Enclosure C
L-14-120

NTTF 2.1 Seismic Hazard and Screening Report
for Davis-Besse Nuclear Power Station
Ottawa County, Ohio
(85 pages follow)

ABS Consulting

2734296-R-009
Revision 1

Paul C. Rizzo Associates, Inc.
ENGINEERS/CONSULTANTS/CM

NTTF 2.1 Seismic Hazard and Screening Report Davis-Besse Nuclear Power Station Ottawa County, Ohio

March 20, 2014

Prepared for:

FirstEnergy Nuclear Operating Company

ABSG Consulting Inc. • 300 Commerce Drive, Suite 200 • Irvine, California 92602

REVISION 1 REPORT

NTTF 2.1 SEISMIC HAZARD AND SCREENING REPORT
DAVIS-BESSE NUCLEAR POWER STATION
OTTAWA COUNTY, OHIO

ABSG CONSULTING INC. REPORT NO. 2734296-R-009
REVISION 1
RIZZO REPORT NO. R10 12-4737
MARCH 20, 2014

ABSG CONSULTING INC.
PAUL C. RIZZO ASSOCIATES, INC.

ABS Consulting

APPROVALS

Report Name:	NTTF 2.1 Seismic Hazard and Screening Report Davis-Besse Nuclear Power Station Ottawa County, Ohio
Date:	March 20, 2014
Revision No.:	1

Approval by the responsible manager signifies that the document is complete, all required reviews are complete, and the document is released for use.

Originators:

Digitally signed by Richard Quittmeyer
DN: cn=Richard Quittmeyer, o=Paul C. Rizzo Associates, Inc., ou=Seismology, email=richard.quittmeyer@rizzoassoc.com, c=US
Date: 2014.03.20 16:25:17 -04'00'

Jeffrey K. Kimball — 03/20/2014 Date
Principal Seismologist

Digitally signed by Jose E Blanco Beltran
DN: cn=Jose E Blanco Beltran, o=Paul C Rizzo Associates, ou=Seismic, email=jose.blanco@rizzoassoc.com, c=US
Date: 2014.03.20 17:01:25 -04'00'

José E. Blanco, Ph.D. — 03/20/2014 Date
Technical Director

Digitally signed by Nishikant Vaidya
DN: cn=Nishikant Vaidya, o=Paul C. Rizzo Associates, ou=V.P. Advanced Engineering Projects, email=nish.vaidya@rizzoassoc.com, c=US
Date: 2014.03.20 17:06:02 -04'00'

Nishikant R. Vaidya, Ph.D., P.E. — 03/20/2014 Date
Vice President – Advanced Engineering Projects

Independent Technical Reviewer:

Digitally signed by Richard Quittmeyer
DN: cn=Richard Quittmeyer, o=Paul C. Rizzo Associates, Inc., ou=Seismology, email=richard.quittmeyer@rizzoassoc.com, c=US
Date: 2014.03.20 16:25:44 -04'00'

Richard C. Quittmeyer, Ph.D. — 03/20/2014 Date
Vice President – Seismology

Project Manager:

Digitally signed by Nishikant Vaidya
DN: cn=Nishikant Vaidya, o=Paul C. Rizzo Associates, ou=V.P. Advanced Engineering Projects, email=nish.vaidya@rizzoassoc.com, c=US
Date: 2014.03.20 17:06:22 -04'00'

Nishikant R. Vaidya, Ph.D., P.E. — 03/20/2014 Date
Vice President – Advanced Engineering Projects

Approver:

Thomas R. Roche, P.E. — 03/20/2014 Date
Vice President

CHANGE MANAGEMENT RECORD

Report Name: NTTF 2.1 Seismic Hazard and Screening Report
Davis-Besse Nuclear Power Station
Ottawa County, Ohio

Revision No.: 1

REVISION NO.	DATE	DESCRIPTIONS OF CHANGES/AFFECTED PAGES	PERSON AUTHORIZING CHANGE	APPROVAL[1]
0	March 6, 2014	Original Issue	N/A	N/A
1	March 20, 2014	Incorporate NEI Final Template, CDF Letter and FENOC Comments	Nishikant R. Vaidya	Thomas R. Roche

Note:

[1] Person authorizing change shall sign here for the latest revision.

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ACI	AMERICAN CONCRETE INSTITUTE
AHEX	ATLANTIC HIGHLY EXTENDED CRUST
AISC	AMERICAN INSTITUTE OF STEEL CONSTRUCTION
ANSI	AMERICAN NATIONAL STANDARD INSTITUTE
API	AMERICAN PETROLEUM INSTITUTE
ASCE	AMERICAN SOCIETY OF CIVIL ENGINEER
ASME	AMERICAN SOCIETY OF MECHANICAL ENGINEERS
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
AWWA	AMERICAN WATER WORKS ASSOCIATED
BDB	BEYOND DESIGN BASIS
BE	BEST ESTIMATE
CEUS	CENTRAL AND EASTERN UNITED STATES
CEUS-SSC	CENTRAL AND EASTERN UNITED STATES SEISMIC SOURCE CHARACTERIZATION
COV	COEFFICIENT OF VARIATION
DBNPS	DAVIS BESSE NUCLEAR POWER STATION
DF	DESIGN FACTOR
DRS	DESIGN RESPONSE SPECTRA
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
ESEP	EXPEDITED SEISMIC EVALUATION PROCESS
FENOC	FIRSTENERGY NUCLEAR OPERATING COMPANY
FLEX	DIVERSE AND FLEXIBLE COPING STRATEGIES
ft	FEET
ft/s	FEET PER SECOND
g	GRAVITY

LIST OF ACRONYMS (CONTINUED)

GIP	GENERIC IMPLEMENTATION PROGRAM
GMM	GROUND MOTION MODEL
GMPE	GROUND MOTION PREDICTION EQUATIONS
GMRS	GROUND MOTION RESPONSE SPECTRUM
HCLPF	HIGH CONFIDENCE OF LOW PROBABILITY OF FAILURE
HZ	HERTZ
IBEB	ILLINOIS BASIS EXTENDED BASEMENT
ICBO	INTERNATIONAL CONFERENCE OF BUILDING OFICIALS
IHS	IPEEE HCLPF SPECTRUM
IPEEE	INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS
ISG	INTERIM STAFF GUIDANCE
ISRS	IN-STRUCTURE RESPONSE SPECTRA
km	KILOMETERS
km/s	KILOMETER PER SECOND
LB	LOWER BOUND
LMSM	LUMPED MASS STICK MODELS
M	MAGNITUDE
MAFE	MEAN ANNUAL FREQUENCY EXCEEDANCE
MESE-N	MESOZOIC AND YOUNGER EXTENDED CRUST – NARROW
MESE-W	MESOZOIC AND YOUNGER EXTENDED CRUST – WIDE
MIDC_A	MIDCONTINENT-CRATON ALTERNATIVE A
MIDC_B	MIDCONTINENT-CRATON ALTERNATIVE B
MIDC_C	MIDCONTINENT-CRATON ALTERNATIVE C
MIDC_D	MIDCONTINENT-CRATON ALTERNATIVE D
MMI	MODIFIED MERCALLI INTENSITY
MYA	MILLION YEARS
NAP	NORTHERN APPALACHIANS
NEI	NUCLEAR ENERGY INSTITUTE

LIST OF ACRONYMS (CONTINUED)

NEP	NON-EXCEEDANCES PROBABILITY
NFSM	NEW MADRID FAULT SYSTEM
NMESE-N	NON-MESOZOIC AND YOUNGER EXTENDED CRUST – NARROW
NMESE-W	NON-MESOZOIC AND YOUNGER EXTENDED CRUST – WIDE
NPP	NUCLEAR POWER PLANT
NRC	UNITED STATES NUCLEAR REGULATORY COMMISSION
NTTF	NEAR-TERM TASK FORCE
NUREG	NUCLEAR REGULATORY COMMISSION TECHNICAL REPORT
NUREG/CR	NUCLEAR REGULATORY COMMISSION CONTRACTOR REPORT
PEZ_N	PALEOZOIC EXTENDED CRUST NARROW
PEZ_W	PALEOZOIC EXTENDED CRUST WIDE
Pf	TARGET PERFORMANCE LEVEL
PGA	PEAK GROUND ACCELERATION
PSHA	PROBABILISTIC SEISMIC HAZARD ANALYSIS
RB	REACTOR BUILDING
RG	REGULATORY GUIDE
RLE	REVIEW LEVEL EARTHQUAKE
RLME	REPEAT LARGE MAGNITUDE EARTHQUAKE
RR	REELFOOT RIFT
RR-RCG	REELFOOT RIFT INCLUDING THE ROUGH CREEK GRABEN
RVT	RANDOM VIBRATION THEORY
s	SECONDS
SDC	SEISMIC DESIGN CATEGORIES
SER	SAFETY EVALUATION REPORT
SEWS	SEISMIC EVALUATION WORKSHEETS
SLR	ST. LAWRENCE RIFT ZONE
SMA	SEISMIC MARGIN ASSESSMENT
SPID	SCREENING, PRIORITIZATION, AND IMPLEMENTATION DETAILS
SPRA	SEISMIC PROBABILISTIC RISK ASSESSMENT

LIST OF ACRONYMS (CONTINUED)

SPT	STANDARD PENETRATION TEST
SQUG	SEISMIC QUALIFICATION UTILITY GROUP
SRSS	SQUARE ROOT OF THE SUM OF THE SQUARES
SSC	SYSTEM, STRUCTURE, AND COMPONENTS
SSE	SAFE SHUTDOWN EARTHQUAKE
SSEL	SAFE SHUTDOWN EQUIPMENT LIST
SSI	SOIL STRUCTURE INTERACTION
STUDY_R	STUDY REGION
UB	UPPER BOUND
UHRS	UNIFORM HAZARD RESPONSE SPECTRA
USAR	UPDATED SAFETY ANALYSIS REPORT
USI	UNRESOLVED SAFETY ISSUE
V_p	PRESSURE WAVE VELOCITY
V_s	SHEAR WAVE VELOCITY

NTTF 2.1 SEISMIC HAZARD AND SCREENING REPORT DAVIS-BESSE NUCLEAR POWER STATION OTTAWA COUNTY, OHIO

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, 2012a) that requests information to assure that these recommendations are addressed by all United States NPPs. The 50.54(f) letter 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 NRC staff include a seismic probabilistic risk assessment (SPRA), or a seismic margin assessment (SMA). Based upon the risk assessment results, the NRC staff will determine whether additional regulatory actions are necessary.

