UNITED STATES
NUCLEAR REGULATORY COMMISSION
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December 15, 2015

Mr. David A. Heacock
President and Chief Nuclear Officer
Dominion Nuclear Connecticut, Inc.
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060

SUBJECT: MILLSTONE POWER STATION, UNITS 2 AND 3 - 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. MF3968 AND MF3969)

Dear Mr. Heacock:

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, Dominion Nuclear Connecticut, Inc (Dominion, the licensee), responded to this request for Millstone Power Station, Units 2 and 3 (Millstone).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for Millstone 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 NRC 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 staff's review and acceptance of Dominion's high frequency confirmation and spent fuel pool evaluation (i.e., Items (4) and (9)) and the full-scope Individual Plant Examination of External Events (IPEEE) relay chatter review (requested to meet the criteria for using an IPEEE program to demonstrate that a seismic risk evaluation (Item 8) is not merited) for Millstone, 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. 50-336 and 50-423

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

MILLSTONE POWER STATION, UNITS. 2 AND 3

DOCKET NOS. 50-336 AND 50-423

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 requested 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 licensees to submit Requested Information Items (1) through (7) within 1.5 years of the date of the 50.54(f) letter for sites within the Central and Eastern United States (CEUS). Specifically, the NRC requested 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,

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

(4) Comparison of the GMRS and SSE. A high-frequency (HF) 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) Selected risk evaluation approach (if 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 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 specified that 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. In addition, industry developed guidance, 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 of up to two times the design-basis. Attachment 2 to the April 9, 2013, letter provided a revised schedule for plants needing to perform (1) the Augmented Approach by implementing the Expedited Seismic Evaluation Process and (2) a seismic risk evaluation. By letter dated May 7, 2013 (NRC, 2013a), the NRC determined that the modified schedule was acceptable and in a 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 following the SPID to develop the SHSR for existing nuclear power plants. By letter dated September 12, 2013 (Grecheck, 2013), Dominion Nuclear Connecticut, Inc. (Dominion, the licensee) submitted at least partial site response information for Millstone Power Station, Units 2 and 3 (MPS2 and MPS3). By letter dated March 31, 2014 (Heacock, 2014), Dominion 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." 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 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, 2013a) 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 (Heacock), Dominion provided the SHSR for MPS2 and MPS3. The licensee's SHSR indicates that the site GMRS exceeds the site SSE for a portion of the frequency range between 1 to 10 Hertz (Hz). However, the licensee indicated that over the frequency range of 1 to 10 Hz, the GMRS is bounded by the site Individual Plant Examination of External Events (IPEEE) plant- level high confidence of low probability of failure (HCLPF) spectra (IHS) for MPS2 and MPS3. The licensee provided the evaluation of the IPEEE program screening criteria referenced in the SPID to allow screening credit for the plant capacity determined in the IPEEE program. As such, the licensee indicated that both MPS2 and MPS3 screen out of performing a plant seismic risk evaluation. At frequencies above 10 Hz, the GMRS exceeds the IHS. Therefore, the licensee stated that it will complete the relay chatter review specified in SPID Section 3.3.1 consistent with the NEI letter to NRC dated October 3, 2013 (Keithline, 2013), on the same schedule as the HF confirmation as proposed in the NEI letter dated April 9, 2013 (Pietrangelo, 2013), and accepted in NRC's letter dated May 7, 2013 (NRC, 2013a). The licensee stated that itwill also perform the HF confirmation per SPID Section 3.4, if the relay chatter review is not successful in demonstrating relay adequacy based on the GMRS. Finally, due to the GMRS exceeding the two SSE spectra in the 1 to 10 Hz frequency range, MPS2 and MPS3 screen-in to perform a SFP evaluation.

On May 9, 2014 (NRC, 2014a), the NRC staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation. In the letter, the NRC staff characterized the MPS site as conditionally screened-in, because additional information was needed to support a screening decision using the SPID IPEEE screening criteria and a prioritization decision. On November 21, 2014 (NRC, 2014b), the NRC staff issued a letter providing the outcome of its final seismic screening and prioritization results. The licensee's GMRS, as well as the staff's confirmatory GMRS, exceeds the SSE spectra for MPS2 and MPS3 over a portion of the frequency range of 1 to 10 Hz. However, the licensee demonstrated that the plant met the IPEEE program screening criteria in the SPID and the IHS for MPS2 and MPS3 bound the GMRS over the 1 to 10 Hz range, therefore, MPS2 and MPS3 were screened out for conducting a seismic risk evaluation. This screening decision is based on the licensee's commitment of the successful completion of the IPEEE relay chatter review in accordance with the IPEEE program screening criteria in the SPID. If the IPEEE relay chatter review is not successfully completed, the GMRS comparison would be with the SSE for the screening decision. Because the GMRS exceeds the SSE in the frequency range of approximately 6 to 10 Hz for MPS2 and 8 to 10 Hz for MPS3, MPS would screen in for a plant seismic risk evaluation. Additionally, the HF confirmation is not considered a substitute for the IPEEE relay chatter review. The GMRS exceeds the IHS above approximately 15 Hz for MPS2 and MPS3 and therefore, a HF confirmation is merited for MPS2 and MPS3. Finally, because the IPEEE program did not include the SFP, a SFP evaluation is merited.

