Exelon Generation.

RS-14-069 10 CFR 50.54(f)

March 31, 2014

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
11555 Rockville Pike,
Rockville, MD 20852

Limerick Generating Station, Units 1 and 2
Facility Operating License Nos. NPF-39 and NPF-85
NRC Docket Nos. 50-352 and 50-353

Subject: Exelon Generation Company, LLC, Seismic Hazard and Screening Report (Central and Eastern United States (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

References:

1. NRC Letter, Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident, dated March 12, 2012
2. NEI Letter, Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations, dated April 9, 2013
3. NRC Letter, Electric Power Research Institute Final Draft Report XXXXXX, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations, dated May 7, 2013
4. Exelon Generation Company, LLC letter to the 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, dated September 12, 2013
5. 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
6. NRC Letter, Endorsement of Electric Power Research Institute Final Draft Report 1025287, "Seismic Evaluation Guidance," dated February 15, 2013
7. EPRI Technical Report 3002000704, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," dated May 2013

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 1 requested each addressee located in the Central and Eastern United States (CEUS) to submit a Seismic Hazard Evaluation and Screening Report within 1.5 years from the date of Reference 1.

In Reference 2, the Nuclear Energy Institute (NEI) requested NRC agreement to delay submittal of the final CEUS Seismic Hazard Evaluation and Screening Reports so that an update to the Electric Power Research Institute (EPRI) ground motion attenuation model could be completed and used to develop that information. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted to the NRC by September 12, 2013, with the remaining seismic hazard and screening information submitted by March 31, 2014. NRC agreed with that proposed path forward in Reference 3. In Reference 4, Exelon Generation Company, LLC (EGC) provided the description of subsurface materials and properties and base case velocity profiles for Limerick Generating Station, Units 1 and 2.

Reference 5 contains industry guidance and detailed information to be included in the Seismic Hazard Evaluation and Screening Report submittals. NRC endorsed this industry guidance in Reference 6.

The enclosed Seismic Hazard Evaluation and Screening Report for Limerick Generating Station, Units 1 and 2, provides the information described in Section 4 of Reference 5 in accordance with the schedule identified in Reference 2. As described in Enclosure 1, Limerick Generating Station, Units 1 and 2, meet the requirements of SPID Sections 3.2 and 7 (Reference 5) and therefore screen out and do not need to prepare an Expedited Seismic Evaluation Process (ESEP) Report in accordance with Reference 7. Additionally, no Seismic Risk Assessment or Spent Fuel Pool evaluation is needed. Limerick Generating Station, Units 1 and 2, will perform a High Frequency Confirmation evaluation as determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations per Reference 1.

A list of regulatory commitments contained in this letter is provided in Enclosure 2. If you have any questions regarding this report, please contact Ron Gaston at (630) 657-3359.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 31st day of March 2014.

Respectfully submitted,

James Barstow
Director - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Enclosures:

1. Limerick Generating Station, Units 1 and 2, Seismic Hazard and Screening Report
2. Summary of Regulatory Commitments

cc: Director, Office of Nuclear Reactor Regulation
Regional Administrator - NRC Region I
NRC Senior Resident Inspector – Limerick Generating Station
NRC Project Manager, NRR – Limerick Generating Station
Ms. Jessica A. Kratchman, NRR/JLD/PMB, NRC
Mr. Eric E. Bowman, NRR/DPR/PGCB, NRC or Ms. Eileen M. McKenna, NRO/DSRA/BPTS, NRC
Director, Bureau of Radiation Protection - Pennsylvania Department of Environmental Resources
R. R. Janati, Chief, Division of Nuclear Safety, Pennsylvania Department of Environmental Protection, Bureau of Radiation Protection

Enclosure 1

Limerick Generating Station, Units 1 and 2

Seismic Hazard and Screening Report

(46 pages)

SEISMIC HAZARD AND SCREENING REPORT

IN RESPONSE TO THE 50.54(f) INFORMATION REQUEST REGARDING FUKUSHIMA NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC

for the
LIMERICK GENERATING STATION UNITS 1 & 2
3146 Sanatoga Road, Pottstown, PA 19464
Facility Operating License No. NPF-39 & NPF-85
NRC Docket No. STN 50-352 & STN 50-353
Correspondence No.: RS-14-069

Exelon Generation Company, LLC (Exelon)
PO Box 805398
Chicago, IL 60680-5398

Prepared by:
Enercon Services, Inc.
500 Townpark Lane, Kennesaw, GA 30144

Report Number: EXLNLIM065-PR-001, Revision 0

	Printed Name	Signature	Date
Preparer:	Mitchell McKay		3/14/14
Reviewer:	Benjamin Kosbab		3/14/14
Approver:	Paul Hansen		3/14/14
Lead Responsible Engineer:	Joseph Dullinger		3/17/14
Risk Management Engineer (Section 5.4 only):	Larry Lee		3/17/2014
Branch Manager:	Gregory Wallace		3/18/2014
Senior Manager Design Engineering:	Wayne Lewis		3/19/2014
Corporate Acceptance:	Jeffrey Clark		3/19/14

RECORD OF REVISIONS

Revision	Affected Pages	Description
0	All	Initial issue.

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PURPOSE

Following the accident at the Fukushima Dai-ichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) issued a 50.54(f) letter (Reference 1) requesting information in response to NRC Near-Term Task Force (NTTF) recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. The 50.54(f) letter (Reference 1) requests that licensees and holders of construction permits under Title 10 Code of Federal Regulations Part 50 (Reference 2) reevaluate the seismic hazards at their sites using updated seismic hazard information and present-day regulatory guidance and methodologies. This report provides the information requested in items (1) through (7) of the "Requested Information" in Enclosure 1 of the 50.54(f) letter (Reference 1), pertaining to NTTF Recommendation 2.1: Seismic for Limerick Generating Station (LGS) in accordance with the documented intention of Exelon Generation Company, LLC transmitted to the NRC via letter dated April 29, 2013 (Reference 13).

SCOPE

In response to the 50.54(f) letter (Reference 1) and following the Screening, Prioritization and Implementation Details (SPID) industry guidance document (Reference 3), a seismic hazard reevaluation for LGS was performed to develop a Ground Motion Response Spectrum (GMRS) for comparison with the plant-level seismic capacity. The new GMRS represents an alternative seismic demand determined using recently developed techniques. The new GMRS does not constitute a change in the plant design or licensing basis as described in the NRC letter dated February 20, 2014 (Reference 12). Section 1 provides an introduction. Section 2 provides a summary of the LGS regional and local geology and seismicity, other major inputs to the seismic hazard reevaluation, and detailed seismic hazard results including definition of the GMRS. Seismic hazard analysis for LGS, including site response evaluation and GMRS development (Sections 2.2, 2.3, and 2.4 of this report), was performed by the Electric Power Research Institute (Reference 16). A more in-depth discussion of the calculation methods used in the seismic hazard reevaluation can be found in References 3, 6, 7, 8, and 15. Section 3 describes the characteristics of the plant design basis ground motion for LGS. Section 4 provides a GMRS screening evaluation for LGS. Sections 5 and 6 discuss interim actions and conclusions, respectively, for LGS.

CONCLUSIONS

For LGS, the Safe Shutdown Earthquake envelopes the GMRS in the frequency range from 1 to 10 Hz. Therefore per the SPID Sections 3.2 and 7 (Reference 3), LGS screens out of further seismic risk assessments in response to NTTF 2.1: Seismic, including seismic probabilistic risk assessment (SPRA) or seismic margin assessment (SMA), as well as spent fuel pool integrity evaluations. Additionally, LGS screens out of the

Expedited Seismic Evaluation Process (ESEP) interim action per the "Augmented Approach" guidance document, Section 2.2 (Reference 4). Due to the GMRS exceeding the SSE in the frequency range above 10 Hz, high frequency confirmations are needed for LGS in accordance with the SPID Sections 3.2 and 3.4 (Reference 3). Actions to address NTTF 2.1: Seismic for central and eastern United States nuclear plants will be performed in accordance with the schedule provided in the April 9, 2013 letter from the industry to the NRC (Reference 5), as agreed to by the NRC in the May 7, 2013 letter to the industry (Reference 23).

1 Introduction

Following the accident at the Fukushima Dai-ichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the Nuclear Regulatory Commission (NRC) established a Near Term Task Force (NTTF). The NTTF was tasked with conducting a systematic review of NRC processes and regulations to determine if the agency should make additional improvements to its regulatory system. The NTTF developed a set of recommendations intended to clarify and strengthen the regulatory framework for protection against natural phenomena. Subsequently, the NRC issued a 50.54(f) letter requesting information to assure these recommendations would be addressed by all U.S. nuclear power plants (Reference 1). The 50.54(f) letter (Reference 1) requests that licensees and holders of construction permits under Title 10 Code of Federal Regulations Part 50 (10CFR50) (Reference 2) reevaluate the seismic hazards at their sites using updated seismic hazard information and present-day regulatory guidance and methodologies. Depending on the outcome of the comparison between the reevaluated seismic hazard and the current site-specific design basis, performance of a seismic risk assessment may be necessary. Risk assessment approaches acceptable to the NRC staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon the risk assessment results, the NRC staff will determine whether additional regulatory actions are necessary to provide additional protection against the updated hazards.

This report provides the information requested in items (1) through (7) of the "Requested Information" in Enclosure 1 of the 50.54(f) letter (Reference 1), pertaining to NTTF Recommendation 2.1: Seismic for Limerick Generating Station (LGS), located in Montgomery County, Pennsylvania in accordance with the documented intention of Exelon Generation Company, LLC (Exelon) transmitted to the NRC via letter dated April 29, 2013 (Reference 13). In providing this information LGS followed the Screening, Prioritization, and Implementation Details (SPID) industry guidance document (Reference 3). The "Augmented Approach" guidance document (Reference 4) defines interim actions/evaluations for addressing a higher seismic hazard relative to the plant's current design/licensing basis prior to completion of the seismic risk assessments to demonstrate additional seismic margin. This short term aspect of the Augmented Approach is referred to as the Expedited Seismic Evaluation Process (ESEP). In response to NTTF Recommendation 2.3, seismic walkdowns for LGS have been performed as initially documented and supplemented in Exelon Correspondence Numbers RS-12-171 and RS-13-138 (References 11 and 29), respectively, to satisfy the 50.54(f) letter (Reference 1).

The original geologic and seismic siting investigations for LGS were performed in accordance with Appendix A to 10 CFR Part 100 (Reference 17) and meet General Design Criterion 2 in Appendix A to 10CFR50 (Reference 2). The Safe Shutdown Earthquake Ground Motion (SSE) was developed in accordance with Appendix A to 10CFR100 (Reference 17) and used for the design of seismic Category I structures, systems and components (SSC). See Section 3 of this report for further discussion on

the development of the LGS SSE. All seismic Category I SSCs are analyzed under the loading conditions of the Safe Shutdown Earthquake (SSE) and Operating Basis Earthquake (OBE). Since the two earthquakes vary in intensity, the design of seismic Category I SSCs to resist each earthquake and other loads is based on levels of material stress, or load factors, whichever is applicable, and yield margins of safety appropriate for each earthquake. The margins of safety provided for safety-related SSCs for the SSE are sufficiently large to ensure that their design functions are not jeopardized (Reference 9, Section 3.2.1).

In response to the 50.54(f) letter (Reference 1) and following the guidance in the SPID (Reference 3), a seismic hazard reevaluation for LGS was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

2 Seismic Hazard Reevaluation

LGS is located on the east bank of the Schuylkill River in Limerick Township of Montgomery County, Pennsylvania, approximately 4 river miles downriver from Pottstown, 35 river miles upriver from Philadelphia, and 49 river miles above the confluence of the Schuylkill with the Delaware River (Reference 9, Section 1.1). LGS is located in the Triassic Lowland section of the Piedmont physiographic province. The area is within the Newark-Gettysburg basin, which is underlain by red sandstones, shales and siltstones of the Triassic Newark Group. These sedimentary basin deposits are gently tilted and warped, and are cut by diabase dikes and sills and by minor faulting. Some minor Jura-Triassic faults occur near the site; detailed studies carried out by LGS show that they are not significant to the construction and operation of the plant. The principal plant structures are founded on competent bedrock, about 100 feet above the river. Bedrock at the site, which consists of Triassic siltstone, sandstone, and shale, is moderately to closely jointed, and joints are generally vertical to nearly vertical (Reference 9, Section 2.5).

Earthquake activity in historic time within 200 miles of the site has been moderate. Zones of major earthquakes in the eastern United States are far away, and have not had an appreciable effect at the site. Evaluation of tectonic structures and the historical seismic record indicate a design intensity of VII (Modified Mercalli Scale) is adequately conservative for the site. Intensity VII corresponds to a peak ground acceleration of 0.13g; for additional conservatism, 0.15g has been adopted for the SSE. (Reference 9, Section 2.5)

2.1 Regional and Local Geology

The Limerick site is located in the Triassic Lowland section of the Piedmont physiographic province. The northeast-southwest trending Piedmont province is an eroded plateau of low relief and rolling topography. The surface of the plateau slopes gently to the southeast. The Piedmont is divided into an upland and a lowland section. The less rugged lowland section, in which LGS is located, is north and west of the Piedmont uplands and is formed largely on shales and sandstones of Triassic-age (Reference 9, Section 2.5.1.1.1). The dominant structural feature in the region surrounding the site is the Appalachian Orogenic Belt (Reference 9, Section 2.5.1.1.3). This part of the Appalachian Piedmont in Pennsylvania, New Jersey, and Maryland is typified by the presence of several Triassic basins such as the Culpeper, Gettysburg, and Newark (Reference 9, Section 2.5.2.2.2).