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, 2012a) pertaining to NTTF Recommendation 2.1 for the Davis Besse Nuclear Power Station (DBNPS). DBNPS is located on Lake Erie in Ottawa County, Ohio. It consists of one, 925 megawatt (MW) pressurized water reactor unit. The Nuclear Steam Supply System (NSSS) was designed by Babcock and Wilcox. Bechtel Power Corporation designed the balance of plant and served as the construction manager. The plant began commercial operation in July 1978, as stated in the Updated Safety Analysis Report (USAR), (Toledo Edison, 2012).

In providing the information contained here, FirstEnergy Nuclear Operating Company (FENOC) has 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* (Electric Power Research Institute [EPRI], 2013a). The Augmented Approach, *Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima NTTF Recommendation 2.1: Seismic* (EPRI, 2013b), has been developed as the process for evaluating, if required, critical plant equipment as an interim action to demonstrate additional plant safety margin prior to performing the complete plant seismic risk evaluations.

Reference is made to FENOC's Partial Submittal (FENOC, 2013a) summarizing the site geologic and geotechnical information. The "Description of Subsurface Materials and Properties," and the "Development of Base-Case Profiles and Nonlinear Material Properties" presented in FENOC, (2013a) are repeated here for completeness.

1.1 Summary of Licensing Basis

The original geologic and seismic siting investigations for DBNPS 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 (SSC). The Category I SSCs are identified in Table 3.2-1 of the USAR (Toledo Edison, 2012).

1.2 Summary of Ground Motion Response Spectrum and Screening Results

In response to the 50.54(f) letter (NRC, 2012a) and following the guidance provided in the SPID (EPRI, 2013a), a seismic hazard reevaluation for DBNPS was performed. For screening purposes, a Ground Motion Response Spectrum (GMRS) was developed. Based on the results of the screening evaluation, DBNPS screens in for risk evaluation, a Spent Fuel Pool evaluation, and a High Frequency Confirmation. In the 1 to 10 Hertz (Hz) part of the response spectrum, the GMRS exceeds the horizontal SSE and above 10 Hz the GMRS also exceeds the horizontal SSE.

1.3 Organization of this Report

The remainder of this Report is organized as follows: ***Section 2.0*** provides the Seismic Hazard Reevaluation that was performed for the DBNPS Site, including the probabilistic seismic hazard analysis (PSHA) for hard-rock site conditions, the site response evaluation, seismic hazard at the SSE control point, and the derivation of the GMRS. ***Section 3.0*** provides a summary of the DBNPS SSE ground motion. ***Section 4.0*** provides the screening evaluation, including a comparison between the GMRS and SSE, and the screening evaluation outcome. ***Section 5.0*** describes interim actions completed for DBNPS and ***Section 6.0*** provides conclusions.

2.0 SEISMIC HAZARD REEVALUATION

The DBNPS Site is located on the southwestern shore of Lake Erie in Ottawa County, Ohio. It lies in the Lake Plains sub-province of the Central Low Land Physiographic province. The Lake Plains sub-province is nearly flat and has poor surface drainage characteristics. The Site bedrock consists of horizontally stratified, sedimentary, argillaceous dolomite containing interbedded gypsum, anhydrite, and shale of the Tymochtee Formation. Approximately 15 feet (ft) of glacial tills and glaciolacustrine deposits overlie the Site bedrock.

The USAR (Toledo Edison, 2012, Appendix 2C) states that, based on historic records, the intensity felt at the Site is less than Modified Mercalli Intensity (MMI) V. Additionally, no earthquakes of epicentral intensity greater than MMI V have occurred within 50 miles of the Site. The study of the historic regional and local earthquakes concludes that a site intensity of "...MM VI should be considered to have a small probability of occurring, and that it is improbable, but possible, that earthquakes be felt at the Site with the intensity of a medium MM VII (7.5)...". Further, based on the analysis of regional and local geologic structural features, the USAR concludes that with the exception of the Findlay Arch, the Site is not affected by other regional or by local geologic structural features.

Category I SSCs are designed for a safe shutdown due to horizontal PGA at the rock surface at the base of the foundation level of 15 percent of gravity (0.15g).

2.1 REGIONAL AND LOCAL GEOLOGY

The geologic strata in the region result from alternating episodes of deposition and erosion during the Paleozoic and the subsequent glacial stages during the Pleistocene. The glaciolacustrine deposits overlie glacial till deposits, Paleozoic sedimentary rocks, and deep basement igneous and metamorphic rocks of the Precambrian. The nominal plant grade elevation (EL) is 583 ft. The bedrock at the Site is a soft to hard, thinly bedded to massive, laminated, and argillaceous dolomite of the Tymochtee Formation. The top of bedrock varies from EL 560 to 540 ft. The local sedimentary bedrock exposures have a very slight dip. The base of the Reactor Building (RB) is founded in the bedrock at EL 540 ft.

Based on the pre-glacial geologic history of the region described by Hough (1958), during the Paleozoic Era more than 10,000 ft of sediments accumulated in the Michigan and the Illinois basins. These sediments consisted of sands, calcareous material, and clays deposited by advancing and receding seas during the Late Cambrian, and continuing into the Ordovician (about 500 Million Years [MYa]), characterized by widespread flooding. Partial isolation of the Michigan basin in the Late Silurian resulted in extensive evaporitic deposits of salt and gypsum. Toward the end of the Silurian, re-transgression of the seas deposited the usual marine calcareous sediments, which were subsequently lithified to dolomite. The duration from the Devonian to the Permian periods was characterized by diminishing flooding episodes as the seas alternately transgressed and regressed. The Paleozoic Era ended with the Appalachian Orogeny.

The predominant geologic processes in the subsequent Mesozoic and Cenozoic eras, during which the region apparently remained above water, were erosion and glaciations. Glacial till deposited during the Pleistocene Epoch by advancing glaciers varies in thickness from a few feet to over 400 ft (Goldthwait et al., 1961). The surficial glaciolacustrine deposits formed when the ice sheets retreated and outlets for lakes were considerably higher than at present.

The major structural features in the region are the Findlay Arch, the Michigan Basin, the Appalachian Geosyncline, the Ohio-Indiana Platform, and three faults: the Bowling Green Fault, the Electric Fault, and the Osborn Fault. These features are described in Appendix 2C of the USAR (Toledo Edison, 2012). Of these regional features, the USAR identifies only the Findlay Arch as of significance to the site seismicity.

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 (NRC, 2012a) and following the guidance in the SPID (EPRI, 2013a), a PSHA was completed using the recently developed Central and Eastern United States Seismic Source Characterization (CEUS-SSC) for Nuclear Facilities (EPRI/DOE/NRC,

2012). The PSHA uses a minimum moment magnitude cutoff of 5.0 for hazard integration, as specified in the 50.54(f) letter.

The CEUS-SSC model consists of distributed seismicity sources and repeated large magnitude earthquake (RLME) sources. Distributed seismicity sources are characterized following two approaches; the Mmax approach and the seismotectonic approach.

The DBNPS PSHA accounts for the CEUS-SSC distributed seismicity source zones out to at least a distance of 400 mi (640 km) around the DBNPS. This distance exceeds the 200 mile (320 km) recommendation contained in NRC (2007) and was chosen for completeness. Distributed seismicity sources included in this Site PSHA are the following:

- Mesozoic and younger extended crust – narrow and wide (MESE-N and MESE-W)
- Non-Mesozoic and younger extended crust – narrow and wide (NMESE-N and NMESE-W)
- Study Region (STUDY_R)
- Atlantic Highly Extended Crust (AHEX)
- Northern Appalachians (NAP)
- St. Lawrence Rift Zone, including the Ottawa and Saguenay grabens (SLR)
- Extended Continental Crust – Atlantic Margin (ECC_AM)
- Illinois Basin Extended Basement (IBEB)
- Midcontinent-Craton alternatives A to D (MIDC_A, MID_B, MID_C, and MID_D)
- Paleozoic Extended Crust narrow and wide (PEZ_N and PEZ_W)
- Reelfoot Rift (RR and RR-RCG)

RLME seismic sources within or near 1,000 km from the Site are included in the PSHA as follows:

- Charlevoix
- Charleston
- New Madrid Fault System (NMFS)

- Eastern Rift Margin Fault northern and southern segments (ERM-N and ERM-S)
- Marianna Zone
- Commerce Fault
- Wabash Valley

For each of the above distributed seismicity and RLME sources, the mid-continent version of the updated EPRI Ground Motion Model (GMM) was used (EPRI, 2013c).

2.2.2 Base-Rock Seismic Hazard Curves

While the SPID (EPRI, 2013a) does not require that base-rock seismic hazard curves be provided, they are included here as background information. These were developed by FENOC as part of an on-going SPRA effort. ***Figure 2-1 and Table 2-1*** present the mean hard-rock hazard curves at the DBNPS Site resulting from the PSHA. The hazard curves show the mean annual frequency of exceedance (MAFE) for spectral acceleration at the seven response spectral frequencies (100 Hz, 25 Hz, 10 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz) for which the updated EPRI GMM (2013c) is defined.

