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 D:
CONTINUITY BETWEEN THE ESP STAGE AND COL STAGE

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

A.1. (TC) Thomas M. Cheng. I am employed as a Senior Structural/Geotechnical Engineer in the geosciences and Civil Engineering Branch A (EGCA), Division of Engineering (DE), Office of Reactor Regulation (NRR), 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. (TC) As part of the NRC Staff's health and safety review of the SERI ESP application, documented in NUREG-1840, the "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 that concerned geotechnical engineering related issues.

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 slope and foundation stability, the Board stated that it believed that the geotechnical stability

of the bearing strata and exterior earthen slopes (*i.e.*, bluff) is a fundamental site characteristic that could be quantified and addressed in this ESP application. Please address this comment.

A.3. (TC) The issues associated with both slope and foundation stability are not fundamental site characteristics since the importance of each of these site characteristics on plant behavior is directly a function of both soil properties and plant characteristics. The evaluation of foundation stability (or bearing capacity) is computed as the ratio of maximum demand (peak induced seismic toe pressure, for example) to available soil shear strength. The demand is directly related to characteristics of the plant, while the soil strength is directly related to the depth at which the plant foundation is to be located.

The evaluation of the effect of slope stability of the loess soils comprising the bluff is related not only to the strength parameters of the bluff material, but to the horizontal bluff standoff distance and depth of the foundation. Preliminary estimates made by SERI with the use of simplified slope stability evaluations and summarized in Section 2.5.5 of the SSAR indicated that, with stand-off distances of the order of 100 ft, potential failure surfaces through the bluff material would not intersect the plant cross-section.

The Staff believes that both of these issues can best be addressed at the COL stage, when specific plant geometries and locations are provided which can then be evaluated.

Q.4. In its November 6, 2006, Order, the Board identified certain issues to be addressed in connection with the mandatory hearing. With regard to slope and foundation stability, the Board requested that the Staff provide a comprehensive geologic description (*e.g.*, cross-sections, profiles, isopach maps, etc.) of site strata from beneath the ESP power block and extending to the Mississippi River, showing the location of the various strata at the site and using the most recent nomenclature that will be carried over to the COL stage. Please provide such a description and, in doing so, resolve any discrepancies between SSAR Figures 2.5-36, 2.5-37, and 2.5-75 to 2.5-77. Additionally, in this description, show (or eliminate as an

archaic term) the following: loess, upland complex, upland alluvium, new alluvium, young alluvium, old alluvium, clay-silt alluvium, sand-gravel alluvium, fill, Catahoula Formation.

A.4. (TC) A description of site soils is provided in SSAR section 2.5.4 and Entergy Grand Gulf ESP Engineering report ENTO002-ER-02 (ER-02). The figures in these documents show cross-sections of the site strata beneath and adjacent to the planned ESP power block location. The deposits were classified into four distinct layers based upon evaluation of sample texture, grain-size, estimated relative density (based on Standard Penetration Test [SPT] and Cone Penetrometer Test [CPT] measurements) and color. Stratigraphic profiles estimated from these identifications were developed and are shown in Figures ER-02-5 through 7. These are based on the few sample evaluations from the three ESP borings along with the borings available from the GGNS investigations. The primary soil layers are:

1. Loess - a medium stiff, slightly to moderately plastic, silt or clayey silt; average SPT blow counts between 5 and 13; shear wave velocities of 800 to 900 fps;
2. Upland Complex Alluvium - generally stiff interbedded sand, clayey sand, gravelly sand and sandy gravel with little fines content and little or no plasticity; SPT blow counts of 20 to 85; shear wave velocity of 800 to 1,800 fps;
3. Upland Complex Old Alluvium - interbedded clayey sands, silty sands and gravelly sands typically exhibiting poorer sorting than alluvium materials above; SPT blow counts of 33 to 85 bpf; shear wave velocity of 1,000 to 2,600 fps;
4. Catahoula Formation - a very stiff, hard clay to claystone material; one SPT sample with blow count of 82 bpf; shear wave velocity estimated from 1,600 to 2,800 fps;

Localized fill was placed at or near plant grade level to fill local swales that crossed the site. This fill was placed in a generally uncontrolled manner and consists of excavated loess materials. Since this material will be excavated during construction of any new facilities, its engineering significance is relatively minor except for the possible impact on surface facilities and/or

embedded components. The Staff will conduct an evaluation when the excavation information is available during the COL stage. The specific terminology used to characterize the alluvium does not impact the engineering properties of the site soils that control the assessments of suitability of the site for new plant construction. In some cases, the Staff may perform confirmatory analysis to support its conclusions.

