August 14, 2015

Mr. Bryan C. Hanson
President and Chief
Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1 - 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 NO. MF3905)

Dear Mr. Hanson:

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, the licensee), responded to this request for Three Mile Island Muclear Station, Unit 1 (TMI).

The NRC staff has reviewed the information provided related to the reevaluated seismic hazard for TMI 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 the NRC staff's review and acceptance of the licensee's expedited seismic evaluation process and seismic risk evaluation including the high frequency confirmation and spent fuel pool evaluation (i.e., Items (4), (6), (8), and (9)) for TMI, 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 No. 50-289

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

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

DOCKET NO. 50-289

1.0 INTRODUCTION

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

Enclosure 1 to the 50.54(f) letter requests that addressees perform a reevaluation of the seismic hazards at their sites using present-day NRC requirements and guidance to develop a ground motion response spectrum (GMRS).

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

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

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

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

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

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

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

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 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 NRC 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 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 agreed to follow the SPID to develop the SHSR for existing nuclear power plants. By letter dated September 12, 2013 (Kaegi, 2013),

Exelon Generation Company, LLC (Exelon, the licensee) submitted partial site response information for the Three Mile Island Nuclear Station, Unit 1 (TMI). By letter dated March 31, 2014 (Barstow, 2014), Exelon submitted its SHSR for TMI.

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 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 (Barstow, 2014), the licensee provided the SHSR for the TMI site. The licensee's SHSR indicates that the site GMRS exceeds the SSE for TMI over the frequency range of 1 to 10 Hertz (Hz). As such, TMI screens-in to perform a seismic risk evaluation, as well as a SFP evaluation. The GMRS also exceeds the SSE at frequencies above 10 Hz. The licensee indicated that the risk evaluation would address the high frequency exceedance.

On May 9, 2014 (NRC, 2014), the NRC staff issued a letter providing the outcome of its 30-day screening and prioritization evaluation. As indicated in the letter, the NRC staff confirmed the licensee's screening results. The licensee's GMRS, as well as the confirmatory GMRS, developed by the NRC staff, exceeds the SSE for TMI over the frequency range of approximately 8 to 100 Hz. Therefore, a seismic risk evaluation, SFP evaluation, and a high frequency confirmation are merited for TMI.

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 20 -30 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 TMI. The licensee stated that the SSE for TMI was derived from a smoothed approximation of the response spectrum developed from the horizontal ground motion of the 1957 San Francisco earthquake recorded at the Golden Gate Park. Based on historic seismicity of the region, the maximum postulated earthquake within 50 miles [80 km] of the site was determined to have an intensity of VI on the Modified Mercalli Intensity Scale which attenuates to an intensity of V at the TMI site. This intensity value was converted to a PGA value of 0.12 g, which is used as the anchor point for the SSE.

The licensee specified that the SSE control point is located at the top of the rock surface at Elevation 280 ft [85.3 m]. Although the SSE control point is not specified in the TMI Updated Final Safety Analysis Report (UFSAR), the licensee noted that the TMI site is a hard rock site

with approximately 20 ft [6.1 m] of soil overlying sedimentary rocks with a top of rock depth varying from Elevation 275 to 279.5 ft [83.8 to 85.2 m]. The staff reviewed the licensee's description of the SSE for TMI and confirms that the SSE, as described in the SHSR, is consistent with information provided in the UFSAR.The staff concludes that the selection of the control point is consistent with guidance provided in Section 2.4.2 of the SPID to define the control point.

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 Charleston, 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_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 NRC 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 PSHA calculations for base rock conditions at the TMI 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 TMI 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 Charleston, Charlevoix and Wabash Valley RLME sources. 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 the licensee provide a GMRS developed from the

site-specific seismic hazard curves at the control point elevation. In addition, the 50.54(f) letter specifies that the subsurface site response model, for both soil and rock sites, should extend to sufficient depth to reach the 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 TMI UFSAR(Exelon, 2014) and supported by a more recent review of site parameter data. The licensee stated that the site is underlain by approximately 20 ft [6.1 m] of soil, and the soil is underlain by up to 3 ft [1 m] of weathered rock with hard bedrock below.

The licensee provided a brief description of the subsurface materials in terms of geologic units and thickness in its SHSR. Shear-wave velocities were unspecified, but compressional wave velocities associated with subsurface materials range from 1,000 to 2,000 feet per second (fps) [305 to 610 meters per second (m/s)] for the soil, 2,300 to 3,800 fps [701 to 1,160 m/s] for the weathered bedrock and 8,000 to 12,000 fps [2,440 to 3,660 m/s] for the competent Gettysburg Formation sandstone bedrock.

