PSEG Nuclear LLC
P.O. Box 236, Hancocks Bridge, NJ 08038-0236

PSEG
Nuclear LLC

10 CFR 50.54(f)

LR-N14-0035

MAR 28 2014

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Hope Creek Generating Station
Renewed Facility Operating License No. NPF-57
NRC Docket No. 50-354

Subject: PSEG Nuclear LLC's Seismic Hazard and Screening Report (CEUS Sites) Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident – Hope Creek Generating Station

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 to NRC, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," dated April 9, 2013 (ADAMS Accession No. ML13101A379)

3. NRC Letter, "Electric Power Research Institute Final Draft Report XXXXXX, 'Seismic Evaluation Guidance: Augmented Approach for the Resolution of 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 (ADAMS Accession No. ML13106A331)

4. 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" (ADAMS Accession No. ML12333A170)

5. NRC Letter, "Endorsement of Electric Power Research Institute Final Draft Report 1025287, 'Seismic Evaluation Guidance'," dated February 15, 2013 (ADAMS Accession No. ML12319A074)

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued a request for information (Reference 1) pursuant to 10 CFR 50.54(f) to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of the 10 CFR 50.54(f) letter 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 the request. The enclosed Hope Creek Generating Station (HCGS) Seismic Hazard and Screening Report is provided in response to the 10 CFR 50.54(f) letter.

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 the information needed to complete the reports. NEI proposed that descriptions of subsurface materials and properties and base case velocity profiles be submitted by September 12, 2013, with the remaining seismic hazard and screening information to be provided by March 31, 2014. By letter dated May 7, 2013 (Reference 3), the NRC agreed with the path forward proposed by NEI.

EPRI Report 1025287 (Reference 4) provides industry guidance and detailed information to be included in the Seismic Hazard Evaluation and Screening Report submittals. The NRC endorsed EPRI Report 1025287 via Reference 5. Enclosure 1 is the HCGS Seismic Hazard Evaluation and Screening Report based on the NRC-endorsed guidance and schedule.

Based on the results of the screening evaluation provided in Section 4 of Enclosure 1, HCGS will perform a relay chatter review. There are regulatory commitments contained in this letter as identified in Enclosure 2.

10 CFR 50.54(f)

If you have any questions or require additional information, please do not hesitate to contact Mr. Lee Marabella at 856-339-1208.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 3-28-14
(Date)

Sincerely,

Paul J. Davison

Paul J. Davison
Site Vice President
Hope Creek Generating Station

Enclosures:

1. Hope Creek Generating Station - Seismic Hazard and Screening Report
2. Summary of Commitments

cc: Mr. E. Leeds, Director of Office of Nuclear Reactor Regulation
Mr. W. Dean, Administrator, Region I, NRC
Mr. J. Hughey, Project Manager, NRC
NRC Senior Resident Inspector, Hope Creek
Mr. P. Mulligan, Manager IV, NJBNE
Hope Creek Commitment Tracking Coordinator
PSEG Corporate Commitment Coordinator

LR-N14-0035

Enclosure 1

Hope Creek Generating Station - Seismic Hazard and Screening Report

Hope Creek Generating Station
PSEG Nuclear LLC

MPR
ASSOCIATES INC.
ENGINEERS

Hope Creek Generating Station – Seismic Hazard and Screening Report

0108-1310-REPT-02

March 26, 2014
Revision 0

QUALITY ASSURANCE DOCUMENT
This document has been prepared, reviewed, and approved in accordance with the Quality Assurance requirements of 10CFR50 Appendix B and/or ASME NQA-1, as specified in the MPR Nuclear Quality Assurance Program.

Prepared by: ____________________
Craig Swanner

Reviewed by: ____________________
Joseph Konefal

Approved by: ____________________
James Moroney

Principal Contributors

C. Swanner
C. Bagley
R. Ashworth
C. Hamm

Prepared for

PSEG Nuclear
Alloway Creek Neck Road
Hancocks Bridge, NJ 08038

Hope Creek Generating Station
Seismic Hazard and Screening Report

1.0 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations and 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 [1] that requests information to assure that these recommendations are addressed by all U.S. nuclear power plants. The 50.54(f) letter [1] requests that licensees and holders of construction permits under10 CFR Part 50 reevaluate the seismic hazards at their sites against present-day NRC requirements. Depending on the comparison between the reevaluated seismic hazard and the current design basis, the result is either no further risk evaluation or the performance of a seismic risk assessment. Risk assessment approaches acceptable to the 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.

This report provides the information requested in items (1) through (7) of the "Requested Information" section and Attachment 1 of the 50.54(f) letter [1] pertaining to NTTF Recommendation 2.1 for the Hope Creek Generating Station (HCGS), located in Lower Alloways Creek Township, Salem County, New Jersey. In providing this information, PSEG Nuclear followed the guidance provided in the *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* [2]. The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* [3], has been developed as the process for evaluating critical plant equipment as an interim action to demonstrate additional plant safety margin prior to performing the complete plant seismic risk evaluations.

The original geologic and seismic siting investigations for HCGS were performed in accordance with Appendix A to 10 CFR Part 100 and meet General Design Criterion 2 in Appendix A to 10 CFR Part 50. The Safe Shutdown Earthquake Ground Motion (SSE) was developed in accordance with Appendix A to 10 CFR Part 100 and used for the design of seismic Category I systems, structures and components.

In response to the 50.54(f) letter [1] and following the guidance provided in the SPID [2], a seismic hazard reevaluation for HCGS. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed.

2.0 Seismic Hazard Reevaluation

Except where otherwise noted, all information provided in Section 2 is taken from the Hope Creek Seismic Hazard and Screening Report [4].

2.1 Regional and Local Geology

The regional and local geology of the Hope Creek site is provided in Section 2.5 of the HCGS UFSAR [5]. Information from the UFSAR is summarized below.

The Hope Creek site is located on the southern part of Artificial Island on the east bank of the Delaware River in Lower Alloways Creek Township, Salem County, New Jersey. HCGS is located approximately 19 miles south of Wilmington, Delaware. The site lies within the Atlantic Coastal Plain Physiographic Province, about 18 miles southeast of the Piedmont Physiographic Province. The Fall Zone marks the contact of the low lying, gently undulating terrain of the Coastal Plain and the higher, more rugged terrain of the Piedmont Province. The site structures are founded on the Paleocene-Eocene Vincentown Formation, a competent, cemented, granular soil. Below the Vincentown are about 1800 feet of increasingly older sediments.

The Vincentown Formation was determined to be the closest stratum to the ground surface suitable for foundation support. In the HCGS area, the Vincentown is located about 70 feet below grade. A lean concrete fill was placed between the Vincentown and the base of the Category I structures.

The site is underlain by about 1800 feet of Cretaceous, Tertiary, and Quaternary-aged sediments. Crystalline basement rock outcrops near the Fall Zone, about 18 miles northwest of the site. Conditions encountered at the site are completely consistent with the known regional picture. There is no indication of faulting or folding in the site area, no evidence was identified that indicated adverse behavior of the surficial subsurface materials during prior earthquakes.

Earthquake activity in historic time within 200 miles of the plant site has been moderate. Sources of major earthquakes in the central and eastern United States (CEUS) are distant, and have not had an appreciable effect at the site. The original investigation of historical seismic activity in the region indicated that a design intensity of VII (Modified Mercalli Scale) at an epicentral distance of about 15 to 20 miles is adequately conservative for the site. PSEG Nuclear determined that Intensity VII corresponds to a peak ground acceleration of 0.13 g, which was increased to 0.20 g for the SSE.

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter [1] and following the guidance in the SPID [2], 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 [6] together with the updated EPRI Ground-Motion Model (GMM) for the CEUS [7]. For the PSHA, a lower-bound moment magnitude of 5.0 was used, as specified in the 50.54(f) letter [1].

For the PSHA, the CEUS-SSC background seismic sources out to a distance of 400 miles (640 km) around HCGS were included. This distance exceeds the 200 mile (320 km) recommendation contained in Regulatory Guide 1.208 [8] 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. Mesozoic and younger extended prior – narrow (MESE-N)
4. Mesozoic and younger extended prior – wide (MESE-W)
5. Midcontinent-Craton alternative A (MIDC_A)
6. Midcontinent-Craton alternative B (MIDC_B)
7. Midcontinent-Craton alternative C (MIDC_C)
8. Midcontinent-Craton alternative D (MIDC_D)
9. Northern Appalachians (NAP)
10. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
11. Non-Mesozoic and younger extended prior – wide (NMESE-W)
12. Paleozoic Extended Crust narrow (PEZ_N)
13. Paleozoic Extended Crust wide (PEZ_W)
14. St. Lawrence Rift, including the Ottawa and Saguenay grabens (SLR)
15. Study region (STUDY_R)

For sources of large magnitude earthquakes, designated Repeated Large Magnitude Earthquake (RLME) sources in [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 [7] was used.

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID [2], 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 3 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 [1] and in the SPID [2] for nuclear power plant sites that are not sited on hard rock (defined as 2.83 km/sec), a site response analysis was performed for HCGS.

2.3.1 Description of Subsurface Material

The HCGS site is located in the eastern US on the Delaware River within the Coastal Plain physiographic province. The Coastal Plain is underlain by a thick wedge of unconsolidated sediment ranging from Cretaceous to recent in age. Bedrock is estimated to be at a depth of about 1,800 ft [9].

The site region includes parts of several other physiographic provinces: the Continental Rise, Continental Slope, and Continental Shelf (from east to west), all located in the eastern portions of the site region, and (to the west) the Piedmont, New England, Blue Ridge, Valley and Ridge and Appalachian Plateau provinces [9].

The Coastal Plain province is characterized by low-lying, gently rolling terrain developed on sequences of deltaic, shallow, marine and continental shelf clastics consisting primarily of unconsolidated to semi-consolidated gravels, sands, silts, and clays that dip gently oceanward. The surface has been modified by erosional and depositional landforms associated with several transgressional and regressional marine cycles. The site stratigraphy described below is based on recent work completed for the PSEG Early Site Permit Application (ESPA) [10] for potential future construction at the HCGS site [9]:

1) Basement Complex (Section 2.5.1.2.2.2 of [10])

    a) Control of the nature of basement lithologies that underlie the Early Site Permit (ESP) Site is provided by PSEG No. 6 production well located approximately 0.6 mi.from the site center. The log for this well reports residual clay, which is interpreted to be Wissahickon schist from a sidewall core at depth 1800 ft.

2) Coastal Plain Stratigraphic Sequences underlying the Site (Section 2.5.1.2.2.2 of [10])

    a) Lower Cretaceous Strata

i. Potomac Group (Formation): Potomac Group (Formation) strata were sampled in one deep boring within the ESP site (NB-1), and in another deep boring (PSEG Well No.6) located near the new plant location. The lithologies in these samples consisted of hard plastic, red, gray, and white mottled clay. Boring NB-1 within the ESP site encountered Potomac Group (Formation) at elevation 454 ft. Based on the information provided by Benson from the PSEG No. 6 production well, the Potomac Group (Formation) strata are approximately 1300 ft thick beneath the site.

b) Upper Cretaceous Strata

i. Magothy Formation: The Magothy Formation unconformably overlies the Potomac Group (Formation). The Magothy Formation consists primarily of interbedded gray to dark gray, locally mottled, silts and clays containing trace amounts of lignite and carbonaceous material. The silts and clays were interbedded with sands that contain variable amounts of silt and clay. The Magothy Formation is 52 ft thick beneath the site location.

ii. Merchantville Formation: The Merchantville Formation is composed primarily of dark greenish-black glauconitic silts and clays with variable amounts of sand and mica. These characteristics are representative of those described regionally for this formation. Based on the deep boring NB1, the Merchantville Formation is 30 ft thick beneath the site.

iii. Woodbury Formation: The Woodbury Formation consists of black, micaceous and highly plastic clay. This formation is distinguished from the overlying Englishtown by increased clay and mica content. Based on boring NB-1, the Woodbury Formation is 36 ft thick at the site.

iv. Englishtown Formation: The Englishtown Formation consists of dark gray to black sandy clay, to clayey sand with shell fragments, grading to black silt and clay with trace amounts of glauconite and mica. These characteristics are representative for those reported regionally. The Englishtown is 44 ft thick beneath the site.

v. Marshalltown Formation: The Marshalltown Formation consists of glauconitic, silty, and clayey fine sand. The presence of significant amounts of glauconite and fine-grained nature of the clastic component are characteristic of this unit regionally. Based on borings NB-1 and NB-2, the Marshalltown Formation is 25 ft thick beneath the site.

vi. Wenonah Formation: The Wenonah Formation exhibits a gradational contact with the underlying Marshalltown Formation. The Wenonah Formation consists of sandy clay and clayey sand. Average thickness in borings from the site and nearby areas is 15 ft.

vii. Mount Laurel Formation: The Mount Laurel Formation consists of a dense to very dense brownish-gray to dark green, fine to coarse-grained sand with variable amounts of silt and clay. This unit appears to exhibit a coarsening upward sequence in that glauconite content, in addition to grain size and fine content decrease with depth. Based on borings NB-1, NB-2 and NB-8, at the site, the Mount Laurel Formation ranges from 102 to 105 ft thick.

viii. Navesink Formation: The Navesink Formation consists of fossiliferous, dark green to greenish-black, extremely glauconitic sand. Fossils consisted primarily of pelecypod fragments. Based on all eight of the borings in the site location, the Navesink Formation ranges from 23 to 26 ft thick.

c) Lower Tertiary Strata (Paleocene)

i. Hornerstown Formation: The Hornerstown Formation primarily consists of greenish-gray, to dark green, to greenish-black glauconitic sand with some indurated intervals. Borings at the site location give thickness of 16 to 21 feet.

ii. Vincentown Formation: The Vincentown Formation is a greenish-gray, finegrained to medium-grained silty sand with some zones of clayey sand. Glauconite is commonly present. This unit contains cemented zones from 0.1 to 3.0 ft thick. The Vincentown thickness is highly variable at the ESP site, with thickness of ranging from 35 to 79 ft thick. This variability is due in part to the fact that the top of the Vincentown Formation is a scour surface.

iii. The stratigraphic units overlying the Vincentown Formation are of low strength and are deemed unsuitable to serve as competent layers based on their physical properties. The Vincentown Formation serve as the competent layer for the HCGS foundation. Approximately 70 ft of material is above the Vincentown Formation and consists of the following:

- Artificial Fill (mechanically placed)
- Hydraulic Fill
- Alluvium
- Kirkwood Formation

Table 2-1 shows the geotechnical properties for HCGS.

