UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 27, 2015

Mr. Joseph W. Shea
Vice President, Nuclear Licensing
Tennessee Valley Authority
1101 Market Street, LP 3D-C
Chattanooga, TN 37402

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2 - STAFF ASSESSMENT OF INFORMATION PROVIDED PURSUANT TO TITLE 10 OF THE *CODE OF FEDERAL REGULATIONS* PART 50, SECTION 50.54(f), SEISMIC HAZARD REEVALUATIONS RELATING TO RECOMMENDATION 2.1 OF THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT (TAC NOS. MF3767 AND MF3768)

Dear Mr. Shea:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Part 50, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The purpose of that request was to gather information concerning, in part, seismic hazards at each operating reactor site and to enable the NRC staff, using present-day NRC requirements and guidance, to determine whether licenses should be modified, suspended, or revoked.

By letter dated March 31, 2014, Tennessee Valley Authority (the licensee, TVA) responded to this request for Sequoyah Nuclear Plant, Units 1 and 2 (Sequoyah).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for Sequoyah and, as documented in the enclosed staff assessment, determined that you provided sufficient information in response to Enclosure 1, Items (1) – (3), (5), (7) and screening review portion of Item (4) of the 50.54(f) letter. Further, the staff concludes that the licensee's reevaluated seismic hazard is suitable for other actions associated with Near-Term Task Force Recommendation 2.1, "Seismic".

Contingent upon the NRC's review and acceptance of TVA's expedited seismic evaluation process and seismic risk evaluation including the high frequency and spent fuel pool evaluations (i.e., Items (4), (6), (8), and (9)) for Sequoyah, the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter will be completed.

If you have any questions, please contact me at (301) 415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,

Frankie Vega, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-327 and 50-328

Enclosure:
Staff Assessment of Seismic
Hazard Evaluation and Screening Report

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO SEISMIC HAZARD AND SCREENING REPORT

SEQUOYAH NUCLEAR PLANT, UNITS. 1 AND 2

DOCKET NOS. 50-327 AND 50-328

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), the U.S. Nuclear Regulatory Commission (NRC or Commission) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) "Conditions of license" (hereafter referred to as the "50.54(f) letter"). The request and other regulatory actions were issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in the "Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident" (NRC, 2011b)[1]. In particular, the NRC Near-Term Task Force (NTTF) Recommendation 2.1, and subsequent Staff Requirements Memoranda (SRM) associated with Commission Papers SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d), instructed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f). Enclosure 1 to the 50.54(f) letter requests that addressees perform a reevaluation of the seismic hazards at their sites using present-day NRC requirements and guidance to develop a ground motion response spectrum (GMRS).

The required response section of Enclosure 1 requests that each addressee provide the following information:

(1) Site-specific hazard curves (common fractiles and mean) over a range of spectral frequencies and annual exceedance frequencies,

(2) Site-specific, performance-based GMRS developed from the new site-specific seismic hazard curves at the control point elevation,

(3) Safe Shutdown Earthquake (SSE) ground motion values including specification of the control point elevation,

[1] Issued as an enclosure to Commission Paper SECY-11-0093 (NRC, 2011a).

(4) Comparison of the GMRS and SSE for screening purposes. High-frequency evaluation (if necessary),

(5) Additional information such as insights from NTTF Recommendation 2.3 walkdown and estimates of plant seismic capacity developed from previous risk assessments to inform NRC screening and prioritization,

(6) Interim evaluation and actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the risk evaluation (if necessary),

(7) Statement if a seismic risk evaluation is necessary,

(8) Seismic risk evaluation (if necessary), and

(9) Spent fuel pool (SFP) evaluation (if necessary).

Present-day NRC requirements and guidance with respect to characterizing seismic hazards use a probabilistic approach in order to develop a risk-informed performance-based GMRS for the site. Regulatory Guide (RG) 1.208, A Performance-based Approach to Define the Site-Specific Earthquake Ground Motion, describes this approach. As described in the 50.54(f) letter, if the reevaluated seismic hazard, as characterized by the GMRS, is not bounded by the current plant design-basis SSE, further seismic risk evaluation of the plant is merited.

By letter dated November 27, 2012 (Keithline, 2012),the Nuclear Energy Institute (NEI) submitted Electric Power Research Institute (EPRI) report "Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1 Seismic" (EPRI, 2012), hereafter referred to as the SPID. The SPID supplements the 50.54(f) letter with guidance necessary to perform seismic reevaluations and report the results to NRC in a manner that will address the Requested Information Items in Enclosure 1 of the 50.54(f) letter. By letter dated February 15, 2013 (NRC, 2013b), the staff endorsed the SPID.

The required response section of Enclosure 1 to the 50.54(f) letter specifies that Central and Eastern United States (CEUS) licensees provide their Seismic Hazard and Screening Report (SHSR) by 1.5 years after issuance of the 50.54(f) letter. However, in order to complete its update of the EPRI seismic ground motion models (GMM) for the CEUS (EPRI, 2013), industry proposed a six-month extension to March 31, 2014, for submitting the SHSR. Industry also proposed that licensees perform an expedited assessment, referred to as the Augmented Approach, for addressing the requested interim evaluation (Item 6 above), which would use a simplified assessment to demonstrate that certain key pieces of plant equipment for core cooling and containment functions, given a loss of all alternating current (ac) power, would be able to withstand a seismic hazard up to two times the design-basis. Attachment 2 to the April 9, 2013, letter (Pietrangelo, 2013) provides a revised schedule for plants needing to perform (1) the Augmented Approach by implementing the Expedited Seismic Evaluation Process (ESEP) and (2) a seismic risk evaluation. By letter dated May 7, 2013 (NRC, 2013a), the NRC determined that the modified schedule was acceptable and by letter dated August 28, 2013 (NRC, 2013c), the

NRC determined that the updated GMM (EPRI, 2013) is an acceptable GMM for use by CEUS plants in developing a plant-specific GMRS.