To characterize the subsurface geology, the licensee developed three site base case profiles. The middle, or best estimate, profile was developed using a shallow velocity of 5,000 fps (1,524 m/s) reflecting a Poisson ratio of 0.35 and assumed a shear wave velocity gradient of 0.5 m/s/m. Upper and lower base case profiles were developed using a scale factor of 1.57 to reflect a natural log standard deviation of 0.35. Figure 3.3-1 of this assessment shows the licensee’s three shear-wave velocity base case profiles.

To model the potential dynamic material properties of the subsurface, the licensee used two sets of shear modulus reduction and damping curves for the site profile. For the upper 500 ft [152 m] of the profile, the licensee modeled the rock behavior as either linear or non-linear. To model the potential non-linear dynamic material properties, the licensee used the EPRI rock dynamic material property curves. To model the linear behavior of the rock, the licensee used

the low strain damping values (approximately 3 percent) from the EPRI rock curves for each of the layers. The licensee weighted these alternative material behaviors equally.

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 TMI, with about 6,500 ft [1,969 m] of sedimentary rock below the SSE control point, the licensee estimated kappa based on average shear wave velocity over the upper 100 ft [30 m]. The resulting kappa for the three profiles are 0.015 sec, 0.024 sec, and 0.009 sec.

To account for randomness in material properties across the plant site, the licensee stated that it randomized the base case shear-wave velocity profiles using a natural log standard deviation of 0.25 in the upper 50 ft [15.24 m] and a natural log standard deviation of 0.15 below that depth. The licensee stated that, consistent with the SPID, it correlated shear wave velocities between layers using the footprint correlation model with a limit of +/- 2 standard deviations about the median value in each layer. The licensee also randomized the depth to reference rock ±1,969 ft [600 m], which corresponds to 30 percent of the total profile thickness. The licensee stated that this randomization did not represent actual uncertainty in the depth to reference rock, but was used to broaden the spectral peaks.

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 the cases analyzed. Amplification functions are shown for eleven input loading levels for the median reference (hard rock) peak acceleration (0.01g to 1.50g) for profile P1 and EPRI rock *G/G* max and hysteretic 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 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 2.3.7), 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 site response calculations for the TMI site. The NRC staff independently developed a shear-wave velocity profile, damping values, and modeled the potential nonlinear behavior of the site using measurements and geologic information provided in the TMI UFSAR 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.

Following guidance provided in the SPID for sites with less subsurface information, the staff independently determined best-estimate and upper and lower base case shear-wave velocity profiles. The NRC staff based its best-estimate velocity profile on information in the TMI UFSAR and guidance provided in the SPID. The staff modeled the velocity at the top of rock with a shear-wave velocity of 4,425 fps [1,349 m/s]. This velocity corresponds to a Poisson's ratio of 0.37, given an average compressional wave velocity of 9,700 fps [2,957 m/s], which is based on seismic refraction profiles in the TMI UFSAR. Consistent with guidance in the SPID, the NRC staff used a velocity gradient of 0.5 fps/ft to model the increase in shear-wave velocity with depth. Based on geologic maps of the region surrounding the TMI site (Bert, et al., 1980; Miles, et al., 2001), the NRC staff included a layer of diabase in the site profiles. Because the depth of this layer beneath the TMI site is uncertain, the NRC staff included it at a different depth in each base case. The NRC staff used a natural log standard deviation of 0.3 to calculate upper and lower base case velocity profiles. Figure 3.3-1 of this assessment shows a comparison of the three profiles developed by the licensee with those developed by the staff. Overall, the profiles developed by the NRC staff are weighted towards slightly lower velocities than those assumed by the licensee. The NRC staff randomized the depth to reference rock by ±10 percent to allow for additional uncertainty.

Similar to the approach used by the licensee, the NRC staff assumed both linear and non-linear behavior for the materials beneath the TMI site in response to the range of input motions. The NRC staff developed two profiles that incorporate different degrees of nonlinearity. Similar to the licensee, the NRC staff used the EPRI rock curves to model the upper limit on non-linear behavior or the rock over the upper 500 ft [152 m]. However, for the linear version of the profile, the staff assumed that the rock would behave linearly with a constant low strain damping value of 1 percent over the upper 500 ft [152 m].

