



U.S. NUCLEAR REGULATORY COMMISSION  
**STANDARD REVIEW PLAN**  
OFFICE OF NUCLEAR REACTOR REGULATION

2.5.1 BASIC GEOLOGIC AND SEISMIC INFORMATION

REVIEW RESPONSIBILITIES

Primary - Geosciences Branch (GB)

Secondary - None

I. AREAS OF REVIEW

GB reviews the geologic and seismic information submitted in the applicant's safety analysis report (SAR). The principal regulation used by GB in determining the scope and adequacy of the submitted geologic and seismologic information is Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" (Ref. 3). Additional guidance (regulations and regulatory guides) is provided to the GB through References 1, 2, 4, and 5. GB judges the adequacy of the geologic and seismic information cited in support of the applicant's conclusions concerning the suitability of the plant site. The GB will coordinate other branch evaluations that interface with the geologic and seismologic aspects of the site as follows: Hydrologic and Geotechnical Engineering Branch (HGEB) will determine the adequacy of the hydrologic and geotechnical engineering information cited in support of the applicant's conclusions concerning the suitability of the plant site as part of HGEB's primary review responsibilities for SRP Sections 2.4, 2.5.4, and 2.5.5. For example, as part of its primary review responsibility, the HGEB reviews the adequacy of the applicant's model describing the present and projected use of local and regional groundwater resources. Assessment of this hydrologic information by the HGEB is essential to the GB in making its determination, for example, where applicable, of the subsidence potential of the site environs. An additional primary review responsibility for the HGEB consists in some cases of the verification, through investigations and testing conducted by the applicant, of the preloading history of the plant's soil foundations by means of glacial and other geologic processes. The applicant's information describing the above process is contained in SRP Section 2.5.4. The HGEB, as part of its primary review responsibility for SRP Section 2.5.4, reviews the information presented by the applicant concerning the soil and rock properties which may affect the nuclear power plant facilities. This HGEB coordination is required in those cases where verification of geologic processes affecting the site can be determined through various testing methodologies.

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**USNRC STANDARD REVIEW PLAN**

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

For those areas of review identified above as being reviewed as part of the primary responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch. The geologic and seismic information which must be provided in order for the site review to proceed is divided into the following three categories:

1. Geologic features: mass-wasting, differential subsidence, faulting, chemical weathering, cavernous or karst terrains, evidence of pre-consolidation, for example, by means of overburden removal through erosional processes.
2. Seismic features: ground failure under dynamic loading, liquefaction, vibratory ground motion, tsunami, and residual stresses.
3. Man-made conditions: changes in groundwater conditions, subsidence or collapse caused by withdrawal of fluids or mineral extraction, induced seismicity and fault movement caused by fluid injection (including reservoir impoundment) or withdrawal.

Information relating to the above conditions as presented in SAR Sections 2.5.1.1 (Regional Geology) and 2.5.1.2 (Site Geology), should be reviewed in terms of the regional and site physiography, geomorphology, stratigraphy, lithology, and tectonics. In addition, with specific reference to site geology, the following subjects should be reviewed as they relate to the above-mentioned conditions: topography, slope stability, fluid injection or withdrawal, mineral extraction, faulting, shearing, jointing, seismicity and fracturing.

The above information should be documented by appropriate references to all relevant published and unpublished materials. Illustration should include but should not be limited to physiographic, topographic, geologic, tectonic, gravity, and magnetic maps, structure and stratigraphic sections, boring logs, and aerial photographs. Certain sites will require illustrations of specialized character such as maps of subsidence, irregular weathering conditions, landslide potential, hydrocarbon extraction (oil or gas wells), faults, joints, and karst features. Some site characteristics must be documented by reference to seismic reflection or refraction profiles or to maps produced by various remote sensing techniques.

As appropriate, maps should include a superimposed plot plan of the plant facilities. Other documentation should show the relationship of all seismic Category I facilities (clearly identified) to subsurface geology. Core boring logs, logs and maps of trenches, aerial photographs, Landsat imagery, and geophysical data should be presented for evaluation. In addition, a plot plan showing the locations of all plant structures, borings, trenches, profiles, etc. should be included.

The review can be brought to an earlier conclusion if the following suggestions are followed by the applicant. The SAR should contain sufficient data to allow the reviewer to make an independent assessment of the applicant's conclusions. That is, the reviewer should be led in a logical manner from the data and premises given to the conclusions that are drawn without having to make an extensive independent literature search. Controversial information should not be ignored so as to enhance a particular position. The geologic terminology used should conform to standard reference works (Refs. 6, 11). Finally, the objective of Section 2.5.1 of the SAR is to describe geologic and seismic features as

they affect the site under review, and all data, information, discussions, interpretations, and conclusions should be directed to this objective. Aimless presentation of data, although it may appear to satisfy the investigative requirements, will result in a disjointed SAR and cause needless delays in completing the safety review.

