximum Tsunami*

Present the determination of the probable maximum tsunami. Discuss consideration given to the most reasonably severe geo-seismic activity possible (resulting from, for example, fractures, faults, landslides, volcanism) in determining the limiting tsunami-producing mechanism. Summarize the geo-seismic 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). Discuss how 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) were considered in the analysis. Also discuss hill-slope failure-generated tsunami-like waves on inland sites. Discuss the potential of an earthquake-induced tsunami on a large body of water, if relevant for the site.

C.I.2.4.6.2 *Historical Tsunami Record*

Provide local and regional historical tsunami information, including any relevant paleo-tsunami evidence.

C.I.2.4.6.3 *Source Generator Characteristics*

Provide detailed geo-seismic 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*

Provide a complete description of the analysis procedure used to calculate tsunami wave height and period at the site. Describe 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*

Provide estimates of maximum and minimum (low water) tsunami wave heights from both distant and local generators. 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*

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. Include 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. Provide, where possible, verification of the techniques and coefficients used by reconstituting the tsunami of record.

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

Discuss the effects of the controlling tsunami on safety-related facilities, and discuss the design criteria for the tsunami protection and mitigation to be provided.

C.I.2.4.7 Ice Effects

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 streams, lakes, etc., for both high and low water levels. Include the location and proximity of such facilities to the ice-generating mechanisms. Describe the regional ice and ice jam formation history with respect to water bodies. Describe the potential for formation of frazil and anchor ice at the site. Discuss the effects of ice-induced reduction in capacity of water storage facilities as they affect safety-related SSCs.

C.I.2.4.8 Cooling Water Canals and Reservoirs

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). Discuss and provide bases for protecting the canals and reservoirs against wind waves, flow velocities (including allowance for freeboard), and blockage and (where applicable) describe the ability to withstand a probable maximum flood, surge, etc.

Discuss the emergency storage evacuation of reservoirs (low-level outlet and emergency spillway). Describe verified runoff models (e.g., unit hydro graphs), flood routing, spillway design, and outlet protection.

C.I.2.4.9 Channel Diversions

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. Present the history of flow diversions and realignments in the region. Discuss the potential for adversely affecting safety-related facilities or water supply, and describe available alternative safety-related cooling water sources in the event that diversions are possible.

C.I.2.4.10 Flooding Protection Requirements

Describe the static and dynamic consequences of all types of flooding on each pertinent safety-related facility. 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. Describe various types of flood protection used and the emergency procedures to be implemented (where applicable).

C.I.2.4.11 Low Water Considerations

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

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. Include considerations of downstream dam failures (see Section C.I.2.4.4 of this guide). For non-safety related water supplies, demonstrate that the supply will be adequate during a 100-year drought.

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

Determine the surge-, seiche-, or tsunami-caused low water level that could occur from probable maximum meteorological or geo-seismic events, if such level could affect the ability of safety-related features to function adequately. Include a description of the probable maximum meteorological event (its track, associated parameters, antecedent conditions) and the computed low water level, or a description of the applicable tsunami conditions. Also consider, where applicable, ice formation or ice jams causing low flow, 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, discuss historical low water flows and levels and their probabilities (unadjusted for historical controls and adjusted for both historical and future controls and uses).

C.I.2.4.11.4 *Future Controls*

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. Substantiate any provisions for flow augmentation for plant use.

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

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. Discuss the capability of cooling water pumps to supply sufficient water during periods of low water resulting from the 100-year drought. Refer to Sections 9.2.1, 9.2.5, and 10.4.5 of the FSAR where applicable. Identify or refer to institutional restraints on water use.

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

Identify all sources of normal and emergency shutdown water supply and related retaining and conveyance systems.

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.2.4.11 of this guide). Describe the design-bases (or refer to Section 9.2.5 of the FSAR) for operation and normal or accidental shutdown and cooldown during:

(1) the most severe natural and site-related accident phenomena

(2) reasonable combinations of less severe phenomena

(3) single failures of man-made structural components

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

Describe the ability to provide sufficient warning of impending low flow or low water levels to allow switching to alternative sources where necessary. Identify conservative estimates of heat dissipation capacity and water losses (such as drift, seepage, and evaporation). Indicate whether, and if so how, guidance in Regulatory Guide (RG) 1.27, "Ultimate Heat Sink for Nuclear Power Plants," has been followed; if such guidance has not been followed, describe the specific alternative approaches used.

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, describe the ability of the principal portion of the system to survive the failure of the secondary portion. Describe and provide the bases for the measures to be taken (dredging or other maintenance) to prevent loss of reservoir capacity as a result of sedimentation.

C.I.2.4.12 Groundwater

Present all groundwater data or cross-reference the groundwater data presented in Section 2.5.4 of the FSAR.