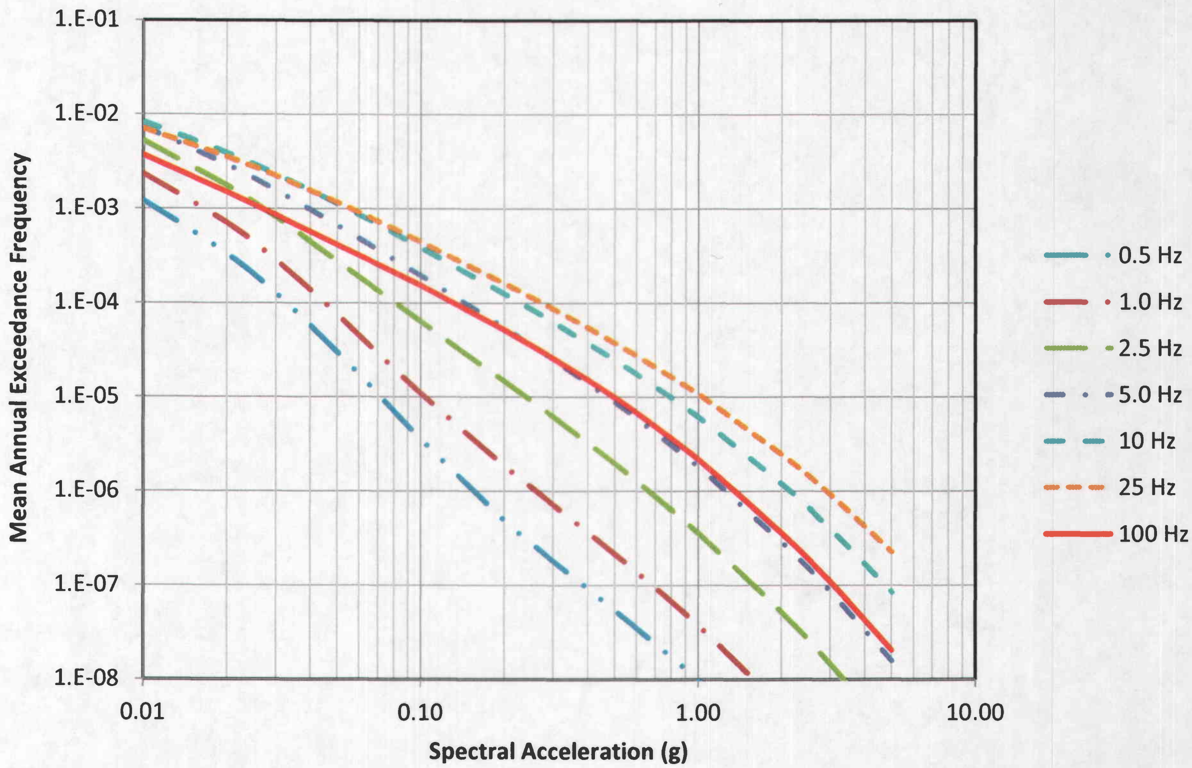


FIGURE 2-1
DBNPS MEAN SEISMIC HAZARD AT HARD ROCK

Consistent with the SPID (EPRI, 2013a), Approach 3 of NUREG/CR-6728 (McGuire et al., 2001) is used to calculate the seismic hazard curves at the SSE control point elevation (the base of the RB foundation). This method uses the median and log standard deviations of the site amplification factors (AFs) developed as described in ***Section 2.3***. The control point hazard curves are presented in ***Section 2.4.4***.

TABLE 2-1
MEAN SEISMIC HAZARD AT HARD ROCK
DBNPS SITE

GROUND MOTION LEVEL [g]	MEAN ANNUAL FREQUENCY OF EXCEEDANCE FOR SPECTRAL FREQUENCIES						
	0.5 Hz	1.0 Hz	2.5 Hz	5.0 Hz	10 Hz	25 Hz	100 Hz
0.01	1.20E-03	2.34E-03	5.20E-03	7.31E-03	8.26E-03	7.01E-03	3.70E-03
0.02	3.30E-04	7.07E-04	1.74E-03	2.92E-03	3.87E-03	3.53E-03	1.50E-03
0.03	1.25E-04	2.87E-04	8.04E-04	1.56E-03	2.31E-03	2.22E-03	8.54E-04
0.04	5.74E-05	1.38E-04	4.44E-04	9.72E-04	1.55E-03	1.55E-03	5.70E-04
0.05	3.01E-05	7.58E-05	2.77E-04	6.63E-04	1.12E-03	1.16E-03	4.16E-04
0.06	1.73E-05	4.58E-05	1.87E-04	4.82E-04	8.53E-04	9.09E-04	3.21E-04
0.07	1.08E-05	2.97E-05	1.34E-04	3.68E-04	6.73E-04	7.34E-04	2.58E-04
0.08	7.07E-06	2.04E-05	1.01E-04	2.90E-04	5.46E-04	6.09E-04	2.13E-04
0.09	4.90E-06	1.47E-05	7.85E-05	2.35E-04	4.53E-04	5.15E-04	1.79E-04
0.10	3.54E-06	1.10E-05	6.28E-05	1.94E-04	3.83E-04	4.43E-04	1.54E-04
0.20	4.89E-07	1.88E-06	1.46E-05	5.43E-05	1.24E-04	1.61E-04	5.21E-05
0.25	2.79E-07	1.11E-06	9.08E-06	3.55E-05	8.47E-05	1.15E-04	3.57E-05
0.30	1.80E-07	7.21E-07	6.11E-06	2.49E-05	6.18E-05	8.62E-05	2.59E-05
0.40	9.12E-08	3.68E-07	3.23E-06	1.40E-05	3.71E-05	5.44E-05	1.53E-05
0.50	5.38E-08	2.16E-07	1.94E-06	8.77E-06	2.45E-05	3.75E-05	9.86E-06
0.60	3.48E-08	1.38E-07	1.26E-06	5.90E-06	1.73E-05	2.73E-05	6.77E-06
0.70	2.39E-08	9.44E-08	8.67E-07	4.18E-06	1.27E-05	2.08E-05	4.87E-06
0.80	1.72E-08	6.71E-08	6.23E-07	3.07E-06	9.71E-06	1.62E-05	3.63E-06
0.90	1.28E-08	4.95E-08	4.63E-07	2.32E-06	7.58E-06	1.30E-05	2.77E-06
1.00	9.72E-09	3.74E-08	3.53E-07	1.80E-06	6.04E-06	1.06E-05	2.16E-06
2.00	1.43E-09	5.16E-09	5.11E-08	2.86E-07	1.18E-06	2.44E-06	3.59E-07
3.00	4.11E-10	1.42E-09	1.44E-08	8.50E-08	3.94E-07	9.11E-07	1.09E-07
5.00	7.34E-11	2.39E-10	2.48E-09	1.57E-08	8.36E-08	2.26E-07	2.03E-08

2.3 SITE RESPONSE EVALUATION

Category I structures of the DBNPS are founded in the dolomite bedrock (Toledo Edison, 2012, Section 3.7.2.6) at elevations varying from 540 ft for the RB to 555 ft for the Auxiliary Building Area 8. The dolomite bedrock is characterized by a shear wave velocity (V_S) of about 5,000 ft/s. Following the guidance contained in Seismic Enclosure 1 of the 50.54(f) Request for Information (NRC, 2012a) and in the SPID (EPRI, 2013a) for NPP sites that are not sited on hard rock

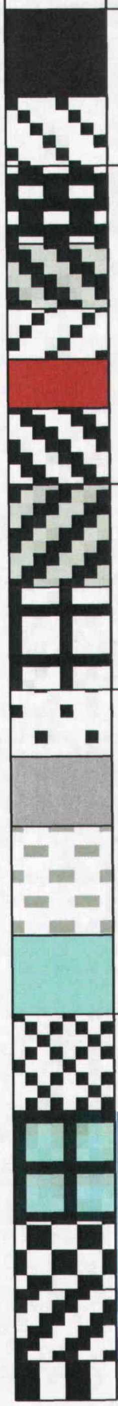
(defined as 2.83 km/s), a site response analysis was performed for DBNPS Site. The following sections describe the various inputs to the site response analysis. These inputs are summarized in ***Appendix A***.

2.3.1 Description of Subsurface Materials and Properties

The site stratigraphy presented here is based in part on site-specific geotechnical investigations reported in the USAR (Toledo Edison, 2012, Section 2.5.4 and Appendix 2C). Of the 51 rock core borings, four borings penetrated to a depth of about 195 ft from the surface and were terminated in the Upper Silurian Greenfield Formation underlying the dolomite bedrock of the Tymochtee Formation. The remaining rock cores were terminated at a depth of about 115 ft, a few feet below the Tymochtee.

The geologic profile below the reported subsurface investigation depth is based on the analysis of formation tops and bottoms from available deep well logs in the vicinity of the Site, obtained from the Ohio Geological Survey. The units and thicknesses down to rock of Middle Ordovician age were obtained from deep wells located about 2-3 miles west of the Site in Ottawa County, while the units and thicknesses below rock of Middle Ordovician age are interpreted from deeper wells located about 15-20 miles to the south of the Site in Sandusky County, along with some wells about 35 miles southwest of the Site in Wood County. Due to the relative proximity of these deep wells to the Site and the general flat lying (low dip) nature of the geologic units, the unit lithologies and thicknesses can be reliably assumed to be similar to those below the Site.

The USAR (Toledo Edison, 2012) does not make reference to the well data. However, the site stratigraphy constructed here on the basis of the well data is consistent with the Regional and Local Geology discussed in Appendix 2C of the USAR. ***Figure 2-2*** presents the stratigraphic soil/rock column underlying the Site, and ***Table 2-2*** presents the stratigraphy extending to Precambrian age deposits, identifying unit boundary elevations and depths as estimated from the subsurface investigations reported in the USAR and available well logs in the Site vicinity.