By letter dated April 9, 2013 (Pietrangelo, 2013), industry committed to following the SPID to develop the SHSR for existing nuclear power plants. By letter dated March 31, 2014 (Shea, 2014), Tennessee Valley Authority (TVA, the licensee) submitted partial site response information for Sequoyah Nuclear Plant, Units 1 and 2. By letter dated March 31, 2014 (Shea, 2014), TVA submitted its SHSR.

2.0 REGULATORY BACKGROUND

The structures, systems, and components (SSCs) important to safety in operating nuclear power plants are designed either in accordance with, or meet the intent of Appendix A to 10 CFR Part 50, General Design Criteria (GDC) 2: "Design Bases for Protection Against Natural Phenomena;" and Appendix A to 10 CFR Part 100, "Reactor Site Criteria." GDC 2 states that SSCs important to safety at nuclear power plants shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

For initial licensing, each licensee was required to develop and maintain design bases that, as defined by 10 CFR 50.2, identify the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for the design. The design bases for the SSCs reflect appropriate consideration of the most severe natural phenomena that had been historically reported for the site and surrounding area. The design bases also considered limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The seismic design bases for currently operating nuclear power plants were either developed in accordance with, or meet the intent of GDC 2 and 10 CFR Part 100, Appendix A. Although the regulatory requirements in Appendix A to 10 CFR Part 100 are fundamentally deterministic, the NRC process for determining the seismic design-basis ground motions for new reactor applications after January 10, 1997, as described in 10 CFR 100.23, requires that uncertainties be addressed through an appropriate analysis such as a probabilistic seismic hazard analysis (PSHA).

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. On March 12, 2012, the NRC staff issued requests for licensees to reevaluate the seismic hazards at their sites using present-day NRC requirements and guidance, and identify actions planned to address plant-specific vulnerabilities associated with the updated seismic hazards.

Attachment 1 to Enclosure 1 of the 50.54(f) letter describes an acceptable approach for performing the seismic hazard reevaluation for plants located in the CEUS. Licensees are expected to use the CEUS Seismic Source Characterization (CEUS-SSC) model in NUREG-2115 (NRC, 2012b) along with the appropriate EPRI (2004, 2006) GMMs. The SPID provides further guidance regarding the appropriate use of GMMs for the CEUS. Specifically, Section 2.3 of the SPID recommends the use of the updated GMM (EPRI, 2013) and, as such, licensees used the NRC-endorsed updated EPRI GMM instead of the older EPRI (2004, 2006) GMM to develop PSHA base rock hazard curves. Finally, Attachment 1 requested that licensees conduct an evaluation of the local site response in order to develop site-specific hazard curves and GMRS for comparison with the plant SSE.

2.1 Screening Evaluation Results

The licensee's SHSR indicated that the site GMRS exceeds the SSE for Sequoyah, Units 1 and 2 over the frequency range of 3 to 10 Hertz (Hz). Therefore, the licensee will perform a seismic risk evaluation and a SFP evaluation. Further, the licensee indicated that since the GMRS also exceeds the SSE above 10 Hz, that a high-frequency confirmation will be performed.

On May 9, 2014 (NRC, 2014), the staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation. As indicated in the letter, the staff confirmed the licensee's screening results. The licensee's GMRS, as well as the confirmatory GMRS developed by the staff, exceed the SSE for Sequoyah, Units 1 and 2 above 3 Hz. Therefore, a seismic risk evaluation, SFP evaluation and a high-frequency confirmation are merited for Sequoyah, Units 1 and 2.

3.0 TECHNICAL EVALUATION

The NRC staff evaluated the licensee's submittal to determine if the provided information responded appropriately to Enclosure 1 of the 50.54(f) letter with respect to characterizing the reevaluated seismic hazard.

3.1 Plant Seismic Design-Basis

Enclosure 1 of the 50.54(f) letter requests the licensee provide the SSE ground motion values as well as the specification of the control point elevation(s) for comparison to the GMRS. For operating reactors licensed before 1997, the SSE is the plant licensing basis earthquake and is characterized by (1) a peak ground acceleration (PGA) value which anchors the response spectra at high frequencies (typically at 33 Hz for the existing fleet of NuclearPower Plants); (2) a response spectrum shape which depicts the amplified response at all frequencies below the PGA; and (3) a control point where the SSE is defined.

