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**COMPLIANCE DETERMINATION METHOD FOR REVIEW PLAN NO. 3.2.1.6
POTENTIALLY ADVERSE CONDITION: HISTORICAL EARTHQUAKES**

3.0 REVIEW PROCEDURES AND ACCEPTANCE CRITERIA

3.1 Acceptance Review

In conducting the *Acceptance Review* for docketing, the staff will compare information in the License Application (LA) concerning the Potentially Adverse Condition (PAC) on earthquakes which have occurred historically that, if they were to be repeated, could affect the site significantly (henceforth, historical earthquakes) with the corresponding section of the Format and Content Regulatory Guide (FCRG) and with the staff's resolution status of objections to the LA submittal in the Open Item Tracking System (OITS) and determine if this information meets the following criteria.

- (1) The information presented in the LA is clear, is completely documented consistent with the level of detail presented in the corresponding section of the FCRG, and the proper references have been provided.
- (2) DOE has either resolved, at staff level, the NRC objections to LA submittal that apply to this regulatory requirement topic or provided all information requested in Section 1.6 of the FCRG for unresolved objections. Namely, DOE has:
 - identified all unresolved objections
 - explained the differences between NRC and DOE positions that have precluded resolution of each objection
 - described all attempts to achieve resolution
 - explained why resolution has not been achieved
 - described the effects of the different positions on demonstrating compliance with 10 CFR Part 60.
- (3) DOE has presented information and analyses in review areas listed in Section 3.2.1. If DOE has not presented information in these areas an explanation for not providing it should be presented.
- (4) Unresolved objections individually or in combination with others will not prevent the reviewer from conducting a meaningful compliance review and the Commission from making a decision regarding construction authorization within the 3-year statutory period after the license application is submitted.

3.2 Compliance Reviews

The compliance determination undertaken by NRC staff will consider whether Acceptance Criteria specified for the following *Compliance Review* have been met. Results of the compliance determination

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should be documented by the staff to provide the basis for actual *Evaluation Findings* in the Safety Evaluation Report (SER).

3.2.1 Safety Review of 10 CFR 60.21(c)(1)(ii)(A),(B),(F) and 10 CFR 60.122(c)(12)

The staff will determine whether the assessment of presence or absence of historical earthquakes has been accomplished in an acceptable manner, and whether description of the geology and seismicity of the site properly supports the assessments required by 10 CFR 60.21(c)(1)(ii)(A),(B), and (F) as they relate to 10 CFR 60.122(c)(12). For 10 CFR 60.21(c)(1)(ii)(A) specifically, the staff will review and evaluate information provided by DOE in the LA to support the DOE analysis of the geology of the site as related to historical earthquakes and determine whether the analysis has been conducted in a manner acceptable for supporting review of 10 CFR 60.122(c)(12). The staff restricts the analysis of this PAC to only those earthquakes and their locations that have been historically documented.

3.2.1.1 Determination of Historical Earthquakes

For the purposes of this review, historical earthquakes are those which are historically reported or instrumentally recorded that have affected or could reasonably be expected to have affected the site. Sources of historical earthquake knowledge include lists or catalogues prepared by individual researchers, groups or government agencies whose function it is to document such occurrences, newspapers, and historical diaries of early observers (e.g. with the U.S. Army or religious missions). In some cases, traditional accounts reported by members of Indian tribes may also be considered. The detail and reliability of information from these diverse sources may vary considerably.

Because of the potential for very large earthquakes at the Sierra Nevada-Basin and Range tectonic province border, and the considerable dispersion of data about the median attenuation functions, an area for the DOE historical earthquake considerations of radius 300 km centered on the site, is considered conservative.

The staff will evaluate the results and techniques used by DOE in their description of historical earthquakes to determine if the following acceptance criteria have been met.