Table 2-1
Geologic profile and estimated layer thicknesses for HCGS [11]

Layer ID number and Formation	Depth Range (feet)	Soil/Rock Description	Density (pcf)	Shear Wave Velocity (fps)	Compressional Wave Velocity (fps)	Poisson's ratio
0	0-71	Hydraulic fill, alluvium and Tertiary sands (this layer is included for completeness only; it is not present below safety-related structures)	100-137	500	-	-
-	71	Bearing surface at 71' depth. Lean concrete fill placed above this point up to base of containment building mats.	-	-	-	-
1 Vincentown Hornerstown Navesink	71-163	Tertiary dense sands and Cretaceous dense silty and clayey sands	121	2250	-	-
2 Mt Laurel	163-181	Cretaceous dense sand	131	3920	-	-
3 Mt Laurel	181-203	Cretaceous dense sand	131	2490		
4 Mt Laurel	203-237	Cretaceous dense sand	131	3020	-	-
5 Mt Laurel Wenonah Marshaltown	237-299	Cretaceous sandy clay and silty sand, very stiff to hard/dense	128	2490	-	-
6 Marshaltown Englishtown Woodbury	299-383	Cretaceous sandy clay and clayey sand, very stiff to hard	125	1710	-	-
7 Woodbury Merchantville	383-409	Cretaceous silt and clay, hard	130	2290	-	-
8 Merchantville Magothy	409-434	Cretaceous clay and silt, hard	130	1780	-	-
9 Magothy Potomac	434-516	Cretaceous sand with clay and silt, dense	130	2490	-	-
10 Potomac	516-881	Cretaceous Potomac Formation, Upper Zone	135	2200	6200	0.42
11 Potomac	881-1311	Cretaceous Potomac Formation, Middle Zone	135	2630	6200	0.42
12 Potomac	1311-1761	Cretaceous Potomac Formation, Lower Zone	135	3060	6200	0.42
13 Potomac	1761	Seismic Basement, Crystalline Schist	150	11,000	20,450	0.30

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

2.3.2.1 Shear Wave Velocity Profile

Table 2-1 shows the recommended shear-wave velocities and unit weights along with depth ranges and corresponding stratigraphy. The SSE Control Point is located at a depth of 62 ft below grade at the top of the Vincentown Formation (Table 2-1) including 9 ft of Class 1 backfill with an estimated shear-wave velocity of 927 ft/s (282 m/s) [11]. Mean base-case shear-wave velocities and unit weights were taken from Table 2-1 to Precambrian basement at a depth of about 1,760 ft (536 m). The geology and material properties listed in Table 2-1 were taken from the nearby (about 3,000 ft; 1 km) PSEG ESPA Site and reflect direct shear-wave measurements to a depth of the top of the Potomac Formation (Table 2-1). Below that depth, Potomac Formation and below, the shear-wave velocities were based on compressional-wave refraction surveys and assumed Poisson ratios, all at the ESPA site.

To accommodate epistemic uncertainty in shear-wave velocities two scale factors were used: 1.25 to reflect nearby measured shear-wave velocities above the Potomac Formation and 1.57 for the Potomac formation and below, reflecting assumed shear-wave velocities. Profiles extended to a depth (below the SSE control point) of 1,700 ft (515 m), randomized ±510 ft (±155 m). The base-case profiles (P1, P2, and P3) are shown in Figure 2-1 and listed in Table 2-2. The depth randomization reflects ± 30% of the depth and was included to provide a realistic broadening of the fundamental resonance at deep sites rather than reflect actual random variations to basement shear-wave velocities across a footprint.

The scale factors of 1.25 and 1.57 reflect a σ_{ln} of about 0.20 and 0.35, based on the SPID [2] 10th and 90th fractiles which implies a 1.28 scale factor on σ_{μ}.

Table 2-2
Geologic Profile and estimated layer thicknesses for HCGS [11]

Profile 1			Profile 2			Profile 3		
Thickness (ft)	Depth (ft)	Vs(ft/s)	Thickness(ft)	Depth (ft)	Vs(ft/s)	Thickness (ft)	Depth (ft)	Vs(ft/s)
	0	927		0	742		0	1159
4.5	4.5	927	4.5	4.5	742	4.5	4.5	1159
4.5	9.0	927	4.5	9.0	742	4.5	9.0	1159
6.0	15.0	2250	6.0	15.0	1800	6.0	15.0	2812
5.0	20.0	2250	5.0	20.0	1800	5.0	20.0	2812
15.0	35.0	2250	15.0	35.0	1800	15.0	35.0	2812
10.0	45.0	2250	10.0	45.0	1800	10.0	45.0	2812
5.0	50.0	2250	5.0	50.0	1800	5.0	50.0	2812
15.0	65.0	2250	15.0	65.0	1800	15.0	65.0	2812
10.0	75.0	2250	10.0	75.0	1800	10.0	75.0	2812
10.0	85.0	2250	10.0	85.0	1800	10.0	85.0	2812

Profile 1			Profile 2			Profile 3		
Thickness (ft)	Depth (ft)	Vs(ft/s)	Thickness(ft)	Depth (ft)	Vs(ft/s)	Thickness (ft)	Depth (ft)	Vs(ft/s)
10.0	95.0	2250	10.0	95.0	1800	10.0	95.0	2812
6.0	101.0	2250	6.0	101.0	1800	6.0	101.0	2812
4.0	105.0	3920	4.0	105.0	3136	4.0	105.0	4900
7.0	112.0	3920	7.0	112.0	3136	7.0	112.0	4900
7.0	119.0	3920	7.0	119.0	3136	7.0	119.0	4900
10.0	129.0	2490	10.0	129.0	1992	10.0	129.0	3112
10.0	139.0	2490	10.0	139.0	1992	10.0	139.0	3112
2.0	141.0	2490	2.0	141.0	1992	2.0	141.0	3112
11.3	152.3	3020	11.3	152.3	2416	11.3	152.3	3775
11.3	163.6	3020	11.3	163.6	2416	11.3	163.6	3775
11.3	175.0	3020	11.3	175.0	2416	11.3	175.0	3775
10.0	185.0	2490	10.0	185.0	1992	10.0	185.0	3112
10.0	195.0	2490	10.0	195.0	1992	10.0	195.0	3112
10.0	205.0	2490	10.0	205.0	1992	10.0	205.0	3112
10.0	215.0	2490	10.0	215.0	1992	10.0	215.0	3112
10.0	225.0	2490	10.0	225.0	1992	10.0	225.0	3112
10.0	235.0	2490	10.0	235.0	1992	10.0	235.0	3112
2.0	237.0	2490	2.0	237.0	1992	2.0	237.0	3112
7.3	244.3	1710	7.3	244.3	1368	7.3	244.3	2137
7.3	251.6	1710	7.3	251.6	1368	7.3	251.6	2137
7.3	259.0	1710	7.3	259.0	1368	7.3	259.0	2137
7.7	266.7	1710	7.7	266.7	1368	7.7	266.7	2137
7.7	274.5	1710	7.7	274.5	1368	7.7	274.5	2137
7.7	282.2	1710	7.7	282.2	1368	7.7	282.2	2137
7.7	290.0	1710	7.7	290.0	1368	7.7	290.0	2137
7.7	297.7	1710	7.7	297.7	1368	7.7	297.7	2137
7.7	305.5	1710	7.7	305.5	1368	7.7	305.5	2137
7.7	313.2	1710	7.7	313.2	1368	7.7	313.2	2137
7.7	321.0	1710	7.7	321.0	1368	7.7	321.0	2137
8.7	329.6	2290	8.7	329.6	1832	8.7	329.6	2862
8.7	338.3	2290	8.7	338.3	1832	8.7	338.3	2862
8.7	347.0	2290	8.7	347.0	1832	8.7	347.0	2862
8.3	355.3	1780	8.3	355.3	1424	8.3	355.3	2225
8.3	363.6	1780	8.3	363.6	1424	8.3	363.6	2225
8.3	372.0	1780	8.3	372.0	1424	8.3	372.0	2225
11.7	383.7	2490	11.7	383.7	1992	11.7	383.7	3112
11.7	395.4	2490	11.7	395.4	1992	11.7	395.4	3112
11.7	407.1	2490	11.7	407.1	1992	11.7	407.1	3112
11.7	418.8	2490	11.7	418.8	1992	11.7	418.8	3112
11.7	430.5	2490	11.7	430.5	1992	11.7	430.5	3112
11.7	442.2	2490	11.7	442.2	1992	11.7	442.2	3112

Profile 1			Profile 2			Profile 3		
Thickness (ft)	Depth (ft)	Vs(ft/s)	Thickness(ft)	Depth (ft)	Vs(ft/s)	Thickness (ft)	Depth (ft)	Vs(ft/s)
11.7	454.0	2490	11.7	454.0	1992	11.7	454.0	3112
10.3	464.3	2200	10.3	464.3	1408	10.3	464.3	3454
10.3	474.6	2200	10.3	474.6	1408	10.3	474.6	3454
10.3	484.9	2200	10.3	484.9	1408	10.3	484.9	3454
15.0	500.0	2200	15.0	500.0	1408	15.0	500.0	3454
40.0	539.9	2200	40.0	539.9	1408	40.0	539.9	3454
31.0	570.9	2200	31.0	570.9	1408	31.0	570.9	3454
31.0	601.9	2200	31.0	601.9	1408	31.0	601.9	3454
31.0	632.9	2200	31.0	632.9	1408	31.0	632.9	3454
31.0	663.9	2200	31.0	663.9	1408	31.0	663.9	3454
31.0	694.9	2200	31.0	694.9	1408	31.0	694.9	3454
31.0	725.9	2200	31.0	725.9	1408	31.0	725.9	3454
31.0	756.9	2200	31.0	756.9	1408	31.0	756.9	3454
31.0	787.9	2200	31.0	787.9	1408	31.0	787.9	3454
31.0	818.9	2200	31.0	818.9	1408	31.0	818.9	3454
43.0	861.9	2630	43.0	861.9	1683	43.0	861.9	4129
43.0	904.9	2630	43.0	904.9	1683	43.0	904.9	4129
43.0	947.9	2630	43.0	947.9	1683	43.0	947.9	4129
43.0	990.9	2630	43.0	990.9	1683	43.0	990.9	4129
43.0	1033.9	2630	43.0	1033.9	1683	43.0	1033.9	4129
43.0	1076.9	2630	43.0	1076.9	1683	43.0	1076.9	4129
43.0	1119.9	2630	43.0	1119.9	1683	43.0	1119.9	4129
43.0	1162.9	2630	43.0	1162.9	1683	43.0	1162.9	4129
43.0	1205.9	2630	43.0	1205.9	1683	43.0	1205.9	4129
43.0	1248.9	2630	43.0	1248.9	1683	43.0	1248.9	4129
45.0	1293.9	3060	45.0	1293.9	1958	45.0	1293.9	4804
45.0	1338.9	3060	45.0	1338.9	1958	45.0	1338.9	4804
45.0	1383.9	3060	45.0	1383.9	1958	45.0	1383.9	4804
45.0	1428.9	3060	45.0	1428.9	1958	45.0	1428.9	4804
45.0	1473.9	3060	45.0	1473.9	1958	45.0	1473.9	4804
45.0	1518.9	3060	45.0	1518.9	1958	45.0	1518.9	4804
45.0	1563.9	3060	45.0	1563.9	1958	45.0	1563.9	4804
45.0	1608.9	3060	45.0	1608.9	1958	45.0	1608.9	4804
45.0	1653.9	3060	45.0	1653.9	1958	45.0	1653.9	4804
45.0	1698.9	3060	45.0	1698.9	1958	45.0	1698.9	4804
3280.8	4979.7	9285	3280.8	4979.7	9285	3280.8	4979.7	9285

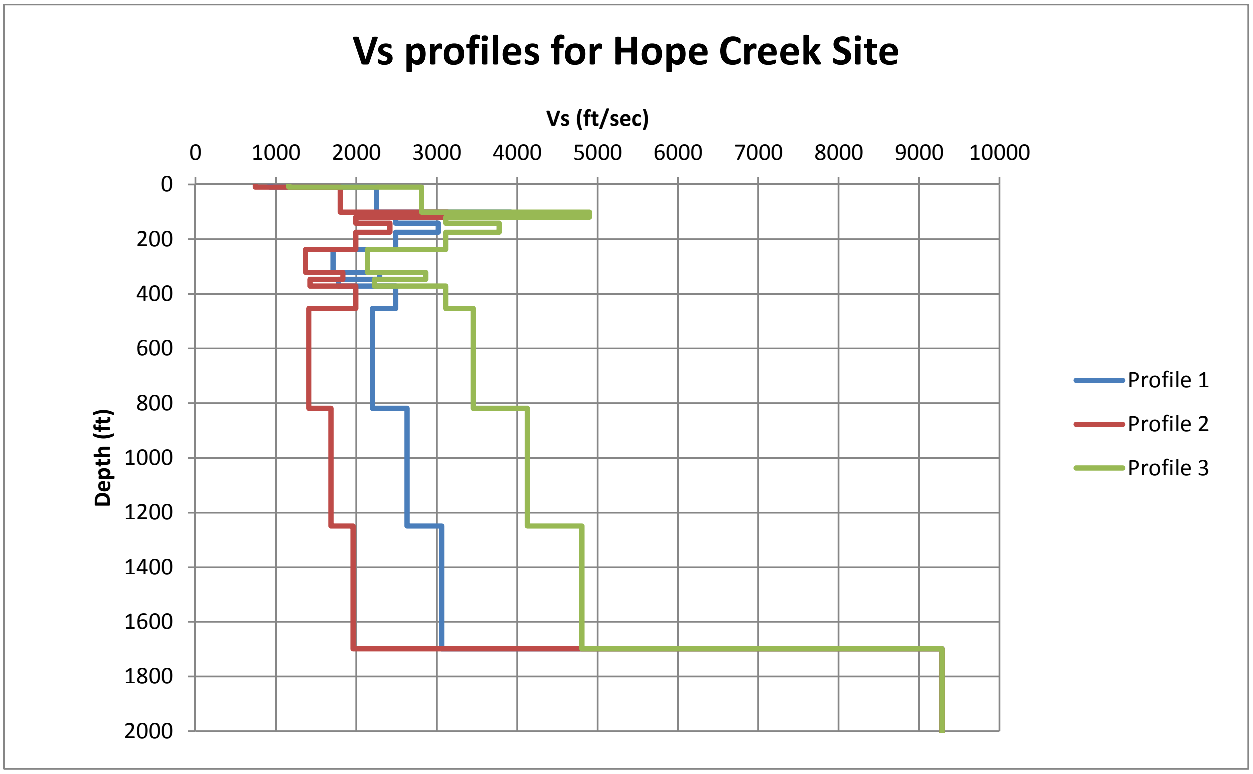


Figure 2-1. Shear-wave velocity profiles for HCGS [11]

2.3.2.2 Shear Modulus and Damping Curves

No site-specific nonlinear dynamic material properties were available for the soils at the HCGS site. The firm soil material over the upper 500 ft (150 m) was assumed to have behavior that could be modeled with either EPRI cohesionless soil or Peninsular Range G/G_{max} and hysteretic damping curves [2]. Consistent with the SPID [2], the EPRI soil curves (model M1) were considered to be appropriate to represent the more nonlinear response likely to occur in the materials at this site. The Peninsular Range (PR) curves [2] for soils (model M2) were assumed to represent an equally plausible alternative more linear response across loading level.

2.3.2.3 Kappa

Kappa is profile damping contributed by both intrinsic hysteretic damping as well as scattering due to wave propagation in heterogeneous material. Base-case kappa estimates were determined using Section B-5.1.3.1 of the SPID [2] for sites with less than 3,000 ft (1,000m) of soil. For soil sites with depths less than 3,000 ft (1,000m) to hard rock, a mean base-case kappa may be estimated based on total soil thickness with the addition of the hard basement rock value of 0.006 s conditioned with an upper bound of 0.040 s [2]. For the Hope Creek NPP site, with about 1,700 ft (518m) of soil the total kappa value was 0.038 s (Table 2-3). Epistemic uncertainty in profile damping (kappa) was considered to be accommodated at design loading levels by the two sets of G/G_{max} and hysteretic damping curves.

Table 2-3
Kappa Values and Weights Used for Site Response Analyses

Velocity Profile	Kappa(s)
P1	0.038
P2	0.038
P3	0.038
Velocity Profile	Weights
P1	0.4
P2	0.3
P3	0.3
G/G_{max} and Hysteretic Damping Curves	
M1	0.5
M2	0.5

*2.3.3 Randomization of Base Case Profile*s

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 HCGS site, random shear wave velocity profiles were developed from the base case profiles shown in Figure 2-1. Consistent with the discussion in Appendix B of the SPID [2], 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 [12] for 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 [2], 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 [2], 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 0.01 to 1.5 g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the HCGS site were the same as those identified in Tables B-4, B-5, B-6 and B-7of the SPID [2] as appropriate for typical CEUS sites.