## II. ACCEPTANCE CRITERIA

The applicable rules and basic acceptance criteria pertinent to the areas of this section of the SRP are given below:

1. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants" General Design Criterion 2 - "Design Bases for Protection Against Natural Phenomena" - This criterion requires that safety-related portions of the structures, systems, and components important to safety shall be designed to withstand the effects of earthquakes, tsunamis, and seiches without loss of capability to perform their safety function (Ref. 1).
2. 10 CFR Part 100, "Reactor Site Criteria" - This part describes criteria which guide the evaluation of the suitability of proposed sites for nuclear power and testing reactors (Ref. 2).
3. 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants" - These criteria describe the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability and identifies geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants (Ref. 3).

The following regulatory guides provide information, recommendations, and guidance and in general describe a basis acceptable to the staff for implementing the requirements of GDC 2, Part 100, and Appendix A to Part 100.

- a. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" - This guide describes programs of site investigations related to geotechnical aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundations and earthquakes under anticipated loading conditions including earthquake. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, the spacing and depth of borings and sampling (Ref. 4).
- b. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations" - This guide discusses the major site characteristics related to public health and safety which the NRC staff considers in determining the suitability of sites for nuclear power stations (Ref. 5).

The information presented in the SAR must be complete and thoroughly documented, and must be consistent with the requirements of Reference 3 and should conform to the format suggested in Reference 12. Information from varied sources, including the United States Geological Survey (USGS) and other Federal or State agency published and open file papers, maps, aerial photographs, geophysical data, etc., and similar data from nongovernmental sources covering the region

in which the site is located, are used to establish the staff's conclusions as to the completeness and acceptability of the SAR.

Specific criteria necessary to meet the relevant requirements of GDC 2, Part 100 and Appendix A to Part 100 are as follows:

Subsection 2.5.1.1, "Regional Geology." In meeting the requirements of References 1, 2, and 3, the subsection will be considered acceptable if a complete and documented discussion is presented of all geologic, seismic, and man-made features. This subsection should contain a review of the regional physiography, geomorphology, stratigraphy, structure, and geologic history to provide a framework within which the geologic, seismic and man-made features of safety significance to the site can be evaluated.

Subsection 2.5.1.2, "Site Geology." In meeting the requirements of References 1, 2, and 3 and the regulatory positions of References 4 and 5, the subsection will be judged acceptable if it contains a description and evaluation of site-related geologic features, seismic conditions, and man-made conditions which may represent a potential hazard to the site. This subsection should also contain the following general site information:

1. The site stratigraphy, including relationship to and correlation with the regional stratigraphy.
2. The structural geology of the site and the relationship of site structure to regional tectonics.
3. The geologic history of the site as it relates to the regional geologic history.
4. The engineering significance of geologic features underlying the site as they relate to:
  - a. Dynamic behavior during prior earthquakes.
  - b. Zones of alteration, irregular weathering, or zones of structural weakness.
  - c. Unrelieved residual stresses in bedrock.
  - d. Materials that could be unstable because of their mineralogy or unstable physical properties.
  - e. Effects of man's activities in the area.
5. The site groundwater conditions.

### III. REVIEW PROCEDURES

The staff review is conducted in three phases. The first phase is the acceptance review, a brief review of the SAR to evaluate its completeness and to identify obvious safety issues that could result in delays at subsequent stages of the review. After an SAR is docketed, the staff conducts a thorough review of the material. In this second phase of the review an effort is made to identify

all safety issues. The reviewer carefully examines the SAR to see that all interpretations are founded on sound geological and seismological practice and do not exceed the limits of validity of the applicant's data or of other data published in the literature. As necessary, questions and comments transmitted to the applicant will identify issues that have not been addressed, areas where staff interpretations differ from those given in the SAR, and issues that have not been sufficiently documented to permit the staff to concur in the conclusions reached by the applicant. When possible, the staff takes positions on safety-related issues at this point. The third review phase is the staff evaluation of the applicant's responses to questions raised in the second phase. At the end of the third phase, the staff takes positions on all safety-related issues, either concurring with the applicant's positions or taking more conservative positions as may be necessary in the staff's view to assure the required degree of safety.

Pertinent references, such as published geological reports, professional papers, open-file material, university theses, physiographic and geological maps, and aeromagnetic and gravity maps, are ordered from the appropriate sources and reviewed. The general references used extensively by the staff are References 6, 7, and 11. GeoRef data base (Ref. 9) and other data bases, such as References 8 and 10, are used to identify specific references.

The judgments on acceptance or rejection of the SAR for review are governed by two criteria: (1) adherence to the Standard Format (Ref. 12) in identifying and describing the geologic, seismic and man-made features that affect safety of the site; and (2) provision of adequate information and documentation to allow for an independent staff review of the conclusions made therein.

During the acceptance review the staff decides to what extent consultants should be involved. The necessary information is then made available to these consultants. Consultants are asked to handle such varied tasks as reviewing the tectonic setting of plants in regions of complex geology, evaluation of the potential for surface displacement, verifying an applicant's mineral identifications, or providing advice on the proper level of earthquake ground motion (response spectrum) to be used (based on state-of-the-art studies) in the seismic evaluation of selected sites.

