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

July 8, 2015

Mr. Joseph W. Shea
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Tennessee Valley Authority
1101 Market Street, LP 3D-C
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SUBJECT: BELLEFONTE 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 FOR RECOMMENDATION 2.1 OF THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT (TAC NOS. MF3944 AND MF3945)

Dear Mr. Shea:

On 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 (TVA), responded to this request for Bellefonte Nuclear Plant, Units 1 and 2 (Bellefonte).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for Bellefonte 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 the comparison 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 NRC's review and acceptance of TVA's seismic risk evaluation including the high frequency and spent fuel pool evaluations (i.e., Items (4), (8), and (9)) for Bellefonte, 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 G. Vega, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-438 and 50-439

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

BELLEFONTE NUCLEAR PLANT, UNITS. 1 AND 2

DOCKET NOS. 50-438 AND 50-439

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 (SRMs) 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 site(s) 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,

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

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

(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 (NRC, 2007), 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 called the SPID. The SPID supplements the 50.54(f) letter with guidance necessary to perform seismic reevaluations and report the results to the 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 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 ground motion model for use by CEUS plants in developing a plant-specific GMRS.

By letter dated April 9, 2013 (Pietrangelo, 2013), industry committed to follow the SPID to develop the SHSR for operating nuclear power plants. By letter dated September 12, 2013 (Shea, 2013), Tennessee Valley Authority (TVA, the licensee) submitted at least partial site response information for Bellefonte Nuclear Plant, Units 1 and 2 (Bellefonte). By letter dated March 31, 2014 (Shea, 2014a), the licensee submitted SHSR. By letter dated December 3, 2014 (Shea, 2014b), the licensee supplemented its SHSR in response to a request for additional information (RAI).

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." The 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 staff issued the request for licensees to reevaluate the seismic hazards at their site(s) using present-day NRC requirements and guidance, and identify actions planned to address plant-specific vulnerabilities associated with the updated seismic hazard.

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) GMM. 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

By letter dated March 31, 2014 (Shea, 2014a), the licensee provided the SHSR for Bellefonte, Units 1 and 2. The licensee's SHSR indicated that the Bellefonte site GMRS exceeded the SSE in the 1 to 10 Hz range as well as above 10 Hertz (Hz). As such, the licensee concluded that a plant seismic risk evaluation, SFP evaluation and high-frequency confirmation would be performed for Bellefonte, Units 1 and 2.

On May 9, 2014 (NRC, 2014a), the staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation applying the SPID screening criteria. As indicated in the letter, the staff confirmed the licensee's screening results based on both the licensee's GMRS, as well as the staff's confirmatory GMRS exceed the SSE for Bellefonte, Units 1 and 2 above approximately 8 Hz. Therefore, a seismic risk evaluation, SFP evaluation and a high-frequency confirmation are merited for Bellefonte, Units 1 and 2.

By letter dated October 21, 2014 (Shea, 2014c), TVA requested a proposed alternative submittal schedule for milestones responsive to the 50.54(f) letter. At the time of issuance of the 50.54(f) letter, TVA construction permits for Bellefonte, Units 1 and 2 were in a deferred plant status. The licensee states that "as of the date of this letter, a timeframe for notifying the NRC of plans to reactivate construction ... has not yet been established." The proposed schedule changes align the schedule for compliance with the 50.54(f) letter to TVA's determination and notification to the NRC of their decision to reactivate construction at Bellefonte, Units 1 and 2. By letter dated February 26, 2015 (NRC, 2015), the NRC staff determined that the proposed alternative submittal schedule is acceptable.

3.0 TECHNICAL EVALUATION

The NRC staff evaluated the licensee's submittals to determine if the provided information followed the guidance, characterized the site sufficiently with the information available, and if the licensee responded appropriately to Enclosure 1 of the 50.54(f) letter with respect to 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 ground motion 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 Nuclear Power 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 3.0 of its SHSR, the licensee described its seismic design-basis. The licensee stated that the SSE response spectrum for Bellefonte is anchored at 0.18 g (18 percent of the acceleration due to earth's gravity). The PGA of 0.18 g is based on the 1897 Giles County, Virginia earthquake. The response spectrum shape is based on Regulatory Guide (RG) 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants". The licensee specified that the control point for the SSE is located at the top of hard rock at the reactor building foundation elevation of 612 ft (187 m). The licensee relied on final analysis report (FSAR) Subsection 2.5.2.4 which states that the control point is located at the reactor building foundation (TVA, 1986).

The staff reviewed the licensee's description of the SSE for Bellefonte and confirms that the SSE, as described in the SHSR, is consistent with information provided in the FSAR. Additionally, the staff confirms that the licensee's SSE control point elevation is consistent with information provided in the Bellefonte FSARs and guidance provided in the SPID.