2.3.5 Methodology

To perform the site response analyses for the HCGS 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 [2]. The guidance contained in Appendix B of the SPID [2] 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 HCGS site.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5% damped 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 oscillator frequency and input rock amplitude. Consistent with the SPID [2] a minimum median amplification value of 0.5 is employed in the present analysis. Figure 2-2 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 (0.01 g to 1.50 g) for profile P1 and EPRI soil 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 HCGS soil site, Figure 2-3 shows the corresponding amplification factors developed with Peninsular Range G/G_{max} and hysteretic damping curves for soil (model M2). Figures 2-2 and Figure 2-3 respectively show only a relatively minor difference for the 0.5 g loading level and below. Above about the 0.5 g loading level, the differences increase mainly in frequencies above 10 Hz to 20 Hz.

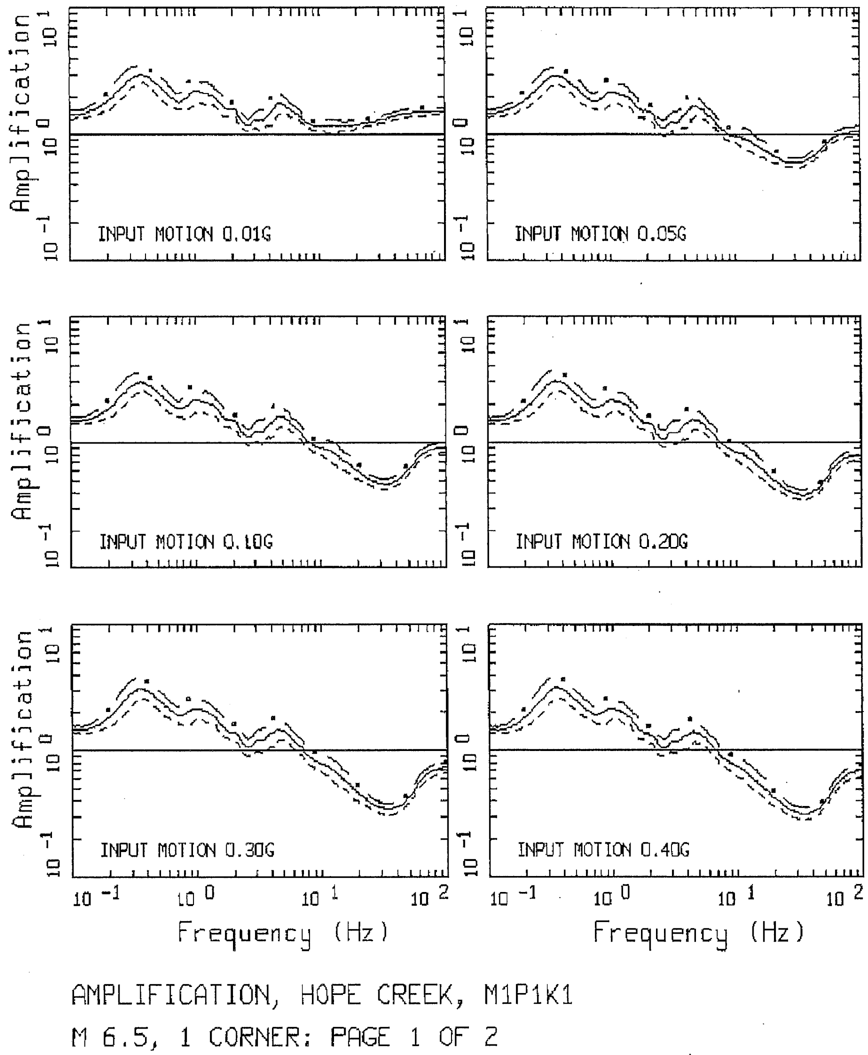
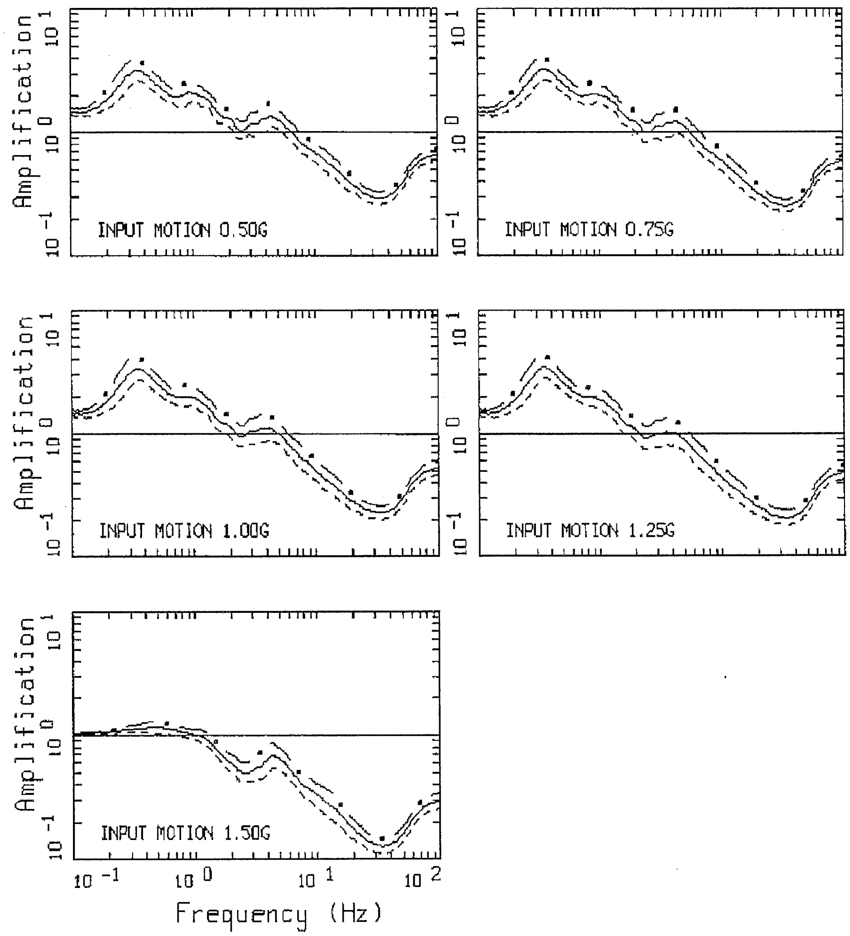


Figure 2-2. Amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), EPRI soil and rock modulus reduction and hysteretic damping curves (model M1), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model [2].



AMPLIFICATION, HOPE CREEK, M1P1K1
M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2-2. (cont.)

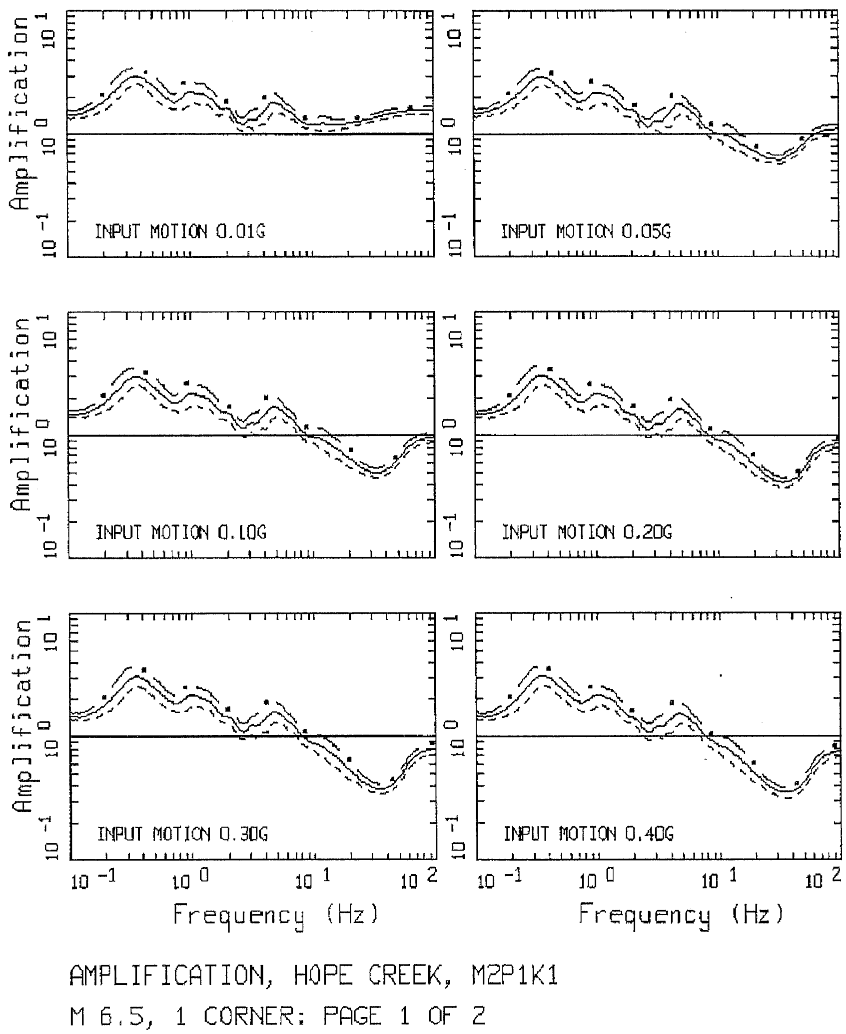
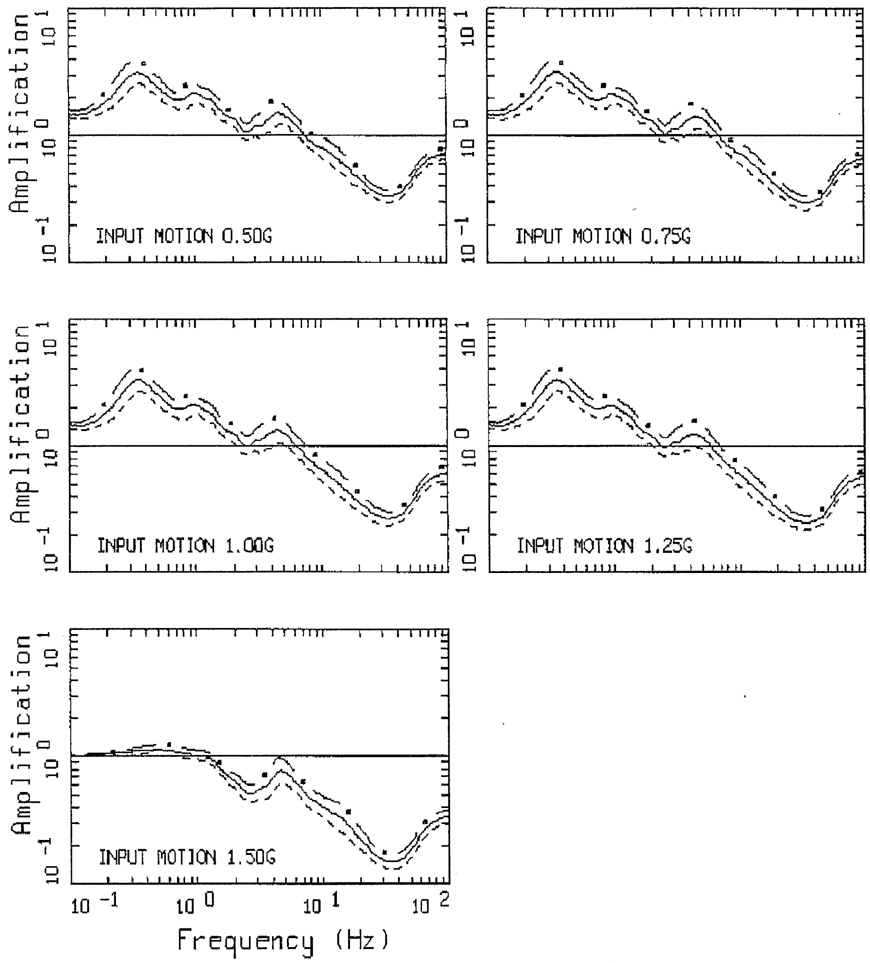


Figure 2-3. Amplification factors (5% damping pseudo absolute acceleration spectra) developed for the mean base-case profile (P1), Peninsular Range modulus reduction and hysteretic damping curves for soil and linear site response for rock (model M2), and base-case kappa at eleven loading levels of hard rock median peak acceleration values from 0.01g to 1.50g. **M** 6.5 and single-corner source model [2].



AMPLIFICATION, HOPE CREEK, M2P1K1

M 6.5, 1 CORNER: PAGE 2 OF 2

Figure 2-3. (cont.)

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 [2]. 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 HCGS are shown in Figure 2-4 for the seven oscillator frequencies for which the ground motion model is defined. Tabulated values of control point hazard curves and site response amplification functions are provided in Appendix A.

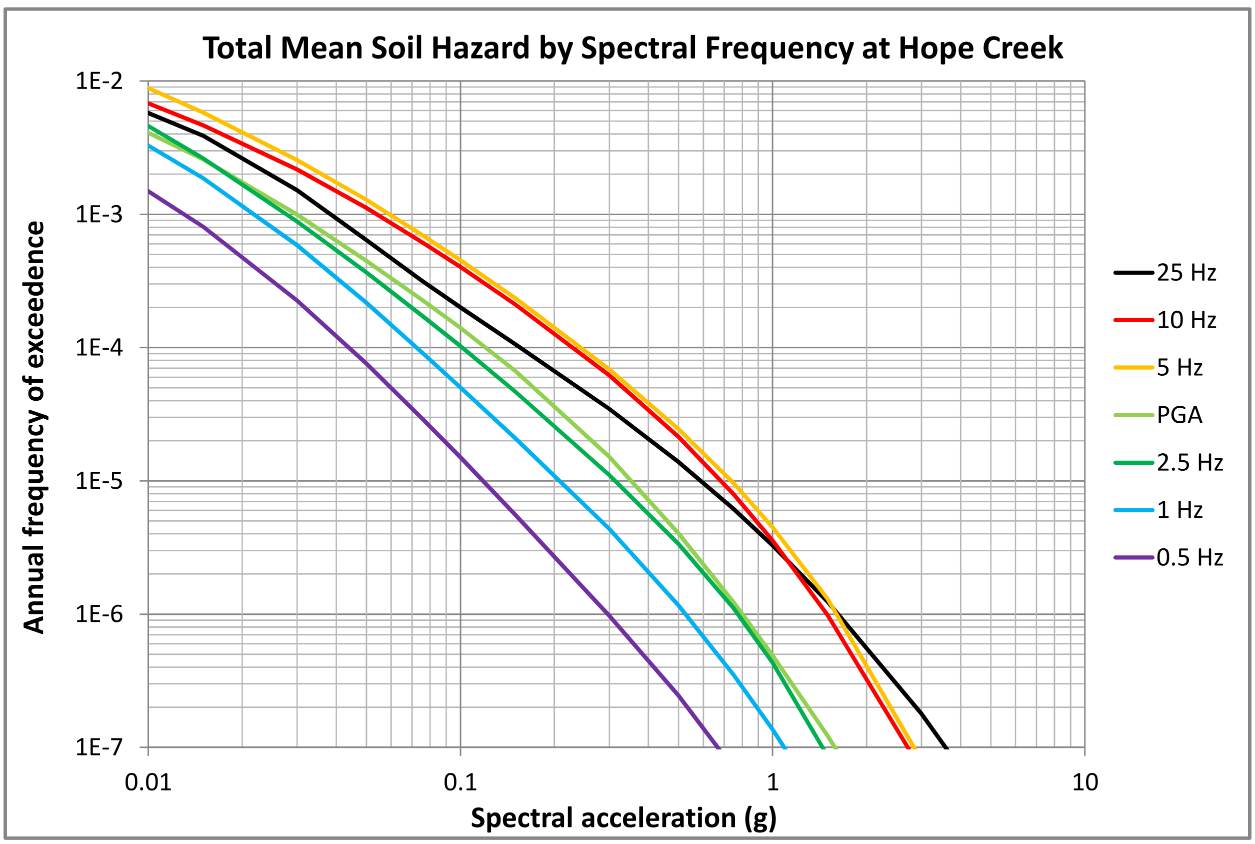


Figure 2-4. Control Point Mean Hazard Curves For Spectral Frequencies of 0.5, 1, 2.5, 5, 10, 25 and 100 Hz at HCGS

2.4 Ground Motion Response Spectrum

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the ground motion response spectrum (GMRS). The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each oscillator frequency for the 10^{-4} and 10^{-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 Regulatory Guide 1.208 [8]. Figure 2-5 and Table 2-4 Figure 2-5 show the 5%-damped UHRS and GMRS spectral accelerations at the control point.

