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

June 16, 2015

Mr. Peter Orphanos
Vice President, Nine Mile Point
Nine Mile Point Nuclear Station
348 Lake Road
Oswego, NY 13126

SUBJECT: NINE MILE POINT NUCLEAR STATION, 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. MF3973 and MF3974)

Dear Mr. Orphanos:

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, Exelon Generation Company, LLC (Exelon), previously as Constellation Energy Nuclear Group, LLC (CENG), responded to this request for Nine Mile Point Nuclear Station, Units 1 and 2 (NMPNS).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for NMPNS 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 screening review portion of Item (4) of the 50.54(f) letter. Information for Enclosure 1 of the 50.54(f) letter Items (6), (8) and (9) are not required since the reevaluated seismic hazard level is bounded by the plant design basis for frequencies between 1 and 10 Hz, in accordance with the SPID criteria. 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".

Contigent upon NRC's review and acceptance of Exelon's high frequency confirmation (i.e., Item (4)) for NMPNS, 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. 50-220 and 50-410

Enclosure:
Staff Assessment of Seismic
Hazard Evaluation and Screening Report

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO SEISMIC HAZARD AND SCREENING REPORT

NINE MILE POINT NUCLEAR STATION, UNITS 1 AND 2

DOCKET NOS. 50-220 AND 50-410

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,

---

[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) 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),

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

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

(8) 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 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 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 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 existing nuclear power plants. By letter dated September 12, 2013 (Spina, 2013), Exelon Generation Company, LLC (Exelon, the licensee), previously as Constellation Energy Nuclear Group, LLC submitted partial site response information for Nine Mile Point Nuclear Station, (NMP) Units 1 and 2. By letter dated March 31, 2014 (Korsnick, 2014), Exelon submitted its SHSR for NMP, Units 1 and 2.

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. Generally plants with construction permits issued prior to May 21, 1971, were approved for construction based on the Principal Design Criteria (PDC) published by the Atomic Energy Commission (AEC). NMP 1 was licensed using the PDC to evaluate the design bases. The PDC is consistent with 10 CFR Part 100 and meets the intent of GDC 2. NMP2 was licensed in accordance with Appendix A to 10 CFR Part 100 and meet GDC 2 in Appendix A to 10 CFR Part 50.

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) ground motion models. 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 requests that the licensee 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 (Korsnick, 2014), Exelon provided the SHSR for NMP, Units 1 and 2. The licensee's SHSR indicates that the site GMRS is bounded by the SSEs for both NMP, Units 1 and 2 over the frequency range of 1 to 10 Hertz (Hz). As such, neither a seismic risk evaluation nor a SFP evaluation is merited. However, due to exceedances above 10 Hz, the licensee indicated that a high-frequency confirmation would be performed for both NMP, Units 1 and 2.

On May 9, 2014 (NRC, 2014), 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. The licensee's GMRS, as well as the confirmatory GMRS, developed by the staff, only slightly exceed the SSE for NMP, Unit 1 over the frequency range of 9 to 10 Hz, which constitutes a narrow band exceedance, as defined by the guidance in the SPID. For NMP Unit 2, the GMRS falls completely below the SSE over the frequency range of 1 to 10 Hz. Therefore, NMP, Units 1 and 2 screen out of conducting a seismic risk evaluation. Additionally, a SFP evaluation is not merited for NMP, Units 1 and 2. The staff also confirmed the licensee's conclusion that a high-frequency confirmation for NMP, Units 1 and 2 is merited because the GMRS exceeds the SSE for both Units 1 and 2 for frequencies above 10 Hz.

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 NPPs; 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 NMP Unit 1. The licensee stated that the SSE for NMP Unit 1 is a Housner-shape design spectrum, which is based on a postulated magnitude 7 earthquake 50 miles from the site. Based on this earthquake, the response spectral shape is anchored at a PGA of 0.11 g (11 percent of the acceleration due to earth's gravity). The licensee stated it used an updated response spectrum during the NRC's Systematic Evaluation Program (SEP) for plant evaluations. The SEP spectrum, a NUREG/CR-0098 (NRC, 1978) spectral shape anchored at 0.13 g, is an additional engineering consideration that the licensee used for seismic screening for NMP Unit 1.