C.I.2.4.12.1 *Description and Onsite Use*

Describe the regional and local groundwater aquifers, formations, sources, and sinks, as well as the type of groundwater use, wells, pumps, storage facilities, and flow requirements of the plant. If groundwater is to be used as a safety-related source of water, compare the design-basis protection from natural and accident phenomena with RG 1.27 criteria. Indicate whether, and if so how, the RG 1.27 guidelines have been followed; if RG 1.27 guidelines were not followed, 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 groundwater or piezometric level fluctuations beneath and in the vicinity of the site. Provide groundwater 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 groundwater flow resulting from local areas of pumping for both plant and non-plant use. Describe the effects of present and projected groundwater use (wells) on gradients and groundwater or piezometric levels beneath the site. Note any potential groundwater 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 all groundwater pathways for a liquid effluent release at the site. Evaluate (where applicable) the dispersion, ion-exchange, and dilution capability of the groundwater environment with respect to present and projected users. Identify potential pathways of contamination to nearby groundwater users and to springs, lakes, streams, etc. Determine groundwater and radionuclide (if necessary) travel time to the nearest downgrading groundwater 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*

Present and discuss plans, procedures, safeguards, and monitoring programs to be used to protect present and projected groundwater 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 for groundwater-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 groundwater flow rates in the various parts of the permanent dewatering system, the area of influence of drawdown, and the shapes of phreatic surfaces to be 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 groundwater levels to exceed design bases. Document the measures that will be taken to repair the system or to provide an alternative dewatering system that would become operational before the site characteristic maximum groundwater level is exceeded.

(e) Provide both the site characteristic maximum and normal operation groundwater levels for safety-related structures, systems, and components. Describe how the site characteristic maximum groundwater 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 RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste Containing Components of Nuclear Power Plants," and RG 1.29, "Seismic Design Classification," either (1) document by pertinent analyses that groundwater level recovery times are sufficient to allow other forms of dewatering to be implemented before the site characteristic maximum groundwater 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 groundwater level is controlled by the system). Provide an analysis of the consequences of pipe ruptures on the proposed under drain 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 groundwater level the plant structures can tolerate under various significant loading conditions in the absence of the under drain system.

(i) Provide a description of the proposed groundwater 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 groundwater level monitoring programs for dewatering.

(j) Provide information regarding the outlet flow monitoring program. The information required includes (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 under drain 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 Pathways of Liquid Effluents in Ground and Surface Waters

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 these requirements will be incorporated 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. In the event emergency procedures are to be used to meet safety requirements associated with hydrologic events, identify the event, present appropriate water levels and lead times available, indicate what type of action would be taken, and discuss the time required to implement each procedure.

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

Provide 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 provide sufficient information to support evaluations performed to arrive at estimates of the SSE ground motion, 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, the investigations performed, results of investigations, conclusions, and a statement as to who did the work.

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

Basic geologic and seismic information is requested throughout the following sections to provide a basis for evaluation. In some cases, this information applies to more than one section. The information may be presented under this section, under the following sections, or as appendices to this section, provided that adequate cross-references are provided 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, non-tectonic, 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 such items 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 regional 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 the 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. Material on site geology included in this section may be cross-referenced in Section 2.5.4 of the FSAR.

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 of 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, origin, 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. Boring logs included in Section 2.5.4 of the FSAR may be referenced.

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 (1:24,000) of the site, showing bedrock surface contours and including the locations of Seismic Category I structures. Furnish a large-scale geologic map (1:24,000) 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 man's activities in the area, such as withdrawal or addition of subsurface fluids or mineral extraction at the site.

Describe the site's groundwater conditions. Information included in Section 2.4.13 of the FSAR may be referenced in this section of the FSAR.

C.I.2.5.2 Vibratory Ground Motion

Present the criteria and describe the methodology used to establish the SSE ground motion and the controlling earthquakes for the site.

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 (MMI) 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 SSE. 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. Provide the following information concerning each earthquake whenever it is available: 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 sources from which the information was obtained. 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 by 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." Describe how the results of the site investigations were used to update the seismic source characterizations in the PSHA or 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 the 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 of model uncertainty.

Provide 15th, median, mean, and 85th fractile PSHA hazard curves for 1, 2.5, 5, 10, 25 and 100 (PGA) 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 performance-based approach is used, as described in American Society of Civil Engineers (ASCE) Standard 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," for seismic design bases (SDB) Category 5D, 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 reference probability approach is used, as described in Regulatory Guide (RG) 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," provide the controlling earthquake magnitudes and distances for the reference probability hazard level at spectral frequencies of 1 and 2.5 Hz (low-frequency) and 5 and 10 Hz (high-frequency). Describe the methodology used and how it either follows or differs from the procedure outlined in Appendix C to RG 1.165. Provide bar graph plots of both the low-frequency and high-frequency deaggregation results for each of the hazard levels. 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 controlling earthquakes and ground motions used in licensing (1) other licensed facilities at the site, (2) nearby plants, or (3) plants licensed in similar seismogenic regions. In addition, compare the controlling earthquakes to 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*

Describe the site response analyses, including the method used to represent the uncertainty and variability across the site. Present 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, and the 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 0spectral 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.