To determine kappa for its three profiles, the NRC staff used guidance in the SPID for sites with a depth to hard rock greater than 3,000 ft [914 m]. Corresponding kappa values for the best-estimate lower and upper base cases are 0.017, 0.026, and 0.011 sec, respectively. These values include the 0.006 sec contribution from the reference rock. To model the uncertainty in kappa, the staff used a natural log standard deviation of 0.35 to calculate lower and upper values of kappa for each profile. This approach results in nine kappa values for the NRC staff's site response analysis, which range from 0.007 to 0.041 sec.

Figure 3.3-2 of this assessment shows a comparison of the NRC staff's and the licensee's median site amplification functions and uncertainties (±1 standard deviation) for 2 of the 11 input loading levels. The amplification functions are highest at frequencies of less than 1 Hz and decrease with increasing frequency. Amplification functions calculated by the NRC staff and the licensee are similar, however uncertainties are higher for the staff's profiles. This is due to the greater epistemic uncertainty in the staff's kappa values and damping parameters.

The licensee's approach to modeling the subsurface rock properties and their uncertainty results in similar site amplification factors to those produced by the NRC staff. As shown in Figure 3.3-3 of this assessment, minor differences in site amplification and uncertainty has a very minor impact on the control point seismic hazard curves and the resulting GMRS, 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 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 TMI 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 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 and NRC staff's GMRS shape are very similar. The licensee's GMRS is somewhat lower than the NRC staff's confirmatory analysis at varying frequencies, particularly above 25 Hz. As described above in Section 3.3, the NRC staff concludes that these minor differences over this frequency range are primarily due to the differences in the site response analyses performed by the licensee and NRC staff.

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, theNRC staff concludes that the GMRS determined by the licensee adequately characterizes the reevaluated hazard for the TMI 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 TMI 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. 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 the comparison portion to 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 confirms the licensee's conclusion that the licensee's GMRS for the TMI site exceeds the SSE over the frequency range of approximately 8 to 100 Hz. As such, a seismic risk evaluation, SFP evaluation, and high-frequency confirmation are merited. The licensee indicated that the high frequency confirmation can be performed as part of its seismic risk evaluation. The NRC review and acceptance of the licensee's seismic risk evaluation, high frequency confirmation, interim ESEP evaluation, and SFP evaluation (i.e., Items (4), (6), (8), and (9)) for TMI will complete 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.