For NMP, Unit 2, the licensee stated that, according to the Updated Final Safety Analysis Report (UFSAR) (Constellation, 2012), the design-basis earthquake was conservatively estimated to have a PGA value of 0.15 g based on a maximum earthquake intensity of VI adjacent to the site. The licensee stated that the site design response spectrum for Nine Mile Point, Unit 2 is a Regulatory Guide 1.60 (NRC, 1974) response spectrum anchored at 0.15 g.

The licensee specified that the SSE control point is located at the top of the Oswego Sandstone at a mean sea level (MSL) elevation of 245 feet (ft) [74.7 m]. In absence of a control point definition in the UFSAR, the licensee relied on UFSAR Section III, which states that the reactor foundation is located on firm rock, along with guidance provided in Section 2.4.2 of the SPID to define the control point.

The staff reviewed the licensee's description of its updated SSE for NMP, Unit 1 in the SHSR. To further confirm the updated SSE, the staff also reviewed the NMP, Unit 1 UFSAR, Revision 22 (Constellation, 2011). Although for Unit 1, the licensee used the SEP response spectrum for its screening comparison with the GMRS, the staff confirmed that the SEP spectrum has not been incorporated in the UFSAR as the SSE for the site. Therefore, the staff performed its screening evaluation for NMP Unit 1 based on a comparison of the GMRS with the licensee's design basis SSE, which is a Housner-shape design spectrum anchored at 0.11 g. With regard to the SSE for NMP Unit 2, based on its review of the SHSR and UFSAR (Constellation, 2012), the staff was able to confirm that the licensee's SSE is a Regulatory Guide 1.60 (NRC, 1974) spectrum anchored at 0.15 g. Finally based on review of the SHSR and the UFSAR, the staff confirmed that the licensee's control point elevation for both the NMP Units 1 and 2 SSEs 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 **M** 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 and Wabash Valley repeated large magnitude earthquake (RLME) sources, which lie 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** >= 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 assessment.

As part of its confirmatory analysis of the licensee's GMRS, the staff performed PSHA calculations for base rock site conditions at the NMP 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 NMP site. In addition, the staff included all of the RLME sources falling within a 620 mi [1000 km] radius of the site, which includes the Charlevoix 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 the 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 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 generic or reference 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 NMP Unit 1 UFSAR (Constellation, 2011), the NMP Unit 2 UFSAR (Constellation, 2012), and the Safety Analysis Report (SAR) for the proposed Nine Mile Point Unit 3 (NMP Unit 3) (UniStar, 2009). The licensee stated that the site is underlain by approximately 1,745 ft [532 m] of firm Ordovician age (490 – 445 Ma) sedimentary rocks consisting of sandstones, shales, and limestones. Overlying the bedrock is glacial till and glacial Lake Iroquois deposits.

Geophysical investigations for NMP Unit 2 consisted of borehole geophysical measurements (cross-hole P and S wave analysis) and refraction profiles. For proposed Unit 3, investigations included cross-hole P and S wave measurements and seismic refraction surveys. Additionally, the combined license applicant for proposed Unit 3 determined shear modulus values and strain dependent damping values based on laboratory measurements of samples collected at the site during siting investigations. The licensee provides a brief description of the subsurface materials in terms of geologic units and thicknesses in its SHSR. Seismic velocities for the approximately 1,745 ft of sedimentary rock beneath the site range from 6,000 feet per second (fps) [1829 meters per second] to 8,600 fps [2621 meters per second].

To characterize the subsurface geology, the licensee developed three site base case profiles. The middle, or best estimate, profile was developed using measured shear-wave velocity from nearby cross-hole geophysical investigations. The licensee determined the shear wave velocities for the upper 325 ft [99 m] of rock from measurements near NMP Unit 2, and it determined the velocities for the deeper rock units from measurements at the proposed NMP Unit 3. Upper and lower base case profiles were developed using a natural log standard deviation of 0.18. Figure 3.3-1 of this assessment shows the licensee's three shear-wave velocity base case profiles.

In SHSR Section 2.3.2.1, the licensee assumed that the behavior of the rock material over the upper 500 ft [152 m] could be modeled as either linear or non-linear. To model the potential non-linear behavior of the rock, the licensee stated that it used the generic EPRI shear modulus reduction and hysteretic damping curves over the upper 500 ft [152 m]. To model the linear behavior of the rock over the upper 500 ft [152 m], the licensee used the low strain damping values (approximately 3 percent) from the EPRI rock curves for each of the rock layers. The licensee weighted these alternative material behaviors equally, assigning 50 percent to each case.

