J. Todd Conner
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DTE Energy

10 CFR 50.54(f)

March 31, 2014
NRC-14-0017

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D C 20555-0001

References:
1) Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

2) 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

3) NEI Letter to NRC, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," dated April 9, 2013

4) NRC Letter, "EPRI Final Draft Report XXXXXX, 'Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic,' as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations," dated May 7, 2013

5) EPRI Report 1025287, "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," dated November, 2012

6) NRC Letter, "Endorsement of Electric Power Research Institute Final Draft Report 1025287, 'Seismic Evaluation Guidance'," dated February 15, 2013

Subject: DTE Electric Company's Seismic Hazard and Screening Report, 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

On March 12, 2012, the NRC issued Reference 2 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 2 requested each addressee located in the Central and Eastern United States (CEUS) to submit a Seismic Hazard Evaluation and Screening Report within 1.5 years from the date of Reference 2.

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

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

The enclosure to this letter contains the Seismic Hazard Evaluation and Screening Report for Fermi 2 as described in Section 4 of Reference 5 in accordance with the schedule identified in Reference 3.

This letter contains no new regulatory commitments.

Should you have any questions or require additional information, please contact Mr. Kirk R. Snyder, Manager, Industry Interface, at (734) 586-5020.

Sincerely,

Enclosure

cc: Director, Office of Nuclear Reactor Regulation
NRC Project Manager
NRC Resident Office
Reactor Projects Chief, Branch 5, Region III
Regional Administrator, Region III
Michigan Public Service Commission,
Regulated Energy Division (kindscl@michigan.gov)

I, J. Todd Conner, do hereby affirm that the foregoing statements are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

J. Todd Conner
Site Vice President
Nuclear Production

On this 31st day of March, 2013 before me personally appeared J. Todd Conner, being first duly sworn and says that he executed the foregoing as his free act and deed.

Sharon S. Marshall
Notary Public

SHARON S. MARSHALL
NOTARY PUBLIC, STATE OF MI
COUNTY OF MONROE
MY COMMISSION EXPIRES Jun 14, 2019
ACTING IN COUNTY OF Monroe

Enclosure to
NRC-14-0017

Fermi 2 NRC Docket No. 50-341
Operating License No. NPF-43

DTE Electric Company's Seismic Hazard and Screening Report, 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

NTTF 2.1 SEISMIC HAZARD AND SCREENING REPORT
FERMI 2 NUCLEAR POWER PLANT

PROJECT NO. 12-4899
REVISION 1
MARCH 24, 2014

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TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS
(CONTINUED)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AB	AUXILIARY BUILDING
BE	BEST ESTIMATE
BDB	BEYOND DESIGN BASIS
CARD	CONDITIONAL ASSESSMENT RESOLUTION DOCUMENT
CEUS	CENTRAL AND EASTERN UNITED STATES
CEUS-SSC	CENTRAL AND EASTERN UNITED STATES SEISMIC SOURCE CHARACTERIZATION
COL	COMBINED OPERATING LICENSE
DF	DESIGN FACTOR
DTE	DTE ENERGY COMPANY
ECC_AM	EXTENDED CONTINENTAL CRUST—ATLANTIC MARGIN
EL	ELEVATION
EPRI	ELECTRIC POWER RESEARCH INSTITUTE
ERM-N	EASTERN RIFT MARGIN FAULT NORTHERN SEGMENT
ERM-S	EASTERN RIFT MARGIN FAULT SOUTHERN SEGMENT
FERMI 2	FERMI 2 NUCLEAR POWER PLANT
FSAR	FINAL SAFETY ANALYSIS REPORT
ft	FEET
ft/s	FEET PER SECOND
g	GRAVITY
GMM	GROUND MOTION MODEL
GMRS	GROUND MOTION RESPONSE SPECTRUM
HCLPF	HIGH CONFIDENCE LOW PROBABILITY OF FAILURE
HZ	HERTZ
IBEB	ILLINOIS BASIN EXTENDED BASEMENT
IHS	IPEEE HCLPF SPECTRUM
IPEEE	INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS
M	MAGNITUDE
MESE-N	MESOZOIC AND YOUNGER EXTENDED PRIOR – NARROW
MESE-W	MESOZOIC AND YOUNGER EXTENDED PRIOR – WIDE
MIDC_A	MIDCONTINENT-CRATON ALTERNATIVE A

LIST OF ACRONYMS (CONTINUED)

MIDC_B	MIDCONTINENT-CRATON ALTERNATIVE B
MIDC_C	MIDCONTINENT-CRATON ALTERNATIVE C
MIDC_D	MIDCONTINENT-CRATON ALTERNATIVE D
NEI	NUCLEAR ENERGY INSTITUTE
NMESE-N	NON-MESOZOIC AND YOUNGER EXTENDED PRIOR – NARROW
NMESE-W	NON-MESOZOIC AND YOUNGER EXTENDED PRIOR – WIDE
NMFS	NEW MADRID FAULT SYSTEM
NPP	NUCLEAR POWER PLANT
NRC	UNITED STATES NUCLEAR REGULATORY COMMISSION
NTTF	NEAR-TERM TASK FORCE
NUREG	NUCLEAR REGULATORY COMMISSION TECHNICAL REPORT
PEZ_N	PALEOZOIC EXTENDED CRUST NARROW
PEZ_W	PALEOZOIC EXTENDED CRUST WIDE
PGA	PEAK GROUND ACCELERATION
PSHA	PROBABILISTIC SEISMIC HAZARD ANALYSIS
RB	REACTOR BUILDING
RC	RESONANT COLUMN
RG	REGULATORY GUIDE
RHR	RESIDUAL HEAT REMOVAL COMPLEX
RLE	REVIEW LEVEL EARTHQUAKE
RLME	REPEATED LARGE MAGNITUDE EARTHQUAKE
RR	REELFOOT RIFT
RR-RCG	REELFOOT RIFT INCLUDING THE ROUGH CREEK GRABEN
RVT	RANDOM VIBRATION THEORY
s	SECONDS
SASW	SPECTRAL ANALYSIS OF SURFACE WAVES
SLR	ST. LAWRENCE RIFT, INCLUDING THE OTTAWA AND SAGUENAY GRABENS
SMA	SEISMIC MARGIN ASSESSMENT
SPID	SCREENING, PRIORITIZATION, AND IMPLEMENTATION DETAILS
SPRA	SEISMIC PROBABILISTIC RISK ASSESSMENT
SSCs	SYSTEMS, STRUCTURES, AND COMPONENTS

LIST OF ACRONYMS (CONTINUED)

SSE	SAFE SHUTDOWN EARTHQUAKE
STUDY_R	STUDY REGION
UHRS	UNIFORM HAZARD RESPONSE SPECTRA
UFSAR	UPDATED FINAL SAFETY ANALYSIS REPORT
USGS	UNITED STATES GEOLOGICAL SURVEY
V_p	COMPRESSION WAVE VELOCITY
V_s	SHEAR WAVE VELOCITY

NTTF 2.1 SEISMIC HAZARD AND SCREENING REPORT
FERMI 2 NUCLEAR POWER PLANT

1.0 INTRODUCTION

Following the accident at the Fukushima Daiichi Nuclear Power Plant (NPP) resulting from the March 11, 2011, Great Tohoku Earthquake, and subsequent tsunami, the United States Nuclear Regulatory Commission (NRC) 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 (NRC, 2012b [Ref. 14]) that requests information to assure that these recommendations are addressed by all United States NPPs. The 50.54(f) letter (NRC, 2012b [Ref.14]) requests that licensees and holders of construction permits under 10 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 this information, 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 (NRC, 2012b [Ref. 14]) pertaining to NTTF Recommendation 2.1 for the Fermi 2 Nuclear Power Plant (Fermi 2). In providing the information contained here, DTE Energy Company (DTE) has followed the guidance provided in *Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (Electric Power Research Institute [EPRI], 2013a [Ref. 6]). The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima NTTF Recommendation 2.1: Seismic* (EPRI, 2013b [Ref. 7]), has been developed as the process for evaluating critical plant equipment prior to performing the complete plant seismic risk evaluations.

The original geologic and seismic siting investigations for Fermi 2 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 (SSE) ground motion 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 (SSCs) (DTE, 2012a [Ref. 3], Sec 1.2.1.2.2).

In response to the 50.54(f) letter and following the guidance provided in the SPID (EPRI 2013a [Ref. 6]), a seismic hazard reevaluation was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed. Based on the results of the screening evaluation, Fermi 2 screens in for risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency Confirmation.

2.0 SEISMIC HAZARD REEVALUATION

The Fermi 2 site is located in the northern portion of the Midwestern United States on the western end of Lake Erie at Lagoona Beach, Frenchtown Township, Monroe County, Michigan. The plant is approximately 8 miles east-northeast of Monroe, Michigan; 30 miles southwest of downtown Detroit, Michigan; and 25 miles northeast of downtown Toledo, Ohio.

Section 2.5.2.10 of the Updated Final Safety Analysis Report (UFSAR) (DTE, 2012a [Ref. 3]) describes the earthquake activity in historic time within 200 miles of the plant site to be "minor or moderate." The UFSAR (DTE, 2012a [Ref. 3]) states that sources of major (Magnitude [M]>6) earthquakes in the Central and Eastern United States (CEUS) are distant, and have not had an appreciable effect at the site. Category I SSCs are designed for a safe shutdown due to horizontal zero period ground accelerations (PGAs) at the rock surface at foundation level, of 15 percent of gravity (0.15g).

2.1 Regional and Local geology

The geologic strata in the region of Fermi 2 consist of glaciolacustrine deposits overlying glacial till deposits, sedimentary rocks of the Paleozoic era, and deep basement igneous and metamorphic rocks of the Precambrian era. The rock units in the region consist of 2,500 to 3,500 feet (ft) of limestones, dolomites, sandstones, and shales. The Precambrian basement in southeastern Michigan consists of crystalline rocks of igneous and metamorphic origin and occurs at a depth of about 3,100 ft.

The site is in the Central Stable Region tectonic province of the North American continent, and lies within the Eastern Lake section of the Central Lowlands physiographic province. Major geologic structures consist of local folding and faulting which dissected broad basins and arches formed as a result of crustal movement during the Paleozoic era (DTE, 2012a [Ref. 3], Section 2.5.1.1.3). Of the major faults identified in the region, the UFSAR describes the Bowling Green Fault located approximately 35 miles from the site, as the more significant relative to the site seismic potential. However, the Central and Eastern United States Seismic Source Characterization (CEUS-SSC) (NRC, 2012a [Ref. 13]) does not attribute any special potential to the Bowling Green Fault.

As described in the UFSAR, Section 2.4.1 (DTE, 2012a [Ref. 3]), local geologic investigations revealed no faults in the bedrock beneath the foundations of the station. The field and literature studies in the site area also did not reveal any faults in the site vicinity.

2.2 PROBABILISTIC SEISMIC HAZARD ANALYSIS

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the 50.54(f) letter and following the guidance in the SPID (EPRI, 2013a [Ref. 6]), a probabilistic seismic hazard analysis (PSHA) was completed (EPRI, 2014 [Ref. 9]) using the recently developed CEUS-SSC for Nuclear Facilities (NUREG-2115, NRC, 2012a [Ref. 13]) together with the updated EPRI Ground-Motion Model (GMM) for the CEUS (EPRI, 2013c [Ref. 8]).

For the PSHA, the CEUS-SSC background seismic source zones out to a distance of 400 miles around the site were included. This distance exceeds the 200 mile recommendation contained in NRC Regulatory Guide (RG) 1.208 (NRC, 2007 [Ref. 12]) and was chosen, so that the background seismicity is more completely represented in the PSHA. Background sources included in the Fermi 2 PSHA are the following (EPRI, 2014 [Ref. 9]):

1. Extended Continental Crust—Atlantic Margin (ECC_AM)
2. Illinois Basin Extended Basement (IBEB)
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. Non-Mesozoic and younger extended prior – narrow (NMESE-N)
10. Non-Mesozoic and younger extended prior – wide (NMESE-W)
11. Paleozoic Extended Crust narrow (PEZ_N)
12. Paleozoic Extended Crust wide (PEZ_W)
13. Reelfoot Rift (RR)
14. Reelfoot Rift including the Rough Creek Graben (RR-RCG)

15. St. Lawrence Rift, including the Ottawa and Saguenay grabens (SLR)

16. Study region (STUDY_R)

For Repeated Large Magnitude Earthquake (RLME) sources in CEUS-SSC (NRC 2012a [Ref. 13]), which represent sites at which repeated large-magnitude (M>6.5) earthquakes have occurred, those that lie within about 620 miles of the site were included in the analysis:

1. Charleston
2. Commerce
3. Eastern Rift Margin Fault northern segment (ERM-N)
4. Eastern Rift Margin Fault southern segment (ERM-S)
5. New Madrid Fault System (NMFS)
6. Wabash Valley

For each of the above background and RLME sources, the mid-continent version of the updated CEUS EPRI GMM was used (EPRI, 2013c [Ref. 8]). The PSHA uses a minimum moment magnitude cutoff of 5.0, as specified in the 50.54(f) letter (NRC, 2012b [Ref. 14]).