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 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 3.1 of its SHSR, the licensee described its seismic design bases for MPS2 and MPS3. The licensee referred to the Final Safety Analysis Report (FSAR) to describe the development of the MPS2 and MPS3 SSE spectra. The MPS2 FSAR refers to the MPS3 FSAR regarding seismology for the site. The MPS3 FSAR states that the maximum earthquake potential for the site is an Intensity VII (Modified Mercalli Intensity) occurring 10 to 20 km from the site and corresponding to a peak ground acceleration of 0.10 g. Based on this intensity earthquake, the response spectral shape is conservatively anchored at a PGA of 0.17 g (17 percent of the acceleration due to earth's gravity). The MPS2 SSE has a Housner-shape spectrum and the MPS3 SSE has a Newmark-shape spectrum.

The licensee specified that the SSE control point is located at the foundation bearing elevation of the rock-founded safety related structures. The foundation and control point elevations are -2 ft. [-0.6 m] MSL for MPS2 and +15 ft. [4.6 m] mean sea level (MSL) for MPS3. Because the control points were similar, the licensee only used the MPS3 profile for site amplification calculations applicable to MPS2 and MPS3.

The NRC staff reviewed the licensee's description of its SSE for MPS2 and MPS3 in the SHSR for the MPS site. With regard to the two MPS site SSE spectra, based on its review of the SHSR and Final Safety Analysis Reports (Dominion, 2011a; Dominion, 2011b), the NRC staff confirmed that the licensee's two SSE spectra are defined in terms of a PGA of 0.17 g and design response spectra shapes, as described by the licensee. Finally, based on review of the SHSR and the FSARs (Dominion 2011a; Dominion, 2011b), the NRC staff confirmed that the licensee's control point elevation for MPS site SSE is defined at a depth of 15 ft. (4.6 m) below grade and is consistent with the 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). For its PSHA, the licensee used a minimum moment magnitude (M_w) 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 Charlevoix repeated large magnitude earthquake (RLME) source, which lies within 620 miles [1,000 km] of the site. The RLME sources are those source areas or faults for which more than one large magnitude (M_w >= 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 in SHSR Section 2.2.2 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 NRC staff performed its own PSHA calculations for base or reference rock conditions at the MPS site. As input, the NRC 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 NRC staff included all CEUS-SSC background seismic sources within a 310 mi [500 km] radius of the MPS site. In addition, the NRC staff included all of the RLME sources falling within a 620 mi [1000 km] radius of the site, which includes the Charlevoix RLME source. For each of the CEUS-SSC sources used in the PSHA, the NRC staff used the mid-continent version of the updated EPRI GMM (EPRI, 2013). The NRC 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 its review of the SHSR, the NRC 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 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 the reference or 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 licensees perform a site response analysis.

Detailed site response analyses were not typically performed for many of the older 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 detailed site profile descriptions in Sections 2.3.1 and 2.3.2 of its SHSR based on information provided in the MPS2 FSAR (Dominion, 2011a) and the MPS3 FSAR (Dominion, 2011b). The licensee stated that very dense basal till overlies bedrock at the MPS site. The bedrock consists of Ordovician Monson Gneiss from the control point to 2000 to 3700 ft. [610 to 1128 m] below the control point. The Monson Gneiss is underlain by Pre-Siluriann Brimfield Shist or Cambrian rock.

The licensee performed geophysical investigations for the MPS site consisted of borehole geophysical measurements including both cross-hole and down-hole P and S wave surveys. The licensee also performed refraction and reflection geophysical surveys. The borehole measurements extended to an elevation of approximately -100 ft. [-30 m] MSL. The licensee provided a brief description of the subsurface materials in terms of geologic units and thicknesses in its SHSR. The licensee's geophysical measurements and analyses indicate a seismic velocity of 6,500 feet per second (fps) [1981 meters per second (mps)] for the near surface Monson Gneiss.