- The areal extent of DOE characterization of historical earthquakes is sufficient to identify those that might affect the site.
- Detection capabilities of the geophysical methods used for identifying geological structures are evaluated and appropriately reported by DOE.
- The DOE investigations have included reasonably available historical accounts and lists of earthquakes. Criteria for acceptability of the listings are:
 - They include all earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0, that have been reported within 300 km of the site. Magnitudes of less than 3 are not considered by the staff to be sufficiently well recorded to contribute to PSHA or to warrant their being listed and plotted. However, for studies of fault planes within the YM/NTS, location of earthquakes having magnitudes smaller than 3 should be used.

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- The descriptions of earthquakes on the lists include the following if available: epicenter coordinates, depth of focus, origin time, highest intensity, magnitude, moment, source mechanism, distance from the site and any strong motion recordings references from which the information was obtained and magnitude designations such as M_L , M_S , M_W , etc. are identified.
 - If available, reports of earthquake induced geologic failures, such as liquefaction, landsliding, landspreading, and lurching are completely described, including the level of strong motion that induced failure and properties of failed geological materials.
 - A regional scale map is presented which shows the listed earthquake epicenters.
 - A local scale map is presented which shows all earthquake epicenters within 100 km of the site and potentially related geologic structures.
 - Correlations of historical earthquakes with faults, to the extent possible, have been made. acceptance criteria for the correlations are:
 - A rationale is developed for the correlation of a hypocenter or group of hypocenters with a geologic structure, which considers characteristics of the geologic structure based upon geologic and geophysical data, seismicity, tectonic history, and a regional tectonic model.
 - The descriptions of hypocenters includes identification of the methods used to locate them, an estimate of accuracy, and a detailed account that compares and contrasts the geologic structure involved with local seismicity and with earthquake activity in other areas of the tectonic province.
 - Uncertainties in data acquisition, data representativeness, data reduction, and stratigraphic relationships and in analytical methods are presented and discussed. The means used by DOE to reduce uncertainty and the resultant residual uncertainty are prominently reported.

3.2.1.2 Determination of Historical Earthquakes that Could Significantly Affect the Site

The staff will review the DOE analysis of which historical earthquakes could significantly affect the site to determine if the following acceptance criteria have been met.

- Earthquake magnitudes, resulting peak ground accelerations, and association with each geologic structure have been assessed, and the earthquake that would produce the maximum vibratory ground motion at the site has been determined. Where an earthquake is associated with geologic structure, the maximum magnitude earthquake that could occur on that structure is evaluated, taking into account significant factors; for example, the type of faulting, fault length, fault slip rate, rupture length, moment, and earthquake history. If geologic or seismologic evidence warrants a maximum earthquake larger than the maximum historical earthquake, the rationale is discussed.

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- Plausible effects to the site which could be caused by historical earthquakes, should they be repeated, include effects on waste isolation, i.e., damage to engineered barrier systems (EBS) that may result in the release of radionuclides from engineered barriers to the geologic setting, and changes to pathways of radionuclide migration within the geologic setting

3.3 Rationale For Review Procedures and Acceptance Criteria

3.3.1 Rationale for Safety Review of 10 CFR 60.21(c)(1)(ii)(A),(B),(F) and 10 CFR 60.122(c)(16)

The reviewer will base the *Safety Review* for historical earthquakes on standard scientific and industry practices, for example those used in Nuclear Power Plant license applications. The reviewer also will identify any site-specific problems, the resolution of which could result in extended delays in completing the review. Qualifications and experience of the reviewers will be of critical importance to the review process. Success of the review will be strongly dependent on professional judgement of the reviewers, who must possess a thorough knowledge of the site's seismicity, geology, and its geologic setting. Historical earthquakes are defined as those earthquakes which have occurred in the area during a period of occupation and reporting by humans. These include earthquakes for which there are instrumentally determined locations and characteristics, earthquakes for which only damage intensity (MMI or similar) data is available, and more uncertain casual reporting of earthquakes for which only one or a few reports are available. Therefore, if these sources of earthquake information are thoroughly investigated, reported and summarized in the LA, the determination of historical earthquakes is considered adequate. The regulation 10 CFR 60.122(c)(12), states the potentially adverse condition as:

"Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly."

