

November 20, 2006

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)
)
SYSTEM ENERGY RESOURCES, INC.) Docket No. 52-009-ESP
)
(Early Site Permit for Grand Gulf ESP Site))

NRC STAFF PRE-FILED TESTIMONY CONCERNING HEARING ISSUE C:
SEISMIC IMPACTS

Q.1. Please state your name, occupation, by whom you are employed and your professional qualifications.

A.1. Yong Li (YL). I am employed as a Senior Geophysicist in the Division of Engineering, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission ("NRC"). A statement of my professional qualifications is attached.

Q.2. Please describe your professional responsibilities with regard to the review of the application by System Energy Resources, Inc. ("SERI" or "Applicant") for an early site permit ("ESP") for a new nuclear power plant or plants to be located on the existing Grand Gulf Nuclear Station ("GGNS") site near Port Gibson, Mississippi.

A.2. (YL) As part of the NRC staff's health and safety review of the SERI ESP application, documented in NUREG-1840, "Safety Evaluation Report for an Early Site Permit (ESP) at the Grand Gulf Site" ("SER"), I reviewed the aspects of the Applicant's Site Safety Analysis Report ("SSAR") that concerned geology and seismology.

Q.3. In its November 6, 2006, Order, the Atomic Safety and Licensing Board ("Board") identified certain issues to be addressed in connection with the mandatory hearing. With regard to seismic impacts, the Board asked for a summary and discussion of the process that was utilized by the NRC staff to evaluate seismicity at the Grand Gulf site, including the specific steps used to evaluate the relevance, precision, and accuracy of analytical and digital models. Please address these issues.

A.3. (YL)

Regional and Site Geology

The Applicant described the regional geology, including the physiography, geological provinces, geologic history, stratigraphy, tectonic settings, and seismicity of the site region. SER at 2-144. The Applicant described these items in detail, including the geologic periods (era) in which they formed. SER at 2-144 through 2-159. The Applicant discussed each of the following seismic source zones and associated seismic activities surrounding the ESP site:

- Appalachian Mountains
- Ouachita Orogenic Belt
- Arkoma and Black Warrior Basins
- Reelfoot Rift
- New Madrid Seismic Zone (NMSZ)
- Gulf Coast Basin
- Pickens-Gilberttown and Southern Arkansas Fault Zones
- Saline River Source Zone (SRSZ)
- nontectonic structural features

The applicant fully considered the NMSZ in its investigation process because the NMSZ can contribute to the seismic hazard at the site, even though it is outside the 320 kilometer (200 mile) radius recommended by RG 1.165. SER at 2-151 through 2-159.

The Staff evaluated the geological and seismological information submitted by the Applicant in SSAR Section 2.5.1. as follows: The technical information presented in Section 2.5.1 of the application (SSAR) resulted from the Applicant's surface and subsurface

geological and seismological investigations performed in progressively greater detail as these investigations approached the site. SER at 2-162. Through its review, the Staff determined whether the Applicant complied with the applicable regulations and conducted its investigations with an appropriate level of thoroughness, as required by 10 C.F.R. § 100.23. SER at 2-162. SSAR Section 2.5.1 contains the geologic and seismic information gathered by the Applicant in support of the vibratory ground motion analysis; site SSE spectrum is provided in SSAR Section 2.5.2. SER at 2-163.

According to RG 1.165, applicants may develop the vibratory design ground motion for a new nuclear power plant using either the Electric Power Research Institute (“EPRI”) or Lawrence Livermore National Laboratory (“LLNL”) seismic source models for the Central and Eastern United States (“CEUS”). SER at 2-163. However, RG 1.165 recommends that applicants update the geological, seismological, and geophysical database and evaluate any new data to determine whether revisions to the EPRI or LLNL seismic source models are necessary. SER at 2-163. As a result, the Staff focused its review on geologic and seismic data published since the late 1980s that could indicate a need for changes to the EPRI or LLNL seismic source models. SER at 2-163. To thoroughly evaluate the geological and seismological information presented by the Applicant, the Staff obtained the assistance of the USGS.¹ SER at 2-163. In addition, the Staff and its USGS advisors visited the ESP site and surrounding area to evaluate and confirm the interpretations, assumptions, and conclusions presented by the Applicant concerning potential geologic and seismic hazards. SER at 2-163.