To characterize the subsurface geology, the licensee developed three site base case profiles. The licensee developed the upper 115 ft. [35 m] of the middle, or best estimate, profile using measured shear-wave velocities from the nearby cross-hole and down-hole geophysical investigations near MPS3. The licensee used a velocity gradient to estimate the shear wave velocities at greater depths. Based on Table 2.3.2-1 of the SHSR, the licensee assumed that the depth to reference rock occurs at either 1,715 ft. [523 m] or 5,500 ft. [1676 m] below the control point. To capture the uncertainty in the subsurface shear wave velocities, the licensee developed lower and upper velocity profiles using a natural log standard deviation of 0.35. Based on the assumed velocity gradient and the two depths to reference rock, the licensee develop both shallow and deep alternative profiles for the lower and best estimate velocity profiles. Figure 3.3-1 of this assessment shows the licensee's five shear-wave velocity base case profiles, which consist of two shallow and deep alternatives for the lower and best estimate profiles and a single upper velocity profile.

In Section 2.3.2.1 of its SHSR, the licensee assumed that the rock material responded in a linear manner, independent of shear strain, at all depths. The damping used by the licensee was based on estimates of site kappa, as described below.

The licensee used kappa to estimate damping for the site response analyses. Kappa is measured in units of seconds (sec), and is the damping contributed by both intrinsic hysteretic damping as well as scattering due to wave propagation in heterogeneous material. The licensee used an empirical relationship relating kappa with the time weighted average shear wave velocity over the upper 100 ft. [30 m] to estimate kappa for the deeper lower and best estimate velocity profiles, which have a depth to reference rock greater than 3,000 ft. [1,000 m]. For the shallower cases where the depth to reference rock was less than 3,000 ft. [1,000 m], a quality factor, Q, of 40 was assigned to each layer to estimate site kappa. The licensee estimated upper and lower case kappa values for the deeper velocity profiles using a logarithmic standard deviation of 0.4. The licensee did not consider uncertainty in kappa for the two shallower profiles. The licensee reported total base case site kappa values of 0.0184 and 0.0113 sec for the deep lower and best estimate base case velocity profiles, respectively. While for the shallow lower and best estimate base case velocity profiles, the licensee reported kappa values of 0.0124 and 0.0053 sec, respectively. Finally, the licensee did not estimate kappa for the upper velocity profile because the shear wave velocity exceeded the reference rock value of 9280 fps [2830 mps].

To account for randomness in material properties across the plant site, the licensee stated that it randomized its base case shear-wave velocity profiles using a lognormal standard deviation of 0.25 in the top 115 ft. [35 m] and 0.15 below. The licensee implemented a beta distribution to model randomness by ± 20 percent in soil and rock strata thickness. In addition, the licensee randomized damping ratios using a lognormal standard deviation of 0.30.

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), 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 NRC staff performed its own site response calculations for the MPS site. The NRC staff independently developed a shear-wave velocity profile and damping values using measurements and geologic information provided in the MPS3 FSAR (Dominion, 2011b), and Appendix B of the SPID. For its site response calculations, the NRC staff employed the RVT approach and developed input ground motions in accordance with Appendix B of the SPID.

As described above, the licensee used multiple geophysical methods to characterize the shear wave velocity in the upper 100 to 115 ft. [30 – 35 m] of the site. As such, the NRC staff used the same best estimate velocity profile as that used by the licensee. In order to characterize the uncertainty in the shear wave velocity, the NRC staff developed lower and upper velocity profiles. Because the NRC staff considered the MPS site to be fairly well characterized, the NRC staff used a log normal standard deviation of 0.15 over the upper 100 ft. [30 m] to develop the lower and upper base case velocity profiles. Below 100 ft., the NRC staff increased the log normal standard deviation to 0.2 to reflect a larger degree of uncertainty. The NRC staff did not use a greater standard deviation below 100 ft. [30 m] to prevent a large artificial impedance contrast at that depth. The NRC staff used a linear velocity gradient below 100 ft. [30 m] with the depth to reference rock at 3700 ft. [1128 m] for the base case and lower base case velocity profiles. For the upper velocity profile, using the velocity gradient resulted in a total profile thickness of 500 ft. [152 m] before reaching reference rock. Because the depth to reference rock varied significantly between the base case and upper case profile, the NRC staff did not implement any additional uncertainty for the depth to reference rock. Figure 3.3-1 of this assessment shows a comparison of the staff's and licensee's base case velocity profiles for the MPS site. As shown in Figure 3.3-1, the staff's lower and upper velocity profiles are closer to the middle or best estimate base case profile than the licensee's lower and upper profiles.