3.2 Probabilistic Seismic Hazard Analysis

In Section 2.2 of its 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). The licensee used a minimum magnitude of **M**5.0, as specified in the 50.54(f) letter, as well as the midcontinent version of the updated EPRI GMM for each CEUS-SSC source. The licensee further stated that it included the CEUS-SSC background sources out to a distance of 400 mi (640 km) around the site; however, the licensee did not provide specific information on which background source zones it used in performing its PSHA calculations. Additionally, the licensee did not specify the Repeated Large Magnitude Earthquake sources (RLME) that it used for its PSHA calculations. 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. As such, by letter dated November 5, 2014 (NRC, 2014b), the staff requested that the licensee specify the source zones, and RLMEs (if any) used to calculate seismic hazard at the Bellefonte site. By letter dated December 3, 2014 (Shea, 2014b), the licensee provided a list of all source zones, as well as the RLMEs used to conduct its PSHA. In addition to using all relevant background sources out to a distance of 400 mi (640 km), the licensee used the Charleston, Commerce, Eastern Rift Margin – North, Eastern Rift Margin – South, Marianna, New Madrid Fault System (NMFS), and Wabash Valley RLME sources which are within a radius of 610 mi (1,000 km) of the site.

As part of its confirmatory analysis of the licensee's GMRS, the staff performed PSHA calculations for the Bellefonte site. As input, the staff used the CEUS-SSC model 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 Bellefonte site. In addition, the staff included all of the RLME sources falling within a 620 mi (1,000 km) radius of the site, including the Meers RLME, which the licensee did not include for its PSHA as the majority of this source lies beyond 1,000 mi (610 km) from the Bellefonte site. 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), except for the Extended Continental Crust-Gulf Coast (ECC GC) background seismic source. For the ECC GC source zone, the staff used the Gulf Coast version of the updated EPRI GMM (EPRI, 2013). Figure 3.2-1 of this assessment shows the hazard curves developed by the licensee and those developed by the staff using the CEUS-SSC at three of the seven spectral frequencies. As expected, the hazard curves developed by the licensee and the staff are similar at all frequencies.

Based on its review of the SHSR and the licensee's RAI response, the NRC staff concludes that the licensee appropriately followed 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 the PSHA calculations for reference rock site conditions, Attachment 1 to Enclosure 1 of the 50.54(f) letter requests that licensees 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 generic 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 licensee's perform a site response analysis.

The licensee stated that the rocks underlying the Bellefonte site are composed primarily of limestones in the Stones River Group, the Nashville Group, and the Sequatchie Formation. The uppermost Stones River Group is described as a limestone containing bands of dolomitic limestones, argillaceous and silty limestone, and cherty limestone. In its SHSR, the licensee stated that these limestones have a shear wave velocity of at least 9,280 feet per second (ft/s) (2,830 meters per second (m/s)), which is considered as reference rock according to guidance in the SPID. Therefore, the licensee did not perform a site response analysis for the Bellefonte site. As such, the licensee used the hard rock hazard curves from the PSHA as its control point hazard curves for determining the GMRS at the Bellefonte site.

The NRC staff reviewed the information in the SHSR, the Bellefonte, Units 1 and 2 FSAR (TVA, 1986), the Bellefonte, Units 3 and 4 FSAR (TVA, 2009) and confirmed that the Bellefonte site is characterized by hard rock and no site response analysis is required. The SSE control point is located on sound rock, which has a shear wave velocity of approximately 9,000 to greater than 11,000 ft/s (2,743 m/s – 3,353 m/s) according to the Bellefonte, Units 1 and 2 FSAR. Additionally, information based on modern data collection methods in the Bellefonte, Units 3 and 4 FSAR states that measured shear wave velocity in the upper 220 ft (67 m) is greater than 9,285 ft/s (2,830 m/s). The staff confirms that based on the shear wave velocity of the subsurface at the Bellefonte site and guidance in the SPID, a site response analysis is not necessary for this application.

3.4 Ground Motion Response Spectra

In Section 2.4 of its SHSR, the licensee stated that it used the control point seismic 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 NRC staff independently calculated the 10^{-4} and 10^{-5} UHRS using the results of its confirmatory PHSA, as described in Section 3.2 of this staff assessment. Figure 3.4-1 of this assessment shows a comparison of the GMRS determined by the licensee to that determined by the NRC staff. As shown in Figure 3.4-1 below, the licensee's GMRS shape and amplitude is nearly identical to that calculated by the NRC staff at all frequencies. The small differences that are present are attributed to differences in software used for hazard calculations.