In Section 3.1 of the SHSR, the licensee described its seismic design bases for Sequoyah, Units 1 and 2. The licensee stated that the SSE for Sequoyah, Units 1 and 2 is based on evaluation of the maximum earthquake potential for the region surrounding the Sequoyah site. Considering the historic seismicity of the site region, the maximum potential earthquake was determined to be intensity VIII on the Modified Mercalli Intensity (MMI) scale. The licensee states in its final safety analysis report (FSAR) that although this earthquake is listed as intensity VIII, there is reason to believe it should have been rated as intensity VII on MMI scale (TVA, FSAR, Section 2.5.2.4 and Figure 2.5.-14). The SSE is defined in terms of a PGA and a design response spectrum. Considering a site intensity of VIII, the licensee used a PGA of 0.18 g (18 percent of the acceleration due to Earth's gravity) as the anchor point for the SSE.

In Section 3.2 of the SHSR, the licensee defined the SSE control point elevation at the base of the Containment Structure, which corresponds to a depth of 64 ft (Elevation 641 ft Mean Sea Level), and is the "Deepest Structure Foundation Control Point" (AMEC, 2013).

The staff reviewed the licensee's description of its updated SSE for Sequoyah, Units 1 and 2 in the SHSR. Based on a comparison of the SSE presented in the SHSR with the Section 2.5.2.4 in the Updated FSAR (UFSAR) (TVA, Amendment 24), the staff found minor discrepancies between the shapes of the SSE spectra, although both spectra are anchored at 0.18 g. Section 2.5.2.4 describes the SSE spectrum as a smooth modified Housner spectrum, which was derived based on the average response spectrum from a set of four artificial time histories and is shown in FSAR Figure 2.5.2-14. As such, the staff performed its screening evaluation for Units 1 and 2 based on a comparison of the GMRS with the licensee's SSE, as described in the UFSAR (TVA, Amendment 24) rather than that SSE design spectrum derived from the seven data points in the SHSR. Because the two SSE spectra do not differ significantly in amplitude or shape, the screening comparison with the GMRS is not affected. Finally based on review of the SHSR and the UFSAR, the staff confirmed that the licensee's control point elevation for Sequoyah, Units 1 and 2 is consistent with the guidance provided in the SPID.

3.2 Probabilistic Seismic Hazard Analysis

In Section 2.2 of the SHSR, the licensee stated that, in accordance with the 50.54(f) letter and the SPID, it performed a PSHA using the CEUS SSC model and the updated EPRI GMM for the CEUS (EPRI, 2013). For its PSHA, the licensee used a minimum moment magnitude (**M**) of 5.0 as specified in the 50.54(f) letter. The licensee further stated that it included CEUS SSC background sources out to a distance of 400 miles [640 km] and included the Charleston, Commerce, Eastern Rift Margin Fault northern segment, Eastern Rift Margin Fault southern segment, Marianna, New Madrid Fault System, and Wabash Valley repeated large magnitude earthquake (RLME) sources, which lie within 620 miles [1,000 km] of the Sequoyah site. The RLME sources are those source areas or faults for which more than one large magnitude (**M** ≥ 6.5) earthquake has occurred in the historical or paleo-earthquake (geologic evidence for prehistoric seismicity) record. The licensee used the mid-continent version of the updated EPRI GMM (EPRI, 2013) for each of the CEUS SSC sources. Consistent with the SPID, the licensee did not provide base rock seismic hazard curves because it performed a site response analysis to determine the control point seismic hazard curves. The licensee provided its control point seismic hazard curves in Section 2.3.7 of its SHSR. The staff's review of the licensee's control point seismic hazard curves is provided in Section 3.3 of this staff assessment.

As part of its confirmatory analysis of the licensee's GMRS, the staff performed PSHA calculations for base rock site conditions at the Sequoyah site. As input, the staff used the CEUS-SSC model as documented in NUREG-2115 (NRC, 2012b) along with the updated EPRI GMM (EPRI, 2013). Consistent with the guidance provided in the SPID, the staff included all CEUS SSC background seismic sources within a 310 mi [500 km] radius of the Sequoyah site. In addition, the staff included all of the RLME sources falling within a 620 mi [1,000 km] radius of the site, which includes the Charleston, Commerce, Eastern Rift Margin Fault northern segment, Eastern Rift Margin Fault southern segment, Marianna, New Madrid Fault System, and Wabash Valley RLME sources. For each of the CEUS SSC sources used in the PSHA, the staff used the mid-continent version of the updated EPRI GMM (EPRI, 2013). The staff used the resulting base rock seismic hazard curves together with a confirmatory site response analysis, described in the next section, to develop control point seismic hazard curves and a GMRS for comparison with the licensee's results.

Based on review of the SHSR, the staff concludes that the licensee appropriately followed the guidance provided in the SPID for selecting the PSHA input models and parameters for the site. This includes the licensee's use and implementation of the CEUS-SSC model and the updated EPRI GMM.

3.3 Site Response Evaluation

After completing PSHA calculations for reference rock site conditions, Attachment 1 to Enclosure 1 of the 50.54(f) letter requests that the licensee provide a GMRS developed from the site-specific seismic hazard curves at the control point elevation. In addition, the 50.54(f) letter specifies that the subsurface site response model, for both soil and rock sites, should extend to sufficient depth to reach the reference or base rock conditions, as defined in the ground motion models used in the PSHA. To develop site-specific hazard curves at the control point elevation, Attachment 1 requests that licensees perform a site response analysis. Detailed site response analyses were not typically performed for many of older the operating plants; therefore, Appendix B of the SPID provides detailed guidance on the development of site-specific amplification factors (including the treatment of uncertainty) for sites that do not have detailed, measured soil and rock parameters to extensive depths.