Legend	Epoch or Period	lithology
	Pleisto-cene	Pleistocene: glaciolacustrine; stiff, fissured, desiccated, gray and brown silty clay
		Pleistocene: Glacial till; hard, fissured, desiccated, gray to brown sandy clay
	Silurian	Upper Silurian Tymochtee formation: argillaceous Dolomite
		Upper Silurian Greenfield formation: Dolomite
		Middle Silurian Lockport Dolomite
		Middle Silurian Rochester (Niagrian) Shale
		Middle Silurian Clinton/Cataract Group: interbedded dolomite, limestone and shale
	Upper Ordovician	Upper Ordovician Queenston formation: shale, siltstone and sandstone
		Upper Ordovician Eden formation: shales and limestones (includes Utica shale)
	Middle Ordovician	Middle Ordovician Trenton formation: Limestone
		Middle Ordovician Black River (Gull River) Formation: limestone and dolomite
		Middle Ordovician Glenwood (Wells Creek) Formation: sandstones, carbonates and shales
		Middle Ordovician St. Peter (Wells Creek) Formation: Sandstone
		Lower Ordovician to Upper Cambrian Knox Formation: Dolomite
	Cambrian	Upper Cambrian Franconia Formation (or Kerbel and Conasauga fms): sandstone and dolomitic sandstone
		Middle Cambrian Eau Claire Formation: Shale, Siltstone, Sandstone and Dolomite
		Lower to Middle Cambrian Mt. Simon formation: Sandstone
		Precambrian Granite

FIGURE 2-2
STRATIGRAPHIC COLUMN UNDERLYING THE DBNPS SITE

TABLE 2-2
SUBSURFACE STRATIGRAPHY AND UNIT ELEVATIONS AND DEPTHS AT THE DBNPS SITE

TOP EL [ft]	BOT. EL [ft]	LITHOLOGY	TOP DEPTH [ft]	BOT. DEPTH [ft]
575	565	Pleistocene: glaciolacustrine; stiff, fissured, desiccated, gray and brown silty clay	0.0	10
565	555	Pleistocene: Glacial till; hard, fissured, desiccated, gray to brown sandy clay	10	20
555	460	Upper Silurian Tymochtee formation: argillaceous dolomite	20	115
460	370	Upper Silurian Greenfield formation: Dolomite	115	205
370	30	Middle Silurian Lockport Dolomite	205	545
30	-20	Middle Silurian Rochester (Niagrian) Shale	545	595
-20	-105	Middle Silurian Clinton/Cataract Group: interbedded dolomite, limestone and shale	595	680
-105	-685	Upper Ordovician Queenston formation: shale, siltstone, and sandstone	680	1260
-685	-850	Upper Ordovician Eden formation: shales and limestones	1260	1425
-850	-1630	Middle Ordovician Trenton formation: Limestone	1425	2205
-1630	-1680	Middle Ordovician Black River (Gull River) formation: limestone and dolomite	2205	2255
-1680	-1690	Middle Ordovician Glenwood (Willis Creek) formation: sandstones, carbonates and shales	2255	2265
-1690	-1750	Middle Ordovician St. Peter (Willis Creek) formation: Sandstone	2265	2325
-1750	-1835	Lower Ordovician to Upper Cambrian Knox formation: Dolomite	2325	2410
-1835	-1975	Middle Cambrian Conasauga Group/Kerbel formation: sandstone	2410	2550
-1975	-2175	Middle Cambrian Rome formation: Dolomite	2550	2750
-2175	-2285	Lower to Middle Cambrian Mt. Simon formation: Sandstone	2750	2860
-2285	--	Precambrian Granite	2860	--

Surface soils consisting of marsh organic and beach sediments overlie the glacial deposits. The upper glaciolacustrine deposit in this stratigraphy is composed of stiff, fissured, desiccated, gray, and brown silty clay. The lower till deposit is composed of hard, fissured, desiccated, and gray to brown sandy clay. The thickness of glacial deposits in Ottawa County averages 25 ft.

Below the glacial deposits, the Upper Silurian Tymochtee Formation is reported to be about 80 to 100 ft thick. The Tymochtee Formation is a soft to hard, thinly bedded to massive, laminated, argillaceous dolomite. The lithology of the Greenfield Formation underlying the Tymochtee is similar to the Tymochtee Formation. Consequently, the contact between the Tymochtee and Greenfield Formations is difficult to detect, but based on results of the borings, it is located at an approximate EL 460 ft at the Site.

The stratigraphy below the Tymochtee and the Greenfield Formations consists of an approximately 2,250 ft thick sequence of various sedimentary rocks, predominantly limestones and dolomites with interbedded shales and sandstones of various thicknesses. These formations overlie the Precambrian granite basement located at approximately EL -2,300 ft.

2.3.2 Development of Base-Case Profiles and Nonlinear Material Properties

Most major structures of the DBNPS are founded in the dolomite bedrock at elevations varying between 540 ft for the RB to 555 ft for the Auxiliary Building Area 8. The base of the RB foundation level (EL 540 ft) is defined as the control point elevation, where the GMRS is developed.

The velocity profiles presented here are based on results of site investigations reported in the USAR (Toledo Edison, 2012) to the investigated depths. Twenty-six seismic refraction shot points and 140 seismic recordings were obtained to determine the in-situ shear-wave (V_S) and compression-wave (V_P) velocities of the Site bedrock material and the soil overburden. These measurements were substantiated by dynamic testing of soil and rock samples reported in the USAR. Variabilities in the V_S of the bedrock material and the overburden soil are estimated respectively, from velocity measurements and lab tests, and the Standard Penetration Test (SPT) data. In the Site area, the V_S and V_P velocities of the bedrock are essentially uniform with the average V_P of 12,700 ft/s and the average V_S of 6,700 ft/s.

Below the investigation depth, the deep rock stratigraphy is derived from well logs within about 2-3 miles of the Site, as well as sonic logs recorded in the wells in Sandusky County, 15-24 miles from the Site, and Wood County about 35 miles from the Site (FENOC, 2013). The sonic data were converted to V_P and V_S based on published literature (Pickett, 1963; Rafavich, 1984; Miller, 1990; and Castagna, 1993) reflecting the material type (limestone and dolomite,

anhydrites and salts), porosity and density, and to a lesser extent, the lithology. Additionally, based on published literature, V_P/V_S ratios for these types of geologic units were used to define the epistemic uncertainty for V_S.

Table 2-3 presents the summary geotechnical profile identifying the layer elevation ranges, V_S, and uncertainties in these parameters. In ***Table 2-3*** the SSE control point is 15 ft below the top of bedrock (EL 540 ft) within the massive dolomite bedrock with best-estimate (BE) V_S of 4948 ft/s.

TABLE 2-3
SUBSURFACE STRATIGRAPHY AND UNIT THICKNESSES - DBNPS SITE

ELEVATION [ft]	LAYER NO.	SOIL/ROCK DESCRIPTION	γ_{total} [pcf][H]	V_s [ft/s][C]	μ[I]
585	**Plant Grade**		-	-	-
585 to 565[G]	1	Glaciolacustrine Deposits	125	511±92[(D)]	0.4[(F)]
565 to 555	2	Glacial Till	132-136	643±116[(D)]	0.4[(F)]
555 to 548	3	Bedded Dolomite	150-152	3860±695[(E)]	0.31[(F)]
548 to 540		Massive Dolomite		4948±891[(E)]	
540	**GMRS Elevation – SSE Control Point at Base of Reactor Building**				
540-528	3	Massive Dolomite	150-152	4948±891[(E)]	
528 to 518	3	Bedded Dolomite	150-152	3970±715[(E)]	0.31[(F)]
518 to 508				5790±1042[(E)]	
508 to 460[(A)]				4071	
460 to 370[(B)]	4	Greenfield Dolomite (Upper Silurian)	176	5,672	0.31
370 to 30	5	Lockport Dolomite (Middle Silurian)	176	8,782	0.31
30 to -20	6	Shale	138	8,682	0.27
-20 to -105	7	Interbedded Dolomite, Limestone, and Shale	176	8,615	0.27
-105 to -685	8	Shale, Siltstone and Sandstone	142	6,514	0.3
-685 to -850	9	Shale and Limestone	176	5,996	0.29
-850 to -1530	10	Limestone	176	10,894	0.29
-1530 to -1580	11	Limestone and Dolomite	176	10,712	0.31
-1580 to -1590	12	Sandstones, Carbonates, and Shales	142	10,212	0.3
-1590 to -1650	13	Sandstone	145	10,212	0.3
-1650 to -1750	14	Dolomite	176	9,049	0.34
-1750 to -1875	15	Sandstone and Dolomite Sandstone	145	7,616	0.3
-1875 to -2075	16	Shale, Siltstone, Sandstone, and Dolomite	176	9,483	0.34
-2075 to -2185	17	Sandstone	145	7,337	0.3