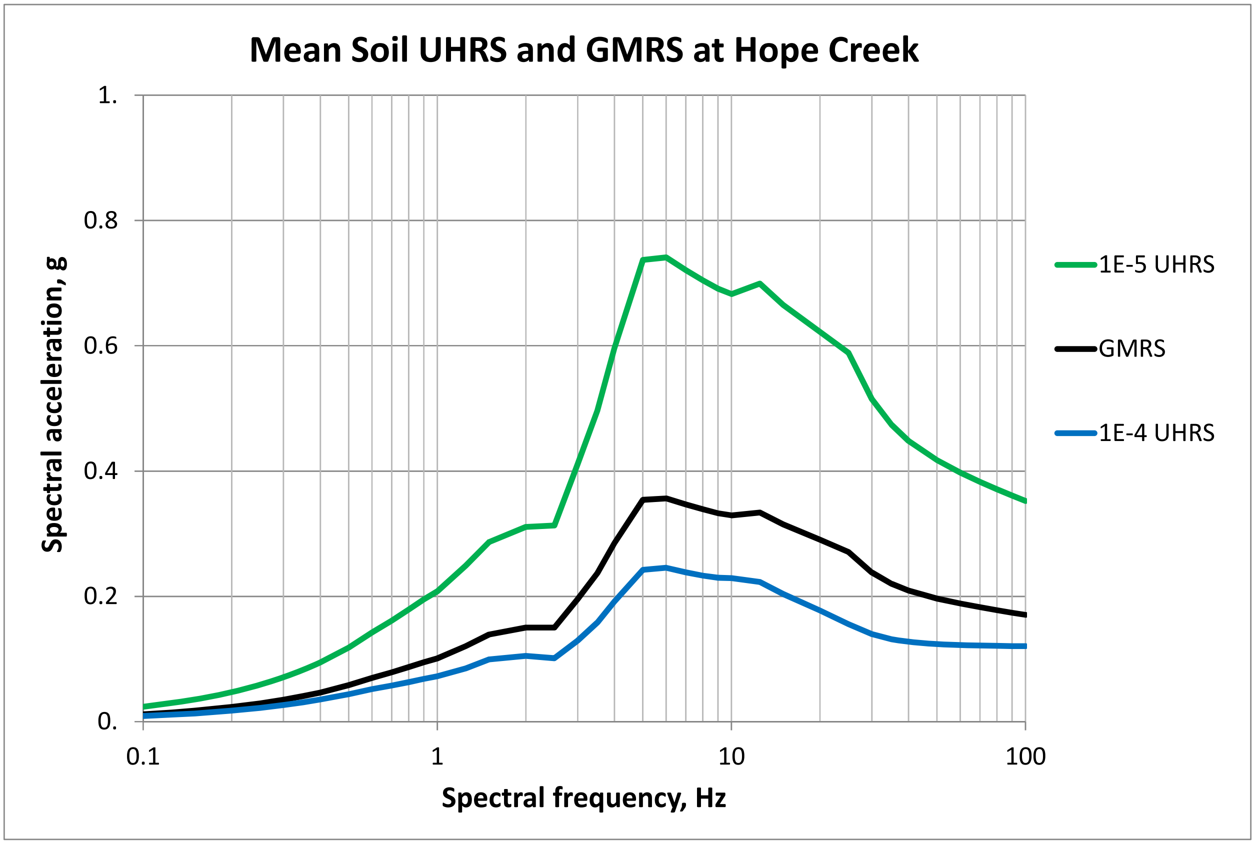


Figure 2-5. UHRS for 10^{-4} and 10^{-5} and GMRS at Control Point for HCGS.

Table 2-4.UHRS for 10^{-4} and 10^{-5} and GMRS at control point for HCGS

Freq. (Hz)	10^{-4} UHRS (g)	10^{-5} UHRS (g)	GMRS (g)
100	0.120	0.352	0.170
90	0.121	0.361	0.174
80	0.121	0.371	0.178
70	0.121	0.383	0.183
60	0.122	0.398	0.188
50	0.124	0.417	0.196
40	0.127	0.448	0.209
35	0.132	0.474	0.220
30	0.140	0.515	0.238
25	0.156	0.589	0.271
20	0.177	0.622	0.290
15	0.204	0.665	0.315
12.5	0.223	0.699	0.334
10	0.229	0.683	0.329
9	0.230	0.691	0.333
8	0.233	0.704	0.339
7	0.238	0.721	0.347
6	0.245	0.741	0.356
5	0.242	0.737	0.354
4	0.192	0.596	0.285
3.5	0.158	0.496	0.273
3	0.129	0.411	0.196
2.5	0.101	0.313	0.150
2	0.105	0.311	0.150
1.5	0.0992	0.287	0.139
1.25	0.0848	0.249	0.120
1	0.0724	0.208	0.101
0.9	0.0683	0.195	0.0950
0.8	0.0628	0.179	0.0871
0.7	0.0575	0.161	0.0786
0.6	0.0519	0.142	0.0698
0.5	0.0439	0.118	0.0581
0.4	0.0351	0.0944	0.0465
0.35	0.0307	0.0826	0.0407
0.3	0.0263	0.0708	0.0349
0.25	0.0219	0.0590	0.0290
0.2	0.0176	0.0472	0.0232
0.15	0.0132	0.0354	0.0174
0.125	0.0110	0.0295	0.0145
0.1	0.00878	0.0236	0.0116

3.0 Plant Design Basis and Beyond Design Basis Evaluation Ground Motion

The design basis horizontal SSE for HCGS is identified in the Updated Final Safety Analysis Report (UFSAR) [5] Figure 2.5-27). An evaluation for beyond design basis (BDB) ground motions was performed in the Individual Plant Examination of External Events (IPEEE). The IPEEE capacity response spectrum is included below for screening purposes.

3.1 Description of Spectral Shape and Anchor Point

The following discussion of the SSE spectral shape is taken from Section 2.5.2 of the UFSAR [5]. The SSE was developed in accordance with 10 CFR Part 100, Appendix A through an evaluation of the maximum earthquake potential for the region surrounding the site. Considering the historic seismicity of the site region, the maximum potential earthquake might be either the intensity VII (Modified Mercalli Scale) 1871 Wilmington, Delaware earthquake occurring near the site or the intensity VII northern New Jersey earthquake of 1927 occurring near the site.

The SSE is defined in terms of a PGA and a design response spectrum. Considering a site intensity of VII, a PGA of 0.13 g at the foundation level was estimated. For additional conservatism, this peak ground acceleration was increased to 0.20 g at the foundation level for the SSE. The 5% damped horizontal SSE is shown in Table 3-1. Values between points in Table 3-1 can be linearly interpolated on a log-log scale.

Table 3-1. SSE for Hope Creek (UFSAR [5] Figure 2.5-27)

Freq. (Hz)	100.0	33.0	9.0	2.5	0.25	0.10
SA (g)	0.20	0.20	0.54	0.63	0.09	0.04

3.2 Control Point Elevation

The SSE control point elevation is defined at the bottom of base mat or 62 ft below grade [11].

3.3 IPEEE Description and Capacity Response Spectrum

The Individual Plant Examination of External Events (IPEEE) for HCGS was performed using methods identified in NUREG-1407 [13]. A Seismic Probabilistic Risk Assessment (SPRA) was taken to identify any potential seismic vulnerabilities at HCGS. The SPRA technique includes consideration of a Seismic Hazard Analysis, a Seismic Fragility Assignment, a Seismic Systems Analysis, and quantification of the seismically induced Core Damage Frequency (CDF). Additional IPEEE related seismic analyses at HCGS focused to evaluate other seismic vulnerabilities through the evaluation of human interactions and recovery actions under seismic conditions, relay chatter during a seismic event, soil seismic liquefaction and slope stability effects, and containment seismic performance.

The IPEEE Adequacy Determination according to SPID [2] Section 3.3.1 is included as Appendix B. The results of the review have shown, in accordance with the criteria established in SPID [2] Section 3.3, that the IPEEE is adequate to support screening of the updated seismic hazard for HCGS. The review also concluded that the risk insights obtained from the IPEEE are still valid under the current plant configuration.

The Full Scope IPEEE detailed review of relay chatter required in SPID [2] Section 3.3.1 has not been completed. PSEG Nuclear intends to complete the relay chatter review consistent with NEI letter to NRC dated October 3, 2013 [33] on the same schedule as the High Frequency Confirmation as proposed in the NEI letter to NRC dated April 9, 2013 [34] and accepted in NRC's response dated May 7, 2013 [35].

The SPRA was performed based on the seismic hazard curve developed by Lawrence Livermore National Laboratory. The total seismic core damage frequency (CDF) for HCGS was 3.6×10^{-6} per year. The plant-level high confidence of low probability of failure (HCLPF) for HCGS calculated from the IPEEE determined CDF is 0.37 g. The IPEEE Probabilistic Seismic Response Analyses for HCGS structures was performed using the EPRI Uniform Hazard Spectrum shape. Accordingly, the 5% damped horizontal IPEEE HCLPF spectrum (IHS) is estimated using the EPRI spectral shape anchored at the plant level HCLPF. The IHS for HCGS is shown in Table 3-2. The SSE and IHS are shown in Figure 3-1.

Table 3-2. IHS for HCGS (See Appendix B).

Freq (Hz)	IHS
1.0	0.10
2.5	0.31
5.0	0.51
10	0.65
25	0.54
40	0.37
100	0.37

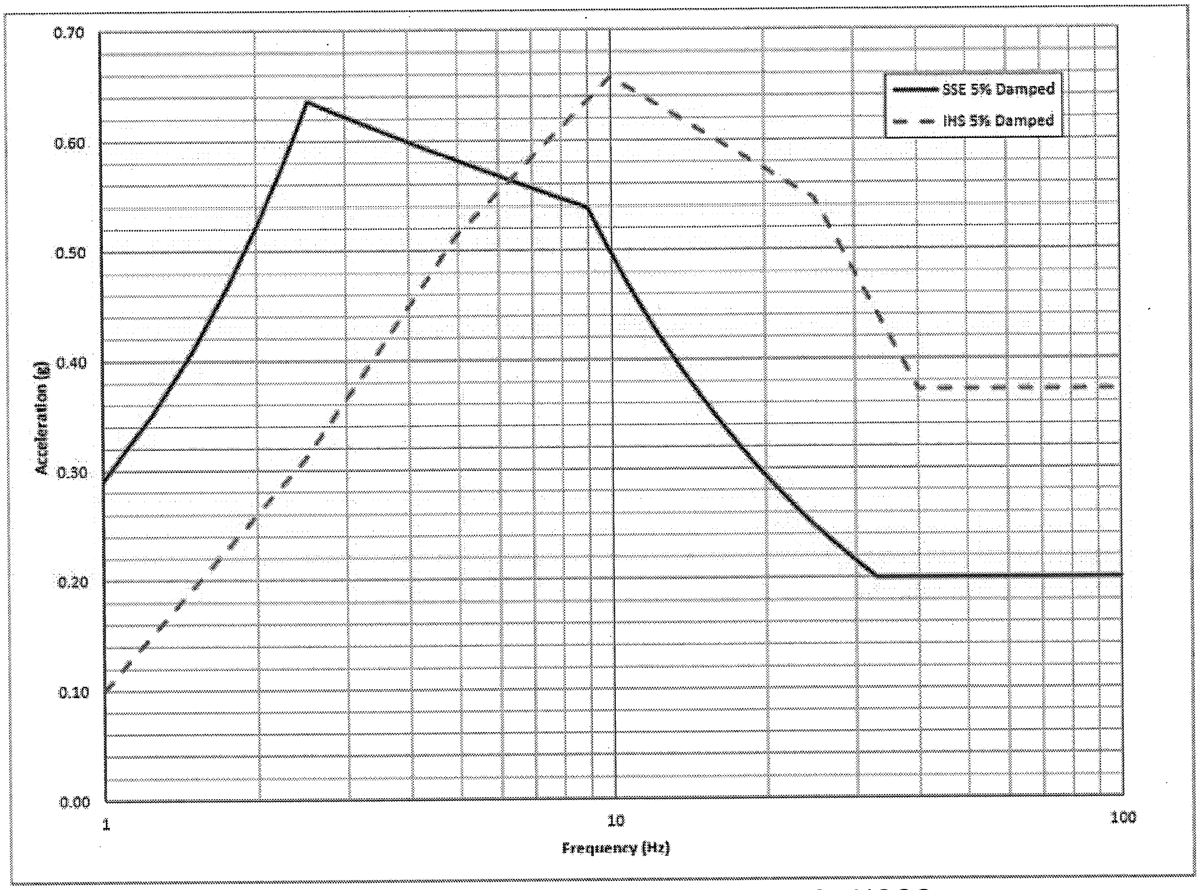


Figure 3-1. SSE and IHS Response Spectra for HCGS.

4.0 Screening Evaluation

In accordance with SPID [2] Section 3, a screening evaluation was performed as described below.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the SSE exceeds the GMRS. Based on this comparison, a risk evaluation will not be performed.

4.2 High Frequency Screening (> 10 Hz)

Above 10 Hz, the IHS exceeds the GMRS. However, the Full Scope IPEEE detailed review of relay chatter required in SPID [2] Section 3.3.1 has not been completed. PSEG Nuclear intends to complete the relay chatter review consistent with NEI letter to NRC dated October 3, 2013 [33] on the same schedule as the High Frequency Confirmation as proposed in the NEI letter to NRC dated April 9, 2013 [34] and accepted in NRC's response dated May 7, 2013 [35]. High Frequency Confirmation per SPID [2] Section 3.4 will only be performed if the relay chatter review is not successful in demonstrating relay adequacy based on the GMRS.

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

In the 1 to 10 Hz part of the response spectrum, the SSE exceeds the GMRS. Therefore, a spent fuel pool evaluation will not be performed.

5.0 Interim Actions

Based on the screening evaluation, no interim actions are necessary for HCGS.

6.0 Conclusions

In accordance with the 50.54(f) letter [1], a seismic hazard and screening evaluation was performed for HCGS. A GMRS was developed solely for purpose of screening for additional evaluations in accordance with the SPID [2]. Based on the results of the screening evaluation, no further evaluations will be performed.

In addition, a Full Scope IPEEE detailed review of relay chatter required in SPID [2] Section 3.3.1 has not been completed. PSEG Nuclear intends to complete the relay chatter review consistent with NEI letter to NRC dated October 3, 2013 [33] on the same schedule as the High Frequency Confirmation as proposed in the NEI letter to NRC dated April 9, 2013 [34] and accepted in NRC's response dated May 7, 2013 [35].

7.0 References

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Appendix A (All information from [4] unless otherwise noted)

Appendix A includes the following tables:

- Table A-1. PGA Seismic Hazard Curves at HCGS
- Table A-2. 25 Hz Seismic Hazard Curves at HCGS
- Table A-3. 10 Hz Seismic Hazard Curves at HCGS
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Note that Tables A-9 and A-10 are tabulation version of the typical amplification factors provided in Figures 2-2 and 2-3. Values are provided for two input motion levels at approximately 10-4 and 10-5 mean annual frequency exceedance. These factors are unverified and are provided for information only. The figures should be considered the governing information.