The site is located approximately 3 miles southeast of Pottstown, Pennsylvania, adjacent to the Schuylkill River. The principal plant structures are located on a broad ridge, approximately 100 feet above the river. Bedrock, encountered at shallow depths, consists predominantly of red siltstone, sandstone, and shale of late Triassic-age. The soils are residual, derived from the weathering of the underlying bedrock. Minor Triassic-age faults, inactive since Middle Mesozoic time, occur to the west and south of the construction area.

Fracture zones with a few inches of offset were encountered in the excavation; however, they are not significant to the plant structures. (Reference 9, Section 2.5.1.2.1)

2.2 PROBABILISTIC SEISMIC HAZARD ANALYSIS

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter (Reference 1) and following the guidance in the SPID (Reference 3), a probabilistic seismic hazard analysis (PSHA) was completed using the recently developed Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities (Reference 6) together with the updated EPRI Ground-Motion Model (GMM) for the CEUS (Reference 7). For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter (Reference 1).

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles (640 km) around LGS were included. This distance exceeds the 200 mile (320 km) recommendation contained in NRC Reg. Guide 1.208 (Reference 15) and was chosen for completeness. Background sources included in this site analysis are the following:

1. Atlantic Highly Extended Crust (AHEX)
2. Extended Continental Crust—Atlantic Margin (ECC_AM)
3. Great Meteor Hotspot (GMH)
4. Mesozoic and younger extended prior – narrow (MESE-N)
5. Mesozoic and younger extended prior – wide (MESE-W)
6. Midcontinent-Craton alternative A (MIDC_A)
7. Midcontinent-Craton alternative B (MIDC_B)
8. Midcontinent-Craton alternative C (MIDC_C)
9. Midcontinent-Craton alternative D (MIDC_D)
10. Northern Appalachians (NAP)
11. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
12. Non-Mesozoic and younger extended prior – wide (NMESE-W)
13. Paleozoic Extended Crust narrow (PEZ_N)
14. Paleozoic Extended Crust wide (PEZ_W)
15. St. Lawrence Rift, including the Ottawa and Saguenay grabens (SLR)
16. Study region (STUDY_R)

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in CEUS-SSC (Reference 6), the following sources lie within 1,000 km of the site and were included in the analysis:

1. Charleston
2. Charlevoix
3. Wabash Valley

For each of the above background and RLME sources, the mid-continent version of the updated CEUS EPRI GMM was used.

2.2.2 *Base Rock Seismic Hazard Curves*

Consistent with the SPID, Section 2.5.3 (Reference 3), base rock seismic hazard curves are not provided as the site amplification approach referred to as Method 3 has been used. Seismic hazard curves are shown below in Section 2.3.7 at the SSE control point elevation.

2.3 SITE RESPONSE EVALUATION

Following the guidance contained in Seismic Enclosure 1 of the 50.54(f) letter (Reference 1) and the SPID, Section 2.4 (Reference 3) for nuclear power plant sites that are not founded on hard rock (considered as having a shear wave velocity of at least 9285 fps), a site response analysis was performed for LGS.

2.3.1 *Description of Subsurface Material*

The Limerick site is located in the Newark-Gettysburg Triassic Basin of southeastern Pennsylvania. The general site conditions consist of about 0 to 10 ft. (3.0m) of Cretaceous residual soils (clays, silts and sands with some gravel-sized rock fragments) over about 8,000 ft. (2,438 m) of sound Triassic sedimentary rocks with a basement of hard crystalline rocks (Reference 14). Table 2.3.1-1 shows the idealized profile of geotechnical properties from the site (reproduced from Reference 14).

Table 2.3.1-1 Summary of site geotechnical profile for LGS (Reference 14)

Elevations of Layer Boundaries Under Reactor Buildings (ft., MSL)	Range in Thickness Across Site (ft.)	Soil/Rock Description and Age	Density (pcf)	Shear Wave Velocity (fps)[e,f]	Compressional Wave Velocity (fps)[e,f]	Poisson's ratio
214[a] to 204	0-10	Cretaceous stiff clayey silt, sandy silt, and silty fine sand with some gravel-sized rock fragments	126-141	UFSAR: N/A ISFSI: 875-1000	UFSAR: N/A ISFSI: 1800	N/A
204[b] to -7800[c]	8000	Triassic Brunswick lithofacies, hard siltstone, sandstone and shale	140-162	UFSAR: 5800-6100 ISFSI: 1900-5000	UFSAR: 7700-20000[d] ISFSI: 3500-8000	0.30-0.33
-7800 and below	N/A	Paleozoic and Precambrian basement rocks	N/A	N/A	N/A	N/A

[a] Finish grade elevation is nominally 217 ft. MSL around the main power block. The elevation shown in the table represents original grade before excavation and backfill. Type I Fill was used for site grading around the main power block. UFSAR Section 2.5.4.2.2.5 states that the dynamic properties of Type I Fill have not been measured. The density is assumed to be 140 pcf in the design evaluations.

[b] The SSE and IPEEE HCLPF control point elevations are at the top of bedrock, at El. 204 ft. MSL.

[c] Bottom of the deepest foundation is at El. 174 ft. MSL, within the unweathered Brunswick lithofacies.

[d] UFSAR Section 2.5.4.2.1 indicates that the variation in compressional wave velocities in the immediate vicinity of the power block is significantly less than that over the entire site. The unbiased one-standard-deviation range is estimated to be 10950-12810 fps in the power block area.

[e] The ISFSI geotechnical investigation and UFSAR provide significantly different ranges for the bedrock shear wave velocity and compressional wave velocity. Consequently, the reported values from each reference are reported separately.

[f] The compressional and shear wave velocities were measured near the surface of the bedrock.

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

Table 2.3.1-1 shows the recommended shear-wave velocities and unit weights versus depth for the profile. Based on Table 2.3.1-1 and the location of the SSE control point at an elevation of 204 ft. MSL (62.2m) (Reference 14) (see Section 3.2 for further control point discussion) the profile consists of about 8,000 ft. (2,438m) of firm rock overlying hard crystalline basement rock.

Shear-wave velocities for the profile reported in the UFSAR likely were based on measurements of compressional-wave velocities (Reference 14) through refraction surveys and assumed Poisson ratios. More recent downhole testing at the nearby independent spent fuel storage installation (ISFSI) provided significantly different ranges for the firm rock shear-wave velocities (Reference 14). The narrow range in shear-wave velocity for the UFSAR is from 5,800 to 6,100 fps (1,768 to 1,859 m/s) (Reference 14). The larger range in shear-wave velocity for the ISFSI is from 1,900 to 5,000 fps (579 to 1,524 m/s) (Reference 14). Since the ISFSI measurements reflect more recent testing they were used to develop the mean or best-estimate base-case firm rock profile.

To develop the mean or best-estimate base-case firm rock profile, the shear-wave velocity of 3,452 fps (1,052m/s) was assumed to reflect the shallow portion of the profile. Provided the materials to basement depth reflect similar sedimentary rocks and age, the shear-wave velocity gradient for sedimentary rock of 0.5 m/s/m (Reference 3) was assumed to be appropriate for the site. The shallow shear-wave velocity of 3,452 fps (1,052m/s) was taken at the surface of the profile with the velocity gradient applied at that point, resulting in a base-case shear-wave velocity of about 7,400 fps (2,255m/s) at a depth of 8,000 ft. (2,438m). The mean or best estimate base-case profile is shown as profile P1 in Figure 2.3.2-1.

Based on the range of shear-wave velocities that reflect either measured compressional-wave velocities and assumed Poisson ratios, or the more recent measurements at the ISFSI, a scale factor of 1.57 was adopted to reflect the lower range base-case. The scale factor of 1.57 reflects a $\sigma_{\mu ln}$ of about 0.35 based on the SPID (Reference 3) 10th and 90th fractiles which implies a 1.28 scale factor on σ_{μ}.

Using the best estimate or mean base-case profile (P1), the depth independent scale factor of 1.57 was applied to develop the lower range base-case profile (P2). Base-case profiles P1 and P2 have a mean depth below the SSE control point of 8,000 ft. (2,438m) to hard reference rock, randomized ± 2,401 ft. (± 732m). Upper range profile P3 was based on the USFAR shear-wave velocity at the SSE control point of 5800-6100 fps (1,768 to 1,859 m/s) with an assumed velocity gradient for sedimentary rock of 0.5 m/s/m (Reference 3). Profile P3 reaches the hard-rock shear-wave velocity of 9,285 fps at a depth of 6,734 ft (2,052 m). The base-case profiles (P1, P2, and P3) are shown in Figure 2.3.2-1 and listed in Table 2.3.2-2. The depth randomization of profiles P1 and P2 reflect ± 30% of the depth to provide a realistic broadening of the fundamental resonance rather than reflect actual random variations to basement shear-wave velocities across a footprint.

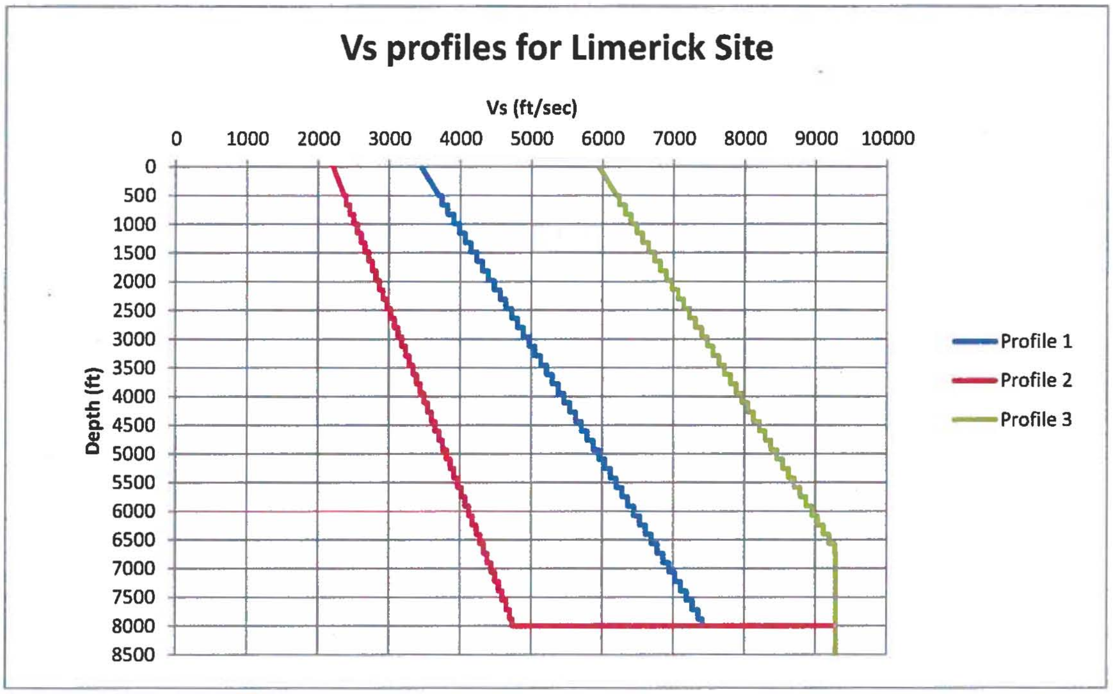


Figure 2.3.2-1 Shear wave velocity profiles for the Limerick site

Table 2.3.2-2 Layer thicknesses, depths, and shear-wave velocities (V_s) for three profiles, the Limerick site

Profile 1			Profile 2			Profile 3		
Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)
	0	3452		0	2209		0	5952
10.0	10.0	3452	10.0	10.0	2209	10.0	10.0	5952
10.0	20.0	3457	10.0	20.0	2213	10.0	20.0	5957
10.0	30.0	3462	10.0	30.0	2216	10.0	30.0	5962
10.0	40.0	3467	10.0	40.0	2219	10.0	40.0	5967
10.0	50.0	3472	10.0	50.0	2222	10.0	50.0	5972
10.0	60.0	3477	10.0	60.0	2225	10.0	60.0	5977
10.0	70.0	3482	10.0	70.0	2229	10.0	70.0	5982
10.0	80.0	3487	10.0	80.0	2232	10.0	80.0	5987
10.0	90.0	3492	10.0	90.0	2235	10.0	90.0	5992
10.0	100.0	3497	10.0	100.0	2238	10.0	100.0	5997
10.0	110.0	3502	10.0	110.0	2241	10.0	110.0	6002
10.0	120.0	3507	10.0	120.0	2245	10.0	120.0	6007
10.0	130.0	3512	10.0	130.0	2248	10.0	130.0	6012
10.0	140.0	3517	10.0	140.0	2251	10.0	140.0	6017
10.0	150.0	3522	10.0	150.0	2254	10.0	150.0	6022
10.0	160.0	3527	10.0	160.0	2257	10.0	160.0	6027