Similar to the approach used by the licensee, the NRC staff assumed linear behavior for the rock beneath MPS in response to the range of input loading motions. To determine kappa, the NRC staff used the SPID guidance for CEUS rock sites with at least 3000 ft. [1000 m] of firm sedimentary rock for the lower and best estimate base case velocity profiles. For the upper base case velocity profile, the staff used a quality factor, Q, of 40 to determine kappa. The NRC staff estimated kappa values of 0.0139, 0.0113, and 0.0075 sec for the lower, base and upper velocity profiles, respectively. The NRC staff used a natural log standard deviation value of 0.4 to calculate lower and upper values of kappa for each of the three base case velocity profiles.

Figure 3.3-2 of this assessment shows a comparison of the staff's and licensee's median site amplification functions and uncertainties (log normal standard deviation) for one of the eleven input loading levels. The results from this one loading level are typical of other loading levels, and there is only moderate difference in amplification at frequencies greater than 20 Hz as the loading level increases due to modeling the rock behavior as linear.

Overall, the licensee's approach to modeling the subsurface rock properties and uncertainty results in similar site amplification factors and standard deviation of the amplification factor. Therefore, as shown in Figure 3.3-3 of this assessment the control point seismic hazard curves and the resulting GMRS, as discussed below are similar. Because the licensee followed the guidance in the SPID for its site response analysis, these differences are acceptable to the NRC staff. 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 the response to the 50.54(f) letter.

In summary, the NRC staff concludes that the licensee's site response was conducted using present-day guidance and methodology, including the NRC-endorsed SPID. The NRC 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 MPS site.

3.4 Ground Motion Response Spectra

In Section 2.4 of its 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 NRC 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 staff assessment, respectively. 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, the licensee's GMRS is similar to that calculated by the NRC staff with slight differences at frequencies greater than 20 Hz. The NRC 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 NRC staff. The NRC 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 MPS site.

The NRC 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 NRC staff performed both a PSHA and site response confirmatory analysis and achieved results consistent with the licensee's horizontal GMRS. As such, the NRC staff concludes that the GMRS determined by the licensee adequately characterizes the reevaluated hazard for the MPS 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 MPS 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. The NRC staff concluded that the licensee demonstrated meeting the IPEEE screening criteria in SPID, and therefore, the IHS could be used for comparison with the GMRS for the screening determination provided that the relay chatter review is completed. Based on the preceding analysis and with the successful completion of the IPEEE relay review, the staff concludes that the licensee provided an acceptable response to Requested Information Items (1) – (3), (5) – (7) and the comparison portion of (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 confirms the licensee's conclusion that the licensee will perform the full-scope IPEEE relay chatter review to complete the criteria for using an IPEEE program to demonstrate that a seismic risk evaluation (Item 8) is not merited, as described in the SPID. Further, the NRC staff confirmed the licensee's conclusion that the licensee's GMRS for the Millstone site exceeds the IHS over the frequency range of above 10 Hz. Therefore, HF confirmation portion of Item (4) is merited. A SFP evaluation (Item 9) is merited because the SFP was not included in the IPEEE program.

If the relay chatter review is not successful in demonstrating relay adequacy, then a case-by-case justification to a limited number of exceptions would be expected. Failure to meet the IPEEE program screening criteria in the SPID would merit screening by the SSE and then a seismic risk evaluation will be merited because the GMRS exceeds the SSE.

The NRC review and acceptance of Dominion's IPEEE relay chatter review, SFP evaluation, and HF confirmation will complete the Seismic Hazard Evaluation identified in Enclosure 1 of the 50.54(f) letter.

REFERENCES

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.

U.S. Nuclear Regulatory Commission Documents and Publications

NRC (U.S. Nuclear Regulatory Commission), 2007, A Performance-based Approach to Define the Site-Specific Earthquake Ground Motion, Regulatory Guide (RG) 1.208, March 2007.

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.

NRC (U.S. Nuclear Regulatory Commission), 2012a, letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, March 12, 2012, ADAMS Accession No. ML12053A340.

NRC (U.S. Nuclear Regulatory Commission), 2012b, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities", NUREG-2115, ADAMS stores the NUREG as multiple ADAMS documents, which are accessed through the web page http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr2115/.

NRC (U.S. Nuclear Regulatory Commission), 2013a. Letter From Eric J. Leeds, to Joseph Pollock, Executive Director NEI, Acceptance Letter for NEI Submittal of Augmented Approach, Ground Motion Model Update Project, and 10 CFR 50.54(f) Schedule Modifications Related to the NTTF Recommendation 2.1, Seismic Reevaluations, May 7, 2013, ADAMS Accession No. ML13106A331.