Table A-1. PGA Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.38E-02	1.60E-02	2.72E-02	3.47E-02	4.13E-02	4.56E-02
0.001	2.51E-02	1.05E-02	1.87E-02	2.49E-02	3.23E-02	3.68E-02
0.005	7.84E-03	3.47E-03	5.05E-03	7.23E-03	1.02E-02	1.51E-02
0.01	4.08E-03	1.72E-03	2.42E-03	3.68E-03	5.27E-03	8.85E-03
0.015	2.59E-03	9.93E-04	1.40E-03	2.25E-03	3.47E-03	6.00E-03
0.03	9.93E-04	2.76E-04	4.19E-04	7.77E-04	1.46E-03	2.68E-03
0.05	4.46E-04	8.35E-05	1.51E-04	3.14E-04	7.13E-04	1.32E-03
0.075	2.30E-04	3.28E-05	6.73E-05	1.53E-04	3.73E-04	7.23E-04
0.1	1.40E-04	1.67E-05	3.95E-05	9.11E-05	2.29E-04	4.43E-04
0.15	6.67E-05	6.83E-06	1.79E-05	4.31E-05	1.07E-04	2.13E-04
0.3	1.51E-05	1.10E-06	3.63E-06	9.79E-06	2.46E-05	4.77E-05
0.5	4.04E-06	2.04E-07	8.12E-07	2.57E-06	6.64E-06	1.32E-05
0.75	1.23E-06	4.19E-08	1.92E-07	7.34E-07	2.01E-06	4.19E-06
1.	4.89E-07	1.11E-08	5.91E-08	2.72E-07	8.00E-07	1.79E-06
1.5	1.22E-07	1.49E-09	8.60E-09	5.66E-08	1.98E-07	5.05E-07
3.	9.08E-09	1.01E-10	2.10E-10	2.19E-09	1.25E-08	4.70E-08
5.	1.04E-09	5.35E-11	9.11E-11	1.90E-10	1.29E-09	6.09E-09
7.5	1.52E-10	5.05E-11	6.09E-11	1.01E-10	2.22E-10	9.93E-10
10.	3.50E-11	5.05E-11	5.05E-11	1.01E-10	1.08E-10	2.72E-10

Table A-2. 25 Hz Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.52E-02	1.92E-02	2.96E-02	3.57E-02	4.19E-02	4.63E-02
0.001	2.71E-02	1.32E-02	2.13E-02	2.68E-02	3.37E-02	3.90E-02
0.005	9.96E-03	4.77E-03	6.73E-03	9.24E-03	1.27E-02	1.90E-02
0.01	5.76E-03	2.72E-03	3.68E-03	5.27E-03	7.34E-03	1.16E-02
0.015	3.87E-03	1.72E-03	2.35E-03	3.52E-03	5.05E-03	7.89E-03
0.03	1.52E-03	5.50E-04	7.89E-04	1.32E-03	2.16E-03	3.28E-03
0.05	6.40E-04	1.77E-04	2.80E-04	5.20E-04	9.79E-04	1.53E-03
0.075	3.20E-04	6.83E-05	1.21E-04	2.49E-04	5.12E-04	8.23E-04
0.1	2.00E-04	3.47E-05	7.23E-05	1.55E-04	3.28E-04	5.35E-04
0.15	1.06E-04	1.53E-05	3.68E-05	8.12E-05	1.74E-04	2.88E-04
0.3	3.47E-05	3.84E-06	1.16E-05	2.72E-05	5.66E-05	9.24E-05
0.5	1.39E-05	1.18E-06	4.43E-06	1.07E-05	2.25E-05	3.79E-05
0.75	6.17E-06	4.63E-07	1.84E-06	4.70E-06	1.02E-05	1.69E-05
1.	3.28E-06	2.25E-07	9.24E-07	2.46E-06	5.42E-06	9.37E-06
1.5	1.24E-06	6.93E-08	3.01E-07	8.98E-07	2.07E-06	3.68E-06
3.	1.79E-07	5.91E-09	2.80E-08	1.13E-07	3.09E-07	6.00E-07
5.	3.35E-08	7.66E-10	3.33E-09	1.74E-08	5.75E-08	1.27E-07
7.5	7.52E-09	1.60E-10	5.20E-10	3.14E-09	1.27E-08	3.09E-08
10.	2.38E-09	1.01E-10	1.72E-10	8.60E-10	3.95E-09	1.04E-08

Table A-3. 10 Hz Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.93E-02	2.88E-02	3.42E-02	3.95E-02	4.50E-02	4.90E-02
0.001	3.21E-02	2.07E-02	2.64E-02	3.19E-02	3.79E-02	4.25E-02
0.005	1.22E-02	6.36E-03	8.60E-03	1.18E-02	1.57E-02	1.98E-02
0.01	6.81E-03	3.42E-03	4.56E-03	6.45E-03	8.72E-03	1.18E-02
0.015	4.64E-03	2.25E-03	3.01E-03	4.37E-03	6.00E-03	8.23E-03
0.03	2.17E-03	9.37E-04	1.31E-03	2.01E-03	2.92E-03	4.01E-03
0.05	1.12E-03	4.19E-04	6.00E-04	9.93E-04	1.60E-03	2.22E-03
0.075	6.23E-04	1.95E-04	2.96E-04	5.35E-04	9.37E-04	1.36E-03
0.1	4.02E-04	1.07E-04	1.74E-04	3.37E-04	6.26E-04	9.24E-04
0.15	2.11E-04	4.50E-05	8.12E-05	1.69E-04	3.37E-04	5.20E-04
0.3	6.20E-05	8.85E-06	2.07E-05	4.77E-05	1.02E-04	1.64E-04
0.5	2.14E-05	2.25E-06	6.45E-06	1.62E-05	3.52E-05	5.91E-05
0.75	7.94E-06	6.36E-07	2.13E-06	5.75E-06	1.32E-05	2.29E-05
1.	3.57E-06	2.32E-07	8.47E-07	2.46E-06	6.00E-06	1.07E-05
1.5	9.83E-07	4.77E-08	1.87E-07	6.26E-07	1.69E-06	3.09E-06
3.	6.78E-08	1.51E-09	7.45E-09	3.52E-08	1.18E-07	2.46E-07
5.	7.57E-09	1.38E-10	4.43E-10	2.64E-09	1.18E-08	3.28E-08
7.5	1.35E-09	6.93E-11	1.01E-10	2.84E-10	1.84E-09	6.73E-09
10.	3.96E-10	5.05E-11	6.36E-11	1.08E-10	5.20E-10	2.04E-09

Table A-4. 5 Hz Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.20E-02	3.33E-02	3.68E-02	4.19E-02	4.70E-02	5.12E-02
0.001	3.69E-02	2.57E-02	3.05E-02	3.73E-02	4.31E-02	4.70E-02
0.005	1.62E-02	8.12E-03	1.15E-02	1.60E-02	2.13E-02	2.49E-02
0.01	8.83E-03	4.19E-03	5.91E-03	8.47E-03	1.20E-02	1.42E-02
0.015	5.80E-03	2.76E-03	3.79E-03	5.58E-03	7.89E-03	9.65E-03
0.03	2.55E-03	1.16E-03	1.60E-03	2.42E-03	3.47E-03	4.43E-03
0.05	1.28E-03	5.35E-04	7.45E-04	1.20E-03	1.79E-03	2.35E-03
0.075	7.08E-04	2.60E-04	3.79E-04	6.45E-04	1.04E-03	1.38E-03
0.1	4.53E-04	1.46E-04	2.22E-04	4.01E-04	6.83E-04	9.37E-04
0.15	2.34E-04	6.17E-05	1.02E-04	1.98E-04	3.68E-04	5.27E-04
0.3	6.85E-05	1.21E-05	2.46E-05	5.50E-05	1.13E-04	1.72E-04
0.5	2.45E-05	3.09E-06	7.66E-06	1.87E-05	4.07E-05	6.54E-05
0.75	9.60E-06	9.11E-07	2.60E-06	6.93E-06	1.62E-05	2.72E-05
1.	4.50E-06	3.33E-07	1.05E-06	3.09E-06	7.66E-06	1.34E-05
1.5	1.30E-06	6.09E-08	2.19E-07	7.77E-07	2.29E-06	4.25E-06
3.	7.97E-08	1.42E-09	5.05E-09	3.28E-08	1.42E-07	3.09E-07
5.	5.92E-09	1.04E-10	1.95E-10	1.60E-09	9.51E-09	2.49E-08
7.5	7.17E-10	5.05E-11	9.11E-11	1.60E-10	9.24E-10	2.96E-09
10.	1.81E-10	5.05E-11	6.09E-11	1.01E-10	2.07E-10	7.77E-10

Table A-5. 2.5 Hz Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.86E-02	2.88E-02	3.28E-02	3.84E-02	4.43E-02	4.90E-02
0.001	3.12E-02	2.01E-02	2.42E-02	3.09E-02	3.84E-02	4.25E-02
0.005	1.03E-02	4.90E-03	6.83E-03	9.79E-03	1.38E-02	1.69E-02
0.01	4.60E-03	2.07E-03	2.88E-03	4.31E-03	6.36E-03	8.12E-03
0.015	2.62E-03	1.13E-03	1.57E-03	2.46E-03	3.63E-03	4.83E-03
0.03	8.83E-04	3.42E-04	4.90E-04	8.00E-04	1.27E-03	1.72E-03
0.05	3.66E-04	1.21E-04	1.82E-04	3.23E-04	5.50E-04	7.66E-04
0.075	1.76E-04	4.83E-05	7.77E-05	1.49E-04	2.72E-04	3.95E-04
0.1	1.02E-04	2.42E-05	4.07E-05	8.35E-05	1.62E-04	2.42E-04
0.15	4.66E-05	8.35E-06	1.60E-05	3.57E-05	7.55E-05	1.20E-04
0.3	1.10E-05	1.16E-06	2.92E-06	7.66E-06	1.84E-05	3.19E-05
0.5	3.36E-06	2.25E-07	7.03E-07	2.16E-06	5.75E-06	1.05E-05
0.75	1.11E-06	5.12E-08	1.84E-07	6.45E-07	1.92E-06	3.68E-06
1.	4.33E-07	1.57E-08	6.17E-08	2.35E-07	7.45E-07	1.51E-06
1.5	8.61E-08	2.46E-09	1.01E-08	4.19E-08	1.44E-07	3.14E-07
3.	2.57E-09	1.23E-10	2.84E-10	1.01E-09	3.79E-09	9.37E-09
5.	1.69E-10	5.05E-11	6.64E-11	1.08E-10	2.22E-10	6.00E-10
7.5	2.37E-11	5.05E-11	5.05E-11	9.11E-11	1.01E-10	1.32E-10
10.	6.06E-12	5.05E-11	5.05E-11	9.11E-11	1.01E-10	1.01E-10

Table A-6. 1 Hz Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.24E-02	1.92E-02	2.46E-02	3.28E-02	3.95E-02	4.37E-02
0.001	2.39E-02	1.21E-02	1.69E-02	2.39E-02	3.05E-02	3.52E-02
0.005	7.17E-03	2.64E-03	4.19E-03	6.83E-03	1.01E-02	1.29E-02
0.01	3.28E-03	9.93E-04	1.67E-03	2.96E-03	4.83E-03	6.73E-03
0.015	1.87E-03	4.98E-04	8.60E-04	1.62E-03	2.84E-03	4.19E-03
0.03	5.86E-04	1.29E-04	2.29E-04	4.70E-04	9.24E-04	1.49E-03
0.05	2.16E-04	4.07E-05	7.55E-05	1.64E-04	3.52E-04	5.75E-04
0.075	9.29E-05	1.51E-05	2.84E-05	6.64E-05	1.57E-04	2.57E-04
0.1	5.02E-05	7.03E-06	1.38E-05	3.42E-05	8.60E-05	1.44E-04
0.15	2.09E-05	2.25E-06	4.83E-06	1.31E-05	3.57E-05	6.54E-05
0.3	4.35E-06	2.53E-07	6.83E-07	2.25E-06	7.23E-06	1.57E-05
0.5	1.16E-06	3.79E-08	1.18E-07	4.90E-07	1.87E-06	4.56E-06
0.75	3.50E-07	6.54E-09	2.19E-08	1.11E-07	5.35E-07	1.49E-06
1.	1.37E-07	1.67E-09	5.58E-09	3.42E-08	2.01E-07	6.00E-07
1.5	3.13E-08	2.49E-10	6.93E-10	5.20E-09	4.13E-08	1.42E-07
3.	1.85E-09	5.83E-11	9.11E-11	1.84E-10	1.64E-09	7.23E-09
5.	2.37E-10	5.05E-11	6.09E-11	1.01E-10	1.67E-10	6.73E-10
7.5	4.85E-11	5.05E-11	5.05E-11	9.11E-11	1.01E-10	1.55E-10
10.	1.51E-11	5.05E-11	5.05E-11	9.11E-11	1.01E-10	1.01E-10

Table A-7. 0.5 Hz Seismic Hazard Curves at HCGS

AMPS(g)	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	2.06E-02	1.16E-02	1.57E-02	2.04E-02	2.53E-02	2.96E-02
0.001	1.33E-02	6.83E-03	9.51E-03	1.31E-02	1.72E-02	2.07E-02
0.005	3.48E-03	9.93E-04	1.69E-03	3.19E-03	5.27E-03	7.13E-03
0.01	1.49E-03	2.88E-04	5.58E-04	1.23E-03	2.42E-03	3.68E-03
0.015	8.06E-04	1.27E-04	2.57E-04	6.09E-04	1.36E-03	2.19E-03
0.03	2.26E-04	2.57E-05	5.50E-05	1.46E-04	4.01E-04	6.93E-04
0.05	7.57E-05	6.73E-06	1.51E-05	4.37E-05	1.38E-04	2.49E-04
0.075	2.98E-05	2.13E-06	4.90E-06	1.53E-05	5.50E-05	1.05E-04
0.1	1.50E-05	8.72E-07	2.10E-06	7.03E-06	2.72E-05	5.58E-05
0.15	5.56E-06	2.16E-07	5.75E-07	2.25E-06	9.37E-06	2.25E-05
0.3	9.73E-07	1.20E-08	4.07E-08	2.42E-07	1.38E-06	4.50E-06
0.5	2.45E-07	9.37E-10	3.90E-09	3.84E-08	3.01E-07	1.16E-06
0.75	6.96E-08	1.57E-10	5.66E-10	7.55E-09	7.77E-08	3.37E-07
1.	2.59E-08	9.79E-11	1.79E-10	2.22E-09	2.68E-08	1.27E-07
1.5	6.22E-09	6.09E-11	1.01E-10	4.13E-10	5.12E-09	2.88E-08
3.	6.19E-10	5.05E-11	6.09E-11	1.01E-10	2.68E-10	2.35E-09
5.	1.07E-10	5.05E-11	5.05E-11	9.24E-11	1.01E-10	4.01E-10
7.5	2.31E-11	5.05E-11	5.05E-11	9.11E-11	1.01E-10	1.32E-10
10.	7.08E-12	5.05E-11	5.05E-11	9.11E-11	1.01E-10	1.01E-10