The purpose of the site response analysis is to determine the site amplification that will occur as a result of bedrock ground motions propagating upwards through the soil/rock column to the surface. The critical parameters that determine what frequencies of ground motion are affected by the upward propagation of bedrock motions are the layering of soil and/or soft rock, the thicknesses of these layers, the shear-wave velocities and low-strain damping of the layers, and the degree to which the shear modulus and damping change with increasing input bedrock amplitude.

3.3.1 Site Base Case Profiles

The licensee provided a detailed description of the site profile in Sections 2.3.1 and 2.3.2 of its SHSR based on the information documented in AMEC (2013) and EPRI (2014). The information used to create the geologic profile at the site is shown in Tables 2.3.1-1 and 2.3.1-2 of the SHSR. According to Table 2.3.1-1, the SSE Control Point at a depth of 64 ft, lies on interbedded limestone and shale bedrock of the Conasauga Formation of Middle Cambrian age. Tables 2.3.1-1 and 2.3.1-2 show the stratigraphic column, description, depth, best estimate shear-wave velocity and the upper and lower velocity range. Depth to hard crystalline basement rock is about 6,200 ft [1,890 m] (EPRI, 2014). In Table 2.3.1-2 the shear-wave velocities range from about 6,000-7,000 ft/s [1,829-2,130 m/s] in the upper 6,000 ft [1,829m] (below the control point). These velocity measurements for the upper portions of the profile are based on the geophysical measurements at the Watts Bar Nuclear Plant site, which consists of similar rock formations (AMEC, 2013) as that for the Sequoyah site.

The licensee used the measured shear-wave velocities to a depth of 103 ft [31 m] in several boreholes at the site, the information on the regional geologic profile (summarized in SHSR Table 2.3.1-1), and the guidance in Appendix B of the SPID to develop shear-wave velocity profiles for the Sequoyah site. To develop the best estimate for base case shear-wave velocity profile, the licensee set the initial shear-wave velocity at the SSE control point (at an elevation of 641 ft [202 m] MSL) to 6,000 ft/s [1,829 m/s]. Based on the range of shear-wave velocities that it measured at shallow depths (4,873 ft/s [1,485 m/s] to 9,697 ft/s [2,955 m/s]), the licensee used a factor of 1.57 (natural-log standard deviation of 0.35) to obtain the upper and lower range velocity profiles.

The licensee stated that no site-specific dynamic material properties were determined in the initial Sequoyah siting. Therefore, the licensee stated that it followed the SPID guidance for firm rock sites and selected two alternative characterizations of dynamic material behavior with equal weights. In the upper 500 ft [152 m], the licensee modeled the rock behavior as nonlinear using EPRI rock shear modulus and damping curves. For the other model, the licensee modeled the rock behavior as linear with a low-strain damping value of about 3 percent. For the profile below 500 ft [152 m] to the reference rock elevation at a depth of about 6,000 ft [1,829 m], the licensee modeled the rock behavior as linear and used a damping value of 1.25 percent.

To estimate kappa, which is combined hysteretic and intrinsic damping, from the rock, the licensee used the guidance in Appendix B-5.1.3.1 of the SPID (EPRI, 2012) for a firm rock site with at least 3,000 ft [1,000 m] in thickness. The resulting kappa values for the three profiles are 0.012, 0.020, and 0.006 sec for the best estimate, lower and upper base case profiles, respectively.

To account for randomness in material properties across the plant site, the licensee stated that it randomized its base case shear-wave velocity profiles in accordance with the SPID. In addition, the licensee randomized the depth to bedrock by 30 percent of the total profile thickness. The licensee stated that this randomization was included to provide a realistic broadening of the spectral peaks and to reflect random variations in depth-to-basement shear velocities across the footprint.

3.3.2 Site Response Method and Results

In Section 2.3.4 of its SHSR, the licensee stated that it followed the guidance in Appendix B of the SPID to develop input ground motions for the site response analysis and in Section 2.3.5, the licensee described its implementation of the random vibration theory (RVT) approach to perform its site response calculations. Finally, Section 2.3.6 of the SHSR shows the resulting amplification functions and associated uncertainties for two of the eleven input loading levels for the base case profile and EPRI rock shear modulus and damping curves.

In order to develop probabilistic site-specific control point hazard curves, as requested in Requested Information Item 1 of the 50.54(f) letter, the licensee used Method 3, described in Appendix B-6.0 of the SPID. The licensee's use of Method 3 involved computing the site-specific control point elevation hazard curves for a broad range of spectral accelerations by combining the site-specific bedrock hazard curves, determined from the initial PSHA (Section 3.2 of this assessment), and the amplification functions and their associated uncertainties, determined from the site response analysis.

3.3.3 Staff Confirmatory Analysis

To confirm the licensee's site response analysis, the staff performed site response calculations for the Sequoyah site. The staff independently developed shear-wave velocity profiles, damping values, and modeled the potential nonlinear behavior of the rock using measurements and geologic information provided in the Sequoyah FSAR, and the guidance in Appendix B of the SPID. For its site response calculations, the staff employed the RVT approach and developed input ground motions in accordance with Appendix B of the SPID.