Profile 1			Profile 2			Profile 3		
Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)
10.0	170.0	3532	10.0	170.0	2261	10.0	170.0	6032
10.0	180.0	3537	10.0	180.0	2264	10.0	180.0	6037
10.0	190.0	3542	10.0	190.0	2267	10.0	190.0	6042
10.0	200.0	3547	10.0	200.0	2270	10.0	200.0	6047
10.0	210.0	3552	10.0	210.0	2273	10.0	210.0	6052
10.0	220.0	3557	10.0	220.0	2277	10.0	220.0	6057
10.0	230.0	3562	10.0	230.0	2280	10.0	230.0	6062
10.0	240.0	3567	10.0	240.0	2283	10.0	240.0	6067
10.0	250.0	3572	10.0	250.0	2286	10.0	250.0	6072
10.0	260.0	3577	10.0	260.0	2289	10.0	260.0	6077
10.0	270.0	3582	10.0	270.0	2293	10.0	270.0	6082
10.0	280.0	3587	10.0	280.0	2296	10.0	280.0	6087
10.0	290.0	3592	10.0	290.0	2299	10.0	290.0	6092
10.0	300.0	3597	10.0	300.0	2302	10.0	300.0	6097
10.0	310.0	3602	10.0	310.0	2305	10.0	310.0	6102
10.0	320.0	3607	10.0	320.0	2309	10.0	320.0	6107
10.0	330.0	3612	10.0	330.0	2312	10.0	330.0	6112
10.0	340.0	3617	10.0	340.0	2315	10.0	340.0	6117
10.0	350.0	3622	10.0	350.0	2318	10.0	350.0	6122
10.0	360.0	3627	10.0	360.0	2321	10.0	360.0	6127
10.0	370.0	3632	10.0	370.0	2325	10.0	370.0	6132
10.0	380.0	3637	10.0	380.0	2328	10.0	380.0	6137
10.0	390.0	3642	10.0	390.0	2331	10.0	390.0	6142
10.0	400.0	3647	10.0	400.0	2334	10.0	400.0	6147
10.0	410.0	3652	10.0	410.0	2337	10.0	410.0	6152
10.0	420.0	3657	10.0	420.0	2341	10.0	420.0	6157
10.0	430.0	3662	10.0	430.0	2344	10.0	430.0	6162
10.0	440.0	3667	10.0	440.0	2347	10.0	440.0	6167
10.0	450.0	3672	10.0	450.0	2350	10.0	450.0	6172
10.0	460.0	3677	10.0	460.0	2353	10.0	460.0	6177
10.0	470.0	3682	10.0	470.0	2357	10.0	470.0	6182
10.0	480.0	3687	10.0	480.0	2360	10.0	480.0	6187
10.0	490.0	3692	10.0	490.0	2363	10.0	490.0	6192
10.0	500.0	3695	10.0	500.0	2365	10.0	500.0	6197
164.0	664.0	3741	164.0	664.0	2394	164.0	664.0	6241
164.0	828.1	3823	164.0	828.1	2447	164.0	828.1	6323
164.0	992.1	3905	164.0	992.1	2499	164.0	992.1	6405
164.0	1156.1	3987	164.0	1156.1	2552	164.0	1156.1	6487
164.0	1320.2	4069	164.0	1320.2	2604	164.0	1320.2	6569
164.0	1484.2	4151	164.0	1484.2	2657	164.0	1484.2	6651
164.0	1648.3	4233	164.0	1648.3	2709	164.0	1648.3	6733

Profile 1			Profile 2			Profile 3		
Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)	Thickness (ft.)	Depth (ft.)	V_s (fps)
164.0	1812.3	4315	164.0	1812.3	2762	164.0	1812.3	6815
164.0	1976.4	4397	164.0	1976.4	2814	164.0	1976.4	6897
164.0	2140.4	4479	164.0	2140.4	2867	164.0	2140.4	6979
164.0	2304.4	4561	164.0	2304.4	2919	164.0	2304.4	7061
164.0	2468.5	4643	164.0	2468.5	2972	164.0	2468.5	7143
164.0	2632.5	4725	164.0	2632.5	3024	164.0	2632.5	7225
164.0	2796.6	4807	164.0	2796.6	3077	164.0	2796.6	7307
164.0	2960.6	4889	164.0	2960.6	3129	164.0	2960.6	7389
164.0	3124.6	4971	164.0	3124.6	3182	164.0	3124.6	7471
164.0	3288.7	5053	164.0	3288.7	3234	164.0	3288.7	7553
164.0	3452.7	5135	164.0	3452.7	3287	164.0	3452.7	7635
164.0	3616.8	5217	164.0	3616.8	3339	164.0	3616.8	7717
164.0	3780.8	5299	164.0	3780.8	3391	164.0	3780.8	7799
164.0	3944.9	5381	164.0	3944.9	3444	164.0	3944.9	7881
164.0	4108.9	5463	164.0	4108.9	3496	164.0	4108.9	7963
164.0	4272.9	5545	164.0	4272.9	3549	164.0	4272.9	8045
164.0	4437.0	5627	164.0	4437.0	3601	164.0	4437.0	8127
164.0	4601.0	5709	164.0	4601.0	3654	164.0	4601.0	8209
164.0	4765.1	5791	164.0	4765.1	3706	164.0	4765.1	8291
164.0	4929.1	5873	164.0	4929.1	3759	164.0	4929.1	8373
164.0	5093.1	5955	164.0	5093.1	3811	164.0	5093.1	8455
164.0	5257.2	6037	164.0	5257.2	3864	164.0	5257.2	8537
164.0	5421.2	6119	164.0	5421.2	3916	164.0	5421.2	8619
164.0	5585.3	6201	164.0	5585.3	3969	164.0	5585.3	8701
164.0	5749.3	6283	164.0	5749.3	4021	164.0	5749.3	8783
164.0	5913.4	6365	164.0	5913.4	4074	164.0	5913.4	8865
164.0	6077.4	6448	164.0	6077.4	4126	164.0	6077.4	8947
164.0	6241.4	6530	164.0	6241.4	4179	164.0	6241.4	9029
164.0	6405.5	6612	164.0	6405.5	4231	164.0	6405.5	9111
164.0	6569.5	6694	164.0	6569.5	4284	164.0	6569.5	9193
164.0	6733.6	6776	164.0	6733.6	4336	164.0	6733.6	9275
164.0	6897.6	6858	164.0	6897.6	4389	164.0	6897.6	9285
164.0	7061.6	6940	164.0	7061.6	4441	164.0	7061.6	9285
164.0	7225.7	7022	164.0	7225.7	4494	164.0	7225.7	9285
164.0	7389.7	7104	164.0	7389.7	4546	164.0	7389.7	9285
164.0	7553.8	7186	164.0	7553.8	4599	164.0	7553.8	9285
164.0	7717.8	7268	164.0	7717.8	4651	164.0	7717.8	9285
164.0	7881.9	7350	164.0	7881.9	4704	164.0	7881.9	9285
117.7	7999.6	7409	117.7	7999.6	4742	117.7	7999.6	9285
3280.8	11280.4	9285	3280.8	11280.4	9285	3280.8	11280.4	9285

2.3.2.1 *Shear Modulus and Damping Curves*

No site-specific nonlinear dynamic material properties were determined in the initial siting of the LGS for sedimentary rocks. The rock material over the upper 500 ft. (150 m) was assumed to have behavior that could be modeled as either linear or non-linear. To represent this potential for either case in the upper 500 ft. of sedimentary rock at the Limerick site, two sets of shear modulus reduction and hysteretic damping curves were used. Consistent with the SPID (Reference 3), the EPRI rock curves (model M1) were considered to be appropriate to represent the upper range nonlinearity likely in the materials at this site and linear analyses (model M2) were assumed to represent an equally plausible alternative rock response across loading levels. For the linear analyses, the low strain damping from the EPRI rock curves were used as the constant damping values in the upper 500 ft. (150m).

2.3.2.2 *Kappa*

For the Limerick site, kappa estimates were determined using Section B-5.1.3.1 of the SPID (Reference 3) for a firm CEUS rock site. Kappa for a firm rock site with at least 3,000 ft. (1 km) of sedimentary rock may be estimated from the average S-wave velocity over the upper 100 ft. (V_{s100}) of the subsurface profile while for a site with less than 3,000 ft. (1 km) of firm rock, kappa may be estimated with a Q_s of 40 below 500 ft. combined with the low strain damping from the EPRI rock curves and an additional kappa of 0.006s for the underlying hard rock. For the Limerick site, with 8,000 ft. (2,438m) of firm sedimentary rock below the SSE, kappa estimates were based on the average shear-wave velocity over the top 100 ft. (30m) of the three base-case profiles P1, P2, and P3. For the three profiles the corresponding average (100 ft., 30m) shear-wave velocities were: 3,475 fps (1,059 m/s), 2,223 fps (678 m/s), and 5,974 fps (1,821m/s) with corresponding kappa estimates of 0.023s, 0.036s, and 0.012s. The range in kappa about the best estimate base-case value of 0.023s (profile P1) is roughly 1.6 and was considered to adequately reflect epistemic uncertainty in low strain damping (kappa) for the profile.

Table 2.3.2-3 Kappa values and weights used for site response analyses

Velocity Profile	Kappa (s)	Weights
P1	0.023	0.4
P2	0.036	0.3
P3	0.012	0.3
G/G_{max} and Hysteretic Damping Curves		
M1		0.5
M2		0.5

2.3.3 *Randomization of Base Case Profiles*

To account for the aleatory variability in dynamic material properties that is expected to occur across a site at the scale of a typical nuclear facility, variability in the assumed shear-wave velocity profiles has been incorporated in the site response calculations. For the Limerick site, random shear wave velocity profiles were developed from the base case profiles shown in Figure 2.3.2-1. Consistent with the discussion in Appendix B of the SPID (Reference 3), the velocity randomization procedure made use of random field

models which describe the statistical correlation between layering and shear wave velocity. The default randomization parameters developed in Reference 8 for United States Geological Survey (USGS) "A" site conditions were used for this site. Thirty random velocity profiles were generated for each base case profile. These random velocity profiles were generated using a natural log standard deviation of 0.25 over the upper 50 ft. and 0.15 below that depth. As specified in the SPID (Reference 3), correlation of shear wave velocity between layers was modeled using the footprint correlation model. In the correlation model, a limit of +/- 2 standard deviations about the median value in each layer was assumed for the limits on random velocity fluctuations.

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID (Reference 3), input Fourier amplitude spectra were defined for a single representative earthquake magnitude (**M** 6.5) using two different assumptions regarding the shape of the seismic source spectrum (single-corner and double-corner). A range of 11 different input amplitudes (median peak ground accelerations (PGA) ranging from 0.01g to 1.5g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the Limerick site were the same as those identified in Tables B-4, B-5, B-6 and B-7 of the SPID (Reference 3) as appropriate for typical CEUS sites.

2.3.5 Methodology

To perform the site response analyses for the Limerick site, a random vibration theory (RVT) approach was employed. This process utilizes a simple, efficient approach for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID (Reference 3). The guidance contained in Appendix B of the SPID (Reference 3) on incorporating epistemic uncertainty in shear-wave velocities, kappa, non-linear dynamic properties and source spectra for plants with limited at-site information was followed for the Limerick site.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% of critical damping pseudo absolute response spectra) which describe the amplification (or de-amplification) of hard reference rock motion as a function of frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated standard deviation (sigma) for each spectral frequency and input rock amplitude. Consistent with the SPID (Reference 3) a minimum median amplification value of 0.5 was employed in the present analysis. Figure 2.3.6-1 illustrates the median and +/- 1 standard deviation in the predicted amplification factors developed for the eleven loading levels parameterized by 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. The variability in the amplification factors results from variability in shear-wave velocity, depth to hard rock, and modulus reduction and hysteretic damping curves. To illustrate the effects of nonlinearity at the Limerick site, Figure 2.3.6-2 shows the corresponding amplification factors developed with linear analyses (model M2). Tabulated values of the amplification factors are provided in Appendix A.