Table A-8. Medians and Logarithmic Sigmas of Amplification Functions for HCGS

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	1.38E+00	9.12E-02	1.30E-02	1.10E+00	8.70E-02	1.90E-02	1.11E+00	1.27E-01	2.09E-02	1.61E+00	1.89E-01
4.95E-02	9.84E-01	1.06E-01	1.02E-01	5.73E-01	1.04E-01	9.99E-02	9.68E-01	1.54E-01	8.24E-02	1.54E+00	1.95E-01
9.64E-02	8.59E-01	1.09E-01	2.13E-01	5.00E-01	1.11E-01	1.85E-01	9.23E-01	1.59E-01	1.44E-01	1.50E+00	1.97E-01
1.94E-01	7.58E-01	1.13E-01	4.43E-01	5.00E-01	1.18E-01	3.56E-01	8.64E-01	1.62E-01	2.65E-01	1.43E+00	1.98E-01
2.92E-01	7.03E-01	1.16E-01	6.76E-01	5.00E-01	1.23E-01	5.23E-01	8.20E-01	1.67E-01	3.84E-01	1.38E+00	2.00E-01
3.91E-01	6.65E-01	1.19E-01	9.09E-01	5.00E-01	1.27E-01	6.90E-01	7.83E-01	1.72E-01	5.02E-01	1.34E+00	2.02E-01
4.93E-01	6.34E-01	1.22E-01	1.15E+00	5.00E-01	1.31E-01	8.61E-01	7.49E-01	1.77E-01	6.22E-01	1.29E+00	2.04E-01
7.41E-01	5.77E-01	1.29E-01	1.73E+00	5.00E-01	1.40E-01	1.27E+00	6.77E-01	1.89E-01	9.13E-01	1.20E+00	2.11E-01
1.01E+00	5.33E-01	1.35E-01	2.36E+00	5.00E-01	1.48E-01	1.72E+00	6.15E-01	1.97E-01	1.22E+00	1.12E+00	2.16E-01
1.28E+00	5.00E-01	1.41E-01	3.01E+00	5.00E-01	1.55E-01	2.17E+00	5.63E-01	2.04E-01	1.54E+00	1.02E+00	2.25E-01
1.55E+00	5.00E-01	1.42E-01	3.63E+00	5.00E-01	1.53E-01	2.61E+00	5.00E-01	2.03E-01	1.85E+00	6.72E-01	2.22E-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	1.23E+00	1.43E-01	1.27E-02	1.99E+00	2.20E-01	8.25E-03	2.16E+00	1.78E-01			
7.05E-02	1.18E+00	1.51E-01	3.43E-02	1.95E+00	2.08E-01	1.96E-02	2.14E+00	1.72E-01			
1.18E-01	1.16E+00	1.56E-01	5.51E-02	1.94E+00	1.99E-01	3.02E-02	2.14E+00	1.70E-01			
2.12E-01	1.13E+00	1.64E-01	9.63E-02	1.92E+00	1.86E-01	5.11E-02	2.15E+00	1.70E-01			
3.04E-01	1.11E+00	1.71E-01	1.36E-01	1.90E+00	1.76E-01	7.10E-02	2.16E+00	1.72E-01			
3.94E-01	1.09E+00	1.78E-01	1.75E-01	1.89E+00	1.69E-01	9.06E-02	1.61E+00	1.69E-01			
4.86E-01	1.07E+00	1.84E-01	2.14E-01	1.87E+00	1.63E-01	1.10E-01	1.62E+00	1.72E-01			
7.09E-01	1.03E+00	2.01E-01	3.10E-01	1.44E+00	1.46E-01	1.58E-01	1.63E+00	1.74E-01			
9.47E-01	9.99E-01	2.16E-01	4.12E-01	1.42E+00	1.44E-01	2.09E-01	1.64E+00	1.74E-01			
1.19E+00	7.37E-01	2.15E-01	5.18E-01	1.40E+00	1.45E-01	2.62E-01	1.65E+00	1.72E-01			
1.43E+00	5.28E-01	1.75E-01	6.19E-01	1.02E+00	9.89E-02	3.12E-01	1.04E+00	8.59E-02			

Table A-9. Median AFs and Sigmas for Model 1, 2 PGA Levels [14].

M1P1K1	PGA=0.194			M1P1K1	PGA=0.741		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.156	0.806	0.098	100.0	0.433	0.585	0.116
87.1	0.157	0.787	0.098	87.1	0.434	0.567	0.116
75.9	0.157	0.754	0.098	75.9	0.434	0.536	0.116
66.1	0.157	0.693	0.099	66.1	0.435	0.481	0.116
57.5	0.158	0.595	0.099	57.5	0.436	0.400	0.117
50.1	0.159	0.498	0.099	50.1	0.437	0.329	0.117
43.7	0.160	0.426	0.099	43.7	0.439	0.280	0.118
38.0	0.163	0.393	0.098	38.0	0.442	0.260	0.118
33.1	0.167	0.381	0.096	33.1	0.447	0.252	0.120
28.8	0.174	0.396	0.096	28.8	0.456	0.261	0.122
25.1	0.186	0.419	0.101	25.1	0.472	0.272	0.127
21.9	0.199	0.471	0.119	21.9	0.494	0.304	0.136
19.1	0.221	0.529	0.169	19.1	0.524	0.332	0.160
16.6	0.240	0.598	0.172	16.6	0.565	0.377	0.188
14.5	0.254	0.664	0.177	14.5	0.605	0.428	0.190
12.6	0.278	0.745	0.197	12.6	0.649	0.478	0.201
11.0	0.297	0.815	0.185	11.0	0.715	0.545	0.194
9.5	0.297	0.854	0.130	9.5	0.766	0.617	0.201
8.3	0.298	0.928	0.143	8.3	0.780	0.687	0.194
7.2	0.317	1.055	0.136	7.2	0.798	0.756	0.191
6.3	0.346	1.226	0.140	6.3	0.868	0.882	0.192
5.5	0.376	1.394	0.152	5.5	0.954	1.022	0.179
4.8	0.400	1.513	0.184	4.8	1.047	1.155	0.183
4.2	0.369	1.441	0.272	4.2	1.074	1.229	0.233
3.6	0.322	1.289	0.216	3.6	1.014	1.199	0.255
3.2	0.284	1.209	0.203	3.2	0.871	1.100	0.238
2.8	0.247	1.106	0.151	2.8	0.782	1.046	0.189
2.4	0.235	1.142	0.161	2.4	0.688	1.002	0.185
2.1	0.259	1.382	0.147	2.1	0.723	1.162	0.186
1.8	0.242	1.447	0.120	1.8	0.702	1.269	0.157
1.6	0.236	1.629	0.177	1.6	0.659	1.381	0.182
1.4	0.237	1.894	0.140	1.4	0.676	1.653	0.155
1.2	0.224	2.032	0.187	1.2	0.663	1.853	0.174
1.0	0.210	2.117	0.170	1.0	0.636	1.983	0.153
0.91	0.190	2.095	0.247	0.91	0.594	2.049	0.182
0.79	0.156	1.908	0.192	0.79	0.521	1.999	0.191
0.69	0.138	1.895	0.133	0.69	0.456	1.982	0.139
0.60	0.133	2.088	0.169	0.60	0.426	2.141	0.151
0.52	0.127	2.353	0.177	0.52	0.404	2.401	0.170
0.46	0.120	2.651	0.175	0.46	0.381	2.732	0.185
0.10	0.003	1.502	0.064	0.10	0.008	1.500	0.066

Table A-10. Median AFs and Sigmas for Model 2, 2 PGA Levels [14].

M2P1K1	PGA=0.194			M2P1K1	PGA=0.741		
Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)	Freq. (Hz)	Soil_SA	med. AF	sigma ln(AF)
100.0	0.166	0.857	0.101	100.0	0.489	0.661	0.115
87.1	0.167	0.837	0.101	87.1	0.490	0.641	0.115
75.9	0.167	0.802	0.101	75.9	0.491	0.606	0.115
66.1	0.168	0.738	0.101	66.1	0.492	0.545	0.115
57.5	0.168	0.634	0.101	57.5	0.494	0.453	0.116
50.1	0.170	0.532	0.101	50.1	0.496	0.374	0.116
43.7	0.172	0.456	0.101	43.7	0.500	0.318	0.117
38.0	0.175	0.423	0.100	38.0	0.506	0.297	0.118
33.1	0.182	0.414	0.095	33.1	0.518	0.292	0.119
28.8	0.191	0.435	0.096	28.8	0.535	0.307	0.122
25.1	0.207	0.467	0.108	25.1	0.566	0.327	0.130
21.9	0.224	0.529	0.125	21.9	0.601	0.370	0.140
19.1	0.248	0.595	0.183	19.1	0.656	0.416	0.180
16.6	0.270	0.674	0.184	16.6	0.713	0.476	0.196
14.5	0.283	0.739	0.194	14.5	0.762	0.539	0.194
12.6	0.310	0.831	0.201	12.6	0.821	0.604	0.207
11.0	0.324	0.890	0.183	11.0	0.899	0.685	0.202
9.5	0.321	0.924	0.119	9.5	0.921	0.741	0.171
8.3	0.324	1.008	0.139	8.3	0.929	0.818	0.147
7.2	0.346	1.151	0.126	7.2	0.979	0.928	0.158
6.3	0.380	1.345	0.139	6.3	1.072	1.090	0.174
5.5	0.408	1.512	0.159	5.5	1.171	1.255	0.176
4.8	0.430	1.629	0.203	4.8	1.247	1.375	0.192
4.2	0.386	1.507	0.288	4.2	1.194	1.367	0.252
3.6	0.327	1.309	0.207	3.6	1.062	1.256	0.234
3.2	0.289	1.231	0.186	3.2	0.909	1.148	0.221
2.8	0.251	1.124	0.150	2.8	0.798	1.067	0.166
2.4	0.245	1.190	0.154	2.4	0.733	1.068	0.162
2.1	0.268	1.430	0.144	2.1	0.779	1.254	0.166
1.8	0.250	1.496	0.114	1.8	0.747	1.351	0.127
1.6	0.246	1.691	0.169	1.6	0.715	1.499	0.151
1.4	0.242	1.940	0.167	1.4	0.725	1.773	0.152
1.2	0.225	2.042	0.183	1.2	0.691	1.931	0.168
1.0	0.214	2.151	0.187	1.0	0.665	2.073	0.151
0.91	0.188	2.081	0.242	0.91	0.608	2.097	0.217
0.79	0.153	1.871	0.180	0.79	0.505	1.937	0.192
0.69	0.136	1.871	0.137	0.69	0.442	1.923	0.149
0.60	0.132	2.074	0.176	0.60	0.418	2.102	0.167
0.52	0.127	2.344	0.181	0.52	0.399	2.371	0.179
0.46	0.120	2.642	0.176	0.46	0.377	2.699	0.187
0.10	0.003	1.499	0.064	0.10	0.008	1.490	0.065

Appendix B - IPEEE Adequacy Review

B.1 Background and Purpose

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the NRC Commission established a Near Term Task Force (NTTF) to conduct 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 [1] to all U.S. nuclear power plants that requests information to assure that these recommendations are addressed. NTTF Recommendation 2.1: Seismic requests information related to performing a seismic risk evaluation.

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," [2] provides guidance for responding to the NRC's request for information. One of the methods in this report that can be used to demonstrate that plants are seismically adequate is to show that the seismic risk assessments performed as part of the Individual Plant Examination for External Events (IPEEE) for Severe Accident Vulnerabilities (Generic Letter 88-20, Supplement 4) [15] result in a High Confidence of Low Probability of Failure (HCLPF) seismic capacity response spectrum (IPEEE HCLPF Spectrum - IHS) that is higher than the new Ground Motion Response Spectrum (GMRS). Plants for which the IPEEE results meet certain criteria can be "screened out" using this method so that it is not necessary to perform new seismic risk analyses.

The purpose of this appendix is to show that the Hope Creek IPEEE results from the report submitted to the USNRC for the Hope Creek Generating Station [16] together with responses to Requests for Additional Information [17] meet the IPEEE adequacy criteria in the SPID [2], Section 3.3.1.

Hope Creek is a single unit plant on the east bank of the Delaware River in Lower Alloways Creek Township, Salem County, New Jersey. The site is considered a soil site for the purposes of seismic evaluations. As discussed in Section 3.7.1.1 of the HCGS FSAR [5], The design basis horizontal Safe Shutdown Earthquake (SSE) is 0.20 g and the Operating Basis Earthquake (OBE) is 0.10 g.

For the IPEEE program, NUREG-1407 [13] assigned Hope Creek as a Focused Scope plant with a Review Level Earthquake (RLE) of 0.30 g for screening purposes. A Seismic Probabilistic Risk Assessment (SPRA) was performed for Hope Creek to address the seismic portion of the IPEEE program; enhancements to the seismic PRA methodology were also implemented to address plant walkdowns, the potential for relay chatter, and the potential for soil failure.

The topics covered in this IPEEE screening evaluation report parallel those described in Section 3.3.1 of the SPID [2] namely, a discussion of the General Considerations for applying the IPEEE screening method, a description of how the Prerequisites are met for using the screening method, a discussion of the Adequacy Demonstration, and an overall Conclusion that the IPEEE results can be used for screening purposes.

B.2 General Considerations

The results from a Focused Scope IPEEE evaluation performed for Hope Creek can be used to screen out of performing new seismic risk analyses in the NTTF 2.1 seismic program if four conditions are met. First, the Focused Scope IPEEE review must be enhanced to include a Full Scope detailed review of relay chatter for components such as electric relays and switches. Second, the Focused Scope IPEEE review must include a Full Scope evaluation of soil failures, such as liquefaction, slope stability, and settlement. Third, the plant-level HCLPF response spectrum, determined from the IPEEE evaluation, must bound the GMRS over two frequency ranges (1 – 10 Hz and greater than 10 Hz). And fourth, where modifications were required to achieve the IPEEE HCLPF, it is necessary to verify that the changes that were identified during the IPEEE program were implemented and remain in effect and subsequent plant modifications have not reduced the plant seismic capability. How each of these conditions is met is described in the following four subsections.

B.2.1 Relay Chatter

To satisfy the IPEEE program requirements for a Focused Scope plant, a relay evaluation, as defined in Section 3.2.4.2 of NUREG-1407 [13], was performed for Hope Creek [18]. The scope of relays included all the low ruggedness relays (LRRs) in the plant, as described in Section 6.3.1.3 of the IPEEE Submittal Report [16].

This scope of relays was evaluated to determine whether they could adversely impact safe shutdown of the plant and containment performance if they chattered. Those that could have a potential impact were evaluated further to determine whether they had sufficient seismic capacity to withstand a seismic demand up to the Review Level Earthquake (RLE) of 0.30 g. Analysis of 16 panels containing LRRs and 38 LRRs led to the conclusion that either median capacities are greater than 1.5 g from the applicable failure modes or that there is no impact on safe shutdown [16, Section 6.3.1.3].

All of the LRRs were screened out from further consideration because (1) they were not associated with safe shutdown or containment function components, (2) relay chatter was acceptable, or (3) they had high seismic capacity.

Therefore, the IPEEE submittal report [16] concludes in Section 7.2 that relay chatter due to a seismic event is not risk significant. This conclusion was confirmed in the Brookhaven National Laboratory report included as Attachment 1 to the NRC Staff Evaluation Report (SER) of the Hope Creek IPEEE program [19, pg 4] where it concluded:

"This evaluation procedure [for relay chatter] appears to be acceptable."

In accordance with SPID [2] Section 3.3.1, Focused Scope margin submittals may be used after having been enhanced to bring the assessment in line with Full Scope assessments. Therefore, a Full Scope detailed review of relay chatter for components such as electric relays and switches is required.

B.2.2 Soil Liquefaction and Soil Failure

The second condition that must be met to screen out from performing new seismic risk analyses is to show that a Full Scope evaluation of soil failures, such as liquefaction, slope stability, and settlement, was completed as a part of the IPEEE program.

As described in Section 3.1.4.4 of the IPEEE submittal report [16], the potential for liquefaction, seismically induced settlement, and lateral spreading at the Hope Creek site was evaluated by Woodward-Clyde Consultants using a probabilistic evaluation approach. This evaluation considered buildings at the power block and the Service Water Intake Structure. Soil at the HCGS site consists of a layer of hydraulic fill at the surface and various sands beneath.