NRC (U.S. Nuclear Regulatory Commission), 2013b, letter from David L. Skeen, Director, Japan Lessons-Learned Directorate, to Joseph E. Pollock, Executive Director, Nuclear Energy Institute, Endorsement of Electric Power Research Institute Draft Report 1025287, "Seismic Evaluation Guidance," February 15, 2013, ADAMS Accession No. ML12319A074.

NRC (U.S. Nuclear Regulatory Commission), 2013c Letter from D. L. Skeen (NRC) to K. A. Keithline (NEI), Approval of Electric Power Research Institute Ground Motion Model Review Project Final Report for Use by Central and Eastern United States Nuclear Power Plants, August 28, 2013 ADAMS Accession No. ML13233A102.

NRC (U.S. Nuclear Regulatory Commission), 2014 Letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation to All Power Reactor Licensees and holders of Construction Permits in Active or Deferred Status, Seismic Screening and Prioritization Results Regarding Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Seismic Hazard Reevaluations for Recommendations 2.1 of the Near-Term Task Force Review of Insights, May 9, 2014, ADAMS Accession No. ML14111A147.

NRC (U.S. Nuclear Regulatory Commission) 2014b. Letter from W. M. Dean (NRC) to Select Operating Power Reactor Licensees, Screening and Prioritization Results Regarding Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Based on Individual Plant Examination of External Events Evaluation, November 21, 2014, ADAMS Accession No. ML14246A428.

<u>Other References</u>

Dominion, 2011a, Millstone Nuclear Power Station – Unit 2 Final Safety Analysis Report, Revision 28.

Dominion, 2011b, Millstone Nuclear Power Station – Unit 3 Final Safety Analysis Report, Revision 23.

Electric Power Research Institute (EPRI), 2004. EPRI Report 1009684, "CEUS Ground Motion Project Final Report." Palo Alto, CA, 2004.

Electric Power Research Institute (EPRI), 2006. EPRI Report 1014381, "Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States." Palo Alto, CA, 2006.

Electric Power Research Institute (EPRI), 2012. EPRI Report 1025287 "Seismic Evaluation Guidance, Screening, Prioritization and Implementation Details [SPID] for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic" November 27, 2012, ADAMS Accession No. ML12333A170.

Electric Power Research Institute (EPRI), 2013. EPRI Ground Motion Model Review Final Report, June 3, 2013, ADAMS Accession No. ML13155A553.

Grecheck, E., 2013, Letter from E. Grecheck (Dominion Nuclear Connecticut, Inc.) to NRC, Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the

Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – 1.5 Year Response for CEUS Sites, September 12, 2013, ADAMS Accession No. ML13259A043.

Heacock, D. A., 2013, Letter from D. Heacock (Dominion Nuclear Connecticut, Inc.) to NRC, Response to March 12, 2012 Information Request Seismic Hazard and Screening Report (CEUS Sites) for Recommendation 2.1, ADAMS Accession No. ML14092A417.

Keithline, 2012, Letter from Kimberly Keithline, Senior Project Manager, NEI, to David L. Skeen, Director, Japan Lessons Learned Project Directorate, NRC, Final Draft of Industry Seismic Evaluation Guidance (EPRI 1025287), November 27, 2012, ADAMS Accession No. ML12333A168.

Pietrangelo, 2013. Letter from A. R. Pietrangelo (NEI) to D. L. Skeen (NRC), Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations, April 9, 2013, ADAMS Accession No. ML13101A379.

Figure 3.3-1 Plot of Staff's and Licensee's Base Case Shear-Wave Velocity Profiles for MPS2 and MPS3