The NRC staff confirms that the licensee used present-day guidance and methodology outline in RG 1.208 and the SPID to calculate the horizontal GMRS, as requested in the 50.54(f) letter. The NRC staff performed a confirmatory PSHA 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 Bellefonte 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 Bellefonte site. Based on its review, the NRC 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. An interim evaluation (Item (6)) is not necessary at this time because Bellefonte, Units 1 and 2 are in a deferred construction status. 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 comparison portion of Item (4), identified in Enclosure 1 of the 50.54(f) letter. Further, the licensee's reevaluated seismic hazard is acceptable to address other actions associated with NTTF recommendation 2.1 "Seismic".

In reaching this determination, the NRC staff confirmed the license's conclusion that the licensee's GMRS for the Bellefonte site exceeds the SSE above approximately 8 Hz. As such, a seismic risk evaluation, SFP evaluation, and high-frequency confirmation are merited on the revised Bellefonte schedule. The NRC review and acceptance of the TVA plant seismic risk evaluation, high-frequency confirmation, and SFP evaluation (i.e., Items (4), (8), and (9)) for Bellefonte, Units 1 and 2 will complete the items requested in Enclosure 1 of the 50.54(f) letter.

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Note: ADAMS Accession Nos. refers 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.

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Figure 3.2-1 Plot comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the Bellefonte Site