The licensee also considered the impact of kappa, or small strain damping, on site response. 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. For NMP, a site with about 1,745 ft [532 m] of firm rock over the assumed base rock material, the licensee used the low strain damping values from the EPRI rock curves (approximately 3 percent) over the upper 500 ft [152 m] and assumed a damping value of 1.25 percent for the rock layers below 500 ft in order to calculate a kappa value for each of the three base case profiles. The licensee also added an additional kappa of 0.006 sec to account for the damping in the underlying base rock material. Total profile kappa values for the best estimate, upper, and lower base case velocity profiles are 0.014, 0.006, and 0.020 sec, respectively.

To account for randomness in material properties across the plant site, the licensee randomized its base case shear-wave velocity profiles. In addition, the licensee randomized the depth to bedrock by ±524 ft (±160 m), which corresponds to 30 percent of the total profile thickness. The licensee stated that this randomization did not represent the actual uncertainty in the depth to bedrock, but was used to broaden the spectral peaks. Through a sensitivity analysis, as discussed in Section 3.3.3 of this assessment, the staff review found that this approach did not impact the control point hazard curves.

3.3.2 Site Response Method and Results

In Section 2.3.4 of its SHSR, the licensee states 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 staff performed site response calculations for the NMP site. The staff independently developed a shear-wave velocity profile, damping values, and modeled the potential nonlinear behavior of the rock using measurements and geologic information provided in the NMP Unit 1 UFSAR (Constellation, 2011), the NMP Unit 2 UFSAR (Constellation, 2012), the proposed NMP Unit 3 SAR (UniStar, 2009), and 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.

Because the site is well characterized and the velocities reported in the NMP Unit 2 FSAR (Constellation, 2012) and the proposed NMP Unit 3 SAR (UniStar, 2009) are similar, the staff used only a single shear wave velocity profile rather than the three profiles used by the licensee. For the depth interval between the control point and 200 ft [61 m] below the control point, the staff used an average of the measured shear wave velocities at NMP Unit 2 and the proposed NMP Unit 3 for its shear wave velocity profile. For depths between 200 ft [61 m] below the control point and the base of the profile, the staff used the shear wave velocities from the proposed NMP Unit 3. To capture the uncertainty in the depth to base rock, the staff used a value of ±150 ft [±46 m], which is considerably less than the ±524 ft (±160 m) depth to base rock randomization used by the licensee. Figure 3.3.-1 of this assessment shows the staff's velocity profile compared to the base case profiles developed by the licensee.

Similar to the approach used by the licensee, the staff assumed both linear and non-linear behavior for the rock beneath NMP in response to the range of input loading motions. However, in contrast to the licensee's use of the generic EPRI rock shear modulus and damping curves to model the non-linear behavior of the rock over the upper 500 ft [152 m] of the site profile, the staff used the site specific damping and shear modulus degradation curves determined by UniStar during its investigations for the proposed NMP, Unit 3. The implementation of these site specific curves provides for very limited non-linear behavior of the rock material even at higher loading levels. For example, the site specific hysteretic damping curves developed for NMP3 are capped at a damping ratio of 1 percent while the EPRI rock damping curves begin at 3 percent and reach 10 to 15 percent for a shear strain value of 0.1 percent. To model the linear behavior of the rock, the staff used a low strain damping value of 0.5 percent. The staff used these two alternative models (non-linear and linear) over the upper 200 ft [61 m] of the site profile, giving each equal weight. Below a depth of 200 ft [61 m], the staff assumed linear behavior for the rock with a damping value of 0.4 percent.

To determine kappa for its single profile, the staff used the low strain damping values, shear wave velocities, and layer thicknesses for each layer to arrive at a value of 0.0085 sec, which includes the 0.006 sec contribution from the base rock. To model the uncertainty in the kappa value, the staff used a natural log standard deviation value of 0.35 to calculate lower and upper values for kappa of 0.006 sec and 0.013 sec.