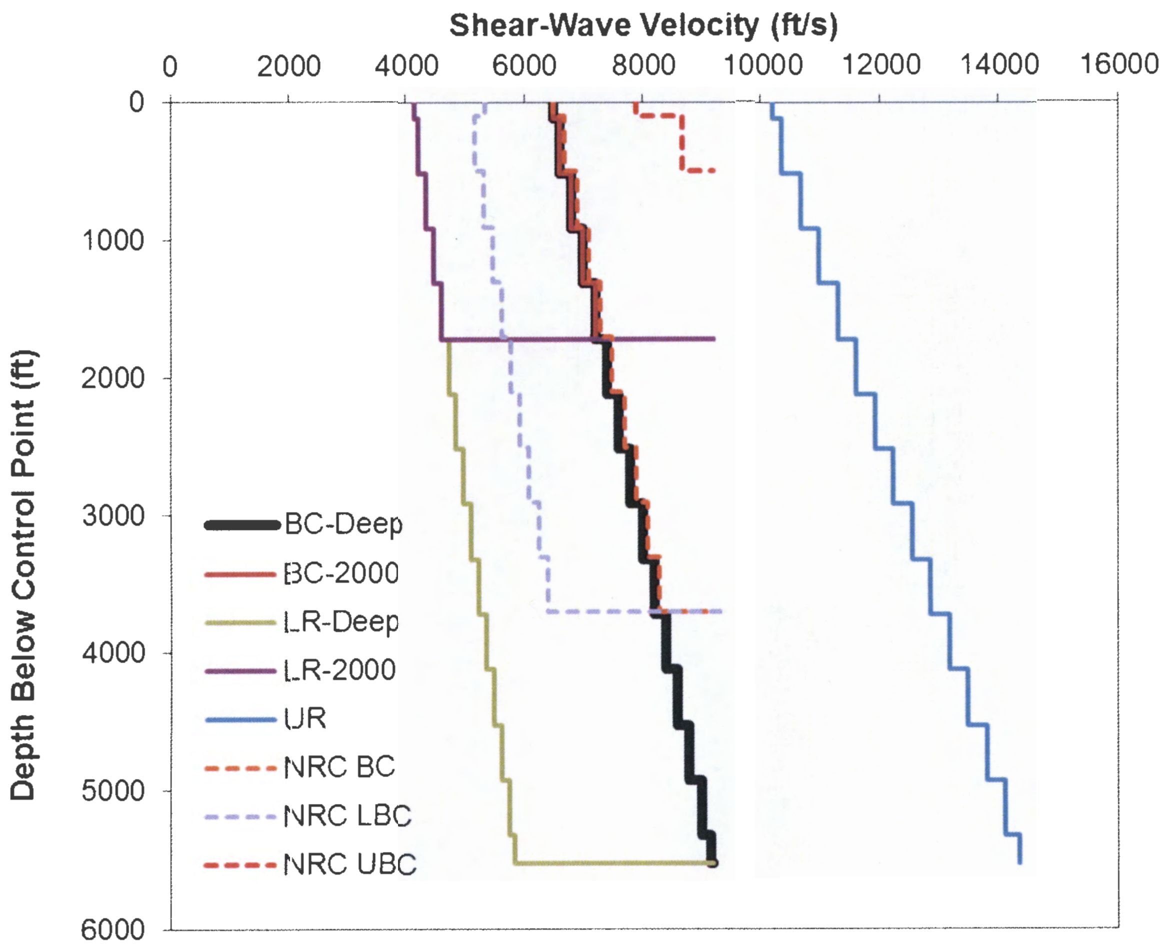


Figure 3.3-2 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for one input loading level for MPS2 and MPS3