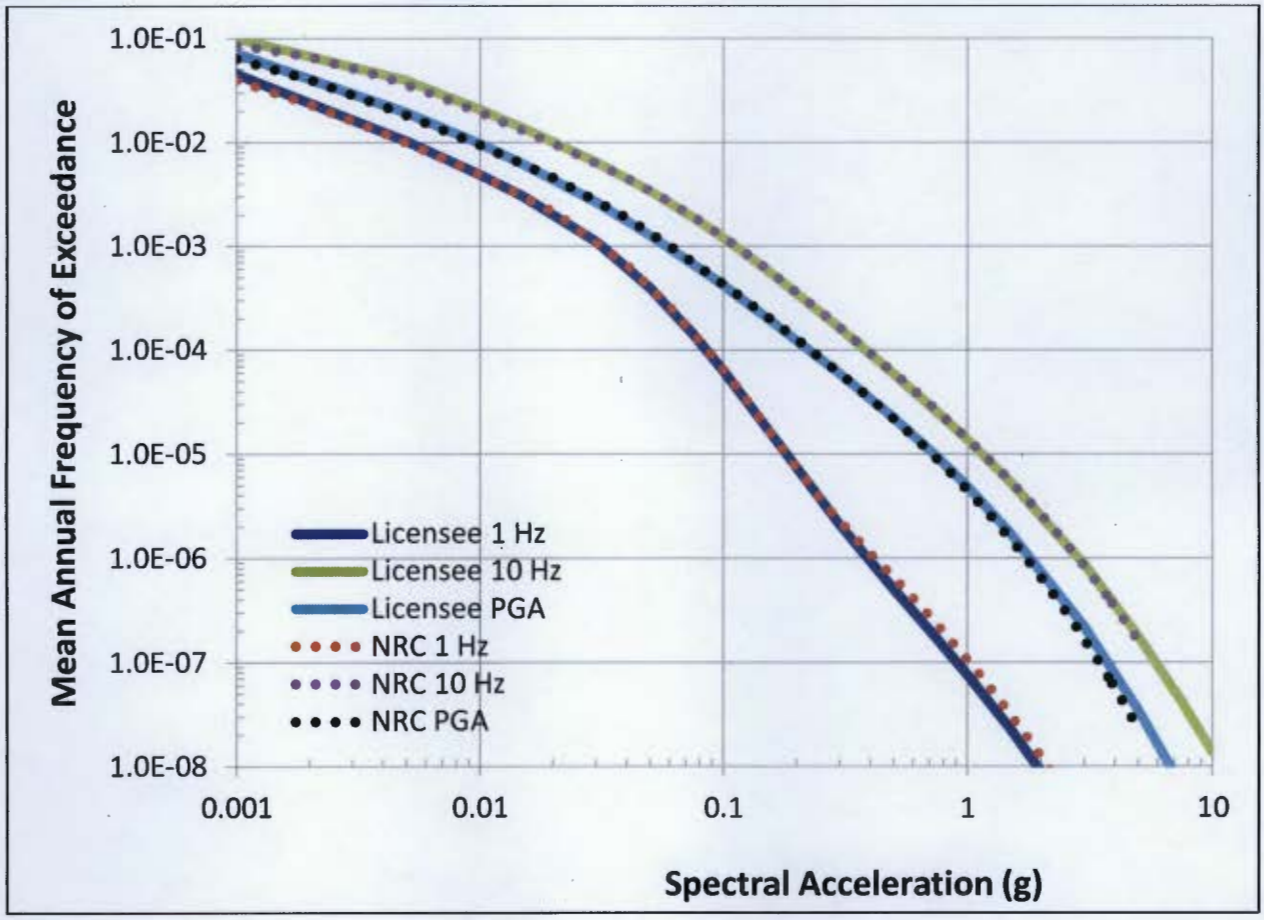
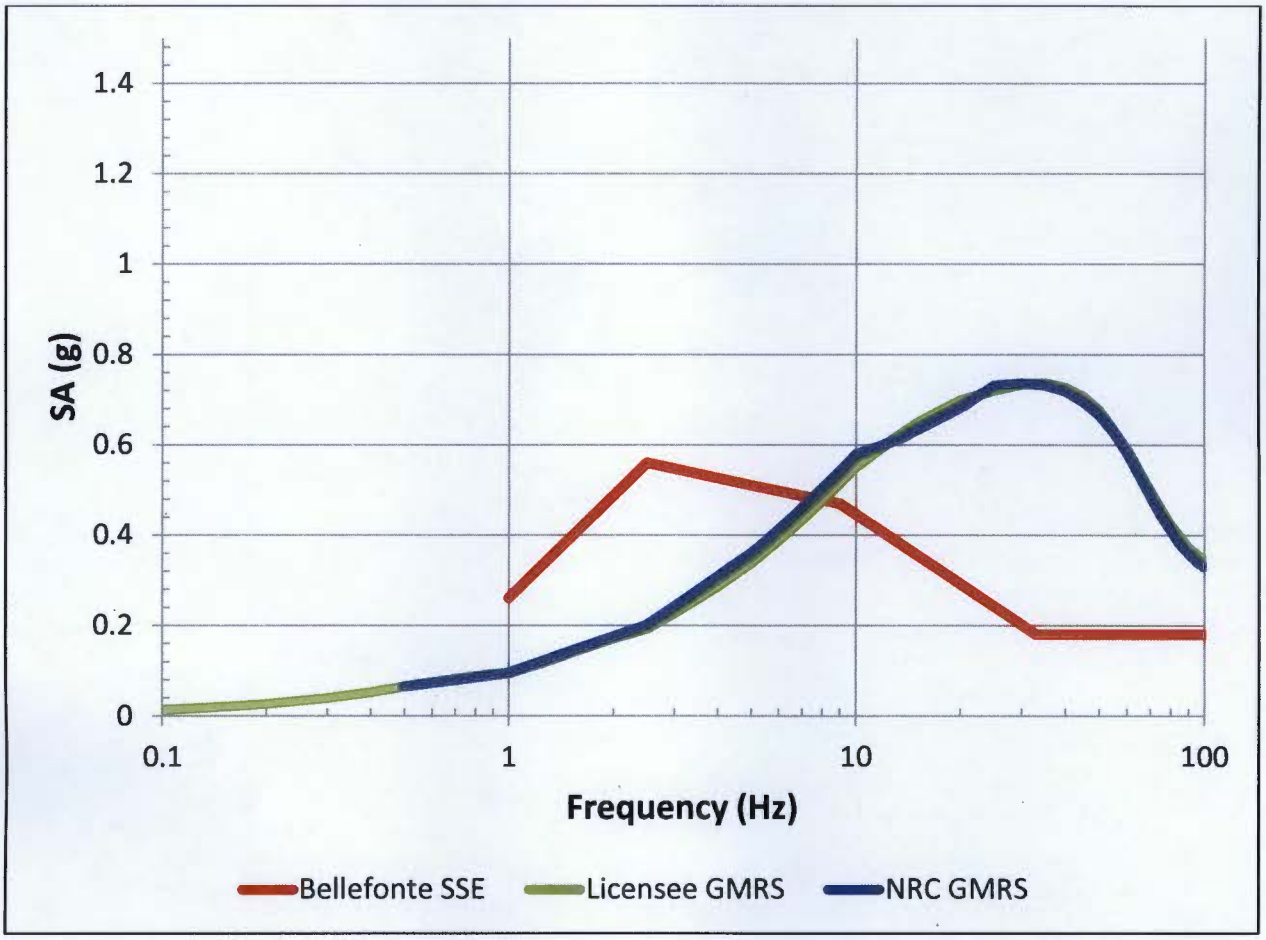


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the Bellefonte Units 1 and 2 SSE.



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

Sincerely,

/RA/

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

Docket Nos. 50-438 and 50-439

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Staff Assessment of Seismic
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