Figure 3.3-2 of this assessment shows a comparison of the staff's and licensee's median site amplification functions and uncertainties (±1 standard deviation) for two of the eleven input loading levels. Due to the use of very low damping values and modeling of the rock behavior as essentially linear for the range of input loading levels, the staff's confirmatory amplification factors are essentially one for the entire frequency range. Above approximately 10 Hz, amplification functions calculated by the licensee are lower than those developed by the staff due to the greater nonlinearity included in the licensee's analyses.

The staff conducted sensitivity tests to evaluate the licensee's use of (1) multiple base case velocity profiles, (2) higher damping values and the assumption of more nonlinearity over a larger portion of the subsurface profiles, (3) higher kappa values, and (4) a large depth to base rock randomization value. Of these four factors, the higher damping values (3 percent and higher), which the licensee used for the upper 500 ft [152 m] of the rock profile, resulted in the largest difference in the sets of amplification factors developed by the licensee and staff. These differences are shown in Figure 3.3-2 of this assessment for frequencies above 10 Hz.

The staff primarily based its approach to modeling the subsurface rock properties for the NMP site on the more recent siting investigations for the proposed NMP, Unit 3. Considering the abundance of rock cores, subsurface geophysical investigations, and laboratory testing of the rock, the staff modeled the rock behavior as essentially linear and used less epistemic uncertainty to capture potential differences in the rock properties between the two operating units (NMP Units 1 and 2) and the proposed NMP Unit 3. The SAR for NMP, Unit 3 (UniStar, 2009) states in Section 2.5.2 that, "in general, RQD (rock quality designation) values of the bedrock cored for this project were above 80%, indicating high rock quality." In contrast, the licensee used, as recommended by the SPID, the generic EPRI rock curves, which, as stated in Appendix B of the

SPID, "assumes that firm rock behaves in a manner similar to gravels being significantly more nonlinear with higher damping than more fine grained sandy soils."

Overall, the licensee's approach to modeling the subsurface rock properties and their uncertainties results in slightly lower site amplification factors relative to the staff's results, particularly at high frequencies. However, as shown in Figure 3.3-3 of this assessment, these differences in the site response analysis do not have a large impact on the control point seismic hazard curves or the resulting GMRS, as discussed below. 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 to confirm 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 NMP site.

3.4 Ground Motion Response Spectra

In Section 2.4 of the SHSR, the licensee states 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 staff assessment, respectively. Figure 3.4-1 of the assessment shows a comparison of the GMRS determined by the licensee to that determined by the staff.

As shown in Figure 3.4-1 below, 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 higher than the licensees at frequencies above 10 Hz. As described above in Section 3.3, 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 for this application because the licensee followed the guidance provided in the SPID with respect to both the PSHA and site response analysis for the NMP 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 NMP 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 NMP site. Based on its review, the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, 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) through (3), (5), (7) and screening review portion of Item (4), identified in Enclosure 1 of the 50.54(f) letter. Information for Enclosure 1 of the 50.54(f) letter Items (6), (8) and (9) are not required based on the reevaluated seismic hazard level being lower than the plant design basis for frequencies between 1 to 10 Hz. 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 staff confirmed the licensee's conclusions, in that, the GMRS in the 1 to 10 Hz frequency range for the NMP site is bounded by the SSE for NMP, Unit 2 and shows only slight exceedance of the SSE in the 9 to 10 Hz frequency range for NMP, Unit 1. The staff also confirms the licensee's conclusion that the GMRS exceeds the SSEs for both units in the frequency range above 10 Hz. As such, a seismic risk evaluation and SFP evaluation are not merited and a high-frequency confirmation is merited for NMP, Units 1 or 2. The NRC review and acceptance of Exelon's high-frequency confirmation (i.e., Item (4)) for NMP, Units 1 and 2 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), 1974, "Design Response Spectra for Seismic Design of Nuclear Power Plants." Regulatory Guide 1.60, Revision 1, 1974

NRC (U.S. Nuclear Regulatory Commission), 1978, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants." NUREG/CR-0098, May 1978.

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 Eric J. Leeds, Director, Office of Nuclear Reactor Regulation, 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 David L. Skeen, Director, Japan Lessons-Learned Directorate to Kimberly 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 David L. Skeen, Director, Japan Lessons-Learned Directorate 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) Regulatory Guide 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion.

NRC (U.S. Nuclear Regulatory Commission) Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants."

Other References

Constellation 2011 Nine Mile Point Nuclear Station Unit 1 Final Safety Analysis Report (Updated) (UFSAR), Revision 22.