The NRC staff developed three velocity profiles based on the up-hole and cross-hole shear-wave velocity measurements at the site as reported in the FSAR (TVA, Amendment 24, Tables 2.5.1-1 and 2.5.1-2). An investigation of the distribution of these measurements indicate nearly lognormal behavior with a median of 6,567 ft/s [2,002 m/s], and a natural-log standard deviation of 0.164. The NRC staff used these values to develop a set of three velocity profiles from the control point to a depth of 5,000 ft [1,524 m] above reference rock. Figure 3.3-1 of this assessment shows a comparison between the staff's and the licensee's base case profiles. The mean base-case velocity profile of the NRC staff is similar to that of the licensee. For the upper and lower base-case velocity profiles, the licensee used a scale factor of 1.57 (a natural-log standard deviation of 0.35) to reflect its understanding of the uncertainty. In contrast, the staff used a factor of 1.23 (a natural-log standard deviation of 0.164), to obtain the upper and lower base cases profiles, which reflects the staff's interpretation of potential variability in the firm sedimentary rock layers beneath the site.

Similar to the approach used by the licensee, the staff used the SPID guidance to characterize the dynamic material behavior of the site response profile. In the upper 500 ft [152 m], the staff used the same two models as the licensee to model the potential nonlinear behavior of the rock. In addition, the staff also modeled the rock as behaving linearly with a damping value of 1.25 percent below 500 ft [152 m]. To determine kappa, the staff used guidance provided in the SPID for sites with more than 3,000 ft [1,000 m] of firm sedimentary rock to estimate kappa. The NRC total kappa values for the best estimate, lower, and upper base case velocity profiles are 11, 19, and 7 ms, respectively. Finally, to account for aleatory variability in material properties across the plant site, the staff randomized its base case shear-wave velocity profiles following the SPID guidance and also randomized the depth to bedrock by 30 percent of the total profile thickness.

Figure 3.3-2 of this assessment shows a comparison of the staff's and the licensee's median site amplification functions and uncertainties for two of the eleven input loading levels. As shown in this figure, the licensee's amplification functions are somewhat higher than those of the staff's. These small differences in the amplification functions reflect the minor differences in the site response analyses performed by the staff and the licensee. These small differences are within the limits of uncertainty and as such judged by the staff to be reasonable.

Overall, the licensee's approach to modeling the subsurface rock properties and their uncertainty, results in similar site amplification factors with slight differences. As shown in Figure 3.3-3 of this assessment, the control point hazard curves of the licensee and NRC at 1 Hz, 10 Hz, and PGA are very similar, with licensee's slightly higher at all frequencies. Appendix B of the SPID provides guidance for performing site response analyses, including capturing the uncertainty for sites with less subsurface data; however, the guidance is neither entirely prescriptive nor comprehensive. As such, various approaches in performing site response analyses, including the modeling of uncertainty, are acceptable for this application.

In summary, the staff concludes that the licensee's site response was conducted using present-day guidance and methodology, including the NRC-endorsed SPID. The staff performed independent calculations which confirmed that the licensee's amplification factors and control point hazard curves adequately characterize the site response, including the uncertainty associated with the subsurface material properties, for the Sequoyah site.

3.4 Ground Motion Response Spectra

In Section 2.4 of the SHSR, the licensee stated that it used the control point hazard curves, described in SHSR Section 2.3.7, to develop the 10^{-4} and 10^{-5} (mean annual frequency of exceedance) uniform hazard response spectra (UHRS) and then computed the GMRS using the criteria in RG 1.208.

The staff independently calculated the 10^{-4} and 10^{-5} UHRS using the results of its confirmatory PSHA and site response analyses, as described in Sections 3.2 and 3.3 of this assessment, respectively. Figure 3.4-1 of this assessment shows a comparison of the GMRS determined by the licensee to that determined by the staff.

As shown in Figure 3.4-1, the licensee's GMRS shape is generally similar to that calculated by the staff at frequencies less than 10 Hz. However, NRC staff's confirmatory GMRS is somewhat lower than the licensees in the 10-35 Hz range, and slightly higher above 40 Hz. As described in Section 3.3 of this assessment, the staff concludes that these minor differences over the higher frequency range are primarily due to the differences in the site response analyses performed by the licensee and staff. The staff concludes that these differences are acceptable because the licensee followed the guidance provided in the SPID with respect to both the PSHA and site response analysis for the Sequoyah site.

The staff confirms that the licensee used the present-day guidance and methodology outlined in RG 1.208 and the SPID to calculate the horizontal GMRS, as requested in the 50.54(f) letter. The staff performed both a PSHA and site response confirmatory analysis and achieved results consistent with the licensee's horizontal GMRS. As such, the staff concludes that the GMRS determined by the licensee adequately characterizes the reevaluated hazard for the Sequoyah site. Therefore, this GMRS is suitable for use in subsequent evaluations and confirmations, as needed, for the response to the 50.54(f) letter.

4.0 CONCLUSION

The NRC staff reviewed the information provided by the licensee for the reevaluated seismic hazard for the Sequoyah site. Based on its review, the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, it appropriately characterized the site given the information available, and met the intent of the guidance for determining the reevaluated seismic hazard. Based upon the preceding analysis, the NRC staff concludes that the licensee provided an acceptable response to Requested Information Items (1) – (3), (5), (7), and screening review portion of Item (4), identified in Enclosure 1 of the 50.54(f) letter, dated March 12, 2012. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF Recommendation 2.1, "Seismic".