The Staff’s review focused on the Applicant’s characterization of the regional and local geologic structure and seismic potential. SER at 2-163. The Staff considered the Applicant’s

¹ One of the staff members from USGS was the key person to study and compile a database for Quaternary faults, liquefaction features and possible tectonic features in the CEUS, east of the Rock Mountain Front.

descriptions of physiographic provinces within the site region, the Mississippi embayment and Gulf Coast Basin, tectonic evolution for major geologic features, and the stratigraphy of the site region. SER at 2-163. The Staff determined that these descriptions reflect well-documented geologic information, and concluded that they provide a relevant, accurate and thorough description of the regional site geology. SER at 2-163. Similarly, the Staff reviewed the Applicant's characterization of the tectonic features in the EPRI seismic source model from the late 1980's, focusing on two seismic zones: SRSZ and NMSZ. SER at 2-163. With the addition of these sources to the site seismic hazards estimate, which only enhanced the conservative estimate of ground motions for the ESP site, the Staff found that the Applicant accurately characterized the tectonic features and their correlations with the regional seismicity. SER at 2-164. Finally, the Staff considered a seismic catalog, which the Applicant revised in response to a Staff question, and determined that the Applicant had provided an accurate and thorough description of the regional seismicity. SER at 2-164.

With respect to site geology, the Applicant described the geologic information of both the site area (within an 8 kilometer radius [5 miles]) and the site location (within a 1 kilometer radius [~0.6 miles]) in terms of the (1) site physiography and geomorphology, (2) site geologic history, (3) site geologic conditions, (4) site structure, and (5) geotechnical properties of subsurface materials. SER at 2-159. The Applicant described these matters in detail. SER at 2-159 through 2-162. The Applicant did not identify any faults within the 8-kilometer radius of the site area. SER at 2-161.

The Staff found that the Applicant provided a thorough and accurate description of the surface features and characteristics for the ESP site. SER at 2-164. The Staff also found that the Applicant provided an accurate and thorough description of the site area stratigraphy, with emphasis on the younger layers of rock and soils. SER at 2-165. The Staff therefore found that the Applicant's description of the geological structures was complete and accurate. SER

at 2-165. Nonetheless, the Staff stated that, based on RG 1.132, any excavation made during construction will provide an opportunity to obtain additional geologic and geotechnical data. SER at 2-165. Therefore, the Staff found that the Applicant must perform geologic mapping of future excavation for safety-related structures, evaluate any unforeseen geologic features that are encountered, and notify the NRC no later than 30 days before any excavations for safety-related structures are opened. This is Permit Condition 3. SER at 2-165. In addition, the Staff also proposed COL Action Items 2.5-3 and 2.5-4 (Appendix A, A5). COL Action Item 2.5-3 requires the applicant to perform additional borings to confirm the current base case material properties and their variabilities throughout the site. COL Action Item 2.5-4 requires the applicant to provide information to correlate plot plans and profiles of each category I structure with subsurface profiles and materials properties to ascertain the sufficiency of selected borings to represent soil variations under each structure. Finally, the Staff found that the effects of human activity (e.g., ground water withdrawal or mining activity) have no potential to compromise the safety of the site. SER at 2-165.

Based on the facts and reasoning set forth above, the Staff concluded that the Applicant properly characterized the site lithology, stratigraphy, geological history, structural geology, and the characteristics of subsurface soils and rocks. SER at 2-165. Accordingly, the Staff concluded that the Applicant identified and appropriately characterized all the significant seismic sources for determining the safe-shutdown earthquake ("SSE") for the ESP site, in accordance with RG 1.165 and Section 2.5.1 of NUREG-0800, and therefore satisfied the associated requirements of 10 C.F.R. § 100.23(c) and GDC 2. Therefore, the Staff concluded that the proposed ESP site is acceptable from a geological and seismological standpoint and meets the requirements of 10 C.F.R. § 100.23. SER at 2-165.