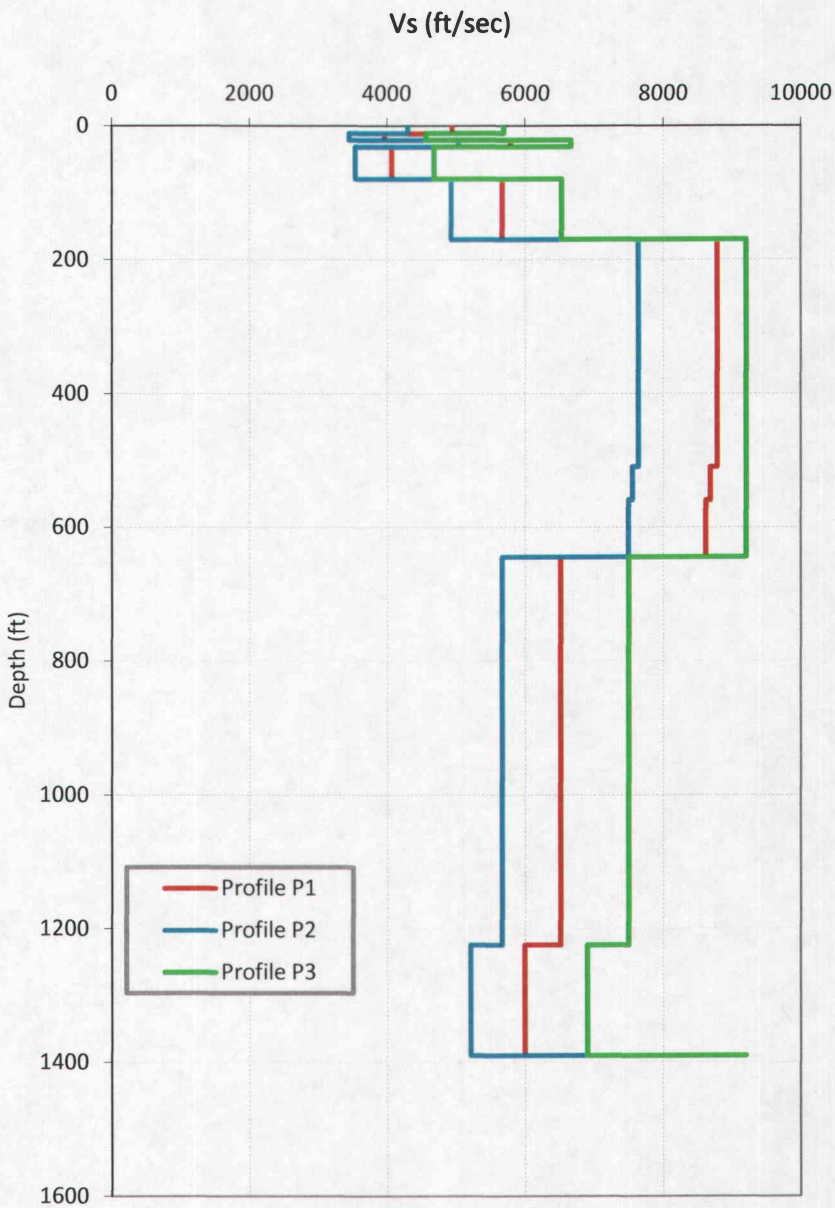
Notes:

A. Velocity data between EL503 ft and EL 482.5 ft is unavailable. Available parameters for stratum 3 are assumed applicable throughout the entire layer. Above EL 482.5 ft, a COV of 0.18 is used for the velocity variability estimates; B. Beginning from EL 482.5 ft and below, the Poisson's ratio, and dry unit weight values are based on literature data and engineering judgment. A 5% water content is assumed for the materials in the soil column; C. Unless otherwise noted, V_s presented here is the best estimate weighted average values based on the Well Log P-wave velocity and the values used for Poisson's ratio; D. Based on SPT-N values from 32 boreholes in Units 2 and 3; E. Obtained from cross-hole measurements in Units 2 and 3; F. Assumption based on Unit 1 data. Water table EL is approximately 575; G. 10 ft of Compacted Backfill, consisting of lacustrine soils and till is assumed to have the same velocities as In-Situ; H. Unit weight; I. Poisson's ratio.

2.3.2.1 Base-Case Shear-Wave Velocity Profiles

Based on the well characterized nature of the site, the generally flat lying geologic units, and the geology-specific V_P/V_S conversions, a scale factor of 1.15 is used for developing upper and lower base-cases to reflect epistemic uncertainty in V_S. The scale factor of 1.15 reflects a realistic range in Poisson's ratio for the type of geologic units found in the Paleozoic rocks underlying the site. The V_S profiles determined using the scale factor represent the epistemic uncertainty in the soil column from the Limestone Formation at EL -850 ft to the top of the massive dolomite bedrock underlying the base of the RB foundation mat.

Using the best-estimate V_S specified in ***Table 2-3***, three base-case profiles were developed using the scale factor of 1.15. The specified V_S were taken as the mean or BE base-case profile (P1) with lower and upper range base-case profiles P2 and P3, respectively. Consistent with the guidance in the SPID (EPRI, 2013a), the upper range base-case profile is constrained to not exceed a V_S of 9200 ft/sec. All three profiles extend to hard-rock at a depth of 1,390 ft below the base of the RB foundation. The base-case profiles (P1, P2, and P3) are shown on ***Figure 2-3*** and listed in ***Table 2-4***.



***Depth 0 ft corresponds to EL 540 ft**

FIGURE 2-3
BASE-CASE V_S PROFILES, DBNPS SITE

TABLE 2-4
BASE-CASE V_S PROFILES, DBNPS SITE

LAYER ELEVATION [ft]	PROFILE P1		PROFILE P2		PROFILE P3	
	V_s [ft/s]	DEPTH [ft]	V_s [ft/s]	DEPTH [ft]	V_s [ft/s]	DEPTH [ft]
540	4948	0	4303	0	5690	0
528	4948	12	4303	12	5690	12
528	3970	12	3452	12	4566	12
518	3970	22	3452	22	4566	22
518	5790	22	5035	22	6659	22
508	5790	32	5035	32	6659	32
508	4071	32	3540	32	4682	32
460	4071	80	3540	80	4682	80
460	5672	80	4932	80	6523	80
370	5672	170	4932	170	6523	170
370	8782	170	7637	170	9200	170
30	8782	510	7637	510	9200	510
30	8682	510	7550	510	9200	510
-20	8682	560	7550	560	9200	560
-20	8615	560	7491	560	9200	560
-105	8615	645	7491	645	9200	645
-105	6514	645	5664	645	7491	645
-685	6514	1225	5664	1225	7491	1225
-685	5996	1225	5214	1225	6895	1225
-850	5996	1390	5214	1390	6895	1390
-850	9200	1390	9200	1390	9200	1390

2.3.2.2 Shear Modulus and Damping Curves

Consistent with the SPID (EPRI, 2013a), uncertainty and variability in material dynamic properties are included in the site response analysis. For the rock material over the upper 500 ft, uncertainty is represented by modeling the material as either linear or non-linear in its dynamic behavior. This material includes the massive and bedded dolomite layers. To represent the epistemic uncertainty in shear modulus and damping, two sets of shear modulus reduction and hysteretic damping curves were used. Consistent with the SPID (EPRI, 2013a), the EPRI rock curves (model M1) were used to represent the upper range nonlinearity likely in the materials at this Site, and linear behavior (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 was used as the constant damping values in the upper 500 ft. Below a

depth of 500 ft, linear material behavior is assumed for both models, with the damping value specified consistent with the kappa estimates for the site (values discussed in ***Section 2.3.2.3*** and shown on ***Table 2-5***).

2.3.2.3 Kappa

Near-surface site damping is often described in terms of the parameter kappa (EPRI, 2013a). Section B-5.1.3.1 of the SPID (EPRI, 2013a) recommends the following procedure for evaluating kappa:

1. Kappa for a firm rock site with at least 3,000 ft (1 km) of sedimentary rock may be estimated from the time-averaged S-wave velocity over the upper 100 ft (V_{s100}) of the subsurface profile.

2. Kappa for a site with less than 3,000 ft (1 km) of firm rock may be estimated with 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 seconds(s) for the underlying hard rock.

For the DBNPS site, kappa was estimated using the second of the above approaches because the thickness of the sedimentary rock overlying hard rock is 1,390 ft. There is confidence in the depth to hard rock, based on the available deep well sonic log data from the vicinity of the Site and the fact that geologic layers are generally flat lying. For each Vs profile, kappa was estimated using the low-strain damping from the EPRI rock curves in the top 500 ft and a Q=40 below that depth to the base of the profile. Using the range of kappa values obtained for the three velocity profiles described above in ***Section 2.3.2.1***, and including a kappa of 0.006s for the underlying hard rock, the total site kappa is estimated to be 0.0140s for profile P1, 0.0152 for profile P2, and 0.0132s for profile P3.

To complete the representation of uncertainty in kappa and, at the same time, reduce computational demands, a 50 percent variation to the base-case kappa estimates was added for profiles P2, and P3. For profile P2, the softest profile, the base-case kappa estimate of 0.0152s was augmented with 50 percent increase in kappa to a value of 0.0227s, resulting in two sets of analyses for profile P2. Similarly uncertainty in kappa for profile P3, the stiffest profile, was augmented with a 50 percent reduction in kappa, resulting in kappa values of 0.0132s and 0.0088s. The suite of kappa estimates and associated weights is listed in ***Table 2-5***. The base-

case kappa estimates were judged to be more likely (by 50 percent) and assessed weights of 0.6 compared to the augmented values with weights of 0.4. To maintain consistency in the site response analyses the low-strain damping values are adjusted consistent with the kappa value associated with each profile.

TABLE 2-5
KAPPA VALUES AND WEIGHTS USED IN SITE RESPONSE ANALYSIS

VELOCITY PROFILE	PROFILE WEIGHT	KAPPA [s]	KAPPA WEIGHT
P1 Base-Case	0.4	0.0140 (Kappa 1)	1.0
P2 Lower Range	0.3	0.0152 (Kappa 1)	0.6
		0.0227 (Kappa 2)	0.4
P3 Upper Range	0.3	0.0132 (Kappa 1)	0.6
		0.0088 (Kappa 2)	0.4

This unsymmetric approach results in an appropriate representation of the epistemic uncertainty in site response. It also significantly reduces computational demands relative to specifying three alternative kappa values for each velocity profile. When uncertainty and variability in other inputs are also considered, it results in 6,600 site response analyses (5 combinations of profiles and kappa values, 2 sets of material behavior models [linear and nonlinear for the upper 500 ft], 2 seismic source models [single and double corner inputs], 11 loading levels, and 30 soil profile realizations). The range of kappa values presented in ***Table 2-5*** is utilized in the site response analysis that is combined with the hard-rock seismic hazard to obtain the control point seismic hazard and the GMRS.