In reaching this determination, staff confirms the licensee's conclusion that the licensee's GMRS for the Sequoyah site exceeds the SSE at approximately 3 to 100 Hz range. As such, Sequoyah Units, 1 and 2 screen in to perform a plant seismic risk evaluation, SFP evaluation and high-frequency confirmation. The licensee indicated that the high frequency confirmation would be performed as part of its seismic risk evaluation. NRC review and acceptance of the TVA seismic risk evaluation which will include the high-frequency confirmation, ESEP interim evaluation and SFP evaluation (i.e., Items (4), (6), (8), and (9)) for Sequoyah, Units 1 and 2 will complete the items requested in Enclosure 1 of the 50.54(f) letter.

REFERENCES

Note: ADAMS Accession Nos. refer to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

U.S. Nuclear Regulatory Commission Documents and Publications

NRC (U.S. Nuclear Regulatory Commission), 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC (U.S. Nuclear Regulatory Commission), 2011b, "Recommendations for Enhancing Reactor Safety in the 21st Century: The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," Enclosure to SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC (U.S. Nuclear Regulatory Commission), 2011c, "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

NRC (U.S. Nuclear Regulatory Commission), 2011d, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," Commission Paper SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

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Figure 3.3-1 Plot of Staff's and Licensee's Base Case Shear-Wave Velocity Profiles for the Sequoyah site

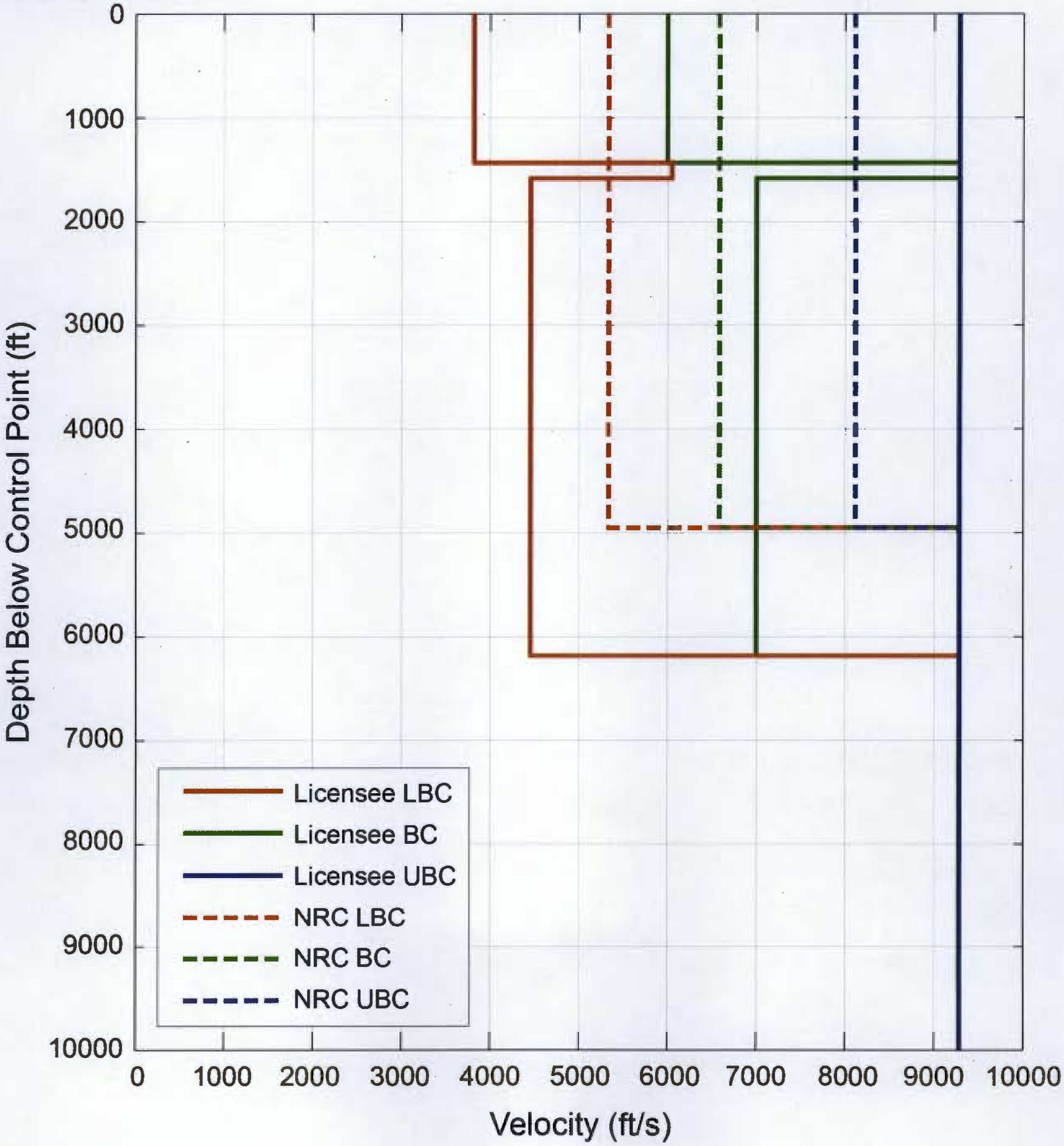


Figure 3.3- 1 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for the Sequoyah site