SSAR Figures 2.5-75 through 2.5-77 present site cross-sections, which incorporate the material descriptions generated from the samples taken from the few available borings drilled for the ESP evaluation together with older borings taken for the construction of the currently operating GGNS. The layer interfaces are sketched thereon using the data available from the borings. Revision 1 of SSAR Figure 2.5-76 shows the cross-section of site strata beneath the planned ESP power block and the geotechnical information extended to the Mississippi River. In this cross-section, the boring log for Boring 3 is presented in Revision 1 of SSAR Figure 2.5-37. In Figure 2.5-77, the boring log for Boring-2A, the deepest available boring for this cross-section, is presented in Figure 2.5-36. The information presented on these logs includes the descriptors from the Unified Soil Classification System, which are descriptors based essentially on grain size distributions, measured in the laboratory or visually estimated from the sample inspections. These descriptors are used to estimate, along with sample SPT blow counts, potential engineering properties of the site soils.

The comparison of Revision 1 of SSAR Figures 2.5-36 and 2.5-37 with Revision 1 of SSAR Figures 2.5-75 through 2.5-77 indicates that a zone of filled material is noted at the top of Soil Boring WLA-3B (between Elevation 134 ft and Elevation 110 ft) in SSAR Figure 2.5-76. This zone of filled material is not shown in SSAR Figure 2.5-37. Based on the Applicant's commitment in its response to RAI 2.5.4-11, which states that soils at the plant foundation depth have a minimum shear wave velocity of 1000 fps (SER at 2-236), the soil material including the fill above Elevation minus 5 ft will potentially be removed for the construction of the plant

foundation mat as shown in Revision 1 of SSAR Figures 2.5-75 through 2.5-77 and Figure 2.5.5-1 (RAI Figure 2.5.5.1-1). SER at 2-244. Based on the above discussion, this discrepancy will not affect the construction of the plant foundation.

Q.5. In its November 6, 2006, Order, the Board identified certain issues to be addressed in connection with the mandatory hearing. With regard to slope and foundation stability, the Board requested that the Staff provide existing geotechnical information with specific emphasis on the shear strength, creep, and consolidation characteristics of the loess, alluvium, and Catahoula Formation. Please provide this information.

A.5. (TC) Existing geotechnical information for the significant layers of the site profile is presented in SSAR Section 2.5.4.1.1 and ER-02. SER at 2-194. The Catahoula formation, the deepest soil layer encountered in the ESP site investigation, is described as a rock-like formation with high shear strengths as indicated by the high SPT blow count shown for Boring 3 (Figure 2.5-36). The shear wave velocity measured is on average about 2,000 fps, generally considered acceptably stiff for nuclear facilities. The alluvium layers encountered higher up in the profile have blow counts of the order of 30 to 40 bpf with shear wave velocity of on average 1,000 to 1,500 fps. According SSAR Section 2.5.4.1, this material is to be the foundation soil on which the plant basemat will be located (SSAR Figures 2.5-76, -77). The SSAR Section 2.5.4.1 indicates that this material is at a depth of about 120 to 140 ft below the ground surface. The softer materials encountered in the borings, primarily the fill and loess soils, have lower recorded SPT blow counts and shear wave velocities that fall below 1,000 fps. Assuming that the foundation depth of the basemat is maintained at from 120 ft to 140 ft below grade, these loess soils will only impact the plant facility along the walls, but will not affect the foundation response. The stiffer soils providing support to the plant tend to be stiff and are generally not susceptible to liquefaction and creep. The upper loess soils, encountered at depths of about 70 ft, tend to be fine-grained, relatively soft and potentially susceptible to sloughing along the bluff; these soils

are not acceptable to provide primary support to the plant. The impact of potential slope erosion needs to be carefully evaluated during the COL stage since slope erosion, even though not influencing the primary support capacity of the stiffer soil layers, can have an impact on seismic stresses due to the unbalanced profile on both sides of the plant. However, since in the SSAR the Applicant restricts the location of the power block foundation to distances of greater than 100 ft from the bluff area on the west side of the plant site, the effect of slope erosion is insignificant. (SER at 2-243).

Q.6. In its November 6, 2006, Order, the Board identified certain issues to be addressed in connection with the mandatory hearing. With regard to slope and foundation stability, the Board requested that the Staff provide a discussion of the potential for slope deformations of the bluff due to creep and/or retrogressive movements. Please discuss the potential for slope deformations of the bluff due to creep and/or retrogressive movements.