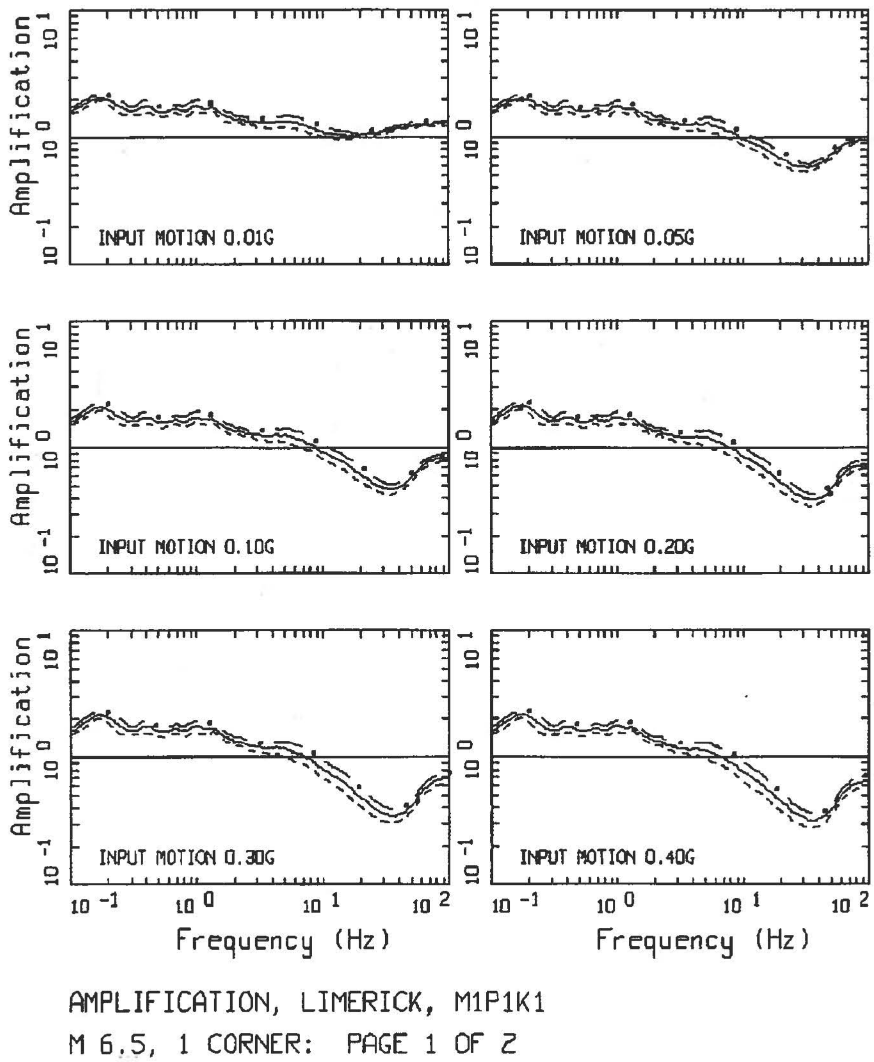
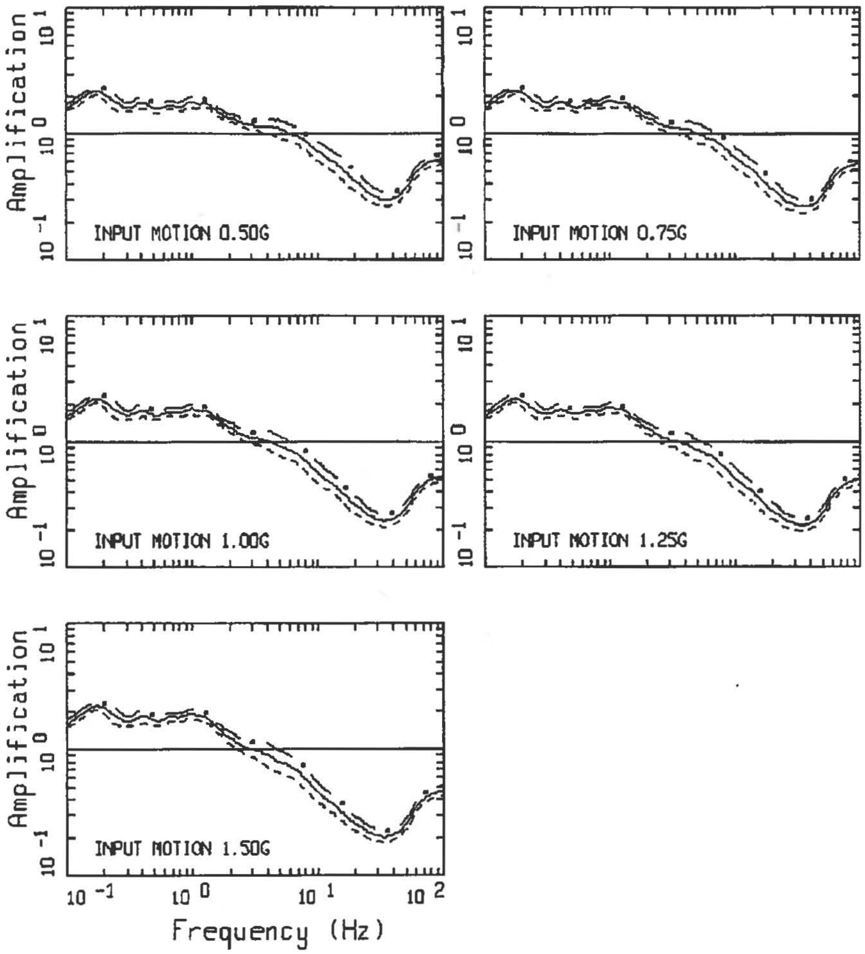


Figure 2.3.6-1 Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (Reference 3)



AMPLIFICATION, LIMERICK, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-1 continued

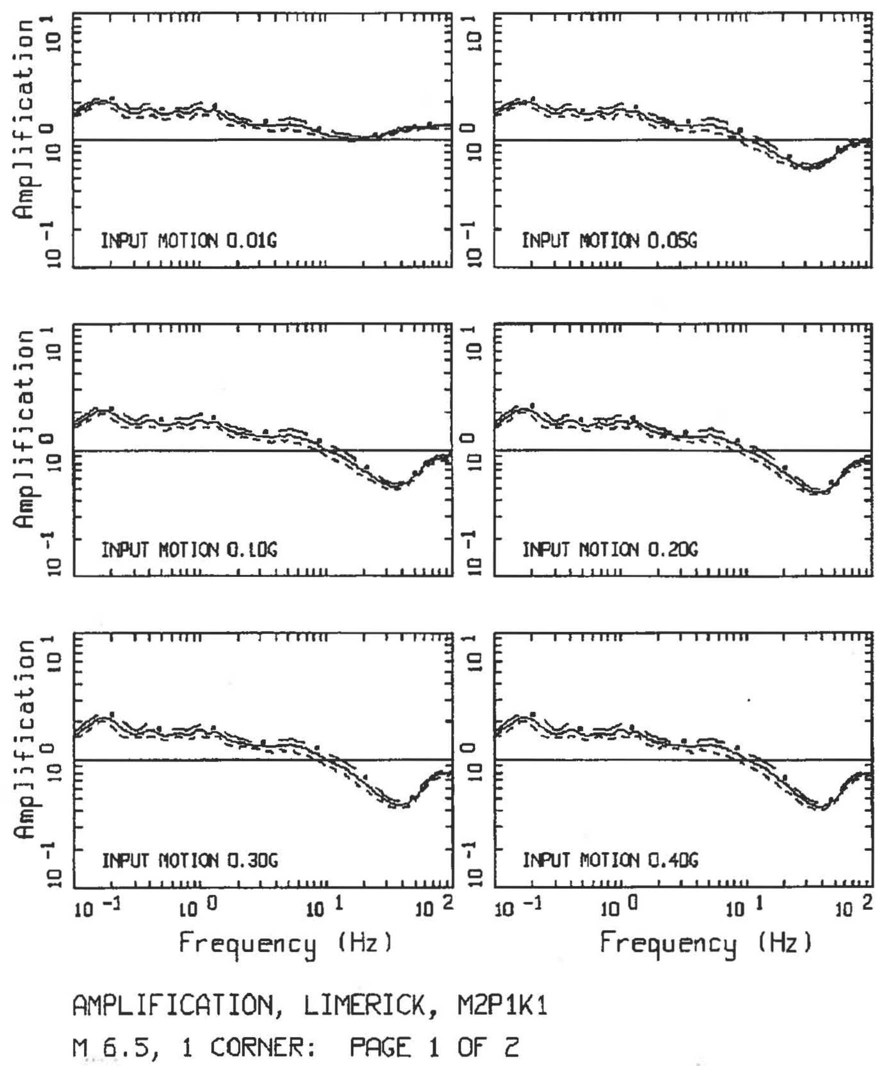
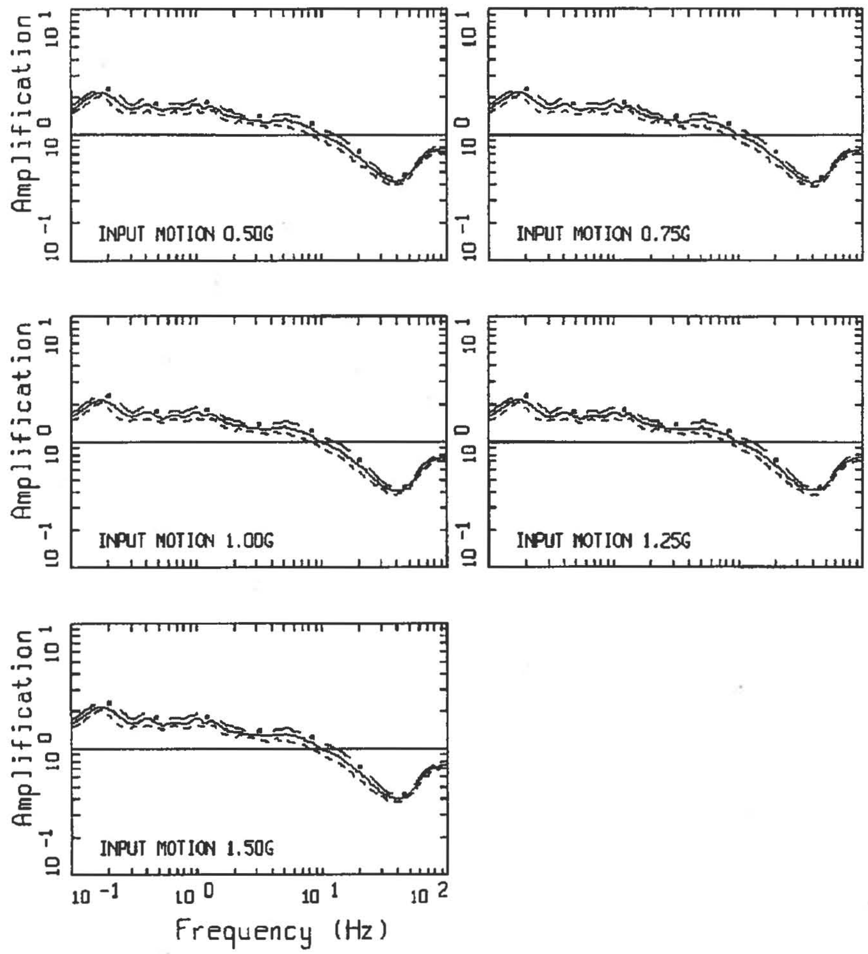


Figure 2.3.6-2 Example suite of amplification factors (5% of critical damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), linear analyses (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model (Reference 3)



AMPLIFICATION, LIMERICK, M2P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2.3.6-2 continued

2.3.7 Control Point Seismic Hazard Curves

The procedure to develop probabilistic site-specific control point hazard curves used in the present analysis follows the methodology described in Section B-6.0 of the SPID (Reference 3). This procedure, referred to as Method 3, computes a site-specific control point hazard curve for a broad range of spectral accelerations given the site-specific bedrock hazard curve and site-specific estimates of soil or soft-rock response and associated uncertainties. This process is repeated for each of the seven spectral frequencies for which ground motion equations are available. The dynamic response of the materials below the control point was represented by the frequency and amplitude-dependent amplification functions (median values and standard deviations) developed and described in the previous section. The resulting control point mean hazard curves for LGS are shown in Figure 2.3.7-1 for the seven spectral frequencies for which ground motion equations are defined. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in Appendix A.

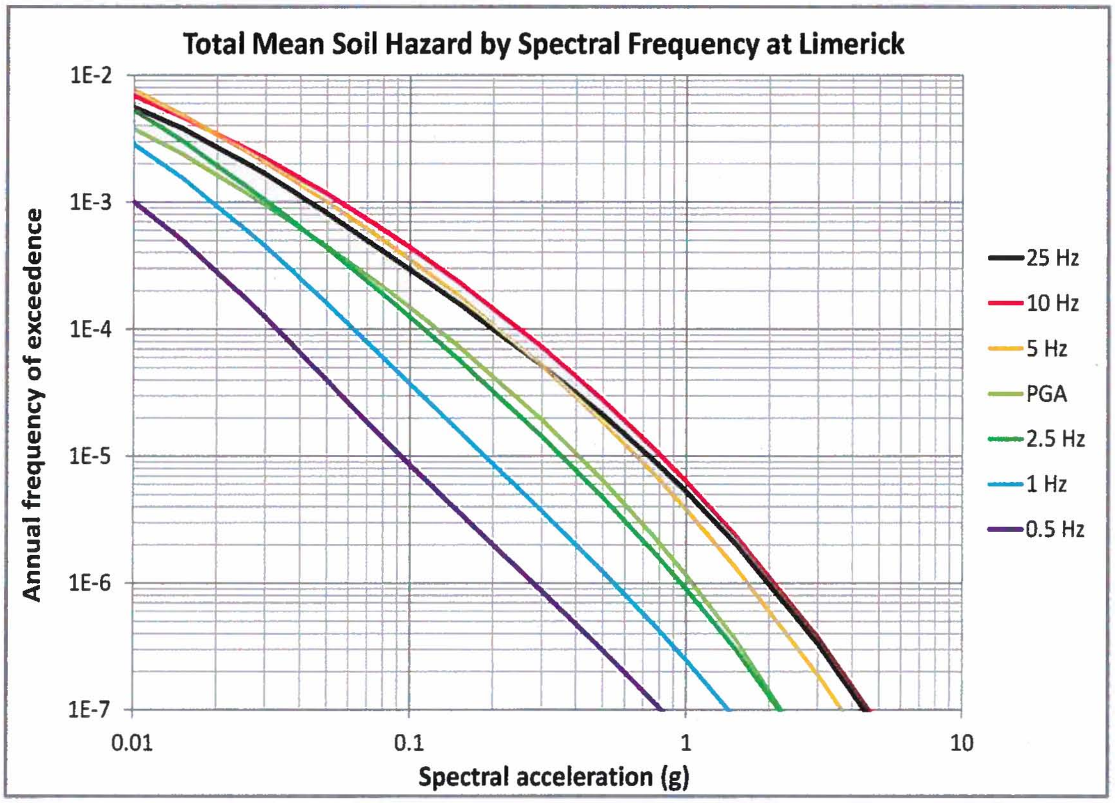


Figure 2.3.7-1 Control point mean hazard curves for spectral frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz (PGA) at LGS (5% of critical damping)

2.4 CONTROL POINT RESPONSE SPECTRA (UHRS & GMRS)

The control point hazard curves described in Section 2.3.7 have been used to develop geometric mean horizontal uniform hazard response spectra (UHRS) and the GMRS. The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the 1E-4 and 1E-5 per year hazard levels. The 1E-4 and 1E-5 UHRS, along with a design factor (DF) are used to compute the GMRS at the control point using the criteria in NRC Reg. Guide 1.208 (Reference 15). The GMRS developed herein represents an alternative seismic demand determined for LGS using recently developed techniques. Table 2.4-1 shows the UHRS and GMRS accelerations for a range of spectral frequencies. Figure 2.4-1 shows the UHRS and GMRS at the control point.