The computed probabilities of liquefaction and seismically induced foundation settlements are very small even at a peak ground acceleration as high as 0.60 g. Specific discussion on settlement and slope instability is provided in the Woodward-Clyde Report on soil liquefaction and slope stability [32] as follows:

- Total seismically induced settlements at the 84th percentile are less than 1/4-inch for the SSE level.
- The critical piping systems that may be susceptible to lateral spreading displacement at HCGS are the service water supply piping and the service water electrical cables. Results of analyses performed to evaluate the earthquake-induced displacements of the compacted fill indicate that buried piping and cables that are located within engineered backfill are likely to experience less than 0.5 ft of earthquake induced displacements for PGA less than 0.6 g.
- The site is generally level with no significant natural or constructed slopes beyond the shoreline. The shoreline consists of riprap slopes at the southern portion of the site, vegetated slopes between the Salem and Hope Creek Service Water Intake Structures (SWIS) and a bulkhead north of the Hope Creek SWIS. These site conditions indicate that flow failures, typically associated with steep slopes, do not appear to be a concern.

The HCLPF capacities (in terms of PGA) for liquefaction were estimated to be 0.60 g at the power block and 0.50 g at the Service Water Intake Structure . The HCLPF value for extensive liquefaction at the Vincentown formation, upon which the Seismic Category I structures are founded, is estimated to be in excess of 0.60 g PGA.

Although the hydraulic fill near the plant grade level may liquefy at an acceleration level much lower than 0.60 g and therefore could result in an increase of lateral pressure on the subgrade walls of the Seismic Category I structures, the seismic fragility evaluation of the structures included the effects of hydrostatic and hydrodynamic pressure as well as the static and dynamic lateral earthquake pressure acting on the below grade exterior walls. Therefore, liquefaction of the hydraulic fill does not have a significant impact on the seismic fragilities of Seismic Category I structures.

The soil failures evaluation described in the IPEEE submittal report is considered to adequately assess the potential for adverse soil failure effects on Hope Creek Seismic Category I structures. Therefore, this second condition is considered to have been satisfactorily met so that the IPEEE results can be used to screen out from performing new seismic risk analyses in the NTTF 2.1 seismic program.

B.2.3 IPEEE HCLPF Spectrum

The third condition that must be met to be able to use the IPEEE results to screen out from performing new seismic risk analyses is to show that the plant-level IPEEE HCLPF spectrum (IHS) bounds the GMRS over two frequency ranges: 1 to 10 Hz and greater than 10 Hz.

The Hope Creek IPEEE evaluation did not determine the plant-level high confidence of low probability of failure (HCLPF) acceleration value. The Hope Creek IPEEE SPRA determined that the total seismic core damage frequency (CDF) was 3.6×10^{-6} per year based on the seismic hazard curve developed by Lawrence Livermore National Laboratory (LLNL). The plant-level HCLPF can be back-calculated from the CDF and the LLNL seismic hazard curve assuming a fragility curve total uncertainty (β_c) of 0.4.[1] Based on this methodology, the Hope Creek plant-level HCLPF is 0.37 g [20]. The IPEEE Probabilistic Seismic Response analysis is developed using the EPRI Uniform Hazard Spectral Shape. Accordingly, the 5% damped horizontal IPEEE HCLPF spectrum (IHS) using the spectral shape associated with the LLNL hazard curve anchored at the plant level HCLPF for HCGS is shown in Table 3-2. The GMRS is provided in Table 2-4.

The IHS is greater than or equal to the GMRS over the 1 to 10 Hz range and exceeds the GMRS above 10 Hz. Therefore, this third condition is considered to have been satisfactorily met so that the IPEEE results can be used to screen out from performing new seismic risk analyses in the NTTF 2.1 seismic program.

[1] This value is consistent with the approach outlined in EPRI 1003121 [21] and is conservative relative to the value recommended for a combined set of component fragilities by Dr. R. Kennedy in NEA/CSNI/R(99)28 [22]. This methodology is consistent with Method 1B used by the NRC Staff to determine the plant-level HCLPF values for plants performing IPEEE SPRAs [23] Appendix C.

B.2.4 Modifications to Achieve IPEEE HCLPF

The fourth condition that must be met to screen out from performing new seismic risk analyses in the NTTF 2.1 seismic program is to verify that the modifications required to achieve the IPEEE HCLPF were implemented and remain in effect. Confirmation of this condition is described in Section B.3.2.

B.3 Prerequisites

Section 3.3.1 of the SPID [2] identifies the following items that must be confirmed in order to use the IPEEE analysis to demonstrate that the IPEEE results can be used for comparison with the GMRS:

1. Confirm that commitments made during the IPEEE program have been met.
2. Confirm that all of the modifications and other changes credited in the IPEEE program are still in place.
3. Confirm that any identified deficiencies or weaknesses to NUREG-1407 [13] in the plant-specific NRC Safety Evaluation Report (SER) are properly justified to ensure that the IPEEE conclusions remain valid.
4. Confirm that major plant modifications implemented after the IPEEE program was completed have not degraded or adversely impacted the conclusions reached in the IPEEE program.

Confirmation of these each of these prerequisites is summarized below.

B.3.1 IPEEE Commitments

No commitments were made as a result of the seismic PRA analysis.

B.3.2 Modifications Credited in IPEEE Analyses

The seismic IPEEE study found no fundamental weakness or vulnerability, so no specific plant improvements or modifications with regard to seismic events were proposed as part of the IPEEE program.

B.3.3 Weaknesses Identified in IPEEE SER

Attachment 1 (pg 11) to the NRC Staff Evaluation Report of the Hope Creek IPEEE program [19] provides a report from the Brookhaven National Laboratory, which identified that "the licensee appears to have satisfied the objectives outlined in the Generic Letter with respect to the IPEEE." The NRC ultimately concluded that Hope Creek's "IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the HCGS IPEEE has met the intent of Supplement 4 to GL-88-20..." [19, pg 6].

B.3.4 Major Plant Modifications Since IPEEE

A review of major plant modifications performed since completion of the Hope Creek IPEEE program in the late 1990s [24] did not identify any adverse impact on the conclusions of the IPEEE. To complete this review, all modifications since July 1997 were screened for relevance to the seismic damage sequences cited in the IPEEE report as having a significant contribution to CDF. Screening was performed via keyword search and also using a line-by-line manual scan of modification descriptions. Details of relevant modifications were then reviewed to assess the potential for adverse impact on the IPEEE results.

Based on the above four confirmation statements, Hope Creek meets the prerequisite requirements to proceed to perform an IPEEE screening evaluation.

B.4 Adequacy Demonstration

Section 3.3.1 of the SPID [2] identifies information that should be included in the submittal report to the NRC when the IPEEE screening method is used. This information addresses the major technical considerations associated with the adequacy of the IPEEE analyses, documentation, and peer review to support use of the IPEEE results for screening purposes.

As noted by NRC staff on page 6 of the Staff Evaluation Report of the Hope Creek IPEEE program [19], the IPEEE program is considered complete and reasonable such that the most likely severe accidents and vulnerabilities can be identified.

> "On the basis of the overall review findings, the staff concludes that: (1) the licensee's IPEEE is complete with regard to the information requested by Supplement 4 to GL 88-20 (and associated guidance in NUREG-1407), and (2) the IPEEE results are reasonable given the HCGS design, operation, and history. Therefore, the staff concludes that the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the HCGS IPEEE has met the intent of Supplement 4 to GL 88-20 and the resolution of specific generic and unresolved safety issues discussed in this SER."

To confirm that the Hope Creek IPEEE also adequately addresses the major technical considerations to support use of the IPEEE screening method for NTTF 2.1, nine areas of the IPEEE program are described and evaluated in the following subsections. For each of these areas, the following discussion includes a discussion of (1) the methodology used, (2) whether the analysis was conducted in accordance with the guidance in NUREG-1407 [13], and (3) a statement, if applicable, as to whether the methodology and results are adequate for screening purposes.

B.4.1 Structural Models and Structural Response Analysis

The IPEEE Submittal Report [16] and its supporting reference documents describe in detail the structural models developed for the IPEEE program as well as the structural responses using those models. In summary, new probabilistic, soil-structure interaction (SSI) building models were developed for the containment building including internal structures, for the auxiliary building, and for the service water intake structure.

Probabilistic response analyses were performed for free field input motions selected to match the 10,000 year EPRI Uniform Hazard Spectrum (UHS) shape anchored to 3 x SSE (i.e., 0.60 g peak ground acceleration). An ensemble of time histories was generated such that their median response spectra matched the median 10,000 year EPRI UHS. Variability in the time histories corresponds to the peak-to-valley variability in real earthquake ground motion spectra. Thirty earthquake motions, three components each, were generated such that their median 5% damped spectra matched the EPRI UHS with coefficient of variation of 0.20. Variability in stiffness and damping of both structures and soil were also considered in these analyses.

The Soil Structure Interaction analysis [25] utilized the substructure approach; structural models for this approach are fixed-base and SSI effects are incorporated using foundation impedances and wave scattering functions. Structural models were developed for the reactor building, the auxiliary building, the turbine building, and the service water intake structure. The modal damping ratios used for the building models were the upper bound damping values from NUREG/CR-0098 [26] corresponding to the at-yield values. The variability in soil and structure properties were incorporated in the probabilistic response analysis by performing a Latin Hypercube Simulation from lognormal probability distributions with the following coefficients of variations:

Soil shear modulus: 0.35
Soil material damping: 0.50
Structural frequencies: 0.25
Structural modal damping: 0.35

The median and 84% non-exceedance probability (NEP) responses were calculated for each selected in-structure response. These included peak accelerations, maximum member forces, and floor response spectra at chosen elevations as needed for equipment fragility estimation.

The structural models and structural response analyses are consistent with the guidelines in NUREG-1407 [13] and SPID [2] Section 6.3.1.

The methodology and results of the IPEEE structural modeling are considered adequate for IPEEE screening purposes.

B.4.2 In-structure Demands and In-structure Response Spectrum (ISRS)

The EQE probabilistic seismic response analysis report [25] describes in detail the methodology used to perform the probabilistic seismic response analyses for the IPEEE program. In summary, the new probabilistic floor response spectra developed for the IPEEE program followed the methodology developed under the Seismic Safety Margins Research Program (SSMRP), conducted in the early 1980s in the United States and applied to several seismic probabilistic risk assessment (PRA) and margin studies. Such an approach was in line with trends in the early 1990s toward an explicit treatment of uncertainties in various phases of the analysis procedure, e.g., specification of free-field ground motion and development of the structure model. This approach provides a complete description of the seismic environment for equipment mounted in structures and was used directly in the seismic PRA for Hope Creek.

The in-structure seismic demands and in-structure response spectra are consistent with the guidelines in NUREG-1407 [13] and SPID [2] Section 6.3.1. In particular, new in-structure seismic demands and in-structure response spectra were developed for the IPEEE program.

The methodology and results for IPEEE in-structure demands and in-structure response spectra are considered adequate for IPEEE screening purposes.

B.4.3 Selection of Seismic Equipment List or Safe Shutdown Equipment List

Section 3.1.2.2.1 of the IPEEE Submittal report [16] describes the details of the methods use to develop the seismic equipment list. Approximately 300 components were initially selected, as shown in Table 3-4 of the IPEEE submittal report [16]. The types of components in this list include:

- Critical components identified in the internal events PRA model
- Components needed for containment performance
- Components associated with such issues as seismic-induced fires and floods
- Passive components that could have significant conditional probabilities of seismic failure
- Components that could inadvertently change state during an earthquake and divert flow
- Instrumentation, racks, cabinets, transformers, switchgear, motor control centers, and panels that provide essential signals, power or control room indication
- Structures housing the components identified above

The selection of components for the seismic equipment list is consistent with the guidelines in NUREG-1407 [13] and EPRI NP-6041-SL [28].

The methodology and results for equipment selection are considered adequate for IPEEE screening purposes.

B.4.4 Screening of Components

The EQE seismic walkdown report [27] describes the details of the method used to screen out from further evaluations components on the seismic equipment list. In summary, as described in Section 2.3.1 of the IPEEE Submittal Report [16], several screens were used to narrow the scope of seismic evaluations. The first screen was to narrow the scope of components to only those described above in Section B.4.3.

The second type of screen was based on plant walkdowns in which components with high seismic capacity were identified and screened out from further evaluations. This screen eliminated such components as valves, horizontal pumps and compressors, small instruments mounted on walls or ceilings, and distributed systems such as piping, cable trays, and HVAC ducts.

The third type of screen eliminated components with relatively high seismic capacity compared to realistic seismic demands based on the Hope Creek probabilistic floor response spectra. Most structures and components on the seismic equipment list were screened out based on their high seismic capacity. The conservative screening criteria used for this screening were: 1) median acceleration capacity greater than 1.50 g, and 2) HCLPF greater than 0.50 g. These criteria are conservative when compared to the seismic margins review level earthquake of 0.30 g and a design basis earthquake (SSE) of 0.20 g.

These screening methods narrowed the scope of components to about 100 items for further evaluations.

The methodology and results for screening of components from the seismic equipment list are reasonable and meet the intent of NUREG-1407 [13]. Therefore, this component screening is considered adequate for IPEEE screening purposes.

B.4.5 Walkdowns

The EQE seismic walkdown report [27] describes in detail the approach used in and results of the seismic walkdowns. In summary, walkdowns were performed to find as-designed, as-built, and as-operated seismic weaknesses of components in the plant. In particular, personnel who participated or supported the seismic walkdowns included individuals who were familiar with plant systems and operations, PRA methods, and structural analysis. A series of walkdowns were performed to further develop the seismic equipment list, to pre-screen components with high seismic capacity, to determine component failure modes, to identify spatial interactions, and to evaluate the likelihood of seismic induced fire and flooding. For each of the components on the seismic equipment list, a Seismic Evaluation Walkdown Sheet (SEWS) was prepared to record the walkdown findings.

The seismic walkdowns are consistent with the guidelines in NUREG-1407 [13]. In particular, as specified in Section 3.1.1.4 of NUREG-1407 [13], the intent of the guidelines in EPRI

NP-6041-SL [28] is met. This was confirmed on page 3 of the Brookhaven National Laboratory report, included as Attachment 1 in the NRC Staff Evaluation Report of the Hope Creek IPEEE program [19] in which it was concluded that the walkdown procedure was appropriate.

The methodology and results of the seismic walkdowns are considered adequate for IPEEE screening purposes.

B.4.6 Fragility Evaluations

The EQE seismic fragility analysis report [29] describes in detail the approach used in and results of determining the seismic fragilities of structures and equipment. A summary of the component fragilities and failure modes is included in the IPEEE Submittal Report [16]. Highlights from these documents are summarized below.

Seismic fragilities of structures and equipment were estimated using EPRI TR-103959 [30] and EPRI NP-6041-SL [28]. Seismic fragilities were developed in terms of the peak ground acceleration capacity of structures and equipment. As such, three fragility parameters were calculated for each screened-in component for its significant failure mode, namely the median ground acceleration capacity (A_m) and the logarithmic standard deviations associated with randomness (β_R), and uncertainty (β_U).

Seismic fragilities of important structures, tanks, and block walls were estimated for significant failure modes using a combination of the probabilistic response analyses as described in the EQE probabilistic seismic response analysis report [25] together with knowledge of the SSE design criteria utilized to build the plant.

Structures were deemed to fail when their inelastic deformation exceeds the level that interferes with the operability of the equipment housed inside or mounted on the structure. In some instances, structures were considered to fail when the sliding displacements exceeded the deformation capability of attached piping. Tanks were considered to fail when they lose their contents. Block walls were deemed to fail when they either collapse on adjacent components or suffer large deformations that may interfere with the functionality of attached equipment.

The fragility for selected structures, tanks, and block walls was evaluated in Section 4.2 of the EQE seismic fragility analysis report [29]. The lowest capacity for these structures was for the Condensate Storage Tank, which had a median PGA capacity of 0.95 g and a HCLPF capacity of 0.34 g.