2.2.2 Base Rock Seismic Hazard Curves

Consistent with the SPID Document (EPRI, 2013a [Ref. 6]), base rock seismic hazard curves are not provided as the site amplification approach referred to as Method 3 has been used to obtain the control point hazard curves. Seismic hazard curves are shown below in ***Section 2.4*** at the SSE control point elevation. Method 3 uses the means and standard deviations of the log site amplification factors developed as described in ***Section 2.3***.

2.3 Site Response Evaluation

Following the guidance contained in Seismic Enclosure 1 of the NRC's March 12, 2012 50.54(f) Request for Information (NRC, 2012b [Ref. 14]) and in the SPID Document (EPRI, 2013a [Ref. 6]), for NPP sites that are not founded on hard rock (defined as having a shear wave velocity [V_s] of 9,285 feet per second [ft/s]), a site response analysis is performed for the Fermi 2 site, to support the calculation of the seismic hazard at the Reactor Building (RB) foundation level.

Category I structures of Fermi 2 are founded in the Bass Island dolomite bedrock (DTE, 2012a [Ref. 3] Section 3.7.2.6) at elevations varying from 535 ft for the RB to 550 ft for the Residual Heat Removal Complex (RHR). The dolomite bedrock is characterized by a V_s (100 ft) of about 5,500 ft/s (Black & Veatch, 2012 [Ref. 1]).

2.3.1 Description of Subsurface Materials

The subsurface material at the Fermi 2 site consists of variable surface soils (Black & Veatch, 2012 [Ref. 1]) (sands and organic deposits) from existing grade to the top of stratified lacustrine clay at an elevation of about 573 ft. The lacustrine clay layer is about 7 ft thick, and overlies a layer of glacial till ranging in thickness from 8 to 15.5 ft. The glacial till consists of silty to sandy clays with varying amounts of gravel and cobbles. The glacial till is underlain by bedrock. The in-situ surface soils and the lacustrine deposits were replaced by structural fill to the nominal plant grade elevation (EL) of 583 ft.

The top of bedrock at the site, EL 552 ft is the upper erosional surface of the Silurian Bass Island Group. The Bass Island Group is underlain by about 2,500 to 3,000 ft of firm to hard Paleozoic sedimentary rocks below which lies Precambrian Basement. The estimated depth to the Precambrian basement rock near the site is 3,100 ft below the top of rock. ***Figure 2-1*** presents the nominal stratigraphic soil/rock column underlying the Fermi 2 site.

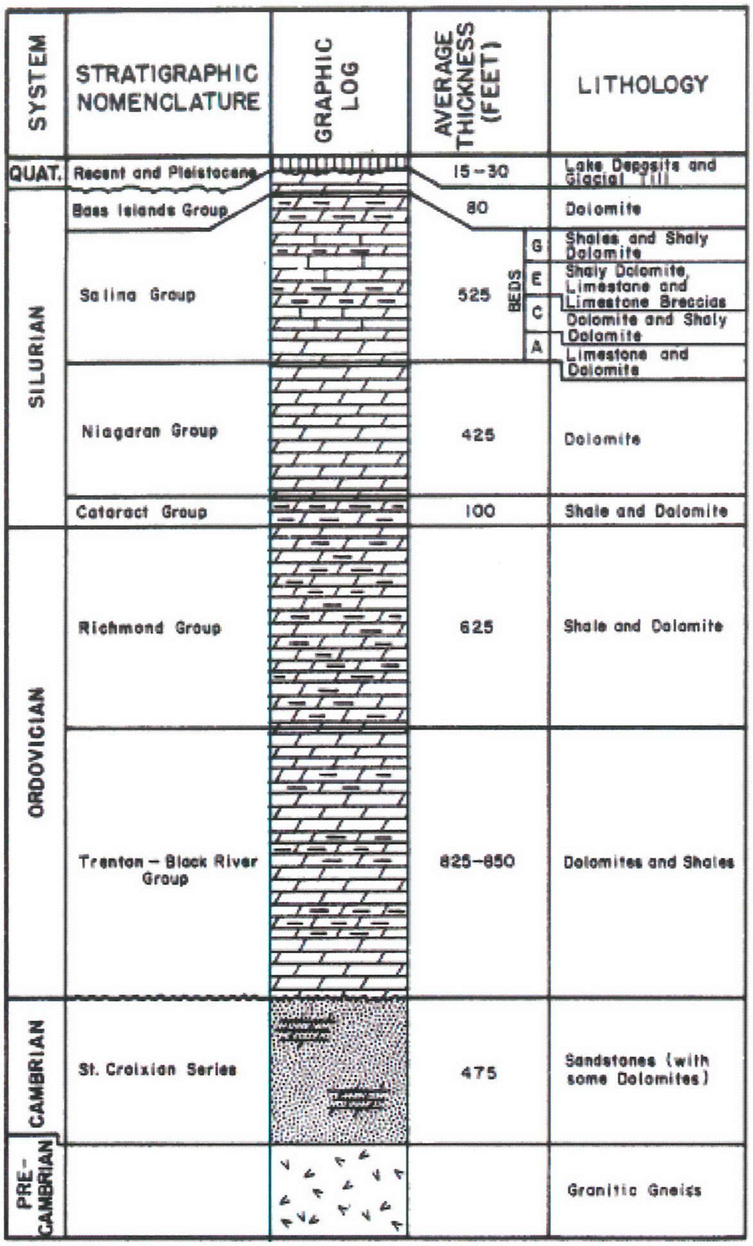

FIGURE 2-1
STRATIGRAPHIC COLUMN UNDERLYING THE FERMI 2 SITE
(DTE, 2012a [Ref. 3] Figure 2.5-11)

The local site stratigraphy is based on site-specific geotechnical investigations reported in the Fermi 2 UFSAR (DTE, 2012a [Ref. 3] Section 2.5.1.1.2 and Appendix 2D), and Fermi 3 Final Safety Analysis Report (FSAR) (Black & Veatch, 2012 [Ref. 1]). The site subsurface investigations at the Fermi 2 site extend to a depth of about 309 ft below the top of bedrock. However, the available subsurface material data at the site also reflects the extensive site investigations performed for the Fermi 3 Combined Operating License (COL) Application (DTE, 2013 [Ref. 5] Section 2.5.4), extending to a depth of 443 ft below top of rock.

The description of the stratigraphic units below Unit C of the Salina Group, presented in the Fermi 2 UFSAR (DTE, 2012a [Ref. 3] Section 2.5.1.1.2 and Appendix 2D) is based on published reports. The estimated thicknesses of these deeper units are based on logs of deep boreholes drilled in the general area and on interpretation of structural geologic maps.

The Bass Island Group is a thinly-bedded, horizontal dolomite that is dense and finely crystalline with interspersed black shale partings. The thickness of the Bass Island Group is variable. The bedrock immediately beneath the Bass Island Group is the Silurian Salina Group. The Salina Group includes three units reported in the Fermi 2 UFSAR (DTE, 2012a [Ref. 3]), referred to as Unit G, Unit E, and Unit C, in descending order. Unit G of the Salina Group is reported to be about 60 ft thick and consists of hard and soft shales, dolomitic shales, and argillaceous dolomites. Unit E of the Salina Group is also about 60 ft thick and consists of vuggy, shaly dolomite, dolomitic limestone, and limestone breccias. All vugs encountered in the borings for Fermi 2 were less than 2 inches in diameter. The underlying Unit C consists of hard, thin to medium bedded dolomite with thin seams of shaly dolomite and anhydrite.

The base of Unit C of the Salina Group was not penetrated by the Fermi 2 borings. However, based on the investigations at the Fermi 3 site, Unit C extends to a depth from 200 to 396 ft below the top of bedrock, and exhibits a marked change in the V_s at a depth of about 306 ft below the top of bedrock. The reference hard rock boundary at the site is placed at this location. Although not shown in the nominal stratigraphic column in ***Figure 2-1***, the Fermi 3 field investigations (DTE, 2013 [Ref. 5] Section 2.5.4) identified the deepest unit of the Salina Group encountered as Unit B. This unit consists of dolomite with anhydrite beds up to 3.6 ft thick. Some shale beds up to 1 ft thick were also encountered. Approximately 48 ft of Unit B of the Salina Group are documented in the site investigations for Fermi 3.

Based on the nominal stratigraphic column in ***Figure 2-1***, the Salina Group extends to a depth of about 605 ft below the top of bedrock. Beneath the Salina Group the rock stratigraphy includes about 425 ft of dolomites of the Silurian Niagaran Group, an estimated 100 ft of dolomites with thin shale layers of the Silurian-age Cataract Group, about 625 ft of shales and dolomite of the Ordovician Richmond Group, followed by 825 to 850 ft of dolomite and dolomitic limestone of the Ordovician-age Trenton-Black River Group. The underlying Cambrian St. Croix Series includes about 475 ft of dolomite, sandstone, and minor amounts of shale. The Precambrian basement rock is a metamorphic-igneous complex composed of granite and granitic gneiss. The estimated depth to the Precambrian basement rock near the site is 3,100 ft.

2.3.2 Development of Base-Case Profiles and Nonlinear Material Properties

As discussed in Black & Veatch, 2012 [Ref. 1] the velocity profiles presented here are based on results of in-situ geophysical measurements reported in the Fermi 2 UFSAR (DTE, 2012a [Ref. 3]) and the Fermi 3 FSAR (DTE, 2013 [Ref. 5]). The Fermi 2 UFSAR (DTE, 2012a [Ref. 3], Section 2.5.1.2.9.1) reports borehole geophysical measurements made in three deep borings. These measurements recorded compression wave velocities (V_p) at one-ft intervals. Additionally, two seismic refraction surveys were conducted to evaluate the bedrock characteristics at the site. The Fermi 2 UFSAR (DTE, 2012a [Ref. 3]) also reports shear modulus values based on resonant column (RC) tests of rock cores from the Bass Island Group and Salina Group (Section 2.5.1.2.10.2).

At the Fermi 3 site, the dynamic characteristics of soil and bedrock were measured using downhole P-S suspension logging, downhole seismic testing, and spectral analysis of surface waves (SASW) logging. The P-S suspension logger obtained in-situ horizontal V_s and V_p measurements at 1.6 ft intervals in uncased boreholes. P-S Suspension logging was used to obtain V_s and V_p of the soil and bedrock units. Downhole seismic testing was used to obtain V_s and V_p in the bedrock. SASW was used to obtain V_s in the soil.

The combined site investigations at the Fermi 2 and the Fermi 3 sites have well characterized the site rock. The V_s in rock to a depth of 306 ft is based on the measured V_p at the Fermi 2 site and the Poisson's ratios reported in the Fermi 3 FSAR (Black & Veatch, 2012 [Ref. 1], Table 2). Below 306 ft the measured V_s in Fermi 3 FSAR (DTE, 2013a [Ref. 5]) Figure 2.5.2-255 are used in developing the V_s profile (Black & Veatch, 2012 [Ref. 1]). The V_s profile terminates at a depth of 396 ft below the top of bedrock. The data demonstrate low-to-moderate variability in velocity at shallow depth with a sigma ln (V_s) of approximately 0.1, increasing to 0.2 in the Salina Group Unit G.

The information used to create the site geologic profile at the Fermi 2 site (EPRI, 2014 [Ref. 9]) is shown in ***Table 2-1***, which shows the geotechnical properties for the site recommended in (Black & Veatch, 2012 [Ref. 1]). As indicated in ***Table 2-1***, the bottom of the RB foundation is

16 ft below top of rock and the bottom of the RHR complex is 5 ft below top of rock. The Control Point for the GMRS is taken to be the bottom of the RB foundation at a depth of 16 ft.

TABLE 2-1
SUMMARY OF SITE GEOTECHNICAL PROFILE FOR FERMI 2
(Black & Veatch, 2012 [Ref. 1])

DEPTH RANGE BELOW TOP OF BEDROCK (ft)	BEDROCK DESCRIPTION	DENSITY (pcf)	SHEAR WAVE VELOCITY (V_S) (ft/s)	COMPRESSIONAL WAVE VELOCITY (V_P) (ft/s)	POISSON'S RATIO
-14 to 0	Glacial Till [a]	130 [b]	1,000	6,500	0.49 [c]
0 – 80	Bass Islands Group	158 [b]	6,550	13,000	0.33 [d]
5	SSE and HCLPF control point (Residual Heat Removal complex)				
16	SSE and HCLPF control point (Reactor Building, Auxiliary Building)				
80 – 140	Salina Group Unit G	138 [b]	3,400	8,000	0.39 [d]
140 – 200	Salina Group Unit E	142 [b]	3,800	9,000	0.39 [d]
200 – 306	Salina Group Unit C	160 [b]	7,400	14,000	0.30 [d]
306 to 396	Salina Group Unit C	160 [e]	9,000 [f]		
396+	Salina Group Unit B	160 [e]	9,000 [f]		

Notes:

[a] Thickness of glacial till is from the EF2 UFSAR Subsection 2.5.1.2.2.1.