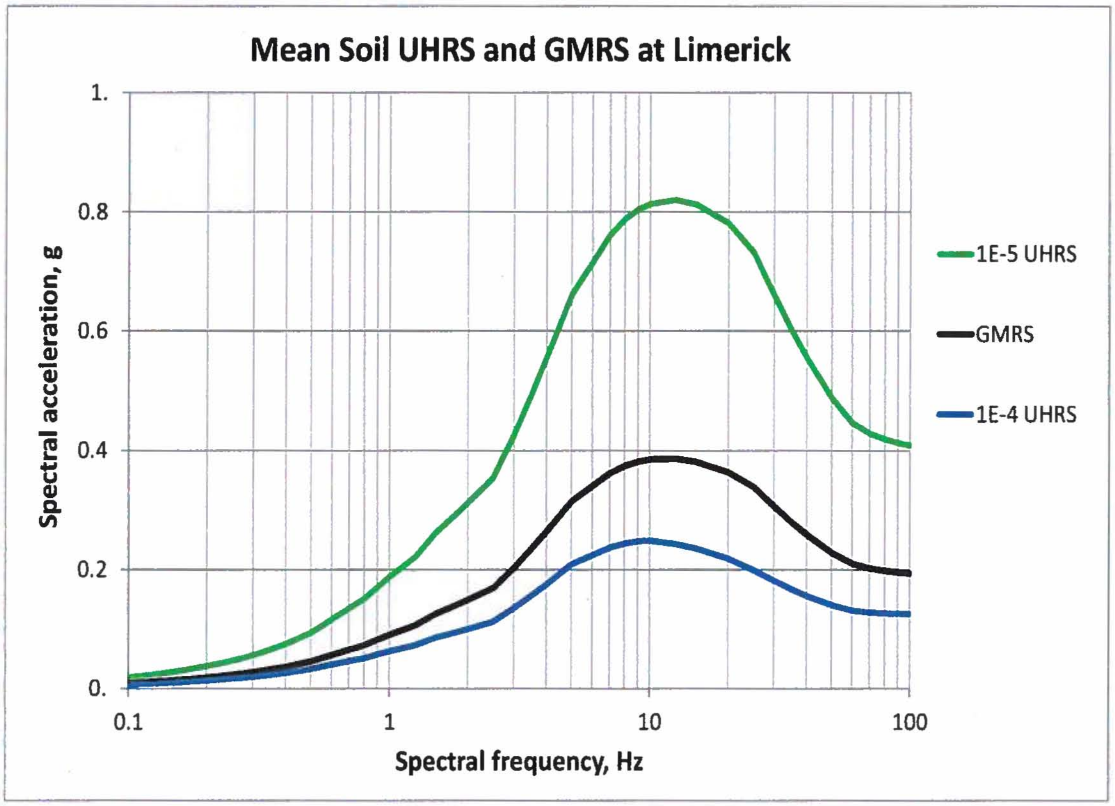


Figure 2.4-1 Plots of 1E-4 and 1E-5 UHRS and GMRS at control point for LGS (5% of critical damping response spectra)

Table 2.4-1 UHRS and GMRS at control point for LGS (5% of critical damping response spectra)

Freq (Hz)	1E-4 UHRS (g)	1E-5 UHRS (g)	GMRS (g)
100	1.26E-01	4.08E-01	1.93E-01
90	1.26E-01	4.13E-01	1.95E-01
80	1.27E-01	4.19E-01	1.98E-01
70	1.28E-01	4.28E-01	2.02E-01
60	1.31E-01	4.46E-01	2.10E-01
50	1.40E-01	4.88E-01	2.28E-01
40	1.56E-01	5.55E-01	2.58E-01
35	1.67E-01	6.01E-01	2.79E-01
30	1.81E-01	6.60E-01	3.06E-01
25	1.99E-01	7.32E-01	3.39E-01
20	2.18E-01	7.81E-01	3.63E-01
15	2.36E-01	8.12E-01	3.81E-01
12.5	2.43E-01	8.20E-01	3.86E-01
10	2.49E-01	8.13E-01	3.85E-01
9	2.47E-01	8.04E-01	3.81E-01
8	2.44E-01	7.88E-01	3.74E-01
7	2.36E-01	7.61E-01	3.61E-01
6	2.24E-01	7.15E-01	3.40E-01
5	2.09E-01	6.61E-01	3.15E-01
4	1.75E-01	5.55E-01	2.64E-01
3.5	1.56E-01	4.93E-01	2.35E-01
3	1.35E-01	4.25E-01	2.03E-01
2.5	1.12E-01	3.54E-01	1.69E-01
2	9.97E-02	3.11E-01	1.49E-01
1.5	8.52E-02	2.61E-01	1.25E-01
1.25	7.27E-02	2.21E-01	1.06E-01
1	6.26E-02	1.87E-01	9.02E-02
0.9	5.73E-02	1.70E-01	8.21E-02
0.8	5.09E-02	1.50E-01	7.26E-02
0.7	4.62E-02	1.35E-01	6.52E-02
0.6	4.03E-02	1.16E-01	5.63E-02
0.5	3.31E-02	9.34E-02	4.55E-02
0.4	2.64E-02	7.47E-02	3.64E-02
0.35	2.31E-02	6.54E-02	3.19E-02
0.3	1.98E-02	5.60E-02	2.73E-02
0.25	1.65E-02	4.67E-02	2.28E-02
0.2	1.32E-02	3.74E-02	1.82E-02
0.15	9.92E-03	2.80E-02	1.37E-02
0.125	8.27E-03	2.33E-02	1.14E-02
0.1	6.61E-03	1.87E-02	9.10E-03

3 Plant Design Basis Ground Motion

The design basis for LGS is identified in the Updated Final Safety Analysis Report (Reference 9). The current licensing basis SSE for LGS is based upon an evaluation of the maximum earthquake potential considering the regional and local geology, seismology, tectonic history and specific characteristics of local subsurface material. The response spectrum is based on data developed from records of previous earthquake activity and represents an envelope of motion expected at a sound rock site from a nearby earthquake (Reference 9, Section 3.7.1.1). Considering the historic seismicity of the site region, the maximum potential earthquake might either be an intensity VII event along the Fall Zone at its closest approach to the site or an intensity VI event very near the site. Because of the uncertainties involved in associating regional activity with specific structures, the maximum potential earthquake is specified as being equivalent to the intensity VII 1871 Wilmington, Delaware earthquake occurring near the site (Reference 9, Section 2.5.2.4).

3.1 SSE Description of Spectral Shape

The SSE is defined in terms of a PGA and a design response spectrum. Considering a site design intensity of VII, the maximum horizontal ground acceleration is conservatively defined with 15% of gravity (0.15g) as the anchor point for the SSE (Reference 9, Section 2.5.2.6). The site design response spectrum for the SSE has a Newmark-type spectral shape (Reference 9, Figure 3.7-2).

The horizontal SSE (5% of critical damping) for LGS is shown below in Figure 3.1-1. Table 3.1-1 shows the spectral acceleration values as a function of frequency for the horizontal SSE (5% of critical damping). The SSE acceleration values are based upon a Newmark-type spectrum with a peak velocity to peak acceleration ratio of 36 in./sec./g and a peak ground displacement to peak acceleration ratio at 12 in./g, which matches Figure 3.7-2 of the UFSAR (Reference 9).

Table 3.1-1 Horizontal SSE for LGS (5% of critical damping response spectrum)

Frequency (Hz)	Spectral Acceleration (g)
0.55	0.11
2	0.41
10	0.41
33	0.15
100/PGA	0.15

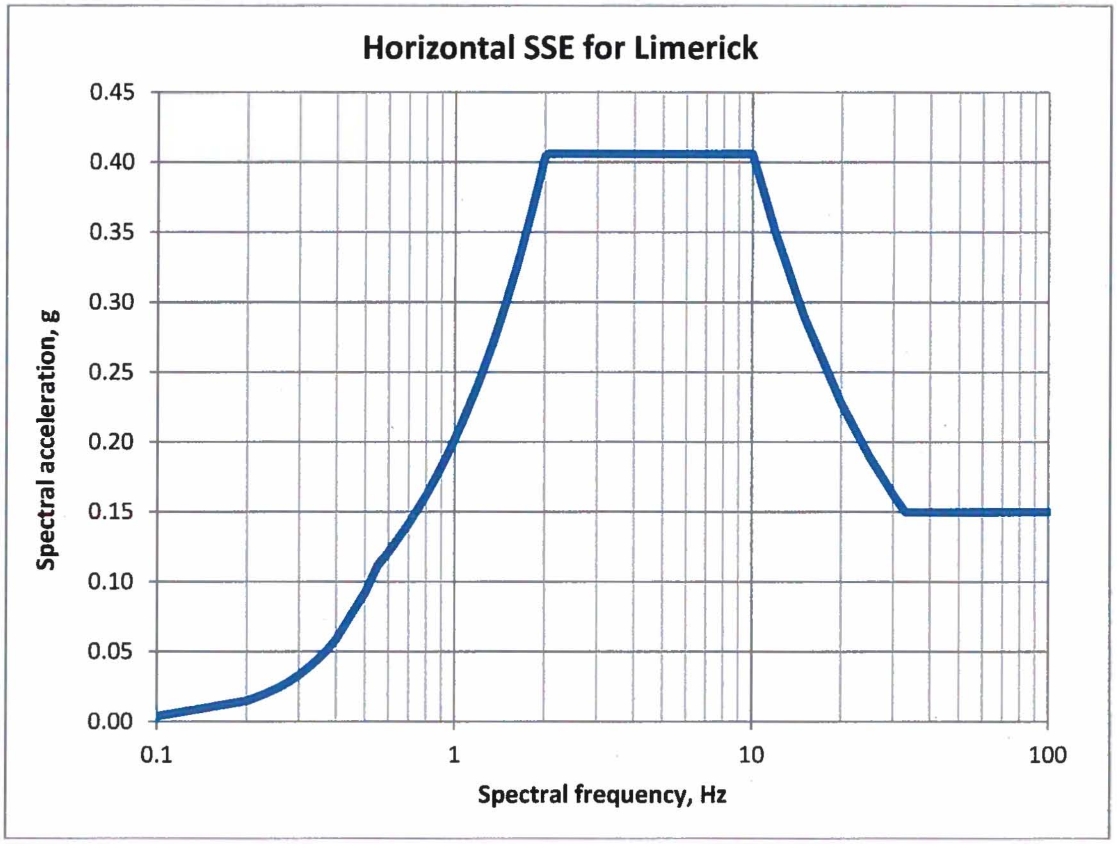


Figure 3.1-1 Horizontal SSE for LGS (5% of critical damping response spectrum)

3.2 Control Point Elevation

The LGS UFSAR (Reference 9) does not define an SSE control point. Bedrock at the site is overlain by up to 40 feet of residual soil derived from the bedrock by weathering (Reference 9, Section 2.5.1.2.6). All Category I rock foundations were excavated to unweathered bedrock (Reference 9, Section 2.5.1.2.7.1). Since LGS is a rock site and all primary safety related structures are founded on bedrock, the SSE control point elevation is taken to be at the top of the rock surface (Triasssic Brunswick lithofacies) at El. 204 ft. MSL. This definition of the control point is consistent with the approach described in the SPID (Reference 3, Section 2.4.2).

4 Screening Evaluation

Following completion of the seismic hazard reevaluation, as requested in the 50.54(f) letter (Reference 1), a screening evaluation is performed in accordance with the SPID Section 3 (Reference 3). The horizontal GMRS determined from the hazard reevaluation is used to characterize the amplitude of the alternative seismic hazard at each of the nuclear power plant sites. The screening evaluation is based upon a comparison of the GMRS with the established plant-level seismic capacity (either the SSE or IPEEE HCLPF Spectrum (IHS), where IPEEE is defined as Individual Plant Examination of External Events and HCLPF is defined as high-confidence-of-low-probability-of-failure), in accordance with the SPID (Reference 3). For LGS, the plant-level seismic capacity is based on the SSE.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the frequency range of 1 to 10 Hz, the SSE for LGS envelopes the GMRS. According to the SPID Section 3.2 (Reference 3), LGS screens out from further risk evaluations, and a seismic risk assessment (SPRA or SMA) is not needed. Additionally, LGS screens out of the ESEP interim action per the "Augmented Approach" guidance document, Section 2.2 (Reference 4).

4.2 High Frequency Screening (> 10 Hz)

In the frequency range above 10 Hz, the LGS SSE spectral acceleration exceeds that of the GMRS up to a spectral frequency of approximately 10.7 Hz. However, in the frequency range above approximately 10.7 Hz, the GMRS envelopes the SSE for LGS. Therefore, a high frequency confirmation is needed for LGS in accordance with the SPID guidance, Sections 3.2 and 3.4 (Reference 3).

As summarized in the SPID (Reference 3), EPRI Report NP-7498 (Reference 24) concludes that high-frequency vibration is not damaging, in general, to components with strain- or stress-based failure modes. However, components, such as relays, subject to electrical functionality failure modes have unknown acceleration sensitivity for frequencies above 16 Hz. EPRI Report 1015108 (Reference 25) provides evidence that supports the conclusion that high-frequency motions are not damaging to the majority of nuclear plant components, excluding relays and other electrical devices whose output signals may be affected by high-frequency vibration.