2.3.3 Randomization of Base Case Profiles

To account for the aleatory variability in dynamic material properties that is expected to occur across a site at the scale of a typical nuclear facility, variability in the V_S profiles and shear-strain dependent shear modulus and damping curves are incorporated in the site response calculations. For the DBNPS site, random V_S profiles were developed from the base case profiles shown on ***Figure 2-3***.

2.3.3.1 Randomization of Shear-wave Velocity Profiles

For the DBNPS site, aleatory variability in the V_s profile for the Site is represented by 30 randomized profiles developed from each of the base-case profiles shown on ***Figure 2-3***. These randomized velocity profiles were generated using a natural log standard deviation of 0.25 over the top 50 ft and a value of 0.15 below a depth of 50 ft. As specified in the SPID (EPRI, 2013a), 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. Additionally, the profiles were constrained to not exceed a V_S of 9,200 ft/s.

2.3.3.2 Randomization of Modulus Reduction and Hysteretic Damping Curves

For the DBNPS Site, aleatory variability in dynamic material property curves is represented using 30 randomizations derived from the base-case for each alternative model. The random generation of G/Gmax and damping ratio values are limited to upper and lower bounds of the BE ± two standard deviations, consistent with the SPID (EPRI, 2103a). The damping ratio values are limited to 15 percent. Also consistent with the SPID (EPRI, 2013a), a log normal distribution is used with a natural log standard deviation of 0.15 and 0.30 for modulus reduction and hysteretic damping, respectively.

2.3.4 Input Fourier Amplitude Spectra

Consistent with the guidance in Appendix B of the SPID (EPRI, 2013a), input Fourier amplitude spectra were defined for a single representative earthquake magnitude (M 6.5) using two different models for the shape of the seismic source spectrum (single-corner and double-corner). By selecting appropriate distances and depths, a suite of 11 different input amplitudes (median PGA ranging from 0.01 to 1.5 g) were modeled for use in the site response analyses. The characteristics of the seismic source and upper crustal attenuation properties assumed for the analysis of the DBNPS site were the same as those identified in Tables B-4, B-5, B-6, and B-7 of the SPID (EPRI, 2013a) as appropriate for typical CEUS sites.

2.3.5 Site Response Methodology

The site response analysis reported here implements an equivalent-linear method using the random vibration theory (RVT) approach. This approach utilizes a simple, efficient method for computing site-specific amplification functions and is consistent with existing NRC guidance and the SPID (EPRI, 2013a). The guidance contained in Appendix B of the SPID (EPRI, 2013a) on incorporating epistemic uncertainty in V_S, kappa, dynamic material properties, and source spectra was followed for the DBNPS Site.

2.3.6 Amplification Factors

The results of the site response analysis consist of factors (5 percent damped pseudo–absolute acceleration response spectra), that describe the amplification (or de-amplification) of reference hard-rock response spectra as a function of frequency and input reference hard-rock PGA amplitude. Amplification is determined for the SSE control point elevation at the base of the RB foundation level. Because of uncertainty and variability incorporated in the site response analysis, a distribution of amplification factors (AFs) is produced. The AFs are represented by a median (i.e., log-mean) amplification value and an associated log standard deviation (sigma ln) for each spectral frequency and input rock amplitude. Consistent with the SPID (EPRI, 2013a), median amplification was constrained to not fall below 0.5 to avoid extreme de-amplification that may reflect limitations of the methodology.

Figure 2-4 presents the median and +/- 1 standard deviation in the predicted amplification factors developed for the 11 loading levels parameterized by the reference (hard-rock) PGA (0.01 to 1.50g) for profile P1 and EPRI rock G/G_{max}, and hysteretic damping curves (EPRI, 2013a). Further, the amplification factors shown on ***Figure 2-4*** are developed for the hard-rock input motion based on the single-corner frequency source model. The variability in the amplification factors results from variability in V_S and modulus reduction and hysteretic damping curves. ***Figure 2-5*** presents similar information for profile P1 using the linear dynamic material property representation.

Comparison of amplification factors, including the effects of material nonlinearity in the DNNPS Site firm rock layers (model M1), with the corresponding amplification factors developed with

linear site response analyses (model M2) shows only minor effects of nonlinearity for frequencies below about 20 Hz and a loading level less than about 0.5g. Above about the 0.5g loading level, the differences increase, but only for spectral frequencies in excess of about 20 Hz.

Appendix A provides several tables that summarize the site response uncertainty analysis including the development of the site response logic tree (V_s models, kappa, dynamic properties) and a summary of the numerical values of the amplification factors at seven spectral frequencies and 11 input PGA values at hard rock. Additionally, ***Appendix A*** provides tables of the amplification factors for three loading levels consistent with the information shown on ***Figures 2-4 and 2-5.***

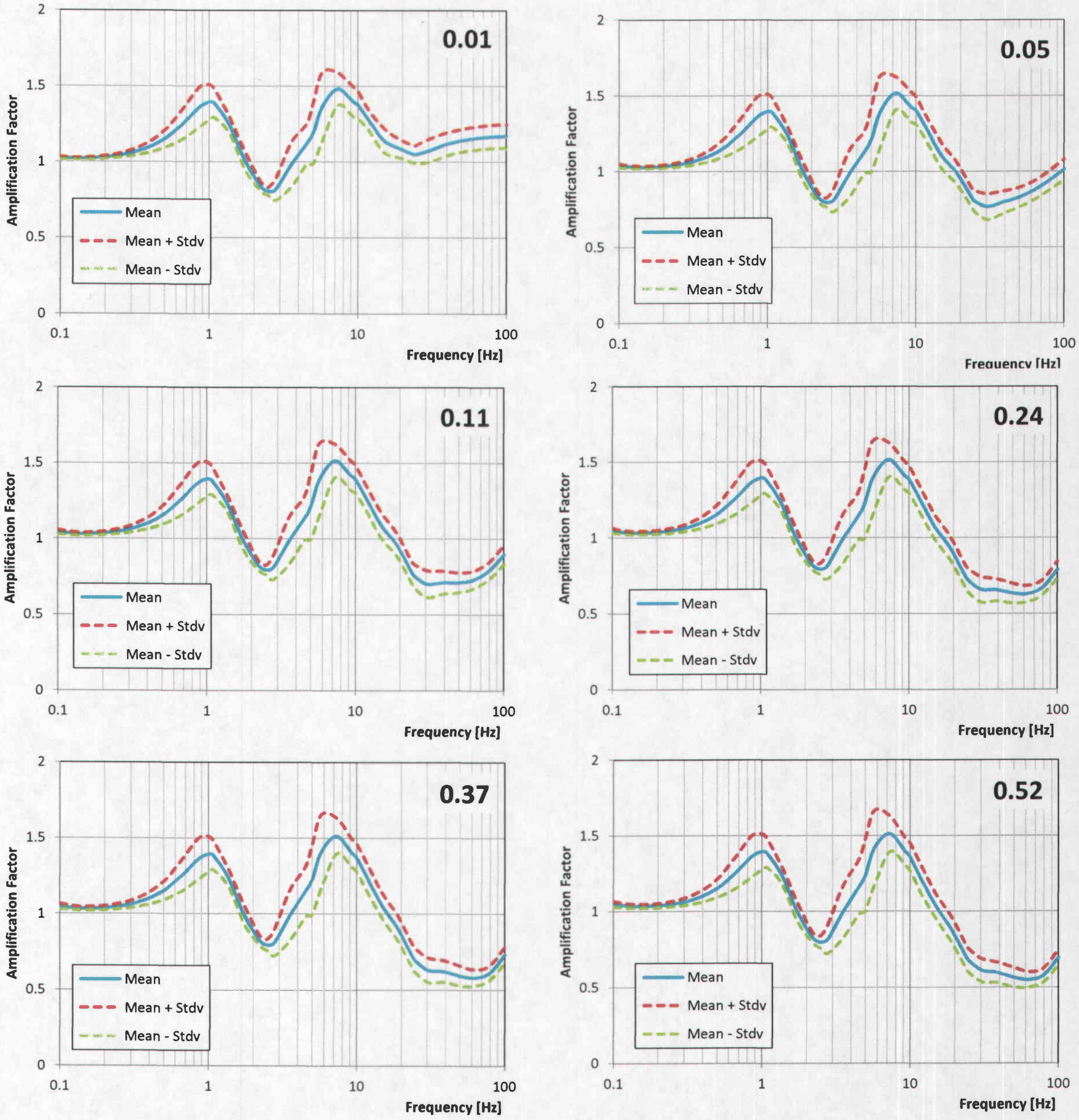


FIGURE 2-4
DBNPS SITE AMPLIFICATION FACTORS, BASE-CASE PROFILE (P1), EPRI ROCK G/GMAX AND DAMPING, KAPPA 1, 1-CORNER SOURCE MODEL

Note:

Quantities in the upper right hand corner represent the hard rock input 100 Hz spectral acceleration in g's.