[b] From the EF2 UFSAR Figure 2.5-28.

[c] Poisson's ratio is from Fermi 3 FSAR Table 2.5.4-202.

[d] Poisson's ratio is calculated using measured shear and compression wave velocities from the same bedrock units during the subsurface investigation documented in Fermi 3 FSAR Table 2.5.4-202.

[e] From EF3 FSAR Table 2.5.4-202.

[f] Measured shear wave velocities from Fermi 3 FSAR Table 2.5.2-220.

Table 2-1 shows the recommended V_S and unit weights versus depth, and firm rock description for the profile. The measured V_S in the Salina Group C from the Fermi 3 site is 9,000 ft/s (Black & Veatch, 2012 [Ref. 1]). Since the measured V_S is within 3 percent of the reference hard rock V_S of 9,285 ft/s, the top of reference hard rock was assumed to be at this depth. Based in ***Table 2-1*** and the location of the SSE at a depth of 16 ft (Black & Veatch, 2012 [Ref. 1]), the profile consists of 290 ft of firm rock overlying hard crystalline basement rock.

Shear-wave velocities for the profile were calculated from measured V_p and estimated Poisson's ratios (Black & Veatch, 2012 [Ref. 1]) for the upper 290 ft. Shear-wave velocities at deeper depths were measured in the Salina Group C (***Table 2-1***). Based on the measured V_S and V_p in the top 300 ft beneath the SSE (***Table 2-1***), a scale factor of 1.25 was adopted to reflect upper and lower range base-cases. The scale factor of 1.25 reflects a $\sigma_{\mu ln}$ of about 0.2. Based on the SPID (EPRI, 2013a [Ref. 6]) the 10th and 90th fractiles implies a 1.28 scale factor on σ_{μ}.

Using the best estimate (BE) or mean base-case profile (P1), the depth independent scale factor of 1.25 was applied to develop lower and upper range base-cases profiles P2 and P3, respectively. Base-case profiles P1, P2, and P3 have a mean depth below the SSE of 290 ft to hard reference rock, randomized ± 58 ft.

The base-case profiles (P1, P2, and P3) are shown on ***Figure 2-2*** and listed in ***Table 2-2***.

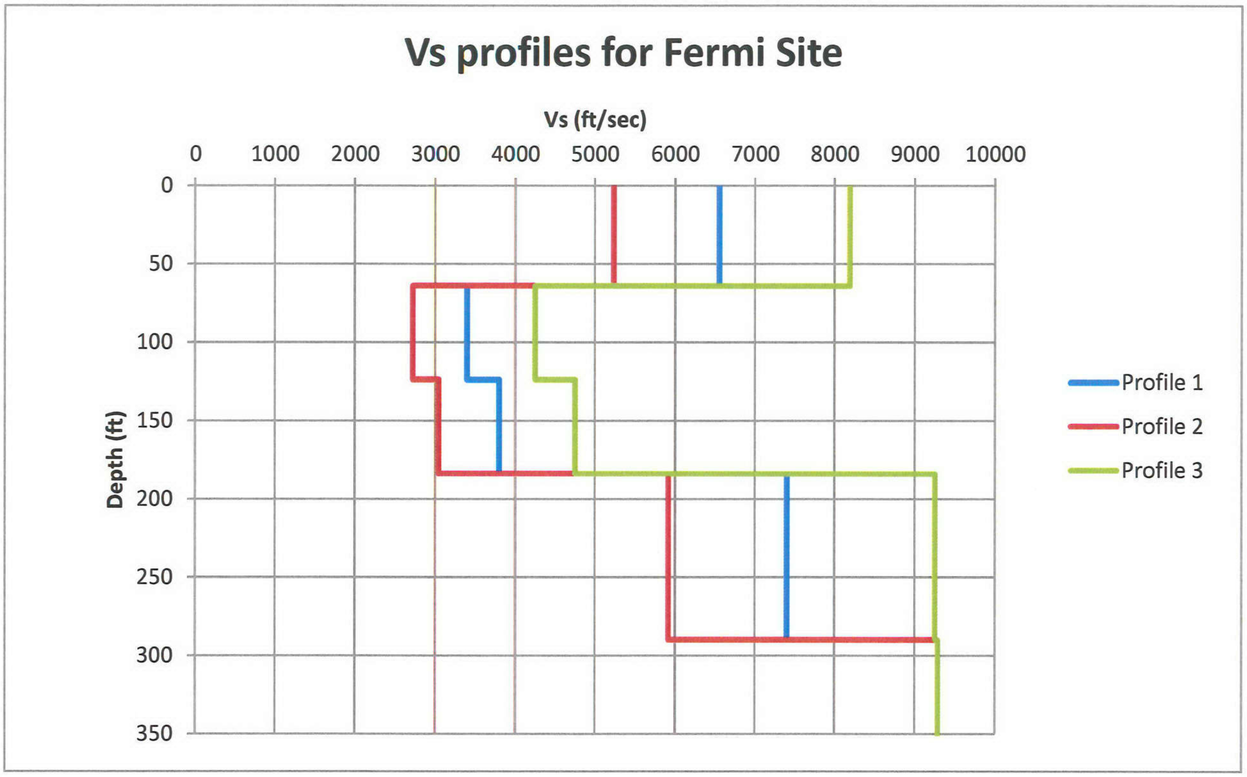

FIGURE 2-2
EPRI BASE CASE V_S PROFILES, FERMI 2 SITE
(EPRI, 2014 [Ref. 9])

TABLE 2-2
EPRI BASE CASE VS PROFILES, FERMI 2 SITE
(EPRI, 2014 [Ref. 9])

PROFILE 1			PROFILE 2			PROFILE 3		
THICKNESS (ft)	DEPTH TO TOP (ft)	V_S (ft/s)	THICKNESS (ft)	DEPTH TO TOP (ft)	V_S (ft/s)	THICKNESS (ft)	DEPTH TO TOP (ft)	V_S (ft/s)
	0	6550		0	5240		0	8187
10.0	10.0	6550	10.0	10.0	5240	10.0	10.0	8187
10.0	20.0	6550	10.0	20.0	5240	10.0	20.0	8187
10.0	30.0	6550	10.0	30.0	5240	10.0	30.0	8187
10.0	40.0	6550	10.0	40.0	5240	10.0	40.0	8187
10.0	50.0	6550	10.0	50.0	5240	10.0	50.0	8187
10.0	60.0	6550	10.0	60.0	5240	10.0	60.0	8187
4.0	64.0	6550	4.0	64.0	5240	4.0	64.0	8187
10.0	74.0	3400	10.0	74.0	2720	10.0	74.0	4250
10.0	84.0	3400	10.0	84.0	2720	10.0	84.0	4250
10.0	94.0	3400	10.0	94.0	2720	10.0	94.0	4250
10.0	104.0	3400	10.0	104.0	2720	10.0	104.0	4250
10.0	114.0	3400	10.0	114.0	2720	10.0	114.0	4250
6.0	120.0	3400	6.0	120.0	2720	6.0	120.0	4250
4.0	124.0	3400	4.0	124.0	2720	4.0	124.0	4250
10.0	134.0	3800	10.0	134.0	3040	10.0	134.0	4750
10.0	144.0	3800	10.0	144.0	3040	10.0	144.0	4750
10.0	154.0	3800	10.0	154.0	3040	10.0	154.0	4750
10.0	164.0	3800	10.0	164.0	3040	10.0	164.0	4750
10.0	174.0	3800	10.0	174.0	3040	10.0	174.0	4750
10.0	184.0	3800	10.0	184.0	3040	10.0	184.0	4750
6.0	190.0	7400	6.0	190.0	5920	6.0	190.0	9250
10.0	200.0	7400	10.0	200.0	5920	10.0	200.0	9250
10.0	210.0	7400	10.0	210.0	5920	10.0	210.0	9250
10.0	220.0	7400	10.0	220.0	5920	10.0	220.0	9250
10.0	230.0	7400	10.0	230.0	5920	10.0	230.0	9250
10.0	240.0	7400	10.0	240.0	5920	10.0	240.0	9250
10.0	250.0	7400	10.0	250.0	5920	10.0	250.0	9250
10.0	260.0	7400	10.0	260.0	5920	10.0	260.0	9250
10.0	270.0	7400	10.0	270.0	5920	10.0	270.0	9250
10.0	280.0	7400	10.0	280.0	5920	10.0	280.0	9250
10.0	290.0	7400	10.0	290.0	5920	10.0	290.0	9250
3280.8	3570.8	9285	3280.8	3570.8	9285	3280.8	3570.8	9285

2.3.2.1 Shear Modulus and Damping Curves

Recent nonlinear dynamic material properties were not available for Fermi 2 for firm Paleozoic sedimentary rocks. The firm rock material over the upper 290 ft was assumed to have behavior that could be modeled as either linear or non-linear. To represent this potential for either case in the upper 290 ft of firm sedimentary rock at the Fermi 2 site, two sets of shear modulus reduction and hysteretic damping curves were used. Consistent with the SPID (EPRI, 2013a [Ref. 6]), the EPRI rock curves (model M1) were considered to be appropriate to represent the upper range nonlinearity likely in the materials at this site and linear analyses (model M2) was assumed to represent an equally plausible alternative rock response across loading level. For the linear analyses, the low strain damping from the EPRI rock curves were used as the constant damping values in the upper 290 ft.

2.3.2.2 Kappa

Section B-5.1.3.1 of the SPID (EPRI, 2013a [Ref. 6]) recommends the following procedure for evaluating kappa:

1. Kappa for a firm rock site with at least 3,000 ft of sedimentary rock may be estimated from the time-average V_s over the upper 100 ft (V_{s100}) of the subsurface profile.
2. Kappa for a site with less than 3,000 ft of firm rock may be estimated with a Q_s of 40 below 500 ft combined with the low strain damping from the EPRI rock curves and an additional kappa of 0.006 second (s) for the underlying hard rock.

For the Fermi 2 site, kappa was estimated using the second of the above approaches because the thickness of the sedimentary rock overlying hard rock is 290 ft. The contribution to kappa from the profile is about 0.004s resulting in a total kappa estimate of 0.010s (***Table 2-3***). Because of the small contribution to kappa at shallow firm rock sites, epistemic uncertainty in profile damping (kappa) has contributions from that incorporated in the hard rock hazard and, at high loading levels, the two sets of dynamic material properties.

TABLE 2-3
KAPPA VALUES AND WEIGHTS USED FOR SITE RESPONSE ANALYSES
(EPRI, 2014 [Ref. 9])

VELOCITY PROFILE	KAPPA(S)
P1	0.010
P2	0.011
P3	0.009
	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

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 V_s profiles has been incorporated in the site response calculations. For the Fermi 2 site, random V_s profiles were developed from the base case profiles shown on ***Figure 2-2***. Consistent with the discussion in Appendix B of the SPID (EPRI, 2013a [Ref. 6]), the velocity randomization procedure makes use of random field models which describe the statistical correlation between layering and V_s. The default randomization parameters developed in Toro (1997 [Ref. 16]) for United States Geological Survey (USGS) "A" site conditions were used for this site.

Thirty random velocity profiles were generated for each base case profile. These random velocity profiles were generated using a natural log standard deviation of 0.25 over the upper 50 ft and 0.15 below that depth. As specified in the SPID (EPRI, 2013a [Ref. 6]), correlation of V_s 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.

In randomizing base-case profiles to represent aleatory variability, the depth to hard reference rock is taken to vary by ± 58 ft. The depth randomization reflects ± 20 percent of the depth to provide a realistic broadening of the fundamental resonance rather than reflect actual random variations to basement V_S across the NPP footprint.

2.3.4 Input Spectra

Consistent with the guidance in Appendix B of the SPID (EPRI, 2013a [Ref. 6]), 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 PGA ranging from 0.01 to 1.5g) were used in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the Fermi 2 Site were the same as those identified in Tables B-4, B-5, B-6 and B-7of the SPID Document (EPRI, 2013a [Ref. 6]) as appropriate for typical CEUS sites.

2.3.5 Methodology

The site response analyses for the Fermi 2 site are performed using the random vibration theory (RVT) approach. This process utilizes a simple, efficient approach for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID Document (EPRI, 2013a [Ref. 6]). The guidance contained in Appendix B of the SPID (EPRI, 2013a [Ref. 6]) on incorporating epistemic uncertainty in V_s, kappa, non-linear dynamic properties, and source spectra for plants with limited at-site information was followed for the Fermi 2 site.