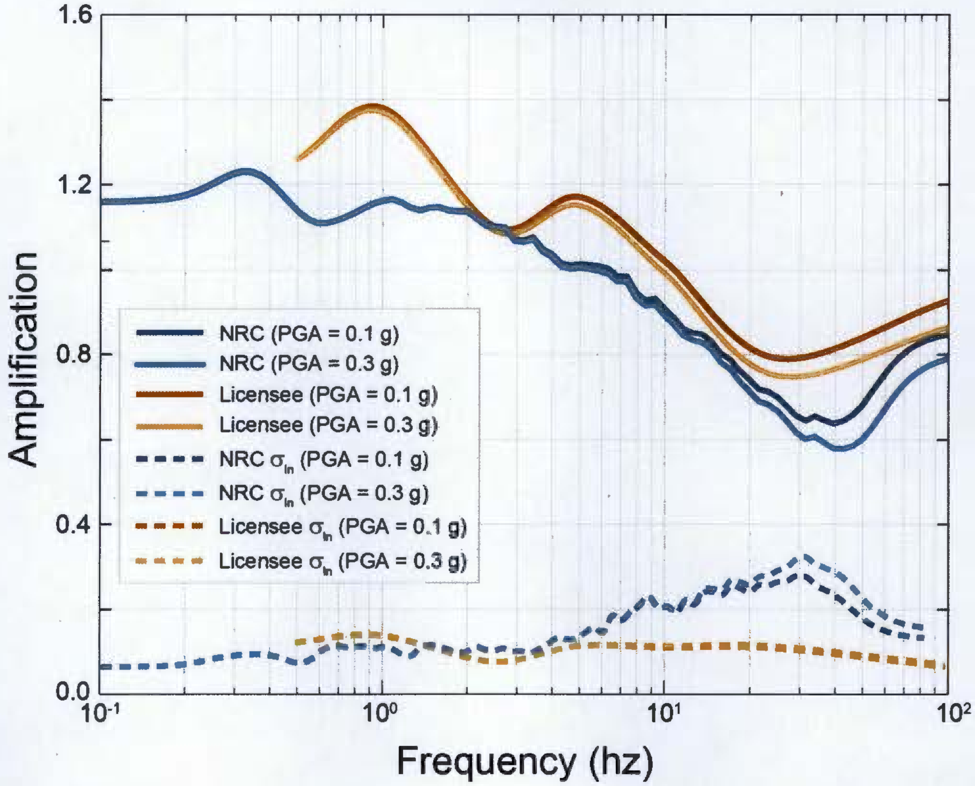


Figure 3.3-2 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at t a Variety of Frequencies for the Sequoyah site