After docketing, a detailed review of the SAR and relevant references is conducted by the staff and its advisors. Questions and comments are developed from items that have not been adequately addressed by the applicant, those which become apparent during the detailed review, or those which develop from the additional information provided as a result of the acceptance review. These questions (Q-1) usually require the applicant to conduct additional investigations or to supply clarifying information. Many questions result from the reviewer's discovery of references not cited by the applicant that contain conclusions which are in conflict with those made by the applicant. When the applicant provides insufficient data to support his interpretations and conclusions, and there are reasonable and more conservative alternative interpretations in the literature, the staff will request additional investigations. This phase of the review will usually involve meetings with the applicant to clarify questions and allow him to present new data. In addition, during the Q-1 phase of the construction permit review, the staff visits the site.

The applicant's responses to Q-1 questions are reviewed and any remaining issues are settled either by additional questions (Q-2) or by staff positions (RSP).

A staff position is usually in the form of a requirement to design for a specific condition in a way which the staff considers to be sufficiently conservative and consistent with the requisites of Reference 3. When all safety issues have been resolved, the staff provides its input to the safety evaluation report (SER).

#### IV. EVALUATION FINDINGS

If the evaluation by the staff, on completion of the review of the geologic and seismologic aspects of the plant site and region, confirms that the applicant has met the requirements of applicable portions of References 1, 2, and 3 and the guidelines contained in References 4 and 5, the conclusion in the SER states that the information provided and investigations performed support the applicant's conclusions regarding the geologic and seismic integrity of the proposed nuclear power plant site. Staff reservations about any significant deficiency presented in the applicant's SAR are stated in sufficient detail to make clear the precise nature of concern. The above evaluation determinations are made by the staff during both the construction permit (CP) and operating license (OL) phases of review.

Operating license (OL) applications are reviewed for any new information developed subsequent to the construction permit (CP) safety evaluation report (SER). The review will also determine whether the CP recommendations have been implemented.

A typical OL-stage finding for this section of the SER follows:

In our review of the geologic and seismologic aspects of the plant we have considered pertinent information gathered since our initial geologic and seismologic review which was made in conjunction with the issuance of the construction permit. This new information includes data gained from both site and near-site investigations as well as from a review of recently-published literature.

As a result of our recent review of the geologic and seismologic information, we have determined that our earlier conclusion regarding the safety of the plant from a geological and seismological standpoint remains valid. These conclusions can be summarized as follows:

- (1) Geologic and seismologic investigations and information provided by the applicant and required by Appendix A to 10 CFR Part 100 provide an adequate basis to establish that no capable faults exist in the plant site area which would cause earthquakes to be centered there.
- (2) No evidence has been found to indicate that a potential exists for surface faulting at the plant.
- (3) The acceleration level 0.25g proposed for the safe shutdown earthquake is the appropriate acceleration level used to anchor a Regulatory Guide 1.60 spectra for the seismic design of the plant in conformance with Appendix A to 10 CFR Part 100.
- (4) The potential for detrimental subsidence (resulting from the near-site extraction of groundwater) affecting the proposed nuclear plant is considered nonexistent.

The new information reviewed for the proposed nuclear power plant is discussed in Sections 2.5.1, 2.5.2, and 2.5.3 below.

The staff concluded that the site is acceptable from a geologic and seismologic standpoint and meets the requirements of (1) 10 CFR Part 50, Appendix A (General Design Criterion 2), (2) 10 CFR Part 100, and (3) 10 CFR Part 100, Appendix A. This conclusion is based on the following:

1. The applicant has met the requirements of:
  - a. 10 CFR Part 50, Appendix A (General Design Criterion 2) with respect to protection against natural phenomena such as earthquakes, faulting, and collapse.
  - b. 10 CFR Part 100 (Reactor Site Criteria) with respect to the identification of physical characteristics such as geology and seismology used in determining the suitability of the site.
  - c. 10 CFR Part 100, Appendix A (Seismic and Geologic Siting Criteria for Nuclear Power Plants) with respect to obtaining the geologic and seismic information necessary to determine (1) site suitability, and (2) to determine the appropriate design of the plant. In complying with this regulation the applicant also meets the staff's guidance described in Regulatory Guide 1.132 (Site Investigations for Foundations of Nuclear Power Plants) and Regulatory Guide 4.7 (General Site Suitability Criteria for Nuclear Power Stations).

## V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

## VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."
2. 10 CFR Part 100, "Reactor Site Criteria."
3. 10 CFR Part 100, Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."
4. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants."

5. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations."
6. R. L. Bates and J. Jackson, eds., "Glossary of Geology," Second Edition, American Geological Institute, Falls Church, Virginia (1980).
7. G. V. Cohee (Chairman) et al., "Tectonic Map of the United States," U.S. Geological Survey and American Association of Petroleum Geologists (1962).
8. American Petroleum Institute data base, accessible through RECON system.
9. GeoRef data base, American Geological Institute, Falls Church, Virginia.
10. RECON/Energy data base, Department of Energy.
11. A. L. Odom and R. D. Hatcher, Jr., "A Characterization of Faults in the Appalachian Foldbelt," U.S. Nuclear Regulatory Commission, NUREG/CR-1621 (1980).
12. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."