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

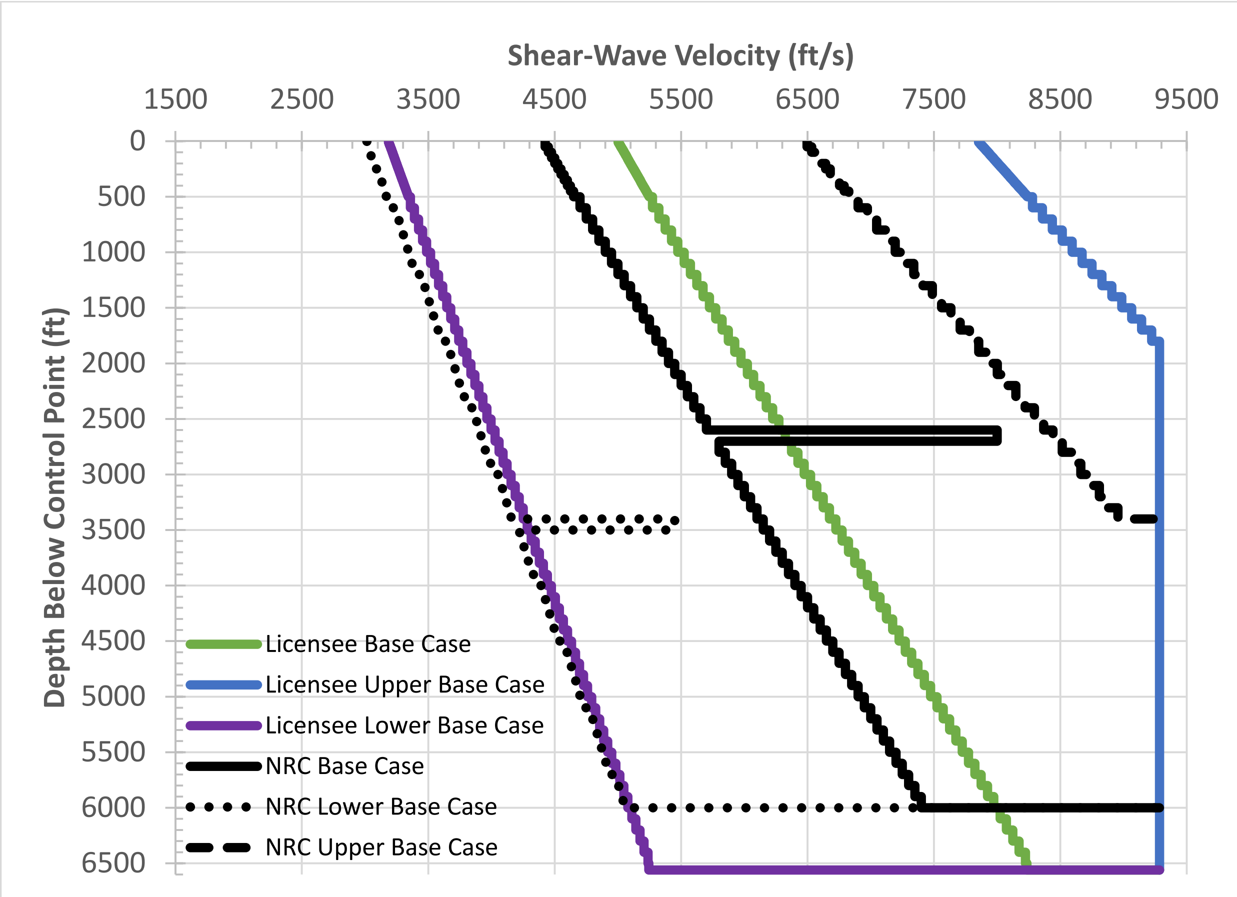


Figure 3.3- 2 Plot Comparing the Staff's and the License's Median Amplification Functions and Uncertainties for Two Input Loading Levels for the TMI Site