2.3.6 Amplification Functions

The results of the site response analysis consist of amplification factors (5 percent damped pseudo absolute response spectra), which describe the amplification (or de-amplification) of hard reference rock motion as a function of oscillator frequency and input reference rock amplitude. The amplification factors are represented in terms of a median amplification value and an associated logarithmic standard deviation (sigma-ln) for each oscillator frequency and input rock amplitude. Consistent with the SPID (EPRI, 2013a [Ref. 6]) a minimum median amplification value of 0.5 was employed in the present analysis.

Figure 2-3 and Figure 2-4 illustrate the median and +/- 1 standard deviation in the predicted amplification factors developed for the 11 loading levels parameterized by the median reference (hard rock) peak acceleration (0.01g to 1.50g). ***Figure 2-3*** shows the results for profile P1 and the EPRI (EPRI, 2014 [Ref. 9]) rock G/G_{max} and hysteretic damping curves (Model M1). ***Figure 2-4*** shows the corresponding amplification factors developed for profile P1 and linear site response (model M2). For both figures, the amplification factors are developed using the base-case kappa model and the single-corner seismic source model. The variability in the amplification factors results from variability in V_s, depth to hard rock, and modulus reduction and hysteretic damping curves. Between the nonlinear (equivalent-linear) and linear analyses (***Figures 2-3 and 2-4,*** respectively) only a minor difference is observed for oscillator frequencies below about 20 Hertz (Hz) across loading level. At the higher oscillator frequencies differences are apparent, but only for loading levels above about 0.4g.

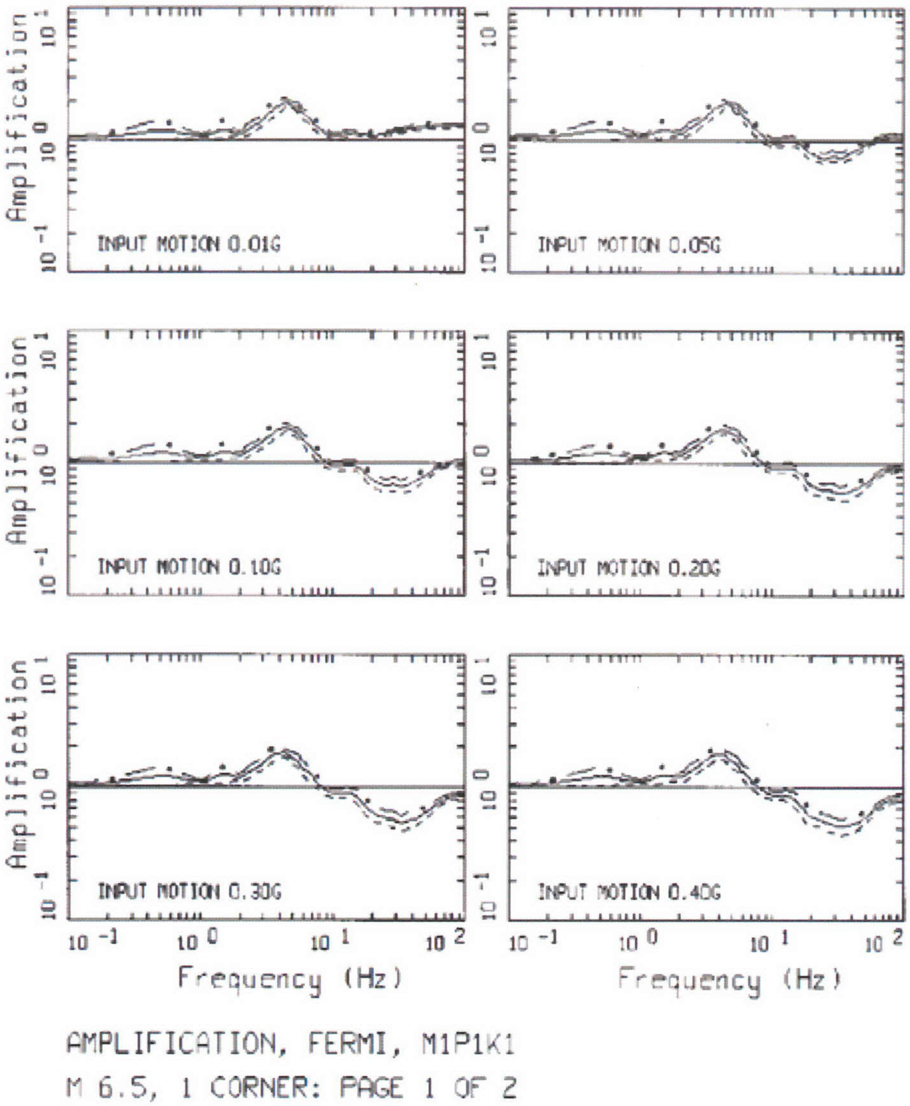

FIGURE 2-3
EXAMPLE SUITE OF AMPLIFICATION FACTORS USING EPRI ROCK MODULUS REDUCTION AND HYSTERETIC DAMPING CURVES (MODEL M1)

Mean base-case profile (P1), and base-case kappa (K1) 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 (EPRI, 2013a [Ref. 6]) (EPRI, 2014 [Ref. 9])

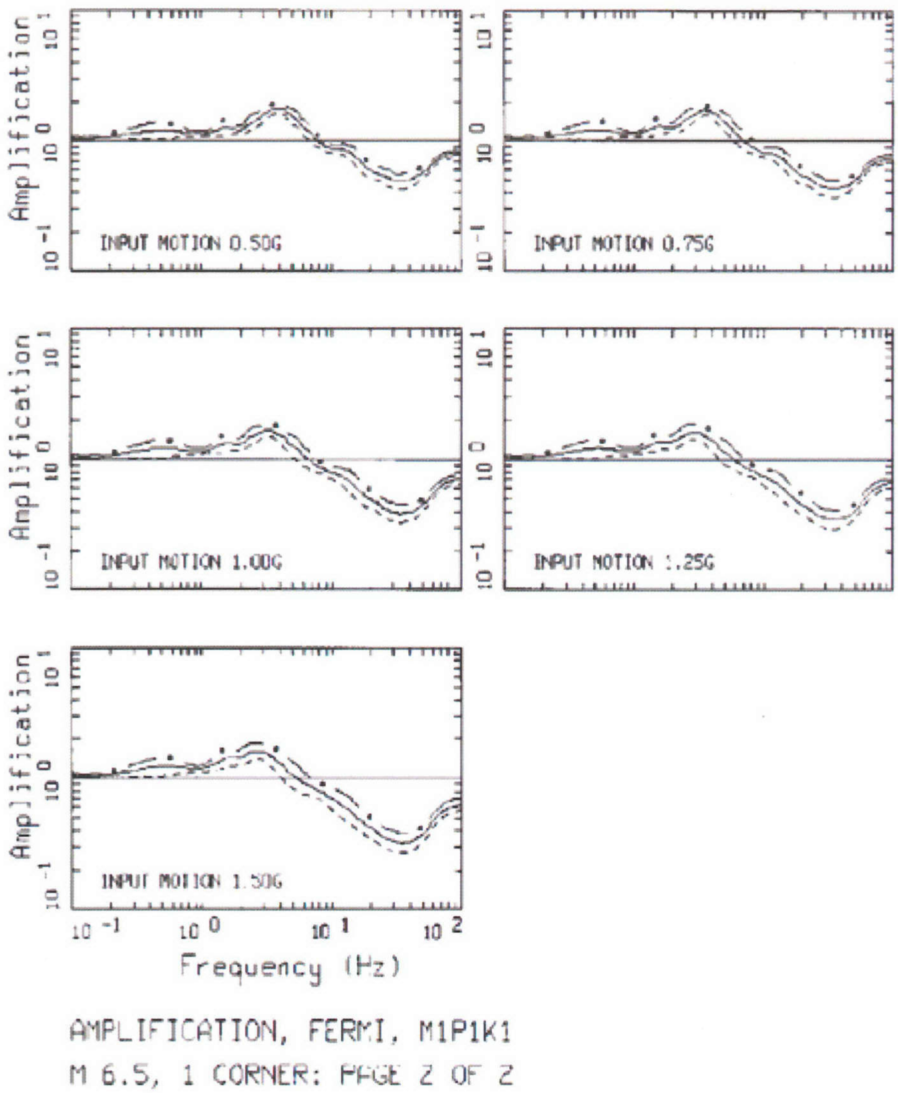

FIGURE 2-3
(CONTINUED)
EXAMPLE SUITE OF AMPLIFICATION FACTORS USING EPRI ROCK MODULUS REDUCTION AND HYSTERETIC DAMPING CURVES (MODEL M1)

Mean base-case profile (P1), and base-case kappa (K1) 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 (EPRI, 2013a [Ref. 6]) (EPRI, 2014 [Ref. 9])

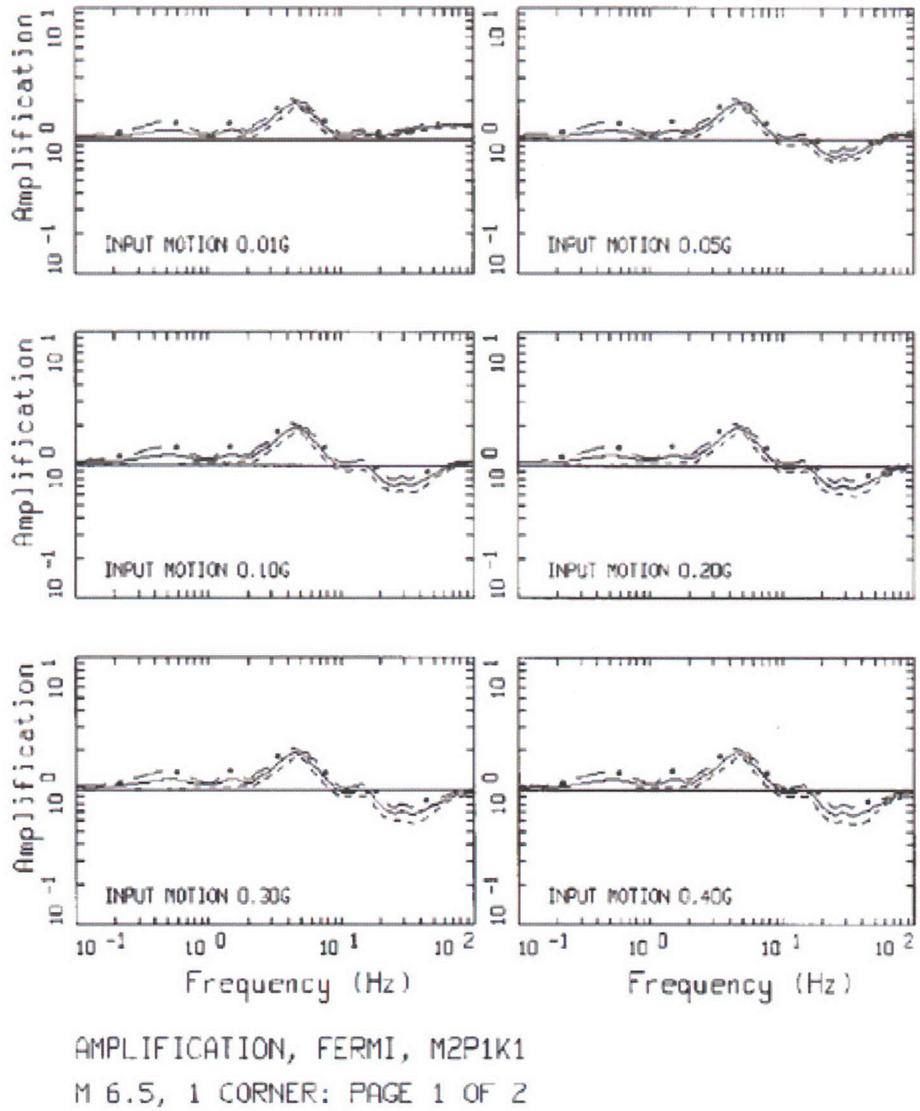

FIGURE 2-4
EXAMPLE SUITE OF AMPLIFICATION FACTORS USING LINEAR SITE RESPONSE (MODEL M2)

Mean base-case profile (P1), and base-case kappa (K1) 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 (EPRI, 2013a [Ref. 6]) (EPRI, 2014 [Ref. 9])