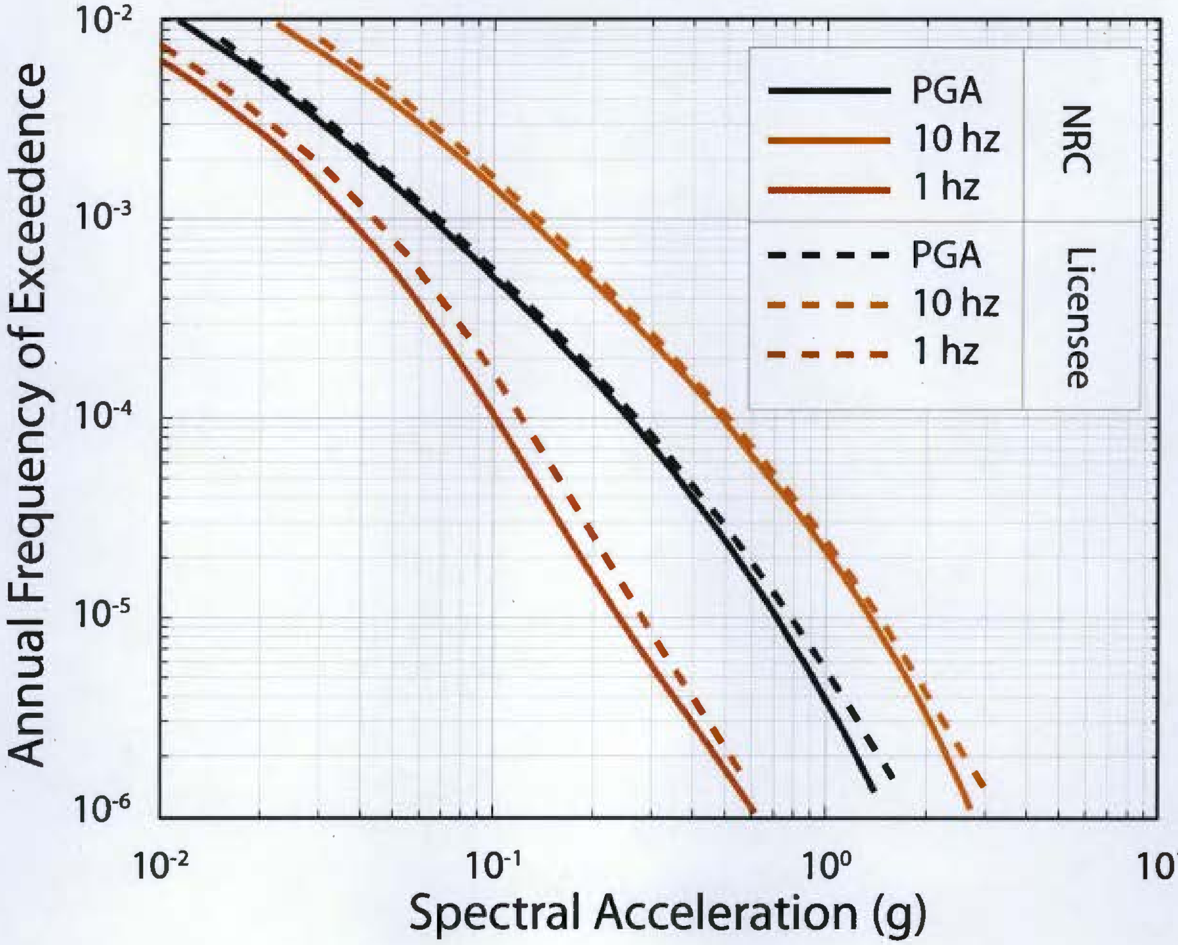
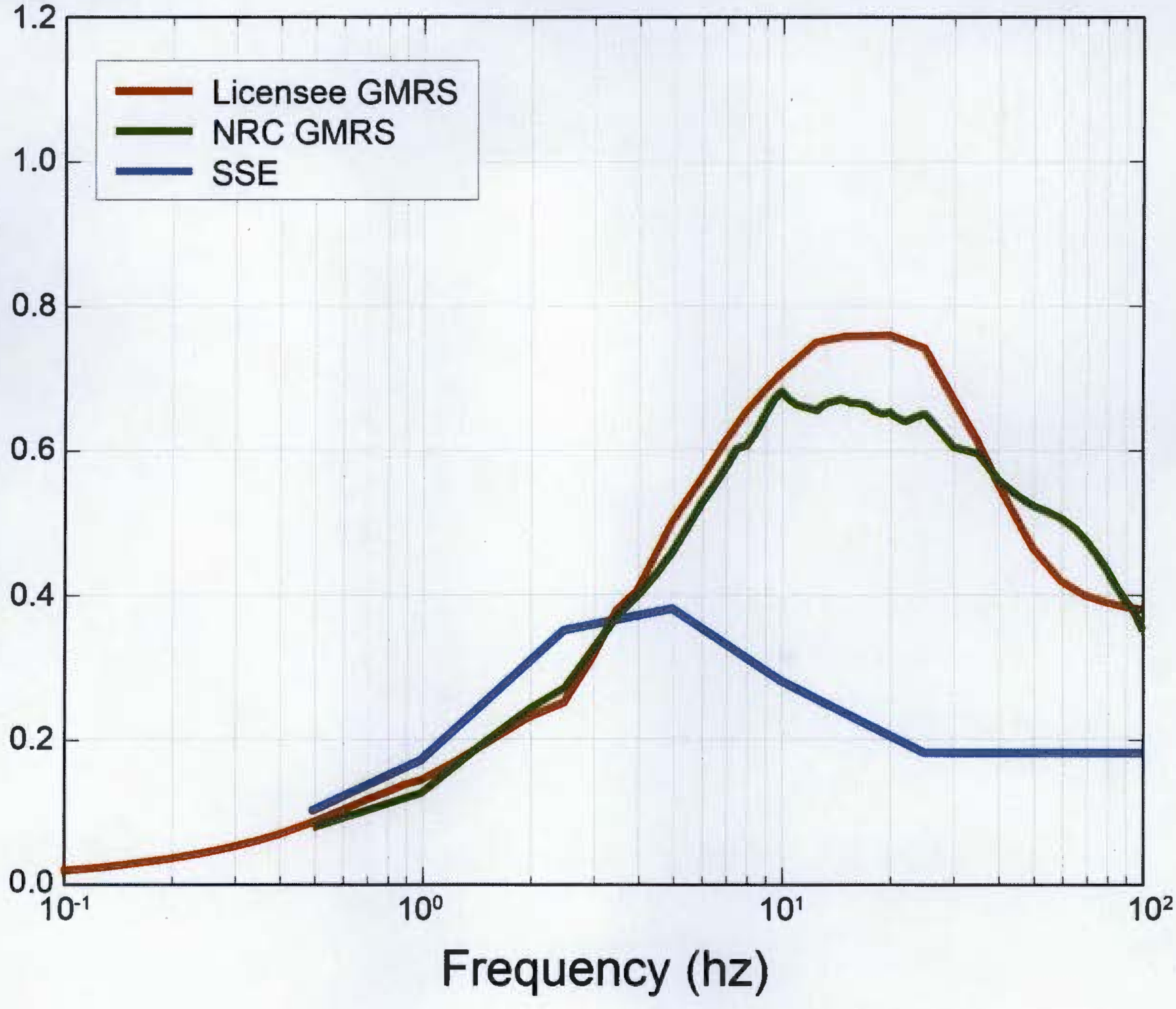


Figure 3.4-1 Comparison of the Staff's GMRS, Licensee's GMRS, and the SSE for the Sequoyah site



If you have any questions, please contact me at (301) 415-1617 or at Frankie.Vega@nrc.gov.

Sincerely,

/RA/

Frankie Vega, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-327 and 50-328

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