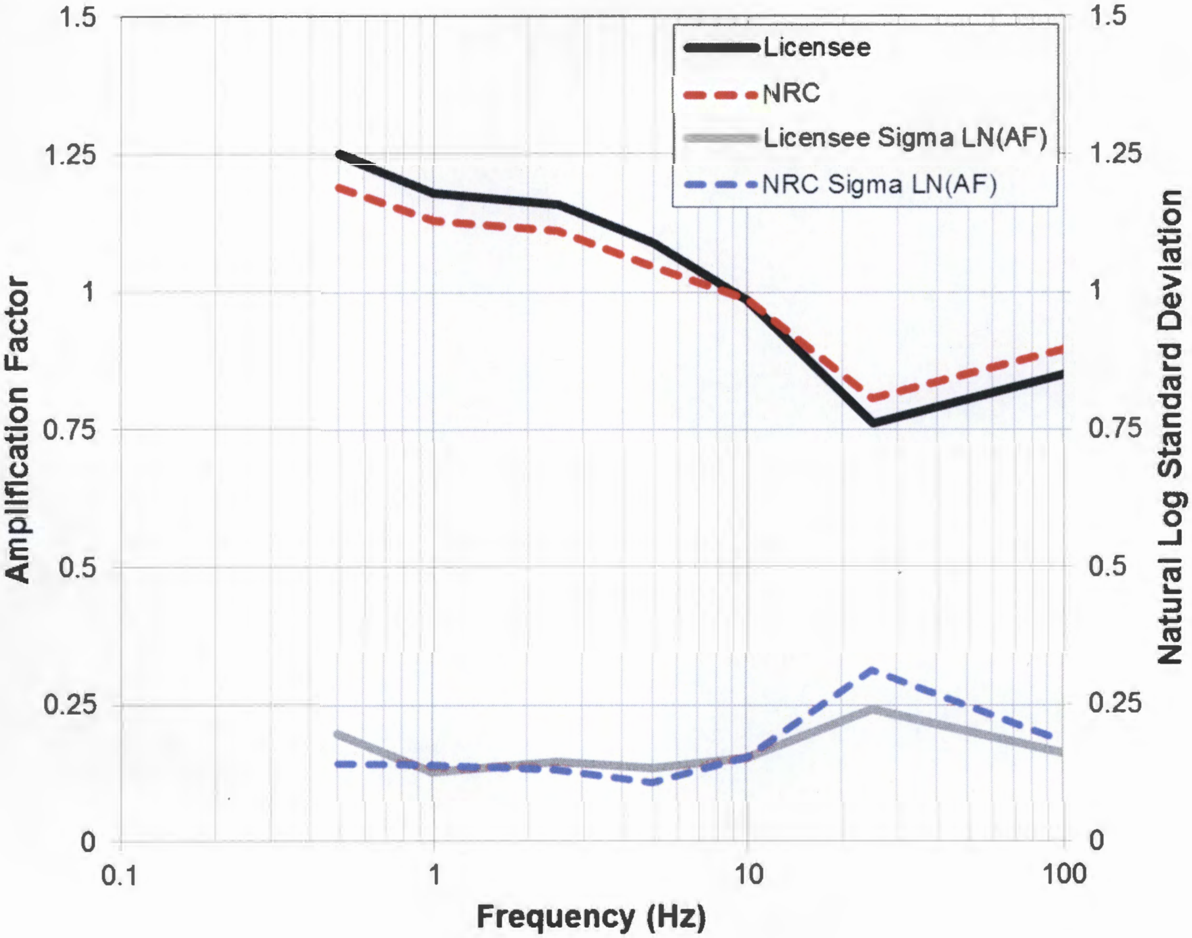


Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for MPS2 and MPS3

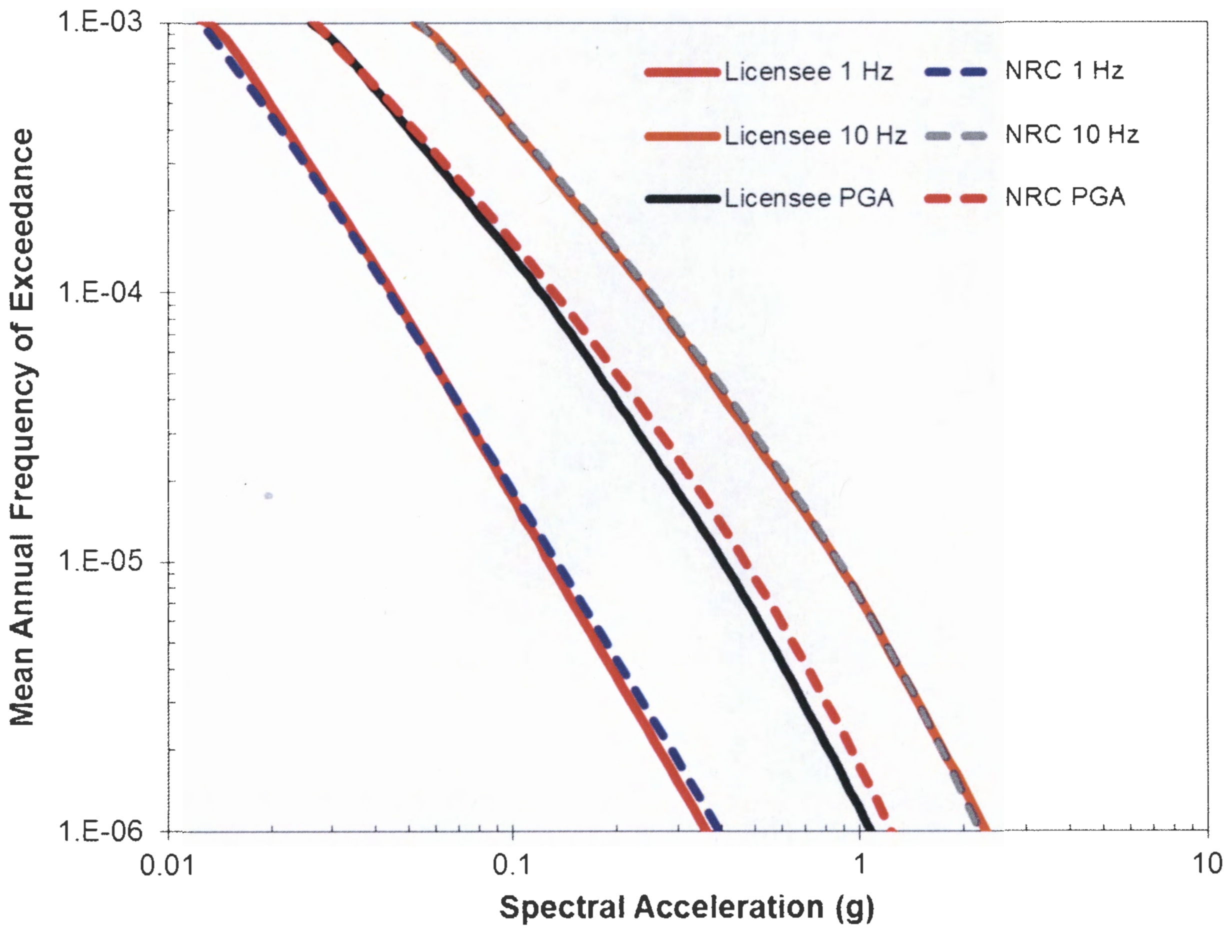
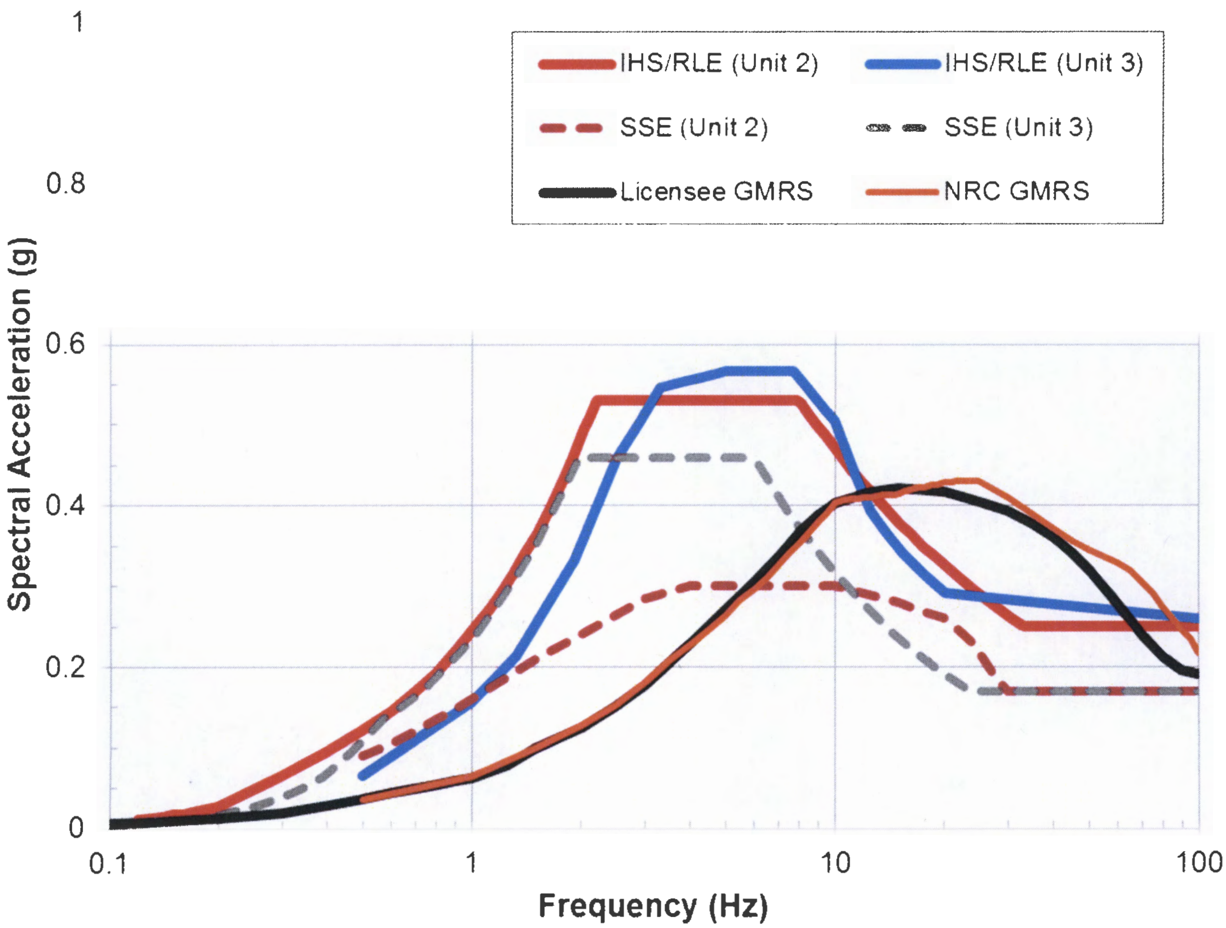


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSEs and IHS/RLEs for MPS2 and MPS3.



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
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Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-336 and 50-423

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