Provide a description of 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 *Safe-Shutdown Earthquake Ground Motion*

Describe the methodology used to determine both the horizontal and vertical SSE ground motion. If the performance-based approach is used, as described in ASCE Standard 43-05 for SDB Category 5D, provide a table with mean 10^{-4}, 10^{-5} UHRS values, design factors, and horizontal SSE. If the reference-probability approach is used, as described in RG 1.165, provide figures showing how the horizontal SSE envelopes the low- and high-frequency controlling earthquake response spectra. Provide the SSE 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 SSE from the horizontal SSE.

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

C.I.2.5.3 Surface Faulting

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 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 to cause 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. In regions of 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 there are no geologic hazards 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 SSE ground motion. 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. Information presented in other sections of the FSAR should be cross-referenced rather than repeated.

C.I.2.5.4.1 *Geologic Features*

Describe geologic features, including the following:

(1) areas of actual or potential surface or subsurface subsidence, solution activity, uplift, or collapse, as well as 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 pre-loading influence on soil deposits

(6) estimates of consolidation and pre-consolidation pressures, and methods used to estimate these values

Relate descriptions, maps, and profiles of the site stratigraphy, lithology, structural geology, geologic history, and engineering geology in order to provide an integrated characterization of the site subsurface.

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. Describe the testing techniques used to determine the classification and engineering properties of soils and rocks. Provide a detailed description of any procedures used to perform field investigations to determine the engineering properties of soil and rock materials that are not described in RG 1.132, “Site Investigations for Foundations of Nuclear Power Plants.” Likewise, indicate the extent to which the procedures used to perform laboratory investigations of soils and rocks conform to RG 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 and provide references to the data sets, used to create the tables and plots. Also 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, 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 *Exploration*

Describe the field exploration program used to characterize the site. Provide a justification for the selected exploratory methods, the locations for exploration, and the depth to which the exploration was conducted. Describe any changes to the site characterization plan as a result of any initial findings and describe the initial findings.

Describe the methods of sample collection, storage, and transportation. Describe the measures used to ensure that the samples remain undisturbed. Describe any measures taken to correlate site specific stratification with CPT data, if CPT data are used to extend the site subsurface profile.

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. Include all formations of engineering significance and identify their areal extent across the boundaries of the site exploration. 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. Describe exploration and laboratory studies and the static and dynamic engineering properties of these materials in the same fashion described 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. Show 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 groundwater during excavation to preclude degradation of foundation materials. Also discuss proposed quality control and quality assurance programs related to foundation excavation, and subsequent protection and treatment. Discuss measures to monitor foundation rebound and heave.

C.I.2.5.4.6 ***Groundwater Conditions***

Discuss groundwater conditions at the site, including the following:

(1) groundwater 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 groundwater fluctuations, as determined by periodic monitoring of local wells and piezometers, including flood conditions

Describe the implementation plan, including milestones.

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

Provide a description of the response of soil and rock to dynamic loading, including the following considerations:

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

(2) P and S wave velocity profiles, as determined from field geophysical surveys (surface refraction and reflection and in-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 to determine the shear modulus and damping degradation with strain

(4) results of soil-structure interaction analysis

Describe how the high to medium strain results have been incorporated in the soil column analysis to simulate the straining level during seismic wave passage. Describe any parametric studies undertaken to establish the location of the input motion based on the soil column studies. In addition, describe the selection of the soil columns to be used in the SSI analysis and the approaches taken to account for variability of the soil properties in these columns.

Material on site geology included in this section may be cross-referenced in Section 2.5.2.5 of the FSAR.

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

Describe the potential for the liquefaction of the site soils under SSE ground motion. Indicate the extent to which the guidance provided in RG 1.198, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites," was followed. Provide a description of any secondary methods used to confirm the potential for liquefaction.

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 groundwater 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 factors of safety, assumptions, and conservatisms in each analysis. Provide references to the analytical methods and the field or laboratory data used. Provide a description of all computer programs used in developing the design along with the validation package.

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

Discuss and provide specifications for measures to improve foundations, such as dynamic compaction, chemical grouting, piling, stone columns, or other stabilization methods. Discuss a verification program designed to permit a thorough evaluation of the effectiveness of foundation improvement measures. If the foundation improvement verification program in this section has not been completed at the time the COL application is filed, 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 man-made earth or rock slopes, (cuts, fills, embankments, dams, etc.) 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. 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 provided in Section C.I.2.5.4 of this guide. Cross-references may be used where appropriate. For the stability evaluation of man-made 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 groundwater and seepage conditions that exist and those assumed for analysis purposes. Describe the type, quantity, extent, and purpose of exploration, and show the location 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 design 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 post-earthquake 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, groundwater levels, exploration and sampling method, recovery, rock quality designation (RQD), and blow counts from standard penetration tests. Discuss drilling and sampling procedures, and indicate where samples were taken on the logs.

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.