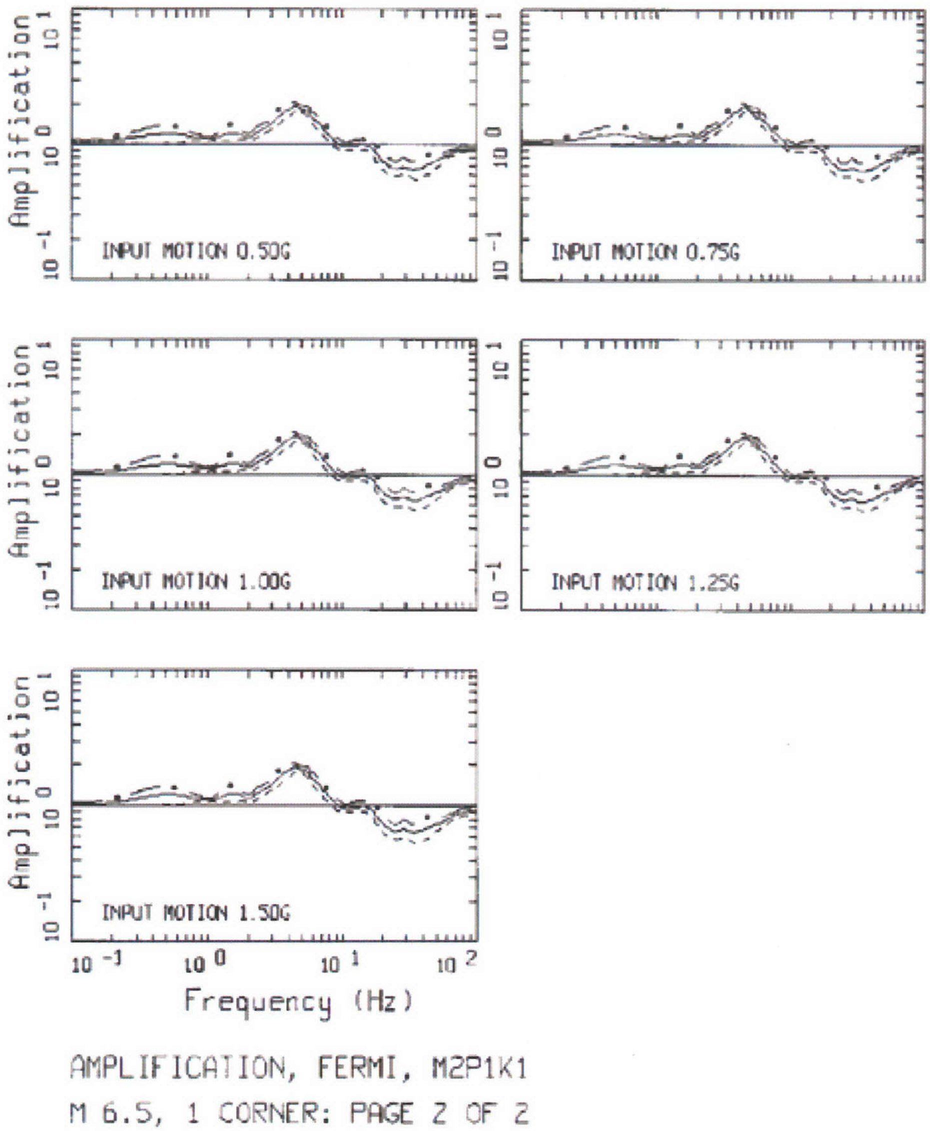

FIGURE 2-4
(CONTINUED)
EXAMPLE SUITE OF AMPLIFICATION FACTORS USING LINEAR SITE RESPONSE (MODEL M2)

Mean base-case profile (P1), and base-case kappa (K1) 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 (EPRI, 2013a [Ref. 6]) (EPRI, 2014 [Ref. 9])

2.3.7 Control Point Seismic Hazard Curves

As presented in ***Section 3.2*** below, the control point elevation is taken to be the RB foundation level (EL 536 ft). 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 (EPRI, 2013a [Ref. 6]). 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 the EPRI (2013c [Ref. 8]) ground motion equations are defined. The dynamic response of the materials below the control point is represented by the frequency- and hard rock PGA-dependent amplification functions (median values and logarithmic standard deviations) described in ***Section 2.3***.

The resulting control point mean hazard curves for Fermi 2 are shown on ***Figure 2-5***. Tabulated values of mean and fractile seismic hazard curves and site response amplification functions are provided in ***Appendix A***. On ***Figure 2-5***, the legend PGA refers to the spectral frequency of 100 Hz.

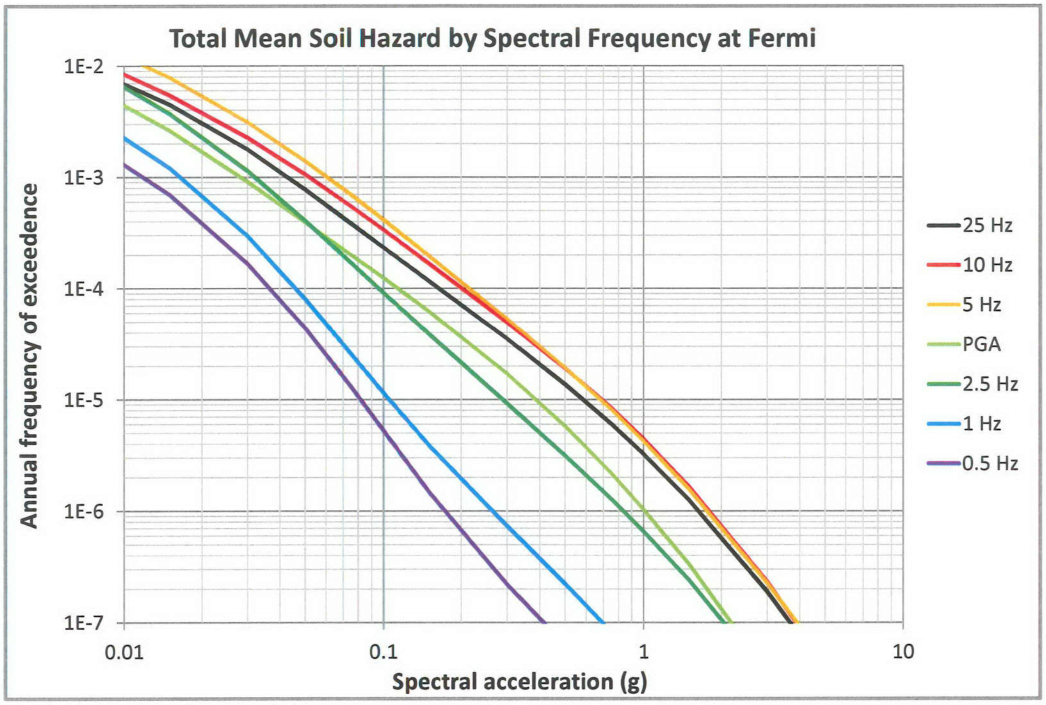

FIGURE 2-5
FERMI 2 MEAN CONTROL POINT SEISMIC HAZARD AT SELECTED SPECTRAL FREQUENCIES
(EPRI, 2014 [Ref. 9])

2.4 CONTROL POINT RESPONSE SPECTRA

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the GMRS. The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each spectral frequency for the mean 1E-4 and 1E-5 per year hazard levels. The GMRS are then developed by scaling the mean 1E-4 UHRS by a design factor (DF) that is related to the ratio of the 1E-5 spectral acceleration to the corresponding 1E-4 spectral acceleration (NRC, 2007 [Ref. 12]). ***Table 2-4 and Figure 2-6*** show the UHRS and GMRS accelerations for a range of frequencies.

TABLE 2-4
FERMI 2 UNIFORM HAZARD RESPONSE SPECTRA AND GMRS AT CONTROL POINT
(EPRI, 2014 [Ref. 9])

FREQUENCY	HORIZ. SPECTRAL ACC (G) AT RB FOUNDATION		
(Hz)	10-4 UHRS	10-5 UHRS	GMRS
100.00	0.1130	0.3850	0.1810
90.00	0.1130	0.3860	0.1810
80.00	0.1140	0.3890	0.1820
70.00	0.1150	0.3980	0.1870
60.00	0.1210	0.4250	0.1980
50.00	0.1350	0.4900	0.2270
40.00	0.1530	0.5650	0.2610
35.00	0.1590	0.5810	0.2690
30.00	0.1600	0.5760	0.2670
25.00	0.1640	0.5840	0.2720
20.00	0.1760	0.6200	0.2890
15.00	0.1950	0.6730	0.3150
12.50	0.1990	0.6860	0.3210
10.00	0.2000	0.6850	0.3210
9.00	0.1980	0.6710	0.3150
8.00	0.1990	0.6630	0.3130
7.00	0.2040	0.6680	0.3160
6.00	0.2100	0.6790	0.3220
5.00	0.2130	0.6800	0.3230
4.00	0.1930	0.5950	0.2850
3.50	0.1680	0.5140	0.2470
3.00	0.1320	0.4050	0.1940
2.50	0.0958	0.2880	0.1390
2.00	0.0795	0.2240	0.1090
1.50	0.0645	0.1670	0.0827
1.25	0.0532	0.1300	0.0654
1.00	0.0458	0.1050	0.0534
0.90	0.0448	0.1020	0.0521
0.80	0.0441	0.1000	0.0511
0.70	0.0430	0.0974	0.0496
0.60	0.0408	0.0917	0.0468
0.50	0.0365	0.0814	0.0416
0.40	0.0292	0.0651	0.0333
0.35	0.0255	0.0570	0.0291
0.30	0.0219	0.0488	0.0249
0.25	0.0182	0.0407	0.0208
0.20	0.0146	0.0325	0.0166
0.15	0.0109	0.0244	0.0125
0.13	0.0091	0.0203	0.0104
0.10	0.0073	0.0163	0.0083

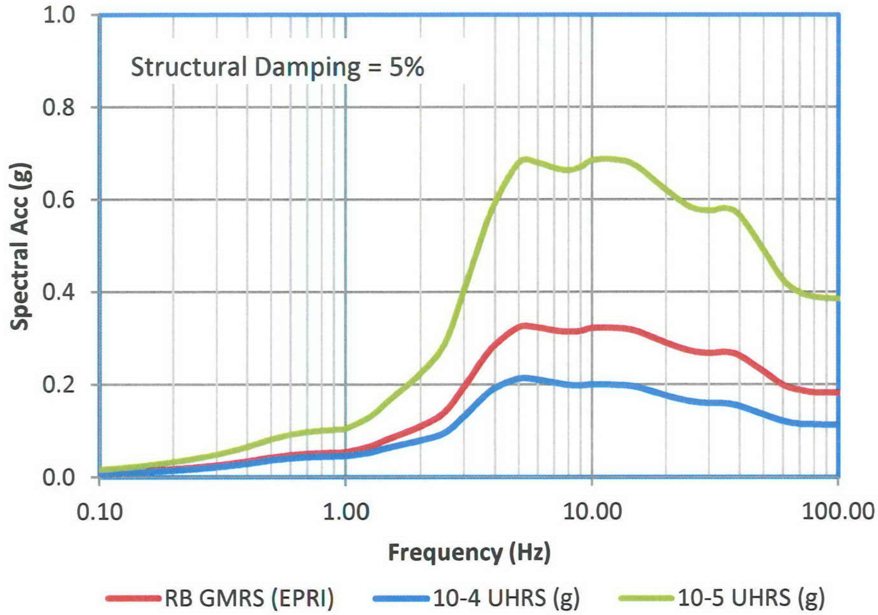

FIGURE 2-6
FERMI 2 UNIFORM HAZARD RESPONSE SPECTRA AND GMRS AT CONTROL POINT
(EPRI, 2014 [Ref. 9])

3.0 PLANT DESIGN BASIS GROUND MOTION

The design basis for Fermi 2 is identified in the UFSAR, Section 3.7 (DTE, 2012a [Ref. 3]).

3.1 SSE DESCRIPTION OF SPECTRAL SHAPE

Based on Section 3.7 of the UFSAR (DTE, 2012a [Ref. 3]), the SSE ground motion derives from the deterministic estimate of the maximum credible event, considering both seismic history and geologic structure. This evaluation reflects the fact that the history of minor to moderate earthquake activity in the stable region cannot be related directly to known tectonic features. The UFSAR identifies seismic events recorded up to July 1986.

Based on historical maximum events placed at the closest plausible locations to the site, as shown in ***Table 3-1***, the UFSAR estimates the site PGA from the maximum credible earthquake to be less than 0.10g.

TABLE 3-1
SEISMIC EVENTS CONSIDERED IN ESTIMATING FERMI 2 SITE PGA
(DTE, 2012a [Ref. 3])

EVENT	EPICENTER	INTENSITY	PLACED AT	PGA
1937	Near Lima, Ohio	VIII	Confluence of the Findlay, Cincinnati, and Kankakee Arches	< 0.05g
1937	Near Lima, Ohio	VIII	Closest approach of the Bowling Green Fault	< 0.10g
1811-1812	New Madrid	XII	Closest approach of the Rough Creek Fault Complex	< 0.05g
1943	Lake Erie	V	Near Site	< 0.10g
1947	South-central Michigan	VI	Near Site	< 0.10g

The SSE response spectra for the Fermi 2 site are anchored at zero period accelerations of 0.15g horizontal and 0.1g vertical (DTE, 2012a [Ref. 3], Sec 2.5.2.10). The shape of the SSE horizontal spectrum conforms to the 1940 El Centro, California earthquake spectra with minor modifications to accommodate for the 1935 Helena, Montana, and the 1949 Olympia, Washington earthquakes. The 5 percent damped horizontal SSE spectrum is presented in ***Table 3-2***.