Vibratory Ground Motion

The Applicant described the regional and local geology and structural background and outlined the major seismotectonic sources and materials in the site region. SER at 2-165. The Applicant described: (1) its determination of the ground motions at the ESP site resulting from possible earthquakes inside or outside the site region; (2) the characteristics of seismic sources used in the ESP site seismic hazard calculation; (3) the procedure for the probabilistic seismic hazard analysis ("PSHA") and its results; (4) site characteristics in seismic wave transmission; and (5) site responses at the ESP site. SER at 2-166. The Applicant then summarized the development of the SSE and operating-basis earthquake (OBE) ground motion for the ESP site. SER at 2-166.

With respect to seismic source characterization, the Applicant described the characteristics of all seismic sources in the ESP site region. SER at 2-166. The Applicant reviewed the original 1986 EPRI earthquake source model related to the ESP site and found that the model adequately captures the regional earthquake source characteristics and the uncertainty associated with the source model at the time the model was developed. SER at 2-166. The Applicant also addressed the SRSZ and updated NMSZ and their associated parameters resulting from the recent studies. SER at 2-166. The Applicant summarized the EPRI seismic source model, and the seismic source information for the seismic sources in the site region. SER at 2-166. This source information includes the maximum magnitude, closest distance to the ESP site, probability of activity, and an indication as to whether new information regarding the seismic source has been identified since the original EPRI seismic hazard analysis. SER at 2-166, 2-167. The Applicant presented detailed characterizations of the NMSZ and the SRSZ. SER at 2-167, 2-168. Finally, the Applicant described the effect of

updating the earthquake catalog on the EPRI-Seismicity Owners Group ("SOG") seismicity parameters. SER at 2-169, 2-170.

In its review, the Staff considered the regulatory requirements of 10 C.F.R. § 52.17(a)(1)(vi) and 10 C.F.R. § 100.23(c) and (d), which require that an applicant for an ESP describe the seismic and geologic characteristics of the proposed site. SER at 2-180. In particular, 10 C.F.R. § 100.23(c) requires that an ESP applicant investigate the geological, seismological, and engineering characteristics of the proposed site and its environs with sufficient scope and detail to support estimates of the SSE and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site. SER at 2-180. Section 100.23(d) states that the SSE for a site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface. Section 2.5.2 of NUREG-0800 provides guidance concerning the evaluation of the proposed SSE, and RG 1.165 provides guidance regarding the use of PSHA to address the uncertainties inherent in estimating ground motion at the ESP site.

First, the Staff found that the Applicant adequately characterized the overall seismic sources at the ESP site. SER at 2-183. The Staff also concluded that the Applicant's descriptions of the NMSZ and the SRSZ are accurate and sufficient to address the need for updated EPRI sources and to calculate the SSE for the ESP site. SER at 2-183. In addition, the Staff concurred with the Applicant's decision to use the original EPRI seismicity parameters based on its comparison of the updated seismic catalog to the original EPRI catalog. SER at 2-183.

Second, the Staff concluded that the Applicant's description of the PSHA parameters and procedures for the ESP site, as clarified through several RAI responses, is reasonably accurate and adequate. SER at 2-188. The Staff concurred with the Applicant on its conservative approaches in overlapping the new characteristic NMSZ onto the original EPRI

source model, and in using only attenuation relationships for the mid-continent to estimate ground motion, although the ESP site is located in the extended Mississippi embayment. SER at 2-188. In addition, the applicant also used point of closest approach, which assumes earthquakes along the three segments of the NMSZ as point sources at the southernmost end of each fault with the closest distance to the ESP site.

Third, the Staff concluded that the Applicant generally used an acceptable approach to characterize the site shear wave properties to the appropriate depth required by the reference rock used in the EPRI ground motion attenuation relationships in order to obtain the site-specific seismic wave responses. SER at 2-188.

Fourth, the Staff found that because of the narrow range in the magnitudes of the controlling earthquakes, it was appropriate to use the Applicant's chosen approach, the 2A approach described in NUREG/CR 6728, "Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-consistent Ground Motion Spectra Guidelines". The Staff therefore concluded that SERI's description of the site responses and its approach in deriving the site soil response are reasonably accurate and adequate. SER at 2-188.

Finally, the Staff considered the SSE developed for the ESP site to be consistent with Appendix S to 10 C.F.R. Part 50, which defines the SSE as the "vibratory ground motion for which certain structures, systems and components must be designed to remain functional." The Staff concluded that the Applicant's approach to calculating the SSE for the ESP site is also consistent with the requirements of 10 C.F.R. §§ 100.23(c) and (d) and RG 1.165, and that the Applicant's description of the SSE and the subsequent operating-basis earthquake ("OBE") is accurate and adequate. SER at 2-189.