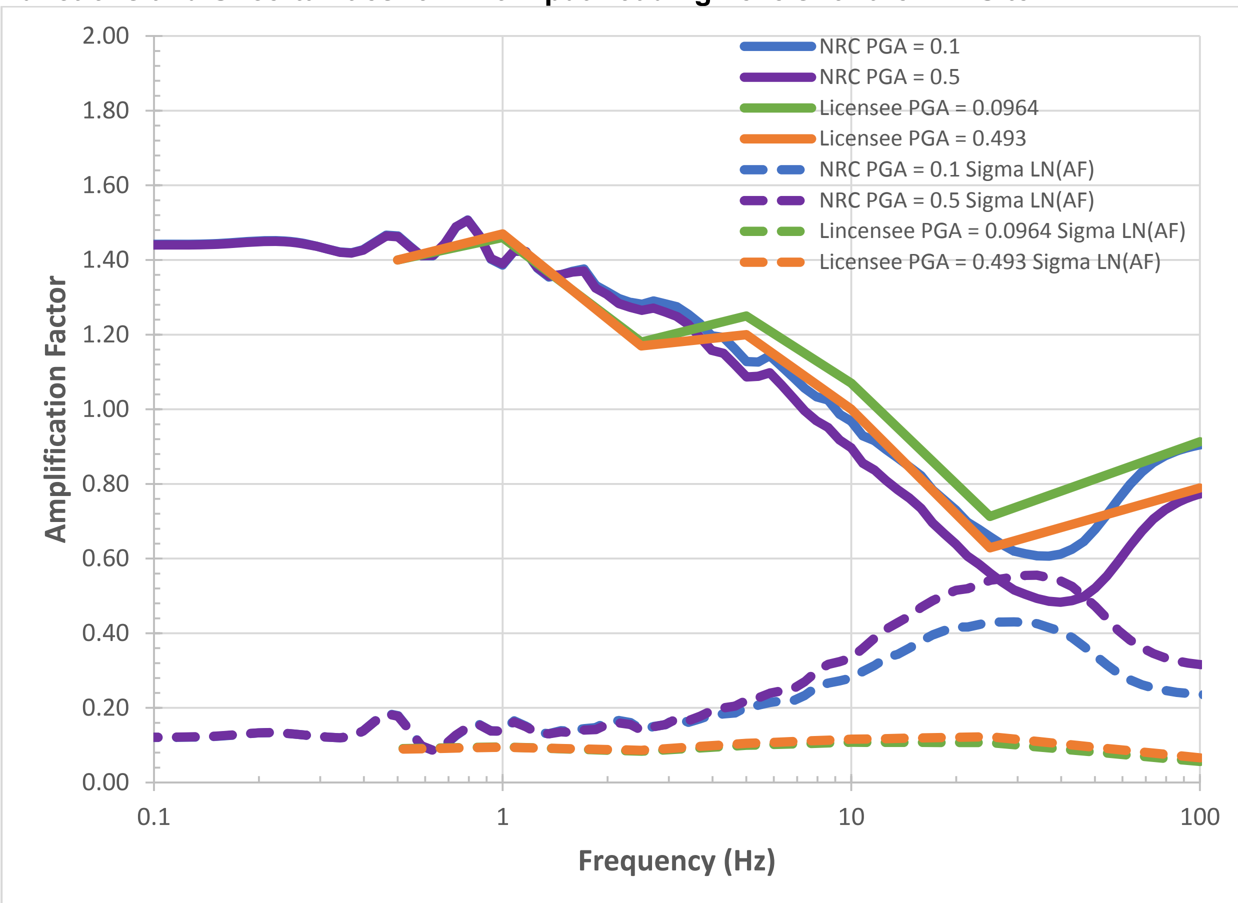


Figure 3.3-3 Plot Comparing the Staff's and the Licensee's Mean Control Point Hazard Curves at a Variety of Frequencies for the TMI Site