The types of SSCs which may be affected by high frequency ground motions include relays, contactors, and similar devices subject to electrical functionality failure modes such as inadvertent change of state, contact chatter, or change in output signal/set-point. EPRI has established a test program to develop data to support high frequency confirmation as described in the SPID, Sections 3.4.2 and 3.4.3 (Reference 3). The test program, which will evaluate the typical component types listed in Table 3-3 of the SPID

(Reference 3), uses accelerations or spectral levels intended to be sufficiently high to address the high-frequency in-structure and in-cabinet responses of various plants. Reports from the EPRI high frequency testing program will serve as critical input to the LGS high frequency confirmation. Example component types reproduced from Table 3-3 of the SPID (Reference 3) are:

- Electro-mechanical relays
- Circuit breakers
- Control switches
- Process switches and sensors
- Electro-mechanical contactors
- Auxiliary contacts
- Transfer switches
- Potentiometers

4.3 Spent Fuel Pool Evaluation Screening (1 to 10 Hz)

LGS is screened from performance of a full seismic risk assessment based on the screening criteria for GMRS comparison to the SSE in the SPID Section 3.2 (Reference 3). Therefore, a spent fuel pool evaluation is not needed for LGS in accordance with the SPID, Section 7 (Reference 3).

5 Interim Actions

Based on the screening results as described in Section 4 of this report, the SSE envelopes the GMRS in the frequency range of 1 to 10 Hz for LGS. Therefore, LGS screens out of a seismic risk evaluation. Additionally, LGS screens out of the ESEP interim action per the "Augmented Approach" guidance document, Section 2.2 (Reference 4).

5.1 Expedited Seismic Evaluation Process

Based on the screening results, LGS screens out of the ESEP interim action per the "Augmented Approach" guidance document, Section 2.2 (Reference 4).

5.2 Interim Evaluation of Seismic Hazard

Consistent with the NRC letter dated February 20, 2014 (Reference 12), the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of LGS. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to 10CFR50.72, "Immediate notification requirements for operating nuclear power reactors" (Reference 2, Section 50.72) and 10CFR50.73, "Licensee event report system" (Reference 2, Section 50.73).

The NRC letter also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, the NEI letter dated March 12, 2014 (Reference 26) provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the CEUS. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment (Reference 18):

> "Overall seismic core damage risk estimates are consistent with the Commission's Safety Goal Policy Statement because they are within the subsidiary objective of 10^{-4}/year for core damage frequency. The GI-199 Safety/Risk Assessment, based in part on information from the U.S. Nuclear Regulatory Commission's (NRC's) Individual Plant Examination of External Events (IPEEE) program, indicates that no concern exists regarding adequate protection and that the current seismic design of operating reactors provides a safety margin to withstand potential earthquakes exceeding the original design basis."

LGS is included in the March 12, 2014 risk estimates (Reference 26). Using the methodology described in the NEI letter, the seismic core damage risk estimates for all plants were shown to be below 1E-4/year; thus, the above conclusions apply.

5.3 Seismic Walkdown Insights

In response to NTTF 2.3, the 50.54(f) letter (Reference 1) also requested licensees to perform seismic walkdowns in order to, in the context of seismic response: 1) verify that the current plant configuration is consistent with the licensing basis; 2) verify the adequacy of current strategies, monitoring, and maintenance programs; and 3) identify degraded, nonconforming, or unanalyzed conditions. Exelon committed to and performed seismic walkdowns in accordance with the seismic walkdown guidance (Reference 27) as initially documented and supplemented in Exelon Correspondence Numbers RS-12-171 and RS-13-138 (References 11 and 29) respectively. The remaining walkdowns for initially inaccessible equipment are scheduled to be completed during the next Unit 1 Refueling Outage, 1R15, or during the next scheduled system outage window, whichever is applicable. The results will be reported to the NRC after completion of the follow-on walkdowns.

Based on the successful completion of seismic walkdowns for all components to date in response to NTTF 2.3, and the lack of adverse seismic conditions identified, Exelon has directly concluded that the LGS current plant configuration is consistent with the plant licensing basis and can safely shut down the reactor and maintain containment integrity following the design basis SSE event. Additionally, the findings of the seismic walkdown program indirectly verify that the current LGS strategies, monitoring, and maintenance programs are adequate for ensuring seismic safety consistent with the licensing basis.

Plant vulnerabilities and commitments identified in the LGS IPEEE (Reference 10) were reviewed as part of the NTTF 2.3 seismic walkdowns (References 11 and 29). The seismic walkdown reports confirmed that there are no outstanding IPEEE vulnerabilities or commitments, and all previously identified IPEEE vulnerabilities and commitments have been resolved (References 11 and 29).

5.4 Beyond-Design-Basis Seismic Insights

An evaluation of beyond-design-basis ground motions was performed for LGS as part of the IPEEE program. The LGS IPEEE program demonstrated plant-level seismic capacity, which can be expressed in terms of a HCLPF. This plant-level seismic capacity is defined in Section 3.3.2 of the SPID (Reference 3) as the IHS. The LGS IPEEE seismic evaluation was initially submitted as a reduced scope SMA (Reference 10). Subsequent to the IPEEE submittal, LGS responded to a series of Requests for Additional Information (RAI) and provided additional information that justified the LGS IPEEE SMA as achieving the intent of a focused-scope EPRI SMA anchored at 0.3g PGA (References 19, 20 and 21). The IHS for LGS is defined by the median-shaped NUREG/CR-0098 spectra for rock sites per LGS IPEEE seismic demand analysis (Reference 22). As a result of the LGS IPEEE seismic evaluations, plant processes for seismic housekeeping were made to enhance the reliability and safety of the plant. There are no outstanding IPEEE vulnerabilities or commitments and all previously identified IPEEE vulnerabilities and commitments have been resolved (Reference 11). The results of the LGS IPEEE showed there were no vulnerabilities to severe accident risk from external events, including seismic events (Reference 10). Based on the results of the IPEEE program for LGS, it may be qualitatively concluded that the plant has significant seismic margin beyond the design basis (Reference 28, Section 2.3.4) as evidenced by a comparison between the site SSE and the IHS in Figure 5.4-1.

The IHS for LGS bounds the GMRS over all frequencies and is provided for context of demonstrating beyond-design-basis seismic margin capacity; however, the IHS is not used for the NTTF 2.1: Seismic screening evaluation. The horizontal IHS (5% of critical damping) is shown below in Table 5.4-1 and plotted in Figure 5.4-1.

Table 5.4-1 Horizontal IHS for LGS (5% of critical damping response spectrum)

Frequency (Hz)	Spectral Acceleration (g)
0.34	0.10
2.2	0.63
8	0.63
33	0.30
100/PGA	0.30

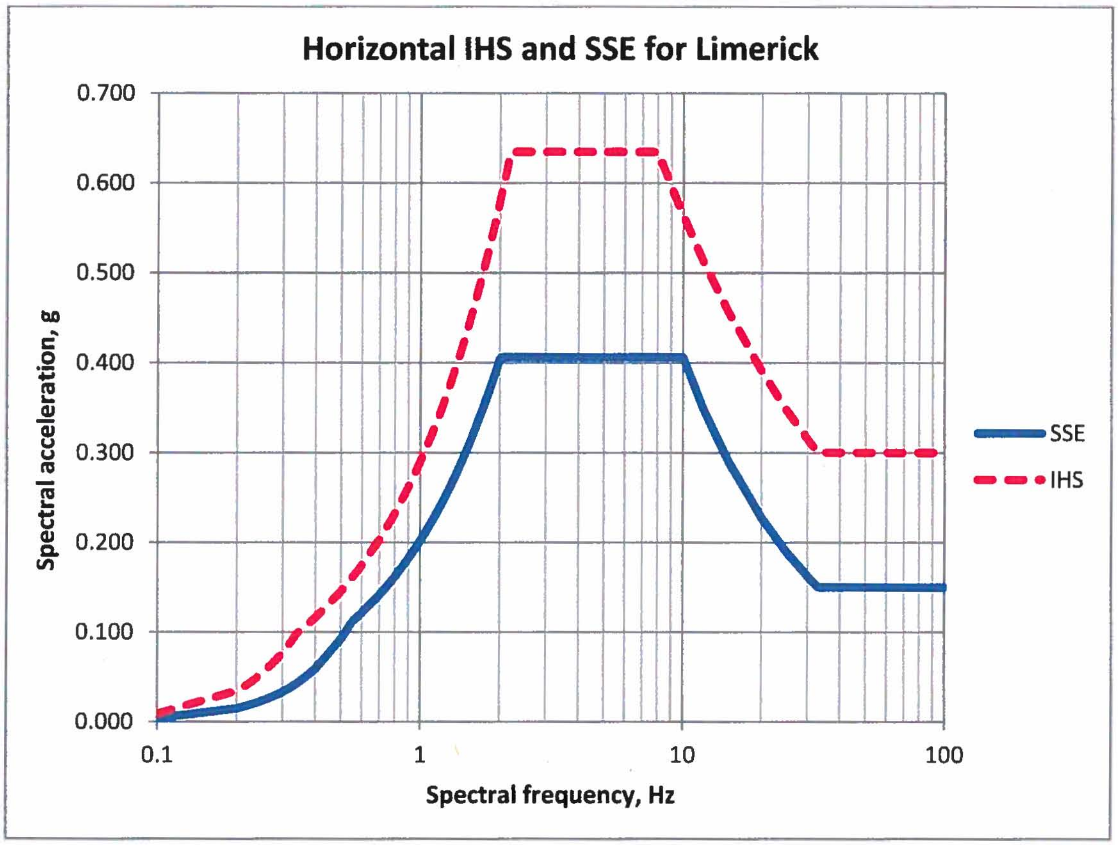


Figure 5.4-1 Horizontal IHS and SSE for LGS (5% of critical damping response spectra)

6 Conclusions

In accordance with the 50.54(f) letter (Reference 1), a seismic hazard and screening evaluation was performed for LGS. This evaluation followed the SPID guidance (Reference 3) in order to develop a site GMRS for the purpose of screening the plant in accordance with the SPID. The new GMRS does not constitute a change in the plant design or licensing basis as described in the NRC letter dated February 20, 2014 (Reference 12).

The screening evaluation comparison demonstrates that for LGS the SSE envelopes the GMRS in the frequency range of 1 to 10 Hz. For this reason, LGS screens out of seismic risk assessments (SPRA/SMA) and spent fuel pool integrity evaluation per the SPID, Sections 3.2 and 7 (Reference 3) in response to NTTF 2.1: Seismic. Additionally, LGS screens out of the ESEP interim action per the "Augmented Approach" guidance document, Section 2.2 (Reference 4). However, due to the GMRS exceeding the SSE in the frequency range above 10 Hz, a high frequency confirmation is needed for LGS in accordance with the SPID Sections 3.2 and 3.4 (Reference 3). Actions to address NTTF 2.1: Seismic for CEUS nuclear plants will be performed in accordance with the schedule provided in the April 9, 2013 letter from the industry to the NRC (Reference 5), as agreed to by the NRC in the May 7, 2013 letter to the industry (Reference 23).

7
References

1. NRC (E. Leeds and M. Johnson) Letter to All Power Reactor Licensees et al., *Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident,* dated March 12, 2012.

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3. EPRI 1025287, *Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic*, Palo Alto, CA, February 2013.

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5. NEI Letter (A. R. Pietrangelo) to the NRC, *Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations,* dated April 9, 2013.

6. EPRI 1021097 (NUREG-2115), *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, Palo Alto, CA, January 2012.

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8. Silva, W.J., N. Abrahamson, G. Toro and C. Costantino, "Description and validation of the stochastic ground motion model", Report Submitted to Brookhaven National Laboratory, Associated Universities, Inc. Upton, New York 11973, Contract No. 770573, 1997.

9. Exelon Generation Company, *Limerick Generating Station, Units 1 and 2, Updated Final Safety Analysis Report (UFSAR)*, Revision 16.

10. PECO Energy Company, Limerick Generating Station, Units 1 and 2, *Individual Plant Examination for External Events,* June 1995.

11. Exelon Generation Company letter to the NRC, *Exelon Generation Company, LLC's 180-day Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident*, RS-12-171, dated November 19, 2012.

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14. SGH Report No. 128018-R-01, Revision 1, *Review of Existing Site Response Data for the Exelon Nuclear Fleet*, July 17, 2012.

15. NRC Regulatory Guide 1.208, *A performance-based approach to define the site-specific earthquake ground motion*, 2007.

16. EPRI RSM-112013-024, *Limerick Seismic Hazard and Screening Report*, dated November 27, 2013.

17. Title 10 Code of Federal Regulations Part 100, *Reactor Site Criteria.*

18. NRC Memorandum (from P. Hiland to B. Sheron), ML100270582, "Safety/Risk Assessment Results for Generic Issue 199, Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants," dated September 2, 2010.

19. PECO Energy Company letter to the NRC, *Limerick Generating Station, Units 1 and 2 Response to Request for Additional Information Regarding Review of Individual Plant Examination of External Events,* dated June 28, 1996.

20. PECO Energy Company letter to the NRC, *Limerick Generating Station, Units 1 and 2 Response to Request for Additional Information Regarding Review of Individual Plant Examination of External Events,* dated July 24, 1997.

21. PECO Energy Company letter to the NRC, *Limerick Generating Station, Units 1 and 2 Response to Request for Additional Information Regarding Review of Individual Plant Examination of External Events,* dated February 17, 1999.