TABLE 3-2
SSE HORIZONTAL GROUND MOTION RESPONSE SPECTRUM FOR FERMI 2

FREQUENCY (Hz)	SPECTRAL ACCELERATION (g)
0.10	0.008
0.20	0.028
0.50	0.077
1.00	0.130
2.50	0.220
5.00	0.236
8.00	0.195
9.00	0.180
25.0	0.155
33.0	0.150
100.0	0.150

3.2 CONTROL POINT ELEVATION

The horizontal and vertical SSE response spectra represent the design basis ground motion input applied at the foundation levels of the Fermi 2 structures. At Fermi 2, the foundation elevations of the RB and the Auxiliary Building (AB) are both at 536 ft, and the RHR is at 547 ft. These elevations place the foundations of the RB and the AB at 16 ft below the top of bedrock, and the foundation of the RHR at 5 ft below the top of bedrock. The SSE control point elevation is taken to be the bottom of the RB foundation level, and the SSE horizontal response spectrum is, therefore, compared to the GMRS at EL 536 ft.

4.0 SCREENING EVALUATION

In accordance with SPID Section 3, a screening evaluation was performed as described below. The horizontal GMRS determined from the hazard reevaluation is used to characterize the amplitude of the new seismic hazard at the Fermi 2 site. The screening evaluation is based upon a comparison of the Control Point GMRS with the five percent damped horizontal SSE.

4.1 Risk Evaluation Screening (1 to 10 Hz)

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, the plant screens in for a risk evaluation.

4.2 High Frequency Screening (> 10 Hz)

For a portion of the range above 10 Hz, the GMRS exceeds the SSE. The high frequency exceedances can be addressed in the risk evaluation discussed in ***Section 4.1*** above.

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

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the SSE. Therefore, the plant screens in for a spent fuel pool evaluation.

5.0 INTERIM ACTIONS

Based on the screening evaluation, the expedited seismic evaluation described in EPRI 3002000704 will be performed as proposed in a letter to NRC dated April 9, 2013, (NEI, 2013 ML131 01A379 [Ref. 10]) and agreed to by NRC in a letter dated May 7, 2013 (NRC, 2013 ML13106A331 [Ref. 15].

Consistent with NRC letter dated February 20, 2014, [ML14030A046] the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of Fermi 2. Therefore, the results do not call into question the operability or functionality of SSCs and are not reportable pursuant to10 CFR 50.72, "Immediate notification requirements for operating nuclear power reactors," and10 CFR 50.73, "Licensee event report system."

The NRC letter also requests that licensees provide an interim evaluation or actions to demonstrate that the plant can cope with the reevaluated hazard while the expedited approach and risk evaluations are conducted. In response to that request, Nuclear Energy Institute (NEI) letter dated March 12, 2014, (NEI, 2014 [Ref. 11]), provides seismic core damage risk estimates using the updated seismic hazards for the operating nuclear plants in the CEUS. These risk estimates continue to support the following conclusions of the NRC GI-199 Safety/Risk Assessment:

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

Fermi 2 is included in the March 12, 2014, risk estimates. Using the methodology described in the NEI letter, all plants were shown to be below 10^{-4}/year; thus, the above conclusions apply.

Additionally, as requested in Enclosure 1 of the 50.54(f) letter (Item 5) the following paragraphs provide insights from the Fermi 2 NTTF Recommendation 2.3 walkdowns, and the Fermi 2 IPEEE program. These programs further illustrate the plant seismic capacity.

5.1 NTTF 2.3 WALKDOWNS

The recently completed NTTF 2.3 walkdowns (DTE, 2012b [Ref. 4]) confirmed that "the plant process improvements that resulted from the IPEEE program in 1995 were confirmed to be effective. No issues were identified with the 20 assets selected from the IPEEE outlier population." Additionally, inaccessible asset walkdowns have been completed during the refueling outage RF16. Walkdown reports are in the process of being updated.

The NTTF 2.3 walkdowns report (DTE, 2012b [Ref. 4]) further states that "the seismic walkdowns and area walk-bys identified 27 potentially adverse seismic conditions." All of the issues identified have been addressed in accordance with the plant Conditional Assessment Resolution Document (CARD) process, and none required a licensing basis evaluation. None of the 27 CARDs generated as a result of these walkdowns were determined to have an immediate impact to the safe operation of the plant." Other issues identified during the NTTF 2.3 walkdowns and recorded in associated CARDs relate to anchorage of sub-assemblies, clearance between components, a few conduit supports, and inconsistencies between some field configurations and existing equipment drawings. CARD process is being followed to address these issues.

Additionally, subsequent walkdowns performed to support the SPRA effort observed that in general, the systems, equipment, and components are consistent with the design information and exhibit no signs of deterioration or inadequate anchorage. A few cases of potential deviations from plant documentation, deteriorations, and potential interactions observed during the walkdowns do not affect the safety functions, but corrections to the deviations may be considered to improve the seismic fragilities of the affected SSCs.

5.2 IPEEE DESCRIPTION AND CAPACITY RESPONSE SPECTRUM

The IPEEE for Fermi 2 is characterized as a focused scope SMA using the EPRI approach (DTE, 1996 [Ref. 2]). The IPEEE evaluation is based on the RLE ground motion defined by the Nuclear Regulatory Commission Technical Report (NUREG)/CR-0098 median rock spectral shape anchored to a PGA of 0.3g. The RLE spectrum is taken to represent the input ground motion at the foundation levels of major structures. The IPEEE seismic evaluation results are summarized in a comprehensive report (DTE, 1996 [Ref. 2]).

The IPEEE HCLPF spectrum (IHS) is not used for screening. However, it is provided here for information and to document the level of the beyond design basis (BDB) seismic ground motion for which the plant SSCs have been evaluated.

The 5%-damped horizontal IHS spectral accelerations are provided in ***Table 5-1***. The SSE spectrum and the IHS are shown on ***Figure 5-1***.

TABLE 5-1
IHS HORIZONTAL GROUND MOTION RESPONSE SPECTRUM FOR FERMI 2

FREQUENCY (Hz)	SPECTRAL ACCELERATION (g)
0.10	0.009
0.20	0.034
0.34	0.100
0.50	0.145
1.00	0.290
2.19	0.636
2.50	0.636
5.00	0.636
8.00	0.636
9.00	0.598
25.00	0.348
33.00	0.300

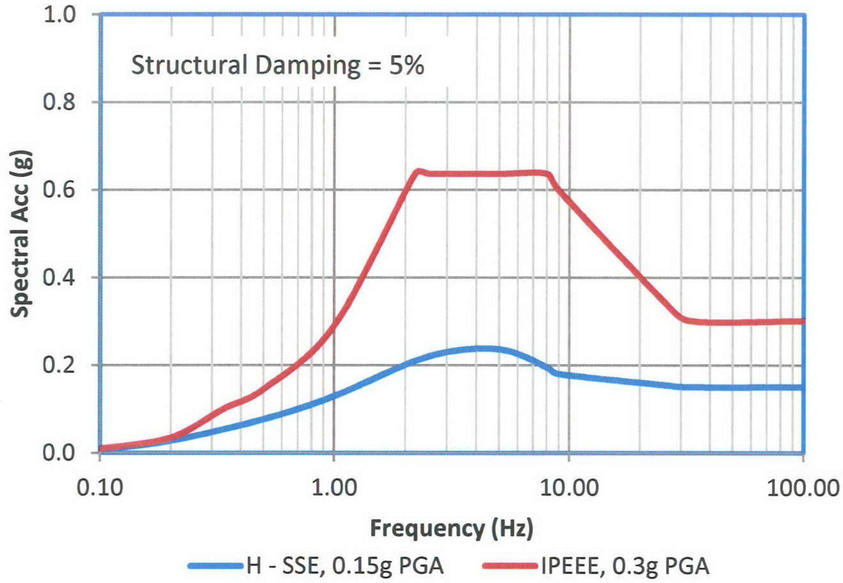

FIGURE 5-1
FERMI 2 SSE AND IPEEE HCLPF SPECTRA

Although the Fermi 2 IPEEE is not full scope and is not used for screening, this report was reviewed and it is concluded that it is of good quality and meets all other pre-requisites and the adequacy requirements in accordance with the SPID (EPRI, 2013a [Ref. 6]). A comparison of the GMRS and the IPEEE spectra was performed and the IPEEE was found to envelope the GRMS at all frequencies.

6.0 CONCLUSIONS

In accordance with the 50.54(f) request for information, a seismic hazard and screening evaluation was performed for Fermi 2. A GMRS was developed solely for purpose of screening for additional evaluations in accordance with the SPID.

Based on the results of the screening evaluation, the plant screens in for risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency Confirmation. The GMRS exceeds the SSE both in the 1 to 10 Hz part of the response spectrum and above 10 Hz.

7.0 REFERENCES

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APPENDIX A

FERMI 2 SITE SPECIFIC AMPLIFICATION FUNCTIONS AND MEAN AND FRACTILE HAZARD CURVES AT BOTTOM OF REACTOR BUILDING FOUNDATION

APPENDIX A

This Appendix presents the mean and fractile hazard curves at the Reactor Building (RB) foundation, and the site-specific amplification functions represented by median values and the associated logarithmic standard deviation at selected spectral frequencies.

Tables A-1A through A-1G present the mean and fractile hazard curves for spectral accelerations at frequencies of 100, 25, 10, 5, 2.5, 1.0, and 0.5 Hz at the bottom of RB foundation, which is the safe shutdown earthquake (SSE) control point elevation).

Table A-2A presents the median amplification factors and the associated logarithmic standard deviations between the ground motion at hard rock and the ground motion at the RB foundation.

TABLE A-1A
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR PGA AT FERMI

Spectral Acceleration (g)	Annual Frequency of Exceedance					
	MEAN	**0.05**	**0.16**	**0.50**	**0.84**	**0.95**
0.0005	4.55E-02	2.04E-02	3.33E-02	4.56E-02	5.83E-02	6.64E-02
0.001	3.25E-02	1.29E-02	2.22E-02	3.19E-02	4.37E-02	5.20E-02
0.005	9.34E-03	3.23E-03	5.58E-03	8.47E-03	1.29E-02	1.87E-02
0.01	4.41E-03	1.46E-03	2.32E-03	3.73E-03	6.09E-03	1.05E-02
0.015	2.60E-03	8.35E-04	1.23E-03	2.10E-03	3.57E-03	6.83E-03
0.03	9.04E-04	2.42E-04	3.52E-04	6.45E-04	1.25E-03	2.84E-03
0.05	3.91E-04	8.35E-05	1.27E-04	2.53E-04	5.66E-04	1.34E-03
0.075	2.00E-04	3.68E-05	6.00E-05	1.23E-04	3.01E-04	7.03E-04
0.1	1.24E-04	2.19E-05	3.63E-05	7.66E-05	1.87E-04	4.31E-04
0.15	6.18E-05	1.08E-05	1.87E-05	3.95E-05	9.24E-05	2.04E-04
0.3	1.70E-05	2.76E-06	5.12E-06	1.15E-05	2.60E-05	5.12E-05
0.5	5.73E-06	7.34E-07	1.49E-06	3.84E-06	9.11E-06	1.69E-05
0.75	2.18E-06	1.87E-07	4.37E-07	1.34E-06	3.63E-06	6.83E-06
1.	1.03E-06	5.66E-08	1.53E-07	5.75E-07	1.77E-06	3.47E-06
1.5	3.30E-07	7.45E-09	2.72E-08	1.46E-07	5.66E-07	1.25E-06
3.	3.57E-08	1.77E-10	7.45E-10	8.60E-09	5.66E-08	1.57E-07
5.	5.23E-09	1.02E-10	1.32E-10	7.45E-10	7.13E-09	2.46E-08
7.5	9.23E-10	8.23E-11	1.16E-10	1.62E-10	1.11E-09	4.43E-09
10.	2.39E-10	8.12E-11	9.11E-11	1.32E-10	3.14E-10	1.23E-09