Based on the facts and reasoning set forth above with respect to vibratory ground motion, the Staff found that: (1) the Applicant provided a thorough characterization of the seismic sources surrounding the site, as required by 10 C.F.R. § 100.23; (2) the Applicant

adequately addressed the uncertainties inherent in the characterization of these seismic sources through a PSHA, which follows the guidance provided in RG 1.165; (3) the controlling earthquakes and associated ground motion derived from the Applicant's PSHA are generally consistent with the seismogenic region surrounding the ESP site; and (4) the Applicant's SSE was determined in accordance with RG 1.165 and Section 2.5.2 of NUREG-0800. SER at 2-189. Accordingly, the Staff concluded that the proposed ESP site is acceptable from a geological and seismological standpoint and meets the requirements of 10 C.F.R. § 100.23. SER at 2-189.

Surface Faulting

The Applicant described the potential for tectonic fault rupture at the ESP site. SER at 2-189. The Applicant performed the following investigations to assess the potential for surface faulting at and within an 8 kilometer (5-mile) radius of the ESP site:

- compilation and review of existing data
- interpretation of aerial photography
- discussions with current researchers in the area
- review of seismicity
- field reconnaissance

SER at 2-190. The Applicant stated that a wealth of information is available for the site regarding the surface faulting studies. The information comes from three primary sources: (1) previous research for the existing GGNS; (2) published and unpublished geologic maps from USGS, the State of Mississippi, and the University of Memphis; and (3) seismicity data compiled from published journal articles and evaluated as part of the Applicant's study. SER at 2-190. The Applicant performed field reconnaissance and interpreted aerial photography, which it used to produce an updated map of surficial deposits and geomorphology for the site location. SER at 2-190. The Applicant used the new map, in combination with other

preexisting maps, to verify the absence of subsurface faulting or other forms of tectonic and nontectonic deformation by showing the surface of buried stratigraphic layers. SER at 2-190.

The Staff and its USGS advisors visited the ESP site and met with the Applicant to assist in confirming its interpretations, assumptions, and conclusions concerning potential surface deformation. SER at 2-192. Specific areas of the Staff's review included the geological, seismological, and geophysical investigations, previous investigations, geological evidence or absence of evidence of surface deformation, correlation of an earthquake with capable tectonic sources, characterization of capable tectonic sources, zones of Quaternary deformation requiring detailed fault investigation, and the potential for surface tectonic deformation at the site. SER at 2-193.

The Staff focused its review on the adequacy of the Applicant's investigations to ascertain the potential for surface deformation that could affect the site. SER at 2-193. The Staff reviewed the Applicant's summary of previous site investigations recorded in the updated final safety analysis report ("UFSAR") along with the Applicant's recent investigations, and concluded that the Applicant adequately investigated the potential for surface deformation in the site area. SER at 2-193. The Staff and its USGS consultants also visited the site area and did not observe any evidence for Quaternary tectonic activity near the site. SER at 2-193. The Staff concluded that the Applicant adequately investigated the potential for surface deformation, as required by 10 C.F.R. § 100.23, and concurred with the Applicant's conclusion that no evidence of Quaternary folding or faulting can be associated with these local faults. SER at 2-193.

In its review of the geological and seismological aspects of the ESP site, the Staff considered the pertinent information gathered by the Applicant during the regional and site-specific geological, seismological, and geophysical investigations. SER at 2-193. The Staff concluded that the Applicant performed its investigations in accordance with 10 C.F.R. § 100.23

and RG 1.165 and provided an adequate basis to establish that no capable tectonic sources exist in the site vicinity that would cause surface deformation in the site area. SER at 2-193. The Staff concluded that the site is suitable from the perspective of tectonic surface deformation and meets the requirements of 10 C.F.R. § 100.23. In addition, the Staff found that the Applicant appropriately considered the most severe surface deformation historically reported for the site and surrounding area, with sufficient margin for uncertainties, and that the application satisfies GDC 2 in that respect. SER at 2-193.