A.6. (TC) As shown in SSAR Figure 2.5-76 (Revision 1), the fine-grained soils (colluvium and/or old landslide deposits derived from loess) along the bluff are known to be susceptible to sloughing and local slope failure over time. This behavior may also be influenced by flooding effects from the Mississippi due to undercutting of the slope face. These slope effects could result in unbalanced static and dynamic loads on the plant structures, which may not have been incorporated into the standard plant design. Such unbalanced forces can influence anticipated site settlements, calculated seismic induced stresses, and the design of plant structures. These responses are all related to both the horizontal standoff distance from the bluff and the foundation depth of the power block structures. In addition, all the current techniques used for seismic analyses are based on the assumption of uniform site conditions on all sides of the plant facility. If these unbalanced configurations occur at the site, the potential impact of the site condition on induced seismic stresses needs to be evaluated. Although the Staff believes that, based on its past review experience, these effects on seismic design forces

and plant floor response spectra will be small, the basis for this judgment needs to be verified at the COL stage, as described in COL Action Item 2.5-10. SER at 2-243.

Q.7. In its November 6, 2006, Order, the Board identified certain issues to be addressed in connection with the mandatory hearing. With regard to slope and foundation stability, the Board requested that the Staff provide a description of the impacts of flooding on erosion of the bluff and slough material on the bluff as it might affect the integrity of the plant. Please describe the impacts of flooding on erosion of the bluff and slough material on the bluff as it might affect the integrity of the plant.

A.7. (TC, GB) During its review of the design basis flood in the Mississippi River, the Staff, in consultation with the U.S. Army Corps of Engineers, determined that the static flood water surface elevation would not be substantially greater than 103 ft mean sea level (MSL), because of the large discharge capacity of the Mississippi River flood-plain west of the levees, once the levees are overtopped. The bluff on the east bank, adjacent to the ESP site, is not protected by engineered revetments from erosion due to river flooding. As a result of a design basis flood, the static flood water surface elevation of 103 ft MSL would result in the inundation of the gradually sloping portion of the bluff and, to a smaller extent, the steeply sloping portion of the bluff. In RAI 2.5.5-1, the Staff requested that the Applicant perform an evaluation to demonstrate the expected behavior of the loess escarpment (bluff) or the extent to which such movements will not occur. In its response, the Applicant noted that it modified the ESP site plan to restrict the location of the proposed power block area (PPBA) to a distance of over 100 ft from the bluff area on the west side of the site, and the foundation level will potentially be up to 130 ft below grade, which is in the zone of the old alluvium. SER at 2-243. The Applicant also stated that, based on a qualitative assessment of stability, the hazard to the ESP site from potential future movements of the loess soils is very low to none. The Staff concurs with this assessment.

Therefore, the impacts of flooding on erosion of the bluff and slough material on the bluff are not expected to affect the integrity of the plant.

Q.8. In its November 6, 2006, Order, the Board identified certain issues to be addressed in connection with the mandatory hearing. With regard to slope and foundation stability, the Board requested that the Staff provide technical analyses that support the opinions expressed in FSER §§ 2.5.4 and 2.5.5 including, but not limited to (i) stability analyses of existing bluff under varying conditions (including high water table conditions, plant setbacks, etc.) to indicate degree of safety; (ii) ground water flow estimates into excavation or measured values from previous construction for existing plant; (iii) bounding values of typical plant loads to verify no fatal flaw. Please provide these requested analyses.

A.8. (TC) The following evaluations were made to address the three items mentioned in this question.

(i) To evaluate the potential effect of a slope failure through the loess material of the bluff on a proposed plant, a simple linear (plane) failure surface assumption was made. Using the estimated shear strength parameter indicated by the Applicant for the loess material, the potential horizontal extent of the failure surface (or break out point at plant grade) can be estimated. This calculation directly led to the conclusion that from a static point of view, a bluff stand-off distance of the order of 100 ft would minimize the potential effect of a slope failure on the plant.

(ii) Ground water flow estimates into the excavation were not made for this evaluation since such inflows can be directly controlled during excavation and construction by means of dewatering schemes typically used during such heavy construction. Previous experience with similar construction of the GGNS indicates that no unusual ground water conditions would be encountered during this new construction.

(iii) Presuming that the depth of the plant foundation will be located in the stiff old alluvium materials at a depth of up to 130 ft below grade (SSAR Figure 2.5-76), the loss of any passive pressure capacity on the west side of the plant by a slope failure through the loess material will not be a major loss since bottom friction as well as lateral capacity through the alluvium should provide enough total capacity required to overcome the lateral seismic demands on the plant. Since bounding calculations for these effects depend upon the specific plant footprint dimensions and depth, this analysis needs to be confirmed during the COL stage evaluations when the specific plant configuration is known.