TABLE A-1B
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR 25 HZ AT FERMI

SPECTRAL ACCELERATION (g)	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	4.87E-02	2.60E-02	3.73E-02	4.90E-02	6.09E-02	6.83E-02
0.001	3.65E-02	1.74E-02	2.64E-02	3.57E-02	4.70E-02	5.58E-02
0.005	1.26E-02	5.20E-03	8.00E-03	1.16E-02	1.69E-02	2.42E-02
0.01	6.87E-03	2.64E-03	4.01E-03	6.00E-03	9.37E-03	1.49E-02
0.015	4.48E-03	1.67E-03	2.49E-03	3.79E-03	6.09E-03	1.02E-02
0.03	1.78E-03	6.17E-04	8.85E-04	1.44E-03	2.46E-03	4.50E-03
0.05	7.75E-04	2.39E-04	3.42E-04	6.00E-04	1.10E-03	2.10E-03
0.075	3.84E-04	1.02E-04	1.55E-04	2.84E-04	5.66E-04	1.07E-03
0.1	2.33E-04	5.58E-05	8.72E-05	1.72E-04	3.52E-04	6.64E-04
0.15	1.16E-04	2.57E-05	4.25E-05	8.60E-05	1.79E-04	3.28E-04
0.3	3.52E-05	7.55E-06	1.31E-05	2.72E-05	5.42E-05	9.11E-05
0.5	1.37E-05	2.76E-06	4.98E-06	1.07E-05	2.16E-05	3.47E-05
0.75	6.05E-06	1.07E-06	2.04E-06	4.70E-06	9.79E-06	1.57E-05
1.	3.24E-06	4.90E-07	9.93E-07	2.42E-06	5.35E-06	8.72E-06
1.5	1.24E-06	1.44E-07	3.14E-07	8.72E-07	2.13E-06	3.57E-06
3.	1.89E-07	1.07E-08	2.84E-08	1.05E-07	3.37E-07	6.45E-07
5.	3.75E-08	1.07E-09	3.23E-09	1.55E-08	6.64E-08	1.44E-07
7.5	8.89E-09	2.04E-10	5.05E-10	2.80E-09	1.51E-08	3.73E-08
10.	2.92E-09	1.32E-10	1.87E-10	7.89E-10	4.70E-09	1.29E-08

TABLE A-1C
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR 10 HZ AT FERMI

SPECTRAL ACCELERATION (g)	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.48E-02	3.79E-02	4.37E-02	5.42E-02	6.64E-02	7.34E-02
0.001	4.39E-02	2.68E-02	3.33E-02	4.37E-02	5.42E-02	6.17E-02
0.005	1.57E-02	7.45E-03	1.04E-02	1.51E-02	2.10E-02	2.68E-02
0.01	8.34E-03	3.52E-03	5.12E-03	7.66E-03	1.15E-02	1.55E-02
0.015	5.40E-03	2.16E-03	3.14E-03	4.83E-03	7.55E-03	1.07E-02
0.03	2.25E-03	8.60E-04	1.20E-03	1.92E-03	3.14E-03	4.98E-03
0.05	1.05E-03	3.68E-04	5.20E-04	8.60E-04	1.49E-03	2.46E-03
0.075	5.42E-04	1.72E-04	2.49E-04	4.37E-04	7.89E-04	1.34E-03
0.1	3.33E-04	9.51E-05	1.44E-04	2.64E-04	4.98E-04	8.47E-04
0.15	1.66E-04	4.19E-05	6.54E-05	1.29E-04	2.53E-04	4.31E-04
0.3	4.92E-05	1.07E-05	1.84E-05	3.79E-05	7.77E-05	1.27E-04
0.5	1.90E-05	3.79E-06	6.83E-06	1.49E-05	3.01E-05	4.83E-05
0.75	8.31E-06	1.51E-06	2.84E-06	6.45E-06	1.34E-05	2.16E-05
1.	4.38E-06	7.13E-07	1.38E-06	3.33E-06	7.23E-06	1.16E-05
1.5	1.62E-06	1.98E-07	4.25E-07	1.15E-06	2.72E-06	4.70E-06
3.	2.30E-07	1.15E-08	3.05E-08	1.25E-07	4.07E-07	8.00E-07
5.	4.38E-08	7.77E-10	2.53E-09	1.72E-08	7.66E-08	1.74E-07
7.5	1.02E-08	1.53E-10	3.23E-10	2.80E-09	1.72E-08	4.50E-08
10.	3.34E-09	1.13E-10	1.40E-10	7.45E-10	5.27E-09	1.53E-08

TABLE A-1D
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR 5 HZ AT FERMI

SPECTRAL ACCELERATION (g)	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.97E-02	4.37E-02	4.83E-02	5.91E-02	7.13E-02	7.77E-02
0.001	5.23E-02	3.42E-02	4.07E-02	5.20E-02	6.45E-02	7.23E-02
0.005	2.25E-02	1.08E-02	1.46E-02	2.16E-02	3.05E-02	3.63E-02
0.01	1.21E-02	5.05E-03	7.45E-03	1.15E-02	1.69E-02	2.07E-02
0.015	7.77E-03	3.01E-03	4.56E-03	7.23E-03	1.10E-02	1.40E-02
0.03	3.10E-03	1.13E-03	1.69E-03	2.76E-03	4.50E-03	6.26E-03
0.05	1.39E-03	4.90E-04	7.13E-04	1.18E-03	2.04E-03	3.01E-03
0.075	6.93E-04	2.29E-04	3.37E-04	5.83E-04	1.02E-03	1.57E-03
0.1	4.12E-04	1.27E-04	1.92E-04	3.42E-04	6.17E-04	9.65E-04
0.15	1.95E-04	5.35E-05	8.35E-05	1.57E-04	2.96E-04	4.70E-04
0.3	5.25E-05	1.20E-05	2.01E-05	4.13E-05	8.23E-05	1.31E-04
0.5	1.91E-05	3.84E-06	6.83E-06	1.49E-05	3.05E-05	4.83E-05
0.75	8.12E-06	1.40E-06	2.64E-06	6.17E-06	1.32E-05	2.13E-05
1.	4.22E-06	6.17E-07	1.23E-06	3.09E-06	7.03E-06	1.16E-05
1.5	1.56E-06	1.60E-07	3.52E-07	1.04E-06	2.68E-06	4.70E-06
3.	2.27E-07	7.55E-09	2.25E-08	1.11E-07	4.07E-07	8.23E-07
5.	4.57E-08	4.77E-10	1.77E-09	1.55E-08	8.00E-08	1.92E-07
7.5	1.13E-08	1.32E-10	2.53E-10	2.57E-09	1.82E-08	5.12E-08
10.	3.87E-09	1.05E-10	1.32E-10	6.83E-10	5.75E-09	1.79E-08

TABLE A-1E
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR 2.5 HZ AT FERMI

SPECTRAL ACCELERATION (g)	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	5.42E-02	3.63E-02	4.25E-02	5.35E-02	6.64E-02	7.34E-02
0.001	4.32E-02	2.49E-02	3.09E-02	4.25E-02	5.58E-02	6.45E-02
0.005	1.41E-02	5.91E-03	8.35E-03	1.32E-02	1.98E-02	2.49E-02
0.01	6.48E-03	2.22E-03	3.37E-03	5.91E-03	9.65E-03	1.27E-02
0.015	3.70E-03	1.10E-03	1.72E-03	3.23E-03	5.75E-03	7.89E-03
0.03	1.13E-03	2.68E-04	4.37E-04	8.98E-04	1.79E-03	2.80E-03
0.05	4.04E-04	8.35E-05	1.42E-04	3.05E-04	6.36E-04	1.07E-03
0.075	1.69E-04	3.19E-05	5.66E-05	1.27E-04	2.72E-04	4.56E-04
0.1	9.12E-05	1.60E-05	2.88E-05	6.73E-05	1.49E-04	2.49E-04
0.15	3.86E-05	6.09E-06	1.15E-05	2.76E-05	6.36E-05	1.08E-04
0.3	9.17E-06	1.08E-06	2.29E-06	6.17E-06	1.53E-05	2.72E-05
0.5	3.13E-06	2.64E-07	6.26E-07	1.95E-06	5.35E-06	9.93E-06
0.75	1.28E-06	7.45E-08	1.98E-07	7.34E-07	2.22E-06	4.37E-06
1.	6.56E-07	2.76E-08	8.23E-08	3.42E-07	1.15E-06	2.32E-06
1.5	2.39E-07	5.75E-09	2.04E-08	1.07E-07	4.19E-07	9.11E-07
3.	3.35E-08	3.33E-10	1.31E-09	1.02E-08	5.50E-08	1.42E-07
5.	6.14E-09	1.32E-10	2.04E-10	1.32E-09	9.11E-09	2.76E-08
7.5	1.35E-09	9.79E-11	1.32E-10	2.76E-10	1.74E-09	6.17E-09
10.	4.19E-10	8.98E-11	1.18E-10	1.44E-10	5.35E-10	1.90E-09

TABLE A-1F
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR 1 HZ AT FERMI

SPECTRAL ACCELERATION (g)	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	0.05	0.16	0.50	0.84	0.95
0.0005	3.42E-02	1.64E-02	2.29E-02	3.37E-02	4.56E-02	5.35E-02
0.001	2.21E-02	9.51E-03	1.40E-02	2.13E-02	3.01E-02	3.63E-02
0.005	5.23E-03	1.51E-03	2.57E-03	4.83E-03	7.89E-03	1.04E-02
0.01	2.25E-03	4.19E-04	7.89E-04	1.84E-03	3.73E-03	5.50E-03
0.015	1.20E-03	1.69E-04	3.33E-04	8.72E-04	2.10E-03	3.33E-03
0.03	2.95E-04	2.84E-05	6.00E-05	1.74E-04	4.90E-04	9.79E-04
0.05	7.97E-05	6.64E-06	1.42E-05	4.43E-05	1.25E-04	2.88E-04
0.075	2.56E-05	1.95E-06	4.31E-06	1.38E-05	4.13E-05	9.51E-05
0.1	1.14E-05	7.89E-07	1.87E-06	5.91E-06	1.95E-05	4.19E-05
0.15	3.86E-06	2.13E-07	5.50E-07	1.90E-06	6.73E-06	1.40E-05
0.3	7.30E-07	1.67E-08	6.09E-08	3.01E-07	1.18E-06	2.92E-06
0.5	2.21E-07	1.92E-09	1.01E-08	7.03E-08	3.52E-07	9.65E-07
0.75	8.18E-08	3.84E-10	2.04E-09	1.95E-08	1.21E-07	3.73E-07
1.	3.89E-08	1.74E-10	6.64E-10	7.13E-09	5.35E-08	1.82E-07
1.5	1.26E-08	1.32E-10	1.87E-10	1.53E-09	1.49E-08	5.91E-08
3.	1.46E-09	9.11E-11	1.25E-10	1.67E-10	1.25E-09	6.26E-09
5.	2.36E-10	8.12E-11	9.11E-11	1.32E-10	2.19E-10	9.37E-10
7.5	4.77E-11	8.12E-11	9.11E-11	1.32E-10	1.32E-10	2.35E-10
10.	1.40E-11	8.12E-11	8.35E-11	1.32E-10	1.32E-10	1.40E-10

TABLE A-1G
MEAN AND FRACTILE SEISMIC HAZARD CURVES FOR 0.5 HZ AT FERMI

SPECTRAL ACCELERATION (g)	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	**0.05**	**0.16**	**0.50**	**0.84**	**0.95**
0.0005	1.88E-02	9.37E-03	1.31E-02	1.82E-02	2.42E-02	2.96E-02
0.001	1.14E-02	5.12E-03	7.45E-03	1.10E-02	1.53E-02	1.95E-02
0.005	2.91E-03	5.05E-04	1.02E-03	2.53E-03	4.83E-03	6.73E-03
0.01	1.29E-03	1.08E-04	2.60E-04	8.85E-04	2.42E-03	3.79E-03
0.015	6.89E-04	3.84E-05	9.93E-05	3.84E-04	1.31E-03	2.29E-03
0.03	1.67E-04	5.12E-06	1.44E-05	6.54E-05	2.84E-04	6.73E-04
0.05	4.36E-05	1.02E-06	2.88E-06	1.44E-05	6.54E-05	1.90E-04
0.075	1.29E-05	2.60E-07	7.45E-07	4.01E-06	1.90E-05	5.66E-05
0.1	5.22E-06	8.98E-08	2.80E-07	1.55E-06	7.89E-06	2.29E-05
0.15	1.48E-06	1.74E-08	6.73E-08	3.84E-07	2.32E-06	6.64E-06
0.3	2.18E-07	7.77E-10	4.43E-09	3.90E-08	2.72E-07	1.07E-06
0.5	6.21E-08	1.57E-10	4.98E-10	6.93E-09	6.17E-08	3.14E-07
0.75	2.29E-08	1.32E-10	1.64E-10	1.55E-09	1.82E-08	1.11E-07
1.	1.10E-08	1.21E-10	1.32E-10	5.42E-10	7.13E-09	5.12E-08
1.5	3.65E-09	9.11E-11	1.32E-10	1.72E-10	1.72E-09	1.53E-08
3.	4.51E-10	8.12E-11	9.11E-11	1.32E-10	1.98E-10	1.40E-09
5.	7.83E-11	8.12E-11	9.11E-11	1.32E-10	1.32E-10	2.60E-10
7.5	1.69E-11	8.12E-11	8.12E-11	1.32E-10	1.32E-10	1.32E-10
10.	5.23E-12	8.12E-11	8.12E-11	1.32E-10	1.32E-10	1.32E-10