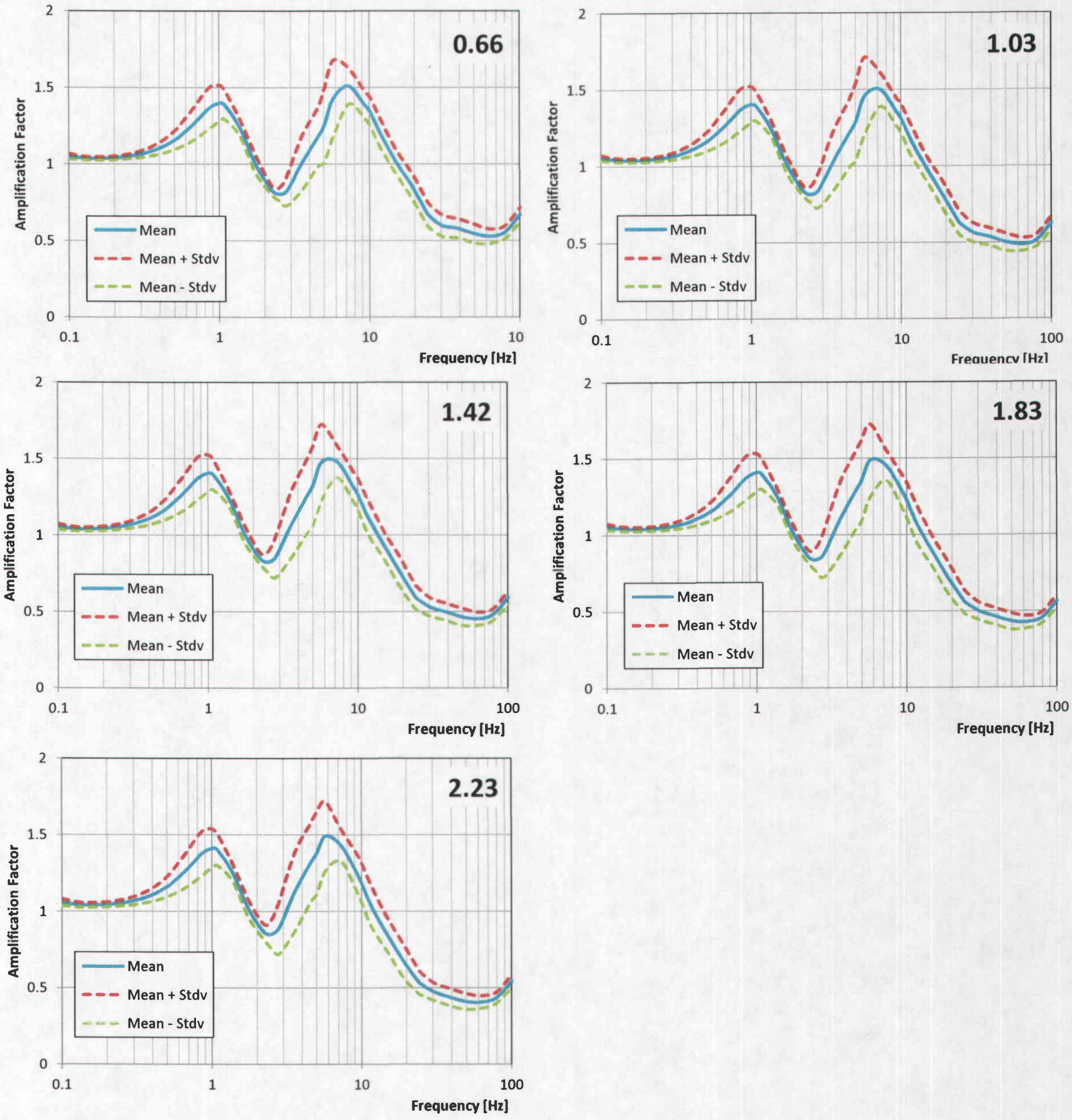


FIGURE 2-4
(CONTINUED)
DBNPS SITE AMPLIFICATION FACTORS, BASE-CASE PROFILE (P1), EPRI ROCK G/GMAX AND DAMPING, KAPPA 1, 1-CORNER SOURCE MODEL

Note:

Quantities in the upper right hand corner represent the hard rock input 100 Hz spectral acceleration in g's.

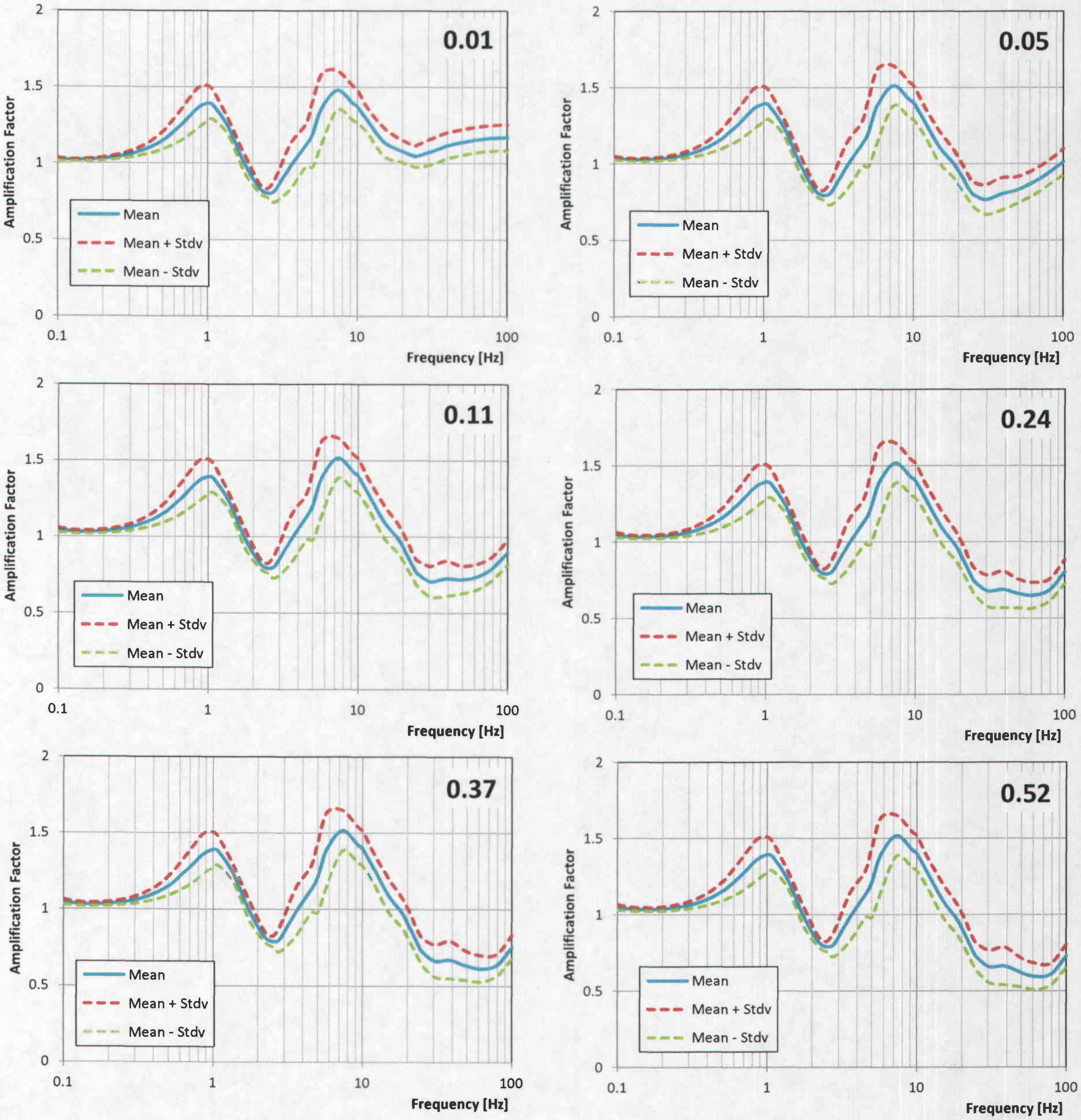


FIGURE 2-5
DBNPS SITE AMPLIFICATION FACTORS, BASE-CASE PROFILE (P1), LINEAR ROCK G/GMAX AND DAMPING, KAPPA 1, 1-CORNER SOURCE MODEL

Note:

Quantities in the upper right hand corner represent the hard rock input 100 Hz spectral acceleration in g's.