The effects of historical earthquakes described should be for waste isolation. Historical earthquakes, if repeated, which could affect waste isolation are not restricted to having an origin within the controlled area, but must have a potentially significant effect on the site. Such effects could be on engineered structures or barriers such that an early or more rapid exposure of radionuclides to the natural geological repository occurs, or the effect could be to the natural geological repository itself such that radionuclide migration is enhanced beyond its original state at the time of construction. For example, water levels or flows may increase for certain periods of time or permanently, or waste canisters could be breached or corrode more rapidly after being stressed repeatedly. Effects of historical earthquakes on engineered barriers and the natural environment must be thoroughly investigated and evaluate.

4.0 IMPLEMENTATION

4.1 Review Responsibilities

The review responsibilities for this review plan are as follows:

Lead: WM/ENGB Geosciences/Geotechnical Engineering
Section

Support: None

4.2 Interfaces

4.2.1 Input Information

Information derived from activities related to other review plans may provide input important for considering historical earthquakes. A list of review plans in which such information may be found follows.

<i>Input Information</i>	<i>Review Plan No.</i>
The geologic setting of historical earthquakes	3.1.1 Geologic System Description
Potential causes of historical earthquakes to aid in evaluation of associations of earthquakes with faults	3.2.1.7 Correlation of Earthquakes with Tectonic Processes
Evaluation of potential earthquakes to asses uncertainty in the historical earthquake assessment	3.2.1.8 Occurrence of more-Frequent/Higher Magnitude Earthquakes
Implications for the number of earthquakes of a given magnitude that should have been seen historically	3.2.1.1 Nature and Rate of Physical Processes
Implication of focal mechanisms for older historical earthquakes	3.2.1.5 Structural Deformation

4.2.2 Output Information

Earthquake information may be conveniently placed in a single location within the license application but may be relevant to the resolution of several PACs. Therefore, output from activities associated with this review plan may provide specific information important for use in other review plans. See the following table.

<i>Output Information</i>	<i>Review Plan No.</i>
Potential view of the Historical Earthquake PAC from a different perspective	3.2.5 Assessment of Compliance With Criteria For Integrated Analyses of Combinations of Favorable Conditions and Potentially Adverse Conditions
Possible assessment of uncertainty associated with the Historical Earthquake PAC	X.X.X. Assessment of Anticipated and Unanticipated Processes and Events
Possible consideration of the impact of the Historical Earthquake PAC on the site	6.1 Assessment of Compliance With the Requirement for Cumulative Releases of Radioactive Materials
Possible scenarios for significant effects on the site caused by historical earthquakes	6.2 Assessment of Compliance With Individual Protection Requirements

5.0 EXAMPLE EVALUATION FINDINGS

The staff should consider the *Example Evaluation Findings* presented below together with the Acceptance Criteria set forth in Section 3.0 when making the actual *Evaluation Findings* resulting from the *Acceptance Review* for docketing and the *Compliance Reviews*. The actual *Evaluation Findings* resulting from the *Compliance Reviews*, and the supporting basis for these findings, should be documented by the staff in the SER.

5.1 Finding for Acceptance Review

The NRC staff finds that the information presented by DOE on the PAC concerned with historical earthquakes is acceptable (not acceptable) for docketing and compliance review.

5.2 Findings for Compliance Reviews

5.2.1 Finding for 10 CFR 60.21(c)(1)(ii)(A),(B),(F) and 10 CFR 60.122(c)(12)

The NRC staff finds that the presence or absence of the PAC related to historical earthquakes has (has not) been acceptably demonstrated and that there is (is not) reasonable assurance that the regulatory requirements of 10 CFR 60.21(c)(1)(ii)(A),(B),(F) and 10 CFR 60.122(c)(12) will be met.

6.0 REFERENCES

NRC, "Format and Content for the License Application for the High-Level Waste Repository" (FCRG), Office of Nuclear Regulatory Research.

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Nuclear Regulatory Commission, "License Application Review Plan for the Review of a License Application for a Geologic Repository for Spent Nuclear Fuel and High-Level Radioactive Waste, Yucca Mountain, Nevada" (LARP), Office of Nuclear Material Safety and Safeguards.