TABLE A-2A
AMPLIFICATION FUNCTIONS FOR FERMI

PGA (g)	MEDIAN AF	SIGMA LN(AF)	25 HZ SA (g)	MEDIAN AF	SIGMA LN(AF)	10 HZ SA (g)	MEDIAN AF	SIGMA LN(AF)	5 HZ SA (g)	MEDIAN AF	SIGMA LN(AF)
1.00E-02	1.31E+00	3.20E-02	1.30E-02	1.11E+00	4.04E-02	1.90E-02	1.12E+00	6.76E-02	2.09E-02	1.73E+00	8.19E-02
4.95E-02	1.10E+00	3.97E-02	1.02E-01	7.73E-01	1.13E-01	9.99E-02	1.05E+00	8.85E-02	8.24E-02	1.71E+00	8.47E-02
9.64E-02	1.02E+00	4.69E-02	2.13E-01	7.13E-01	1.35E-01	1.85E-01	1.03E+00	9.28E-02	1.44E-01	1.69E+00	8.59E-02
1.94E-01	9.54E-01	5.38E-02	4.43E-01	6.70E-01	1.48E-01	3.56E-01	1.01E+00	9.56E-02	2.65E-01	1.66E+00	8.90E-02
2.92E-01	9.18E-01	5.70E-02	6.76E-01	6.46E-01	1.52E-01	5.23E-01	9.91E-01	9.75E-02	3.84E-01	1.63E+00	9.04E-02
3.91E-01	8.92E-01	5.94E-02	9.09E-01	6.28E-01	1.55E-01	6.90E-01	9.77E-01	9.92E-02	5.02E-01	1.60E+00	9.29E-02
4.93E-01	8.72E-01	6.13E-02	1.15E+00	6.13E-01	1.57E-01	8.61E-01	9.64E-01	1.01E-01	6.22E-01	1.58E+00	9.56E-02
7.41E-01	8.36E-01	6.57E-02	1.73E+00	5.83E-01	1.62E-01	1.27E+00	9.33E-01	1.05E-01	9.13E-01	1.53E+00	1.02E-01
1.01E+00	8.09E-01	7.02E-02	2.36E+00	5.59E-01	1.67E-01	1.72E+00	9.07E-01	1.11E-01	1.22E+00	1.49E+00	1.10E-01
1.28E+00	7.86E-01	7.47E-02	3.01E+00	5.39E-01	1.70E-01	2.17E+00	8.83E-01	1.18E-01	1.54E+00	1.45E+00	1.17E-01
1.55E+00	7.68E-01	7.93E-02	3.63E+00	5.24E-01	1.74E-01	2.61E+00	8.62E-01	1.25E-01	1.85E+00	1.42E+00	1.25E-01
2.5 HZ SA (g)	**MEDIAN AF**	**SIGMA LN(AF)**	**1 HZ SA (g)**	**MEDIAN AF**	**SIGMA LN(AF)**	**0.5 HZ SA (g)**	**MEDIAN AF**	**SIGMA LN(AF)**			
2.18E-02	1.29E+00	1.01E-01	1.27E-02	1.10E+00	4.48E-02	8.25E-03	1.19E+00	1.52E-01			
7.05E-02	1.31E+00	9.88E-02	3.43E-02	1.11E+00	4.39E-02	1.96E-02	1.19E+00	1.48E-01			
1.18E-01	1.31E+00	9.86E-02	5.51E-02	1.11E+00	4.39E-02	3.02E-02	1.20E+00	1.46E-01			
2.12E-01	1.33E+00	9.96E-02	9.63E-02	1.12E+00	4.45E-02	5.11E-02	1.20E+00	1.45E-01			
3.04E-01	1.34E+00	1.01E-01	1.36E-01	1.12E+00	4.54E-02	7.10E-02	1.20E+00	1.45E-01			
3.94E-01	1.35E+00	1.03E-01	1.75E-01	1.13E+00	4.65E-02	9.06E-02	1.20E+00	1.45E-01			
4.86E-01	1.36E+00	1.03E-01	2.14E-01	1.13E+00	4.81E-02	1.10E-01	1.20E+00	1.45E-01			
7.09E-01	1.38E+00	1.04E-01	3.10E-01	1.14E+00	5.17E-02	1.58E-01	1.20E+00	1.45E-01			
9.47E-01	1.39E+00	1.11E-01	4.12E-01	1.15E+00	5.41E-02	2.09E-01	1.20E+00	1.45E-01			
1.19E+00	1.38E+00	1.26E-01	5.18E-01	1.15E+00	5.86E-02	2.62E-01	1.21E+00	1.45E-01			
1.43E+00	1.37E+00	1.40E-01	6.19E-01	1.16E+00	6.74E-02	3.12E-01	1.21E+00	1.46E-01			

Tables A2-B1 and A2-B2 are tabular versions of the typical amplification factors provided on ***Figures 2.3 and 2.4***. Values are provided for two input motion levels at approximately 10^{-4} and 10^{-5} mean annual frequency of exceedance. These factors are unverified and are provided for information only. The figures should be considered the governing information.

TABLE A2-B1
MEDIAN AFS AND SIGMAS FOR MODEL 1, PROFILE 1, FOR 2 PGA LEVELS

M1P1K1	ROCK PGA=0.0964			M1P1K1	PGA=0.493		
FREQ. (HZ)	SOIL_SA	MED. AF	SIGMA LN(AF)	FREQ. (HZ)	SOIL_SA	MED. AF	SIGMA LN(AF)
100.0	0.098	1.015	0.043	100.0	0.403	0.818	0.058
87.1	0.099	1.004	0.044	87.1	0.407	0.800	0.059
75.9	0.100	0.984	0.044	75.9	0.413	0.770	0.061
66.1	0.103	0.947	0.046	66.1	0.426	0.715	0.066
57.5	0.109	0.882	0.054	57.5	0.451	0.632	0.077
50.1	0.119	0.817	0.081	50.1	0.492	0.568	0.102
43.7	0.128	0.748	0.114	43.7	0.531	0.518	0.124
38.0	0.133	0.696	0.126	38.0	0.552	0.494	0.147
33.1	0.136	0.666	0.111	33.1	0.562	0.482	0.141
28.8	0.144	0.691	0.122	28.8	0.580	0.503	0.141
25.1	0.144	0.676	0.105	25.1	0.608	0.530	0.141
21.9	0.146	0.707	0.115	21.9	0.614	0.568	0.132
19.1	0.161	0.779	0.136	19.1	0.637	0.604	0.161
16.6	0.180	0.895	0.108	16.6	0.696	0.695	0.170
14.5	0.188	0.966	0.085	14.5	0.754	0.795	0.134
12.6	0.185	0.968	0.084	12.6	0.778	0.850	0.101
11.0	0.179	0.952	0.072	11.0	0.764	0.863	0.074
9.5	0.178	0.980	0.075	9.5	0.742	0.884	0.077
8.3	0.183	1.083	0.095	8.3	0.734	0.955	0.095
7.2	0.196	1.229	0.111	7.2	0.756	1.056	0.120
6.3	0.217	1.436	0.116	6.3	0.811	1.213	0.140
5.5	0.243	1.667	0.097	5.5	0.891	1.404	0.141
4.8	0.260	1.812	0.062	4.8	0.970	1.570	0.118
4.2	0.257	1.838	0.090	4.2	1.025	1.719	0.085
3.6	0.236	1.724	0.122	3.6	1.001	1.733	0.097
3.2	0.198	1.531	0.125	3.2	0.886	1.635	0.123
2.8	0.168	1.362	0.096	2.8	0.753	1.471	0.122
2.4	0.144	1.255	0.105	2.4	0.634	1.347	0.125
2.1	0.121	1.158	0.066	2.1	0.524	1.228	0.087
1.8	0.109	1.160	0.066	1.8	0.461	1.212	0.072
1.6	0.099	1.206	0.130	1.6	0.410	1.248	0.128
1.4	0.084	1.189	0.131	1.4	0.344	1.222	0.130
1.2	0.071	1.132	0.069	1.2	0.286	1.158	0.072
1.0	0.062	1.100	0.034	1.0	0.248	1.120	0.037
0.91	0.057	1.099	0.042	0.91	0.224	1.115	0.042
0.79	0.053	1.119	0.067	0.79	0.204	1.132	0.065

TABLE A2-B1
MEDIAN AFS AND SIGMAS FOR MODEL 1, PROFILE 1, FOR 2 PGA LEVELS (CONTINUED)

M1P1K1	ROCK PGA=0.0964			M1P1K1	PGA=0.493		
FREQ. (HZ)	SOIL_SA	MED. AF	SIGMA LN(AF)	FREQ. (HZ)	SOIL_SA	MED. AF	SIGMA LN(AF)
0.69	0.049	1.150	0.103	0.69	0.185	1.161	0.101
0.60	0.044	1.176	0.139	0.60	0.164	1.186	0.136
0.52	0.038	1.188	0.160	0.52	0.140	1.196	0.157
0.46	0.032	1.181	0.160	0.46	0.116	1.189	0.157
0.10	0.001	1.055	0.038	0.10	0.004	1.050	0.037

TABLE A2-B2
MEDIAN AFS AND SIGMAS FOR MODEL 2, PROFILE 1, FOR 2 PGA LEVELS

M2P1K1	PGA=0.0964			M2P1K1	PGA=0.493		
FREQ. (Hz)	SOIL_SA	MED. AF	SIGMA LN(AF)	FREQ. (Hz)	SOIL_SA	MED. AF	SIGMA LN(AF)
100.0	0.101	1.050	0.041	100.0	0.473	0.960	0.051
87.1	0.102	1.038	0.041	87.1	0.480	0.944	0.051
75.9	0.104	1.020	0.041	75.9	0.493	0.919	0.051
66.1	0.107	0.984	0.040	66.1	0.519	0.872	0.051
57.5	0.114	0.923	0.049	57.5	0.575	0.807	0.069
50.1	0.126	0.863	0.081	50.1	0.666	0.768	0.116
43.7	0.136	0.795	0.119	43.7	0.732	0.713	0.161
38.0	0.141	0.739	0.136	38.0	0.748	0.671	0.176
33.1	0.145	0.708	0.114	33.1	0.760	0.652	0.143
28.8	0.153	0.736	0.122	28.8	0.795	0.690	0.145
25.1	0.150	0.707	0.104	25.1	0.761	0.663	0.122
21.9	0.153	0.744	0.116	21.9	0.760	0.703	0.133
19.1	0.172	0.834	0.133	19.1	0.848	0.805	0.148
16.6	0.192	0.955	0.097	16.6	0.939	0.937	0.105
14.5	0.196	1.011	0.087	14.5	0.946	0.998	0.091
12.6	0.190	0.996	0.084	12.6	0.900	0.984	0.088
11.0	0.184	0.977	0.068	11.0	0.853	0.964	0.071
9.5	0.183	1.011	0.076	9.5	0.838	0.998	0.079
8.3	0.190	1.124	0.095	8.3	0.856	1.113	0.098
7.2	0.205	1.282	0.109	7.2	0.911	1.273	0.112
6.3	0.227	1.504	0.109	6.3	1.000	1.496	0.111
5.5	0.254	1.743	0.084	5.5	1.101	1.735	0.085
4.8	0.269	1.877	0.054	4.8	1.154	1.869	0.053
4.2	0.261	1.864	0.100	4.2	1.107	1.857	0.098
3.6	0.235	1.716	0.119	3.6	0.989	1.712	0.117
3.2	0.196	1.509	0.117	3.2	0.817	1.508	0.115
2.8	0.166	1.344	0.087	2.8	0.688	1.344	0.086
2.4	0.142	1.240	0.101	2.4	0.585	1.242	0.100
2.1	0.120	1.148	0.063	2.1	0.491	1.150	0.062
1.8	0.108	1.152	0.066	1.8	0.439	1.154	0.065
1.6	0.098	1.200	0.130	1.6	0.395	1.202	0.128
1.4	0.084	1.184	0.131	1.4	0.334	1.186	0.129
1.2	0.071	1.129	0.068	1.2	0.279	1.132	0.068
1.0	0.062	1.098	0.033	1.0	0.244	1.101	0.033
0.91	0.057	1.097	0.042	0.91	0.221	1.100	0.041
0.79	0.053	1.118	0.067	0.79	0.202	1.121	0.065
0.69	0.049	1.149	0.104	0.69	0.184	1.152	0.101
0.60	0.044	1.176	0.139	0.60	0.163	1.178	0.136
0.52	0.038	1.187	0.160	0.52	0.139	1.190	0.157
0.46	0.032	1.181	0.160	0.46	0.115	1.183	0.157
0.10	0.001	1.055	0.038	0.10	0.004	1.047	0.036