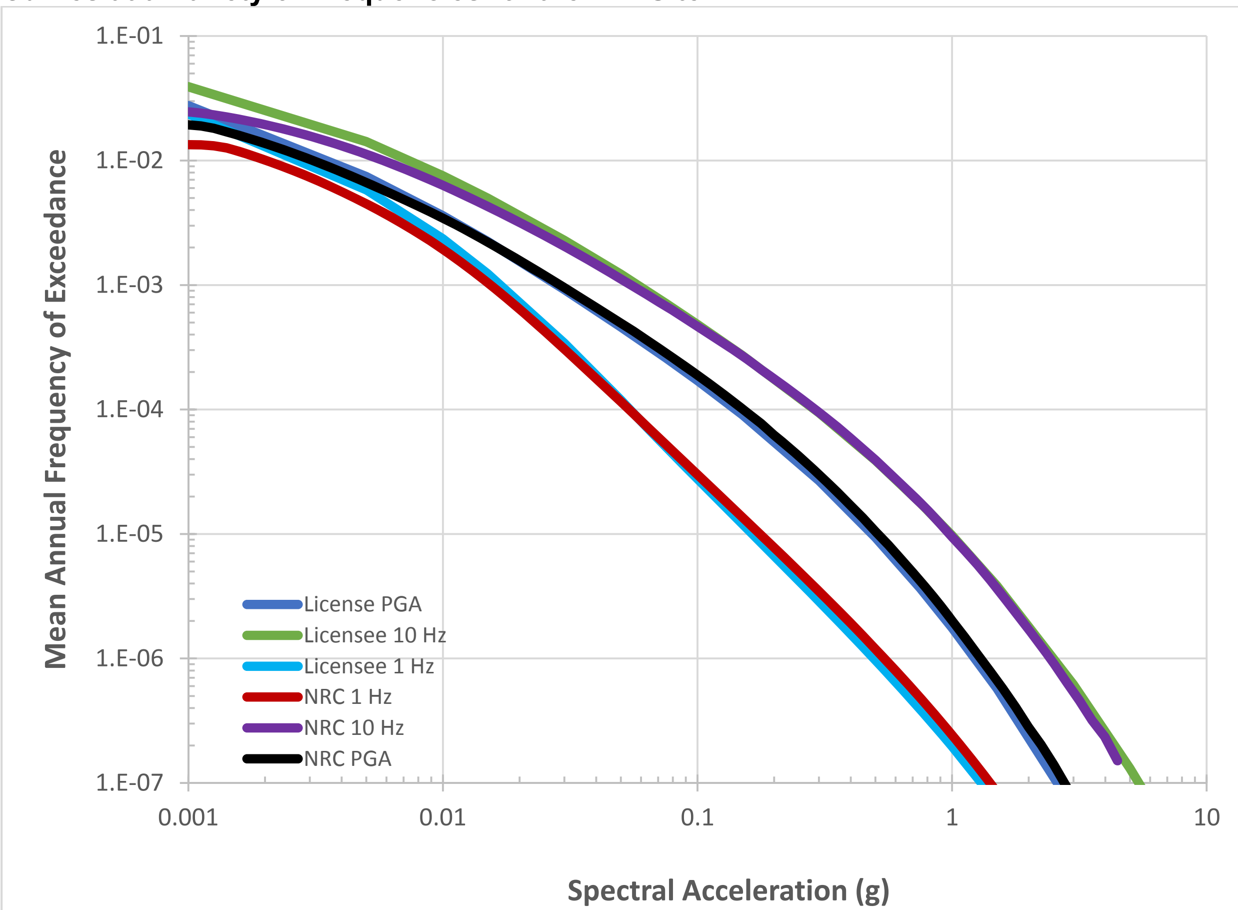
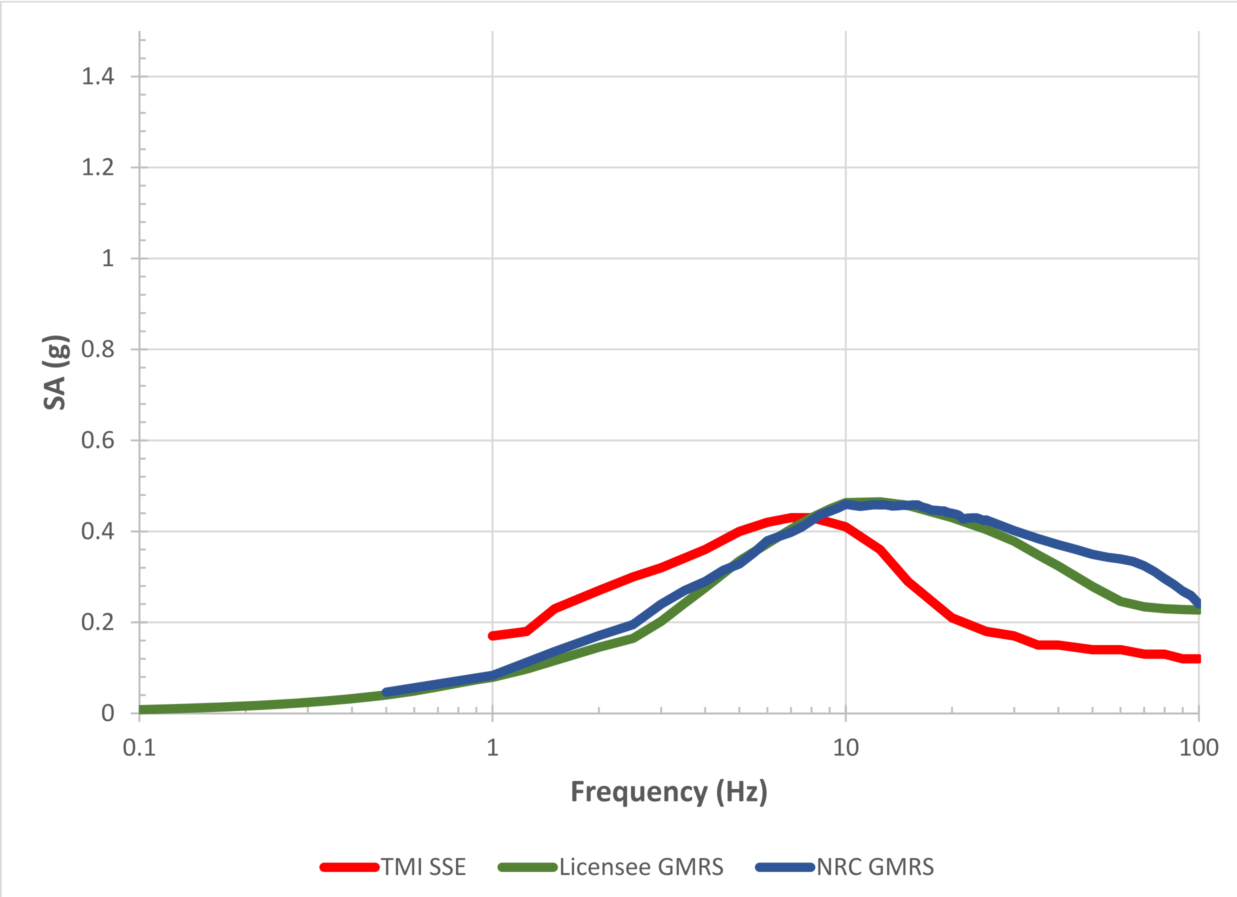


Figure 3.4-1 Comparison of the Staff's GMRS with Licensee's GMRS and the SSE for the TMI Site



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 No. 50-289

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