22. Exelon Calculation LS-0178, *IPEEE-SMA Seismic Demand for LGS,* Rev. 0.

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A

Additional Tables

Table A-1a Mean and fractile seismic hazard curves for PGA at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.79E-02	1.57E-02	2.96E-02	3.84E-02	4.70E-02	5.35E-02
0.001	2.68E-02	1.01E-02	1.95E-02	2.64E-02	3.57E-02	4.13E-02
0.005	7.40E-03	3.28E-03	4.70E-03	6.73E-03	9.51E-03	1.51E-02
0.01	3.78E-03	1.57E-03	2.22E-03	3.42E-03	4.90E-03	8.47E-03
0.015	2.39E-03	8.85E-04	1.29E-03	2.07E-03	3.23E-03	5.75E-03
0.03	9.50E-04	2.53E-04	3.90E-04	7.34E-04	1.44E-03	2.57E-03
0.05	4.47E-04	8.60E-05	1.46E-04	3.19E-04	7.23E-04	1.31E-03
0.075	2.37E-04	3.68E-05	6.93E-05	1.60E-04	3.90E-04	7.13E-04
0.1	1.48E-04	1.98E-05	4.01E-05	9.93E-05	2.42E-04	4.50E-04
0.15	7.34E-05	8.00E-06	1.87E-05	4.83E-05	1.20E-04	2.25E-04
0.3	1.95E-05	1.25E-06	4.07E-06	1.23E-05	3.23E-05	5.91E-05
0.5	6.44E-06	2.49E-07	1.08E-06	3.84E-06	1.08E-05	2.07E-05
0.75	2.44E-06	6.09E-08	3.09E-07	1.34E-06	4.19E-06	8.35E-06
1.	1.15E-06	1.98E-08	1.16E-07	5.75E-07	1.98E-06	4.19E-06
1.5	3.63E-07	3.47E-09	2.29E-08	1.49E-07	6.26E-07	1.42E-06
3.	3.68E-08	1.67E-10	8.47E-10	8.98E-09	5.83E-08	1.57E-07
5.	5.02E-09	6.64E-11	1.18E-10	7.66E-10	6.93E-09	2.19E-08
7.5	8.35E-10	5.05E-11	8.35E-11	1.44E-10	1.04E-09	3.68E-09
10.	2.09E-10	5.05E-11	6.09E-11	1.11E-10	2.80E-10	9.93E-10

Table A-1b Mean and fractile seismic hazard curves for 25 Hz at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.05E-02	2.04E-02	3.37E-02	4.07E-02	4.83E-02	5.42E-02
0.001	3.02E-02	1.34E-02	2.32E-02	2.96E-02	3.84E-02	4.50E-02
0.005	9.88E-03	4.70E-03	6.54E-03	9.11E-03	1.23E-02	1.98E-02
0.01	5.59E-03	2.64E-03	3.57E-03	5.12E-03	6.93E-03	1.16E-02
0.015	3.79E-03	1.67E-03	2.29E-03	3.47E-03	4.90E-03	7.77E-03
0.03	1.66E-03	5.66E-04	8.47E-04	1.46E-03	2.39E-03	3.47E-03
0.05	8.14E-04	2.13E-04	3.47E-04	6.73E-04	1.23E-03	1.90E-03
0.075	4.49E-04	9.79E-05	1.69E-04	3.52E-04	7.03E-04	1.13E-03
0.1	2.92E-04	5.58E-05	1.02E-04	2.25E-04	4.63E-04	7.55E-04
0.15	1.58E-04	2.72E-05	5.20E-05	1.20E-04	2.53E-04	4.19E-04
0.3	5.18E-05	7.03E-06	1.62E-05	3.95E-05	8.47E-05	1.38E-04
0.5	2.09E-05	2.19E-06	6.09E-06	1.60E-05	3.47E-05	5.66E-05
0.75	9.54E-06	7.55E-07	2.49E-06	7.23E-06	1.64E-05	2.64E-05
1.	5.22E-06	3.37E-07	1.25E-06	3.90E-06	9.11E-06	1.46E-05
1.5	2.07E-06	9.37E-08	4.31E-07	1.46E-06	3.68E-06	6.09E-06
3.	3.31E-07	7.89E-09	4.70E-08	2.01E-07	5.91E-07	1.11E-06
5.	6.83E-08	1.01E-09	6.26E-09	3.42E-08	1.18E-07	2.60E-07
7.5	1.68E-08	2.13E-10	1.08E-09	6.83E-09	2.84E-08	7.03E-08
10.	5.74E-09	1.13E-10	3.09E-10	1.95E-09	9.24E-09	2.57E-08

Table A-1c Mean and fractile seismic hazard curves for 10 Hz at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.61E-02	3.33E-02	3.95E-02	4.56E-02	5.35E-02	5.91E-02
0.001	3.70E-02	2.29E-02	3.01E-02	3.68E-02	4.43E-02	5.05E-02
0.005	1.28E-02	6.45E-03	8.85E-03	1.21E-02	1.64E-02	2.16E-02
0.01	6.88E-03	3.47E-03	4.63E-03	6.54E-03	8.85E-03	1.23E-02
0.015	4.66E-03	2.25E-03	3.05E-03	4.37E-03	6.00E-03	8.47E-03
0.03	2.21E-03	9.37E-04	1.31E-03	2.04E-03	3.01E-03	4.07E-03
0.05	1.17E-03	4.19E-04	6.17E-04	1.05E-03	1.69E-03	2.32E-03
0.075	6.69E-04	2.01E-04	3.14E-04	5.83E-04	1.01E-03	1.44E-03
0.1	4.40E-04	1.13E-04	1.87E-04	3.68E-04	6.83E-04	9.93E-04
0.15	2.35E-04	4.83E-05	8.85E-05	1.90E-04	3.79E-04	5.66E-04
0.3	7.27E-05	1.02E-05	2.19E-05	5.58E-05	1.21E-04	1.92E-04
0.5	2.77E-05	2.72E-06	6.93E-06	1.98E-05	4.77E-05	7.89E-05
0.75	1.20E-05	7.89E-07	2.39E-06	8.00E-06	2.13E-05	3.63E-05
1.	6.33E-06	2.96E-07	1.04E-06	3.95E-06	1.15E-05	2.04E-05
1.5	2.42E-06	6.26E-08	2.80E-07	1.34E-06	4.50E-06	8.23E-06
3.	3.75E-07	3.01E-09	2.22E-08	1.55E-07	7.03E-07	1.46E-06
5.	7.73E-08	3.05E-10	2.49E-09	2.25E-08	1.38E-07	3.28E-07
7.5	1.90E-08	1.11E-10	4.01E-10	3.90E-09	3.14E-08	8.47E-08
10.	6.46E-09	8.47E-11	1.46E-10	1.05E-09	9.93E-09	2.92E-08

Table A-1d Mean and fractile seismic hazard curves for 5 Hz at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.85E-02	3.68E-02	4.19E-02	4.77E-02	5.58E-02	6.17E-02
0.001	4.10E-02	2.64E-02	3.28E-02	4.13E-02	4.90E-02	5.50E-02
0.005	1.52E-02	7.13E-03	1.04E-02	1.46E-02	2.04E-02	2.42E-02
0.01	7.62E-03	3.57E-03	4.98E-03	7.23E-03	1.04E-02	1.25E-02
0.015	4.83E-03	2.29E-03	3.14E-03	4.63E-03	6.54E-03	8.12E-03
0.03	2.05E-03	9.24E-04	1.27E-03	1.95E-03	2.76E-03	3.63E-03
0.05	1.01E-03	3.95E-04	5.66E-04	9.37E-04	1.42E-03	1.90E-03
0.075	5.54E-04	1.87E-04	2.84E-04	4.98E-04	8.12E-04	1.10E-03
0.1	3.53E-04	1.05E-04	1.67E-04	3.09E-04	5.35E-04	7.34E-04
0.15	1.81E-04	4.56E-05	7.66E-05	1.53E-04	2.84E-04	4.01E-04
0.3	5.20E-05	9.37E-06	1.87E-05	4.25E-05	8.47E-05	1.27E-04
0.5	1.86E-05	2.46E-06	5.75E-06	1.46E-05	3.14E-05	4.83E-05
0.75	7.56E-06	7.03E-07	1.95E-06	5.50E-06	1.29E-05	2.13E-05
1.	3.80E-06	2.60E-07	8.12E-07	2.57E-06	6.64E-06	1.15E-05
1.5	1.35E-06	4.83E-08	1.90E-07	8.00E-07	2.46E-06	4.56E-06
3.	1.90E-07	1.42E-09	8.23E-09	7.45E-08	3.47E-07	7.66E-07
5.	3.76E-08	1.29E-10	5.58E-10	9.51E-09	6.45E-08	1.64E-07
7.5	9.07E-09	6.26E-11	1.18E-10	1.51E-09	1.40E-08	4.19E-08
10.	3.04E-09	5.42E-11	1.02E-10	4.13E-10	4.25E-09	1.42E-08

Table A-1e Mean and fractile seismic hazard curves for 2.5 Hz at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.61E-02	3.42E-02	3.84E-02	4.56E-02	5.35E-02	5.91E-02
0.001	3.72E-02	2.35E-02	2.84E-02	3.68E-02	4.56E-02	5.20E-02
0.005	1.20E-02	5.50E-03	7.66E-03	1.13E-02	1.64E-02	2.01E-02
0.01	5.30E-03	2.29E-03	3.19E-03	4.90E-03	7.45E-03	9.65E-03
0.015	3.02E-03	1.25E-03	1.77E-03	2.76E-03	4.25E-03	5.66E-03
0.03	1.03E-03	3.84E-04	5.58E-04	9.37E-04	1.49E-03	2.04E-03
0.05	4.34E-04	1.38E-04	2.13E-04	3.84E-04	6.45E-04	9.11E-04
0.075	2.12E-04	5.75E-05	9.24E-05	1.79E-04	3.28E-04	4.70E-04
0.1	1.25E-04	2.92E-05	5.05E-05	1.04E-04	1.98E-04	2.92E-04
0.15	5.78E-05	1.10E-05	2.04E-05	4.56E-05	9.37E-05	1.46E-04
0.3	1.43E-05	1.69E-06	3.90E-06	1.04E-05	2.42E-05	4.07E-05
0.5	4.72E-06	3.47E-07	1.01E-06	3.14E-06	8.23E-06	1.46E-05
0.75	1.83E-06	8.35E-08	2.96E-07	1.10E-06	3.23E-06	6.09E-06
1.	8.96E-07	2.76E-08	1.13E-07	4.90E-07	1.60E-06	3.19E-06
1.5	3.05E-07	5.05E-09	2.53E-08	1.38E-07	5.42E-07	1.18E-06
3.	3.84E-08	2.35E-10	1.21E-09	1.02E-08	6.26E-08	1.69E-07
5.	6.73E-09	9.79E-11	1.49E-10	1.10E-09	9.24E-09	3.14E-08
7.5	1.46E-09	5.35E-11	1.01E-10	1.98E-10	1.69E-09	6.64E-09
10.	4.51E-10	5.05E-11	6.09E-11	1.11E-10	4.90E-10	2.04E-09

Table A-1f Mean and fractile seismic hazard curves for 1 Hz at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.58E-02	1.98E-02	2.60E-02	3.63E-02	4.50E-02	5.12E-02
0.001	2.53E-02	1.20E-02	1.69E-02	2.49E-02	3.33E-02	3.95E-02
0.005	6.74E-03	2.29E-03	3.68E-03	6.26E-03	9.79E-03	1.27E-02
0.01	2.86E-03	7.89E-04	1.32E-03	2.49E-03	4.37E-03	6.26E-03
0.015	1.55E-03	3.79E-04	6.54E-04	1.29E-03	2.42E-03	3.68E-03
0.03	4.49E-04	8.98E-05	1.62E-04	3.47E-04	7.23E-04	1.20E-03
0.05	1.60E-04	2.68E-05	5.05E-05	1.16E-04	2.64E-04	4.43E-04
0.075	6.85E-05	9.65E-06	1.87E-05	4.70E-05	1.16E-04	1.98E-04
0.1	3.73E-05	4.50E-06	9.24E-06	2.42E-05	6.36E-05	1.15E-04
0.15	1.59E-05	1.44E-06	3.28E-06	9.51E-06	2.72E-05	5.27E-05
0.3	3.71E-06	1.72E-07	5.20E-07	1.90E-06	6.26E-06	1.40E-05
0.5	1.23E-06	2.80E-08	1.11E-07	5.20E-07	2.04E-06	4.98E-06
0.75	4.91E-07	5.91E-09	2.92E-08	1.72E-07	8.00E-07	2.10E-06
1.	2.47E-07	1.82E-09	1.02E-08	7.34E-08	3.90E-07	1.10E-06
1.5	8.80E-08	3.52E-10	2.07E-09	1.90E-08	1.29E-07	4.07E-07
3.	1.23E-08	1.01E-10	1.60E-10	1.36E-09	1.40E-08	5.91E-08
5.	2.35E-09	5.35E-11	1.01E-10	1.95E-10	2.01E-09	1.07E-08
7.5	5.52E-10	5.05E-11	6.09E-11	1.11E-10	4.13E-10	2.25E-09
10.	1.82E-10	5.05E-11	5.91E-11	1.11E-10	1.62E-10	7.13E-10

Table A-1g Mean and fractile seismic hazard curves for 0.5 Hz at LGS, 5% of critical damping