Constellation 2012 Nine Mile Point Nuclear Station Unit 2 Updated Safety Analysis Report (USAR), Revision 20.

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.

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.

Korsnick, M., 2014, Letter from Mary Korsnick (Constellation Energy, LLC) to NRC, Seismic Hazard and Screening Report (CEUS Sites), Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, March 31, 2014, ADAMS Accession No. ML14099A196.

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.

Spina, J., 2013, Letter from J. Spina (Constellation Energy, LLC) 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. ML13259A044.

Unistar, 2009- Final Safety Analysis Report (FSAR) of the Nine Mile Point Unit 3 Combined License Application, Revision 1, Section 2.5 – Geology, Seismology, and Geotechnical Engineering, Unistar Nuclear Energy (UNE).

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

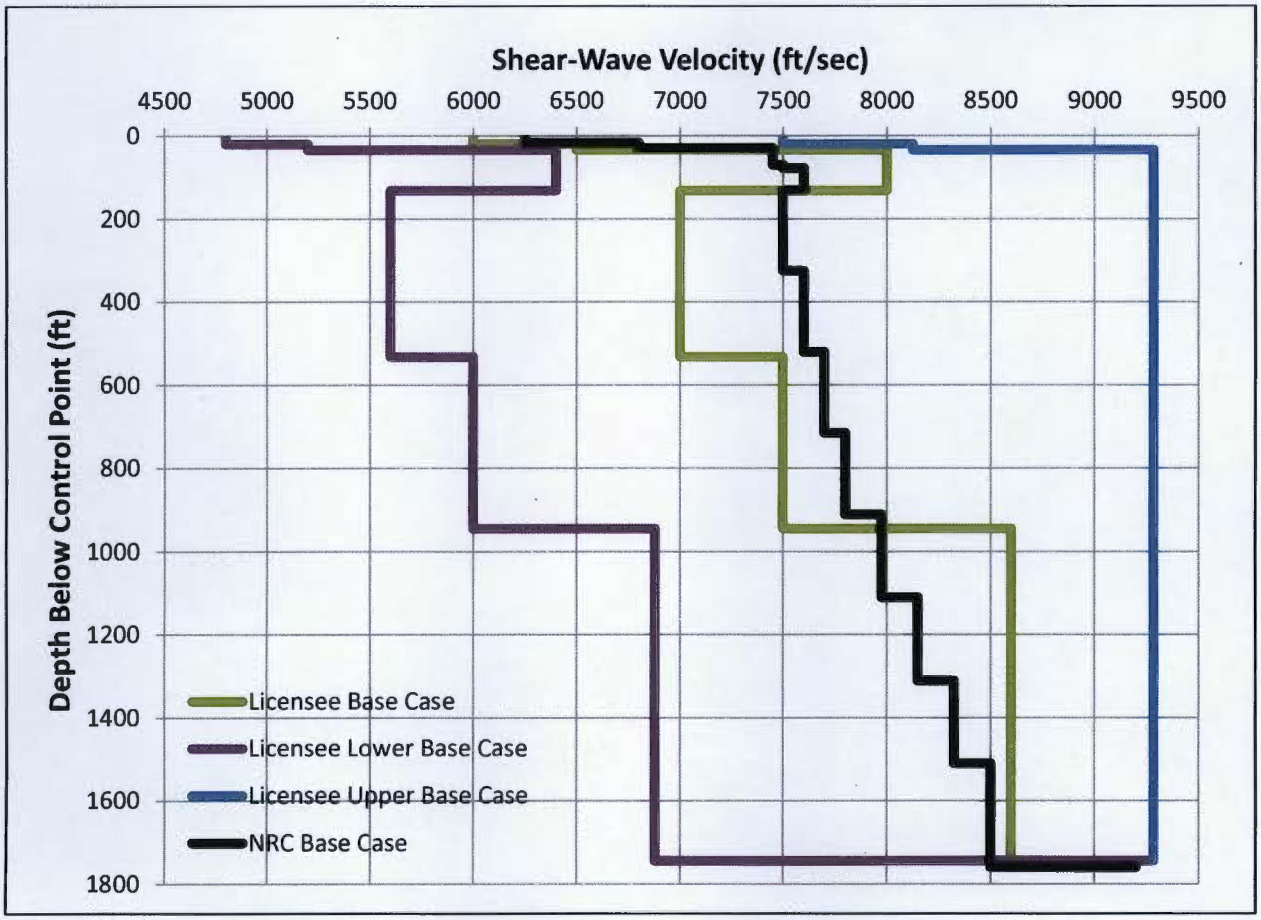


Figure 3.3-2 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for two input loading levels for the NMP site