Seismic fragilities of screened-in equipment from the seismic equipment list were estimated for significant failure modes. Failure modes considered in the fragility evaluation include elastic functional failures, brittle failures, and ductile failures. Elastic functional failures involve loss of intended function while the component is stressed below its yield point. Examples of this type of failure include: elastic buckling in tank walls or component supports; chatter and trip in electrical components; excessive blade deflection in fans; and shaft seizure in pumps.

Brittle failures are those failure modes that have little or no system inelastic energy absorption capability. Examples include: expansion anchor failures; component support weld failures; and shear pin failures.

Ductile failure modes are those in which the structural system can absorb a significant amount of energy through inelastic deformation. Examples include: pressure boundary failure of piping, structural failure of cable trays, and structural failure of ducting.

The equipment fragilities are based on plant-specific analyses, earthquake experience databases, and generic PRA databases.

The fragility parameters for selected equipment (with their abbreviations) are shown in Table B-1 below. This table also shows HCLPF capacities for this equipment.

Table B-1. Seismic Fragility Parameters for Equipment
(Adapted from Table 3-6 of Reference 16)

Equipment	Abbrev	A_m (g)	β_R	β_U	HCLPF (g)
Offsite Power (Station power transformers)	SWYRD	0.31	0.25	0.43	0.10
1E 120V Instrumentation Distribution Panels 1A(B,C,D) J481	PNL481	1.08	0.33	0.36	0.35
1E 120V Instrumentation Distribution Panels 1A(B,C,D) J482	PNL482	1.03	0.33	0.36	0.33
125V DC 1E power to panels 1A(B,C,D)417	125Vdc	1.47	0.17	0.40	0.57
250V DC MCC 10D251 / 10D261	250MCC	0.73	0.25	0.30	0.29
1E 250Vdc buses 10D450 and 10D460	250V BUS	1.36	0.20	0.34	0.56
Firewater tanks 0A-T-508 and 0B-T-508	Not Used	0.73	0.27	0.36	0.26
Firewater Pumps (fragility governed by tanks)	Not Used	0.73	0.27	0.36	0.26
SACS AOV 1EGHV-2325H	Not Used	0.89	0.25	0.29	0.37
Damper 1GKHD 9594A	CREFA	0.89	0.25	0.29	0.37
Dampers 1GKHD-9588AA/AB/BA/BB	CRS	0.89	0.25	0.29	0.37
Fans 1A/B-VH408	PNLHVC	0.50	0.25	0.25	0.22
Fans 1A/B-V-416	Not Used	0.50	0.25	0.25	0.22
Fans 1A/B/C/D-V-406	Not Used	0.50	0.25	0.25	0.22
Condensate Storage Tank	CSTNK	0.95	0.27	0.36	0.34
120V AC fuse panels 1Y-F-401/402/103/404	CNTVNT	1.10	0.39	0.41	0.29
Small LOCA due to seismic event	SLOCA	1.50	0.30	0.50	0.40

The fragility evaluations are consistent with the guidelines in NUREG-1407 [13], EPRI TR-103959 [30] and EPRI NP-6041-SL [28]. In particular, fragilities were based on generic PRA data, plant-specific analyses, earthquake experience data, and design basis data. The fragilities of limiting structures and equipment are documented in the IPEEE submittal report [16] and its supporting references.

The methodology and results of the fragility evaluations are considered adequate for IPEEE screening purposes.

B.4.7 System Modeling

The IPEEE Submittal Report [16] and the PSEG Seismic System Analysis and Quantification Report [31] describe in detail the system modeling and evaluations performed for the IPEEE seismic PRA. In summary, the event and fault tree models developed for the Hope Creek internal events IPE were used as the starting point for the seismic IPEEE models. Traditional event tree techniques were used to delineate the potential combinations of seismic-induced failures, and resulting seismic scenarios, which were termed "seismic damage states" (SDS). The frequencies of these seismic damage states were quantified by convolving the earthquake hazard curve with the structure and equipment seismic fragility curves.

For those seismic damage states with frequency greater than 10^{-7}, the impact on the plant and plant systems was evaluated using the internal events IPE model and its dependency matrices as the primary basis. Only 18 SDSs met this criterion, as shown in the IPEEE Submittal Report [16], Table 3-8, "Hope Creek Seismic Core Damage Frequencies." This table, reproduced below in Table B-2, shows the Seismic Damage State (SDS) for both the EPRI and LLNL hazards, the conditional core damage probability (CDP) for each sequence, and annual core damage frequency (CDF) for each sequence. The meaning of the sequence abbreviations used in this table is based on the failure equations listed in Table B-3 and the equipment abbreviations shown in Table B-1.

Table B-2. Hope Creek Seismic Core Damage Frequencies
(Reproduced from Table 3-8 of Reference 16)

Sequence		Seismic Damage State (SDS) Frequency		Conditional CDP	CDF (per yr)	
		EPRI Hazard	LLNL Hazard		EPRI	LLNL
S2	S-S2	7.9E-08	1.8E-07	6.5E-05	5.1E-12	1.2E-11
S3	S-CV	4.4E-07	6.1E-07	5.8E-05	2.6E-11	3.5E-11
S5	S-CT	2.6E-07	4.0E-07	4.2E-05	1.1E-11	1.7E-11
S9	S-HP	4.4E-07	8.2E-07	4.8E-02	2.1E-08	3.9E-08
S18	S-OP	5.9E-05	6.3E-05	2.1E-03	1.2E-07	1.3E-07
S19	S-OP-S2	1.6E-07	5.4E-07	2.1E-03	3.4E-10	1.1E-09
S20	S-OP-CV	6.4E-07	1.6E-06	2.1E-03	1.3E-10	3.4E-09
S22	S-OP-CT	4.4E-07	1.4E-06	2.1E-03	9.2E-10	2.9E-09
S24	S-OP-CT-CV	3.7E-06	2.3E-07	2.1E-03	7.8E-11	4.8E-10
S26	S-OP-HP	1.1E-06	3.8E-06	6.1E-02	5.6E-08	1.9E-07
S27	S-OP-HP-S2	3.4E-08	2.4E-07	7.8E-02	2.7E-09	1.9E-08
S28	S-OP-HP-CV	1.0E-07	6.7E-07	5.1E-02	5.1E-09	3.4E-08
S30	S-OP-HP-CT	1.0E-07	8.1E-07	5.0E-02	5.0E-09	4.1E-08
S32	S-OP-HP-CT-CV	1.7E-08	2.5E-07	5.1E-02	8.7E-10	1.3E-08
S35	S-IC2	4.6E-08	1.6E-07	1.0E+00	4.6E-08	1.6E-07
S36	S-IC1	6.7E-07	2.5E-06	1.0E+00	6.7E-07	2.5E-06
S37	S-DC	6.8E-08	4.4E-07	1.0E+00	6.8E-08	4.4E-07
S38	S-HV	2.1E-08	5.4E-08	1.0E+00	2.1E-08	5.4E-08
				Total CDF	1.0E-06	3.6E-06

Table B-3. Failure Equations for Top Events
[From Reference 16; Section 3.1.5.2.2]

S	=	(no equation needed since this is the seismic event)
HV	=	PNLHVC * HVREC
DC	=	125Vdc
IC1	=	PNL481
IC2	=	PNL482 * RSDOWN
OP	=	SWYRD
CR	=	CREFA * CRS * RSDOWN
HP	=	250MCC + 250BUS
CT	=	CSTNK
CV	=	CNTVNT
S2	=	SLOCA

Of the 18 SDSs shown in Table B-2, four of them (SDS 35, 36, 37, and 38) directly result in core damage, and loss of containment heat removal systems, i.e., each has a conditional core damage probability (CCDP) of 1.0, or guaranteed failure. Therefore, no conditional core damage probability calculation of non-seismic failures is needed because the plant and containment damage states are delineated. The internal events IPE and IPE models were used to determine CCDPs for the remaining 14 SDSs in Table B-2.

Special attention was given to human interactions and recovery actions in the IPEEE evaluation. For scenarios that required additional non-seismic failures to occur to result in core damage, the IPE internal events model (event trees and fault trees), with appropriate changes for the seismic damage state, was used to develop conditional core damage probabilities. These calculations incorporated random failures of equipment and operator actions. To obtain the overall results (i.e., CDFs), the frequencies of each seismic damage state was multiplied by the conditional core damage probability for that SDS. Human interactions, recovery actions, and specific seismic sequences, were included in this analysis.

The system modeling and evaluations performed for the IPEEE seismic PRA are consistent with the guidelines in NUREG-1407 [13] (see Section 3.2.4.7). In particular, the IPEEE evaluation addressed the development of the event and fault trees, the treatment of non-seismic failures, and how human actions were treated. The Brookhaven National Laboratory report on page 8, included as Attachment 1 in the NRC Staff Evaluation Report of the Hope Creek IPEEE program [19], concluded that the "licensee seems to have done a generally comprehensive and credible job with respect to the logic models."

The methodology and results of the system modeling and evaluations are considered adequate for IPEEE screening purposes.

B.4.8 Containment Performance

Section 3.1.6 of the IPEEE Submittal Report [16] describes in detail the evaluation of the containment performance during a seismic event. In summary, containment performance under seismic conditions was evaluated for containment structural integrity, containment isolation equipment to protect against containment bypass, and containment cooling systems. No vulnerabilities were identified for any aspect of the containment performance.

As defined in NUREG-1407 [13] (Section 3.1.1.5), the purpose of the seismic containment performance evaluation was to identify vulnerabilities that could lead to early failure of containment functions including continued integrity of the containment, containment isolation, prevention of bypass functions, and some specific systems depending on containment design. The components of the containment system that were examined during the IPEEE program are shown in Table B-4.

Table B-4. Components of Containment System Examined in the IPEEE (Reproduced from Table 3-13 of Reference 16)

- Containment vent valves and nitrogen accumulators
- Main Steam Isolation Valves (MSIVs)
- Containment spray pumps and valves
- Activation sensors and system for containment isolation
- Containment hatches and seals

Because no vulnerabilities were identified for any aspect of containment performance, it was not necessary to perform fragility or HCLPF evaluations.

The containment performance evaluation performed for the IPEEE program is consistent with the guidelines in NUREG-1407 [13] (see Section 3.1.1.5). This was confirmed by the NRC on pages 4 and 5 of the NRC Staff Evaluation Report for the Hope Creek IPEEE program [19] that PSEG Nuclear "did a credible job of looking for containment vulnerabilities. The containment was found to be sturdy against seismic damage, except for the effect on the isolation function from the distribution panels, which was modeled with operator recovery."

The methodology and results of the containment performance evaluation is considered adequate for IPEEE screening purposes.

B.4.9 Peer Review

Section 6 of the IPEEE Submittal Report [16] describes in detail how the peer review was conducted, who serviced as peer reviewers, what findings were identified, and how those findings were dispositioned.

In summary, the individuals of the Independent Review Team (IRT) for the Hope Creek IPEEE project had extensive, relevant experience related to the elements of the IPEEE program. The PSE&G personnel on the IRT had knowledge of their plant, system configurations, and operating practices and procedures. They also had combined experience in the areas of systems engineering, seismic capacity engineering, and seismic PRAs. One contractor also participated on the IRT, and he had significant technical expertise in related areas. Dr. Michael Frank had significant experience in risk, safety, reliability, and uncertainty analysis. Section 6.2 of the IPEEE Submittal Report [16] provides the background and qualifications for each of the independent review team members.

The IRT focused their review on the assumptions, modeling approaches, results, and conclusions for the IPEEE. They divided their review into the following three stand-alone segments:

- Seismic/Soil
- Fire
- High Winds, Floods, and Other Environments

The areas evaluated in the Seismic/Soil segment included the seismic, soil, and soil/structure interaction studies. The IRT sought to ascertain whether the methodologies used were adequate and whether the results generated were reasonable. The Screening Evaluation Walkdown Sheets (SEWS) of selected Hope Creek plant components were reviewed by the IRT. They also performed plant walkdowns to verify that the information recorded on the SEWS was reasonable. The IRT thoroughly reviewed the Tier 2 reports associated with the IPEEE seismic program. The comments generated by the IRT were resolved and changes were incorporated into the affected calculations and documents. They also concluded that the conservative methodology limitations used in the seismic evaluations appeared reasonable and that the LLNL seismic hazard information and walkdown results provided acceptable results.

As described in Section 6.3 of the IPEEE Submittal Report [16], significant effort was expended during the IRT review of seismic and soil topics on the following topics. The results of those reviews are summarized below:

- Dynamic Soil Properties – The IRT reported that the Dynamic Soil Properties used in the report were reasonable and representative of the site soil condition.

- Soil Liquefaction and Slope Stability – The report on soil liquefaction potential and slope stability was reviewed. Since the Hope Creek power block foundation is resting on the Vincentown formation, which is a very old formation and has high shear wave velocity, the computed probabilities of soil liquefaction and seismically induced settlements and differential settlements are very small as anticipated.

  The site is generally level with no significant natural or constructed slopes beyond the shoreline. The IRT reported that the site conditions indicate that flow failures, typically associated with steep slopes, do not appear to be a concern.

- Relay Chatter Evaluation - The relay chatter evaluation involved development of a list for bad actors or Low Ruggedness Relays (LRR) as identified by the NRC and SQUG/EPRI and an evaluation of the impacts of potential chatter of the LRRs. The LRR list was developed using five search methods. Sixteen panels which contain LRRs and 38 LRRs were identified. Analysis of these panels and LRRs led to the conclusion that either median capacities are greater than 1.5 g for the applicable failure modes or that there is no impact on safe shutdown.

- Seismic Walkdown - Requirements, results and documentation for seismic walkdowns were reviewed in accordance with EPRI NP-6041-SL [28]. An independent sample seismic walkdown was performed on selected equipment to verify the documented results. The IRT reported that the sample walkdown results agree with the report.

- Probabilistic Seismic Response Analyses – The methodology and procedures used in calculating the Probabilistic Seismic Responses were reviewed. While verifying the numerical results was beyond the scope of the Independent Peer Review, the IRT endorsed the methods used in the process. The IRT reported that the results appear to be reasonable and were consistent with their expectations.

- Seismic Fragility of Structures and Equipment - A list of structures and equipment was developed for seismic fragility evaluation. The IRT reviewed methods for screening and walkdown following the criteria established in EPRI NP-6041-SL [28].

- System Analysis and Core Damage Frequency - The IRT reviewed the seismic system analysis for technical accuracy and consistency. Input quantities were checked whenever possible. The IRT concluded that methodology for these analyses were reasonable and typical. IRT comments were satisfactorily resolved.

The peer review performed for the IPEEE program was consistent with the guidelines in NUREG-1407 [13], which specify that the IPEEE peer review team should be independent (or capable of providing an objective and critical review) and have combined experience in the areas of systems engineering and specific external events.

The methodology and results of the peer review is considered adequate for IPEEE screening purposes.

B.5 Conclusion

The adequacy review concludes that the IPEEE evaluation is adequate to support screening of the updated seismic hazard for Hope Creek provided a Full Scope detailed review of relay chatter is performed in accordance with SPID [2] Section 3.3.1. The review also concludes that the risk insights obtained from the IPEEE are still valid under the current plant configuration.

Summary of 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 Milestone	Commitment Type	
		One-Time Action (Yes/No)	Programmatic (Yes/No)
1. PSEG will perform a relay chatter review for Hope Creek Generating Station on the same schedule as the High Frequency Confirmation in the NEI proposed path forward dated April 9, 2013 (ADAMS Accession No. ML13101A379).	One of the following dates, to be determined using an NRC prioritization process following transmittal of this Seismic Hazard and Screening Report: 6/30/2017, or 12/31/2019, or 12/31/2020	Yes	No