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	1.98E-02	1.04E-02	1.44E-02	1.92E-02	2.53E-02	3.01E-02
0.001	1.22E-02	5.66E-03	8.23E-03	1.18E-02	1.62E-02	2.01E-02
0.005	2.68E-03	6.26E-04	1.15E-03	2.32E-03	4.19E-03	6.00E-03
0.01	1.01E-03	1.62E-04	3.28E-04	7.66E-04	1.69E-03	2.68E-03
0.015	5.00E-04	6.54E-05	1.38E-04	3.52E-04	8.60E-04	1.46E-03
0.03	1.24E-04	1.18E-05	2.57E-05	7.45E-05	2.22E-04	4.01E-04
0.05	4.00E-05	2.96E-06	6.73E-06	2.10E-05	7.45E-05	1.40E-04
0.075	1.62E-05	8.98E-07	2.25E-06	7.55E-06	2.96E-05	6.09E-05
0.1	8.61E-06	3.79E-07	1.01E-06	3.68E-06	1.53E-05	3.47E-05
0.15	3.64E-06	9.93E-08	3.14E-07	1.34E-06	6.00E-06	1.62E-05
0.3	8.69E-07	7.55E-09	3.79E-08	2.25E-07	1.25E-06	4.31E-06
0.5	2.96E-07	9.51E-10	6.45E-09	5.27E-08	3.73E-07	1.53E-06
0.75	1.21E-07	2.13E-10	1.40E-09	1.46E-08	1.32E-07	6.45E-07
1.	6.18E-08	1.16E-10	4.70E-10	5.42E-09	5.91E-08	3.28E-07
1.5	2.27E-08	9.65E-11	1.38E-10	1.25E-09	1.67E-08	1.15E-07
3.	3.34E-09	5.05E-11	7.23E-11	1.34E-10	1.46E-09	1.42E-08
5.	6.65E-10	5.05E-11	6.09E-11	1.11E-10	2.42E-10	2.32E-09
7.5	1.61E-10	5.05E-11	5.05E-11	1.11E-10	1.13E-10	5.05E-10
10.	5.41E-11	5.05E-11	5.05E-11	1.01E-10	1.11E-10	2.01E-10

Table A-2 Amplification functions for LGS, 5% of critical damping

PGA	Median AF	Sigma ln(AF)	25 Hz	Median AF	Sigma ln(AF)	10 Hz	Median AF	Sigma ln(AF)	5 Hz	Median AF	Sigma ln(AF)
1.00E-02	1.18E+00	5.61E-02	1.30E-02	9.84E-01	6.15E-02	1.90E-02	1.04E+00	9.61E-02	2.09E-02	1.28E+00	1.12E-01
4.95E-02	9.12E-01	7.13E-02	1.02E-01	6.22E-01	1.14E-01	9.99E-02	9.53E-01	1.17E-01	8.24E-02	1.24E+00	1.20E-01
9.64E-02	8.24E-01	7.69E-02	2.13E-01	5.61E-01	1.31E-01	1.85E-01	9.25E-01	1.22E-01	1.44E-01	1.22E+00	1.23E-01
1.94E-01	7.54E-01	8.17E-02	4.43E-01	5.17E-01	1.42E-01	3.56E-01	8.92E-01	1.26E-01	2.65E-01	1.20E+00	1.26E-01
2.92E-01	7.18E-01	8.39E-02	6.76E-01	5.00E-01	1.47E-01	5.23E-01	8.69E-01	1.29E-01	3.84E-01	1.18E+00	1.27E-01
3.91E-01	6.94E-01	8.51E-02	9.09E-01	5.00E-01	1.50E-01	6.90E-01	8.50E-01	1.31E-01	5.02E-01	1.16E+00	1.28E-01
4.93E-01	6.77E-01	8.60E-02	1.15E+00	5.00E-01	1.52E-01	8.61E-01	8.35E-01	1.33E-01	6.22E-01	1.14E+00	1.29E-01
7.41E-01	6.46E-01	8.65E-02	1.73E+00	5.00E-01	1.55E-01	1.27E+00	8.03E-01	1.35E-01	9.13E-01	1.11E+00	1.30E-01
1.01E+00	6.23E-01	8.73E-02	2.36E+00	5.00E-01	1.57E-01	1.72E+00	7.77E-01	1.36E-01	1.22E+00	1.08E+00	1.33E-01
1.28E+00	6.05E-01	9.03E-02	3.01E+00	5.00E-01	1.60E-01	2.17E+00	7.55E-01	1.37E-01	1.54E+00	1.05E+00	1.36E-01
1.55E+00	5.91E-01	9.04E-02	3.63E+00	5.00E-01	1.61E-01	2.61E+00	7.37E-01	1.37E-01	1.85E+00	1.03E+00	1.36E-01

2.5 Hz	Median AF	Sigma ln(AF)	1 Hz	Median AF	Sigma ln(AF)	0.5 Hz	Median AF	Sigma ln(AF)
2.18E-02	1.27E+00	7.69E-02	1.27E-02	1.68E+00	1.06E-01	8.25E-03	1.59E+00	9.78E-02
7.05E-02	1.25E+00	7.75E-02	3.43E-02	1.66E+00	1.04E-01	1.96E-02	1.58E+00	9.35E-02
1.18E-01	1.23E+00	7.86E-02	5.51E-02	1.66E+00	1.03E-01	3.02E-02	1.57E+00	9.20E-02
2.12E-01	1.22E+00	8.19E-02	9.63E-02	1.65E+00	1.03E-01	5.11E-02	1.58E+00	9.09E-02
3.04E-01	1.21E+00	8.52E-02	1.36E-01	1.65E+00	1.03E-01	7.10E-02	1.58E+00	9.08E-02
3.94E-01	1.20E+00	8.91E-02	1.75E-01	1.65E+00	1.02E-01	9.06E-02	1.59E+00	9.11E-02
4.86E-01	1.19E+00	9.34E-02	2.14E-01	1.65E+00	1.02E-01	1.10E-01	1.59E+00	9.15E-02
7.09E-01	1.17E+00	1.01E-01	3.10E-01	1.65E+00	1.01E-01	1.58E-01	1.60E+00	9.38E-02
9.47E-01	1.15E+00	1.05E-01	4.12E-01	1.64E+00	1.05E-01	2.09E-01	1.61E+00	9.98E-02
1.19E+00	1.13E+00	1.14E-01	5.18E-01	1.63E+00	1.23E-01	2.62E-01	1.61E+00	1.07E-01
1.43E+00	1.12E+00	1.14E-01	6.19E-01	1.63E+00	1.26E-01	3.12E-01	1.61E+00	1.05E-01

Tables A2-b1 and A2-b2 are tabular versions of the typical amplification factors provided in Figures 2.3.6-1 and 2.3.6-2. Values are provided for two input motion levels at approximately 1E-4 and 1E-5 mean annual frequency of exceedance. These tables concentrate on the frequency range of 0.5 Hz to 25 Hz, with values up to 100 Hz included, and a single value at 0.1 Hz included for completeness. These factors are unverified and are provided for information only. The figures should be considered the governing information.

Table A2-b1 Median AFs and sigmas for Model 1, Profile 1, for 2 PGA levels

M1P1K1		Rock PGA=0.194		M1P1K1		PGA=0.741	
Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)	Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)
100.0	0.145	0.745	0.081	100.0	0.426	0.575	0.092
87.1	0.145	0.728	0.082	87.1	0.426	0.557	0.093
75.9	0.145	0.699	0.082	75.9	0.427	0.528	0.093
66.1	0.146	0.645	0.084	66.1	0.429	0.474	0.094
57.5	0.148	0.557	0.086	57.5	0.431	0.396	0.095
50.1	0.151	0.472	0.091	50.1	0.434	0.327	0.098
43.7	0.155	0.411	0.098	43.7	0.441	0.281	0.103
38.0	0.161	0.388	0.106	38.0	0.450	0.264	0.109
33.1	0.169	0.385	0.116	33.1	0.464	0.262	0.117
28.8	0.179	0.408	0.127	28.8	0.482	0.276	0.126
25.1	0.194	0.437	0.145	25.1	0.507	0.293	0.140
21.9	0.210	0.497	0.158	21.9	0.543	0.334	0.158
19.1	0.228	0.547	0.166	19.1	0.584	0.370	0.171
16.6	0.246	0.614	0.167	16.6	0.633	0.422	0.176
14.5	0.263	0.687	0.160	14.5	0.685	0.485	0.179
12.6	0.278	0.746	0.155	12.6	0.731	0.538	0.181
11.0	0.296	0.813	0.150	11.0	0.782	0.595	0.186
9.5	0.307	0.882	0.144	9.5	0.830	0.668	0.193
8.3	0.314	0.978	0.131	8.3	0.868	0.764	0.185
7.2	0.313	1.042	0.141	7.2	0.894	0.848	0.169
6.3	0.312	1.105	0.139	6.3	0.898	0.913	0.157
5.5	0.313	1.158	0.140	5.5	0.899	0.964	0.169
4.8	0.315	1.190	0.124	4.8	0.925	1.020	0.165
4.2	0.311	1.213	0.103	4.2	0.944	1.081	0.140
3.6	0.297	1.190	0.102	3.6	0.920	1.088	0.118
3.2	0.284	1.208	0.094	3.2	0.877	1.107	0.097
2.8	0.275	1.235	0.077	2.8	0.851	1.138	0.095
2.4	0.264	1.280	0.075	2.4	0.826	1.203	0.090
2.1	0.250	1.333	0.068	2.1	0.809	1.302	0.085
1.8	0.233	1.393	0.085	1.8	0.767	1.386	0.075
1.6	0.217	1.494	0.091	1.6	0.720	1.508	0.086
1.4	0.206	1.648	0.065	1.4	0.690	1.687	0.065
1.2	0.183	1.659	0.087	1.2	0.619	1.729	0.085
1.0	0.170	1.712	0.109	1.0	0.567	1.767	0.101
0.91	0.153	1.692	0.088	0.91	0.510	1.757	0.078
0.79	0.131	1.604	0.083	0.79	0.432	1.659	0.078
0.69	0.121	1.654	0.074	0.69	0.391	1.699	0.074
0.60	0.102	1.611	0.080	0.60	0.328	1.651	0.077
0.52	0.085	1.572	0.083	0.52	0.270	1.604	0.082
0.46	0.075	1.659	0.099	0.46	0.235	1.685	0.099
0.10	0.003	1.618	0.049	0.10	0.009	1.622	0.054

Table A2-b2 Median AFs and sigmas for Model 2, Profile 1, for 2 PGA levels

M2P1K1		PGA=0.194		M2P1K1		PGA=0.741	
Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)	Freq (Hz)	Soil SA	Median AF	Sigma ln(AF)
100.0	0.163	0.838	0.051	100.0	0.571	0.772	0.054
87.1	0.163	0.820	0.051	87.1	0.574	0.751	0.054
75.9	0.164	0.789	0.051	75.9	0.578	0.714	0.054
66.1	0.166	0.730	0.051	66.1	0.585	0.647	0.054
57.5	0.168	0.635	0.051	57.5	0.597	0.549	0.054
50.1	0.174	0.545	0.052	50.1	0.621	0.468	0.055
43.7	0.182	0.483	0.054	43.7	0.657	0.418	0.058
38.0	0.193	0.465	0.057	38.0	0.704	0.413	0.064
33.1	0.207	0.471	0.064	33.1	0.762	0.430	0.072
28.8	0.223	0.507	0.075	28.8	0.827	0.474	0.084
25.1	0.245	0.552	0.095	25.1	0.911	0.525	0.103
21.9	0.265	0.628	0.106	21.9	0.986	0.607	0.114
19.1	0.287	0.689	0.112	19.1	1.063	0.673	0.119
16.6	0.307	0.765	0.116	16.6	1.126	0.752	0.121
14.5	0.324	0.845	0.116	14.5	1.180	0.835	0.119
12.6	0.338	0.907	0.115	12.6	1.222	0.899	0.118
11.0	0.353	0.969	0.111	11.0	1.263	0.962	0.112
9.5	0.359	1.032	0.100	9.5	1.274	1.025	0.102
8.3	0.360	1.122	0.087	8.3	1.268	1.116	0.088
7.2	0.355	1.180	0.108	7.2	1.240	1.175	0.108
6.3	0.352	1.247	0.110	6.3	1.222	1.242	0.111
5.5	0.349	1.291	0.113	5.5	1.200	1.287	0.113
4.8	0.342	1.294	0.097	4.8	1.170	1.290	0.097
4.2	0.334	1.303	0.087	4.2	1.135	1.299	0.087
3.6	0.316	1.268	0.095	3.6	1.069	1.264	0.095
3.2	0.302	1.283	0.086	3.2	1.014	1.280	0.086
2.8	0.290	1.300	0.057	2.8	0.970	1.297	0.057
2.4	0.273	1.328	0.061	2.4	0.910	1.325	0.061
2.1	0.255	1.359	0.074	2.1	0.843	1.356	0.074
1.8	0.236	1.410	0.100	1.8	0.778	1.406	0.099
1.6	0.218	1.501	0.097	1.6	0.714	1.496	0.096
1.4	0.206	1.646	0.074	1.4	0.670	1.640	0.073
1.2	0.181	1.646	0.088	1.2	0.587	1.640	0.087
1.0	0.169	1.701	0.111	1.0	0.544	1.694	0.109
0.91	0.152	1.679	0.095	0.91	0.485	1.672	0.094
0.79	0.130	1.592	0.087	0.79	0.413	1.587	0.085
0.69	0.120	1.645	0.076	0.69	0.377	1.639	0.075
0.60	0.102	1.603	0.081	0.60	0.318	1.598	0.079
0.52	0.085	1.566	0.083	0.52	0.263	1.562	0.081
0.46	0.075	1.654	0.098	0.46	0.230	1.650	0.097
0.10	0.003	1.617	0.049	0.10	0.009	1.614	0.054

Enclosure 2

SUMMARY OF REGULATORY COMMITMENTS

The following table identifies commitments made in this document. (Any other actions discussed in the submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.)

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	PROGRAMMATIC (Yes/No)
Limerick Generating Station, Units 1 and 2, will perform a High Frequency Confirmation evaluation in accordance with EPRI Report 1025287, Section 3.4.	As determined by NRC prioritization following submittal of all nuclear power plant Seismic Hazard Re-evaluations, but no later than December 31, 2019.	Yes	No