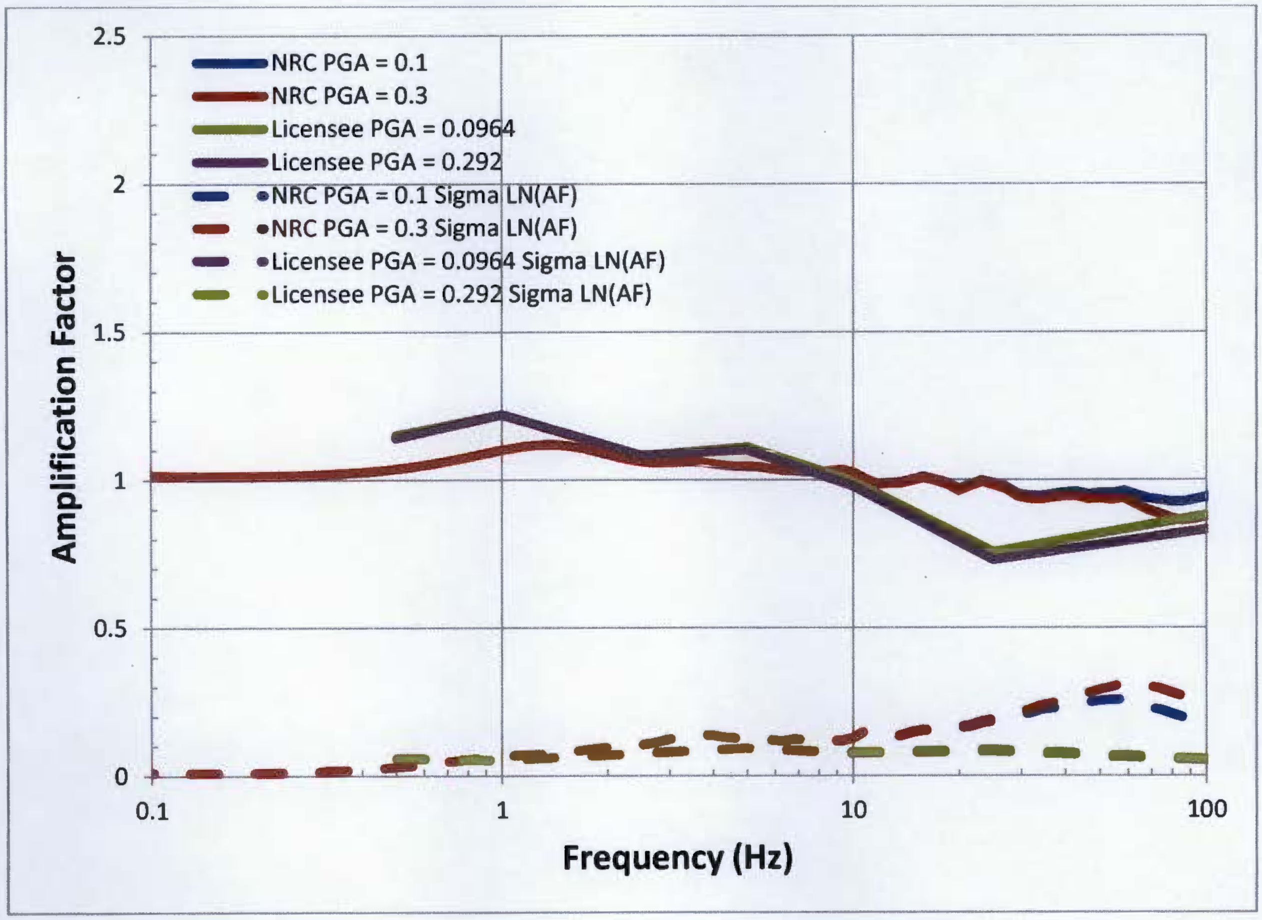


Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the NMP site

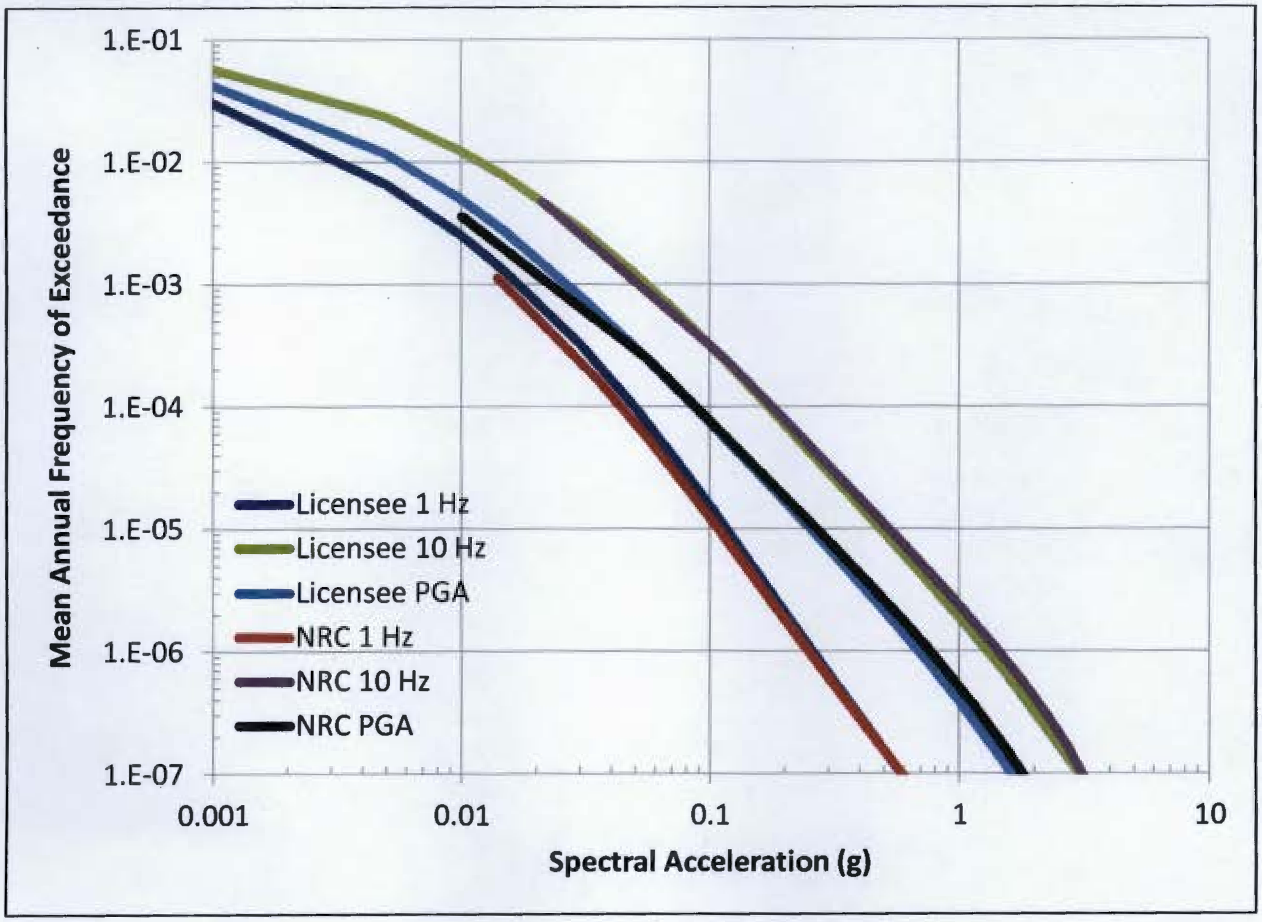
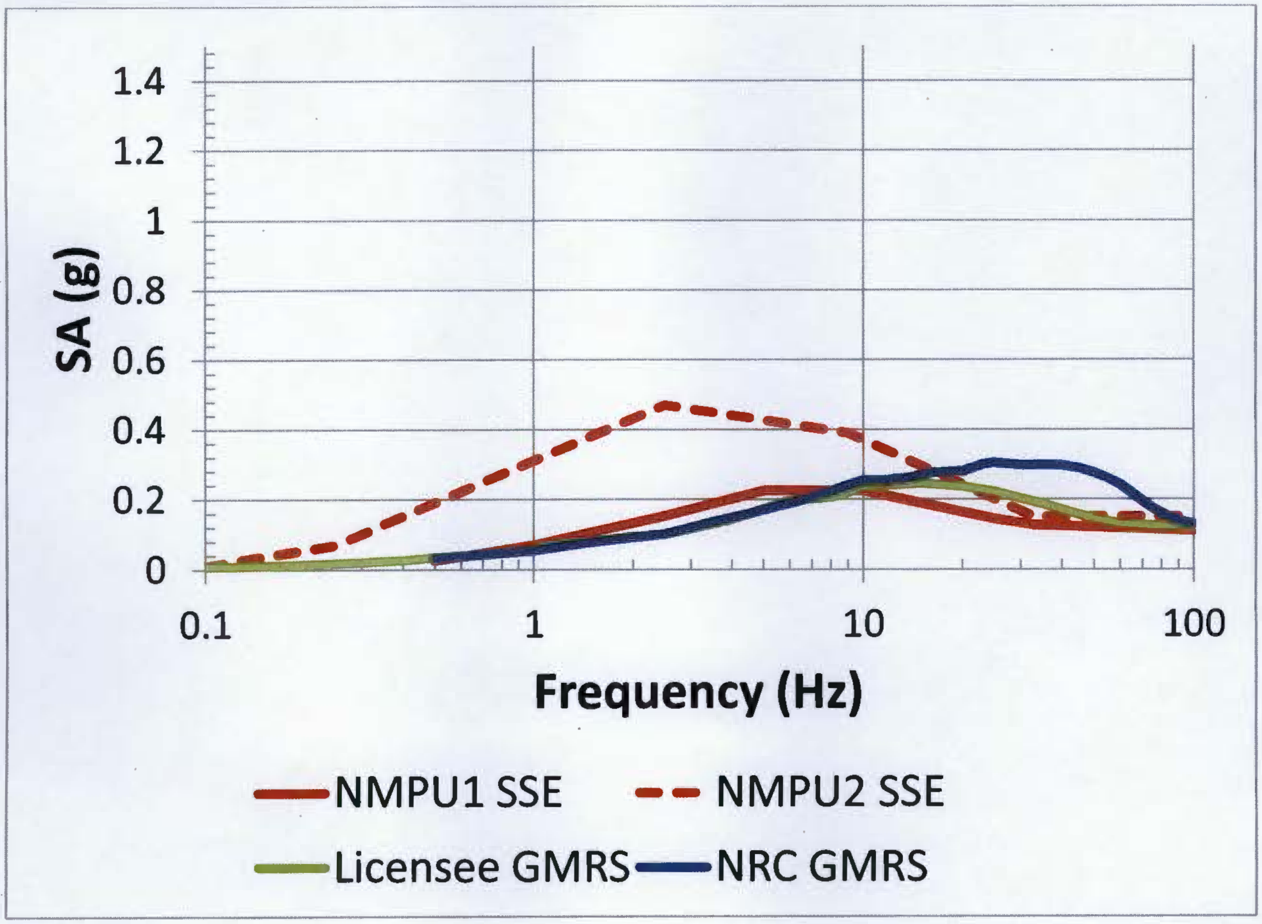


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSEs for NMP Unit 1 (Red) and NMP Unit 2 (Red dashed).



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. 50-220 and 50-410

Enclosure:
Staff Assessment of Seismic
Hazard Evaluation and Screening Report

cc w/encl: Distribution via Listserv

DISTRIBUTION:
PUBLIC
JHMB R/F
RidsNrrDorlLpl1-1Resource
RidsNrrPMNineMile Point Resource
RidsNrrLASLent Resource
RidsAcrsAcnw_MailCTR Resource
FVega, NRR
NDiFranceso, NRR
DJackson, NRO
MShams, NRR

ADAMS Accession No.: ML15153A660 ***via email**

OFFICE	NRR/JLD/JHMB/PM	NRR/JLD/LA	NRO/DSEA/RGS1/BC*
NAME	FVega	SLent	DJackson
DATE	06/05/15	06/05/15	05/29/15
OFFICE	JLD/JHMB/BC	NRR/JLD/JHMB/PM	
NAME	MShams	FVega	
DATE	06/15/15	06/16/15	

OFFICIAL RECORD COPY