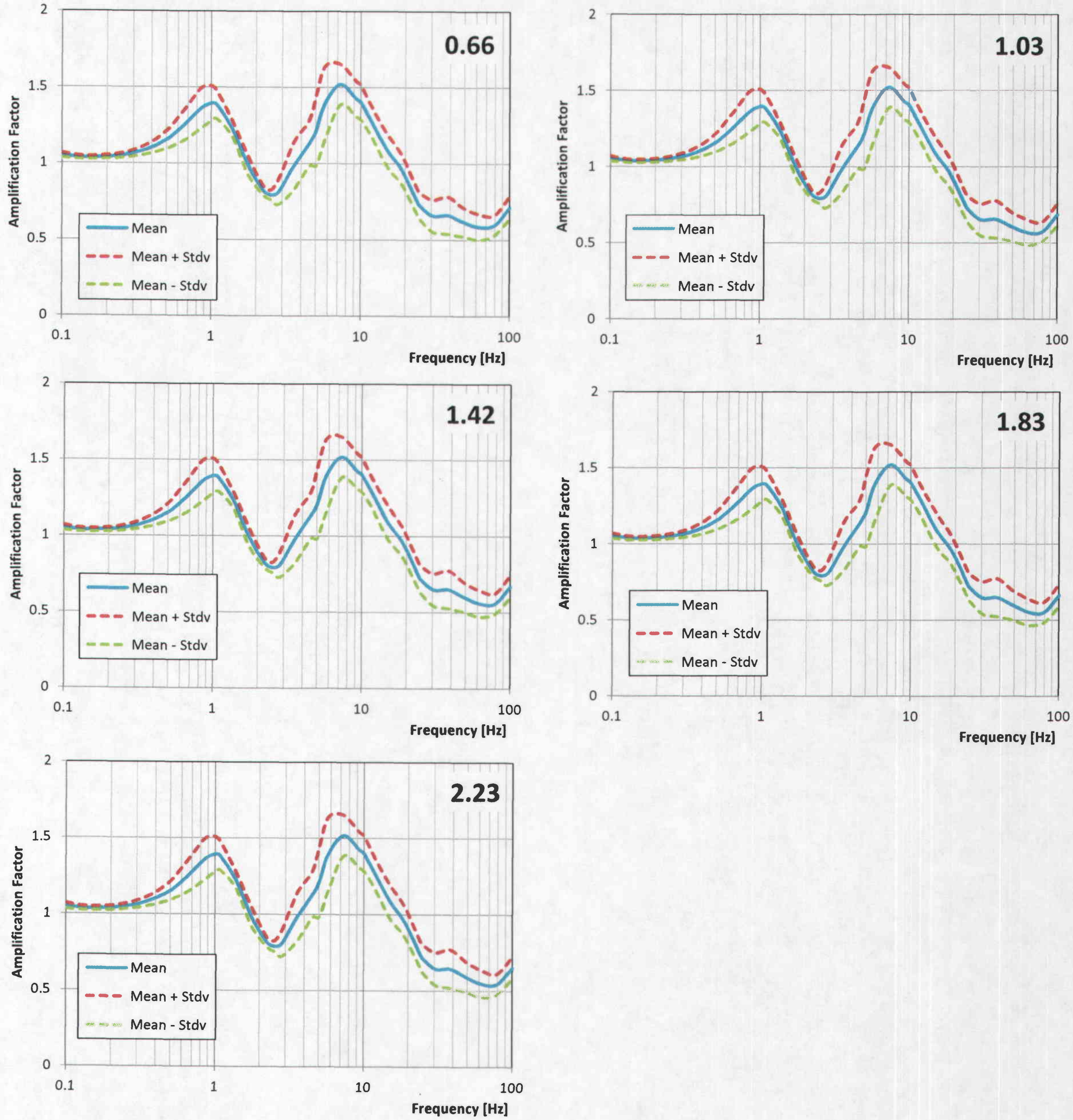


FIGURE 2-5
(CONTINUED)
DBNPS SITE AMPLIFICATION FACTORS, BASE-CASE PROFILE (P1), LINEAR ROCK G/GMAX AND DAMPING, KAPPA 1, 1-CORNER SOURCE MODEL

Note:

Quantities in the upper right hand corner represent the hard rock input 100 Hz spectral acceleration in g's.

2.4 CONTROL POINT SEISMIC HAZARD CURVES

As presented in ***Section 3.2*** below, the control point elevation is taken to be the base of the RB foundation level (EL 540 ft). The procedure to develop probabilistic site-specific control point hazard curves follows the methodology described in Section B-6.0 of the SPID (EPRI, 2013a). This procedure (referred to as Approach 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 specified oscillator frequencies.

The dynamic response of the rock column below the control point elevation is represented by the frequency- and amplitude-dependent amplification functions (median values and ln-standard deviations) developed and described in the previous section. The resulting control point mean hazard curves for the DBNPS Site are shown on ***Figure 2-6 and Table 2-6*** for the seven oscillator frequencies for which the EPRI (2013c) GMM is defined. Tabulated values of the site response amplification functions and control point hazard curves for various fractiles are provided in ***Appendix C***.

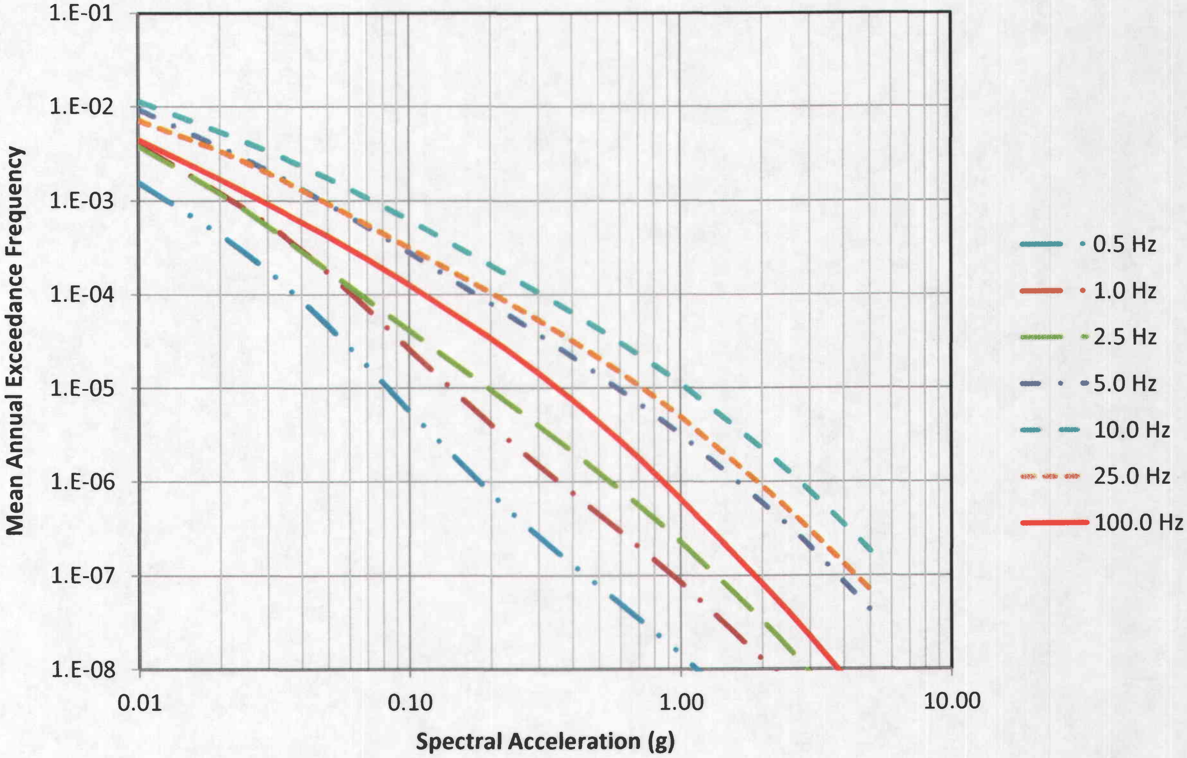


FIGURE 2-6
DBNPS MEAN CONTROL POINT (RB FOUNDATION) SEISMIC HAZARD AT SELECTED SPECTRAL FREQUENCIES

TABLE 2-6
DBNPS MEAN CONTROL POINT (RB FOUNDATION) SEISMIC HAZARD AT SELECTED SPECTRAL FREQUENCIES

GROUND MOTION LEVEL [g]	MEAN ANNUAL FREQUENCY OF EXCEEDANCE FOR SPECTRAL FREQUENCIES:						
	0.5 Hz	1.0 Hz	2.5 Hz	5.0 Hz	10 Hz	25 Hz	100 Hz
0.02	4.27E-04	1.19E-03	1.18E-03	3.69E-03	5.31E-03	3.31E-03	1.67E-03
0.03	1.76E-04	5.59E-04	5.24E-04	2.07E-03	3.33E-03	1.95E-03	9.11E-04
0.04	8.47E-05	2.94E-04	2.86E-04	1.32E-03	2.31E-03	1.29E-03	5.87E-04
0.05	4.57E-05	1.69E-04	1.77E-04	9.17E-04	1.71E-03	9.21E-04	4.14E-04
0.06	2.69E-05	1.05E-04	1.20E-04	6.74E-04	1.32E-03	6.94E-04	3.06E-04
0.07	1.69E-05	6.93E-05	8.62E-05	5.18E-04	1.05E-03	5.44E-04	2.35E-04

TABLE 2-6
DBNPS MEAN CONTROL POINT (RB FOUNDATION) SEISMIC HAZARD AT SELECTED SPECTRAL FREQUENCIES (CONTINUED)

GROUND MOTION LEVEL [g]	MEAN ANNUAL FREQUENCY OF EXCEEDANCE FOR SPECTRAL FREQUENCIES:						
	0.5 Hz	1.0 Hz	2.5 Hz	5.0 Hz	10 Hz	25 Hz	100 Hz
0.08	1.12E-05	4.79E-05	6.49E-05	4.11E-04	8.64E-04	4.41E-04	1.86E-04
0.09	7.75E-06	3.45E-05	5.06E-05	3.34E-04	7.23E-04	3.66E-04	1.51E-04
0.10	5.59E-06	2.57E-05	4.06E-05	2.77E-04	6.15E-04	3.10E-04	1.25E-04
0.20	7.47E-07	4.07E-06	9.42E-06	7.91E-05	2.03E-04	1.03E-04	3.37E-05
0.25	4.06E-07	2.31E-06	5.83E-06	5.24E-05	1.40E-04	7.14E-05	2.12E-05
0.30	2.57E-07	1.48E-06	3.91E-06	3.72E-05	1.03E-04	5.24E-05	1.43E-05
0.40	1.29E-07	7.50E-07	2.06E-06	2.14E-05	6.29E-05	3.15E-05	7.40E-06
0.50	7.64E-08	4.46E-07	1.23E-06	1.37E-05	4.22E-05	2.08E-05	4.31E-06
0.60	4.96E-08	2.91E-07	8.00E-07	9.44E-06	3.02E-05	1.46E-05	2.70E-06
0.70	3.42E-08	2.01E-07	5.51E-07	6.84E-06	2.25E-05	1.06E-05	1.78E-06
0.80	2.47E-08	1.46E-07	3.96E-07	5.14E-06	1.74E-05	8.01E-06	1.22E-06
0.90	1.85E-08	1.09E-07	2.94E-07	3.98E-06	1.37E-05	6.18E-06	8.72E-07
1.00	1.42E-08	8.38E-08	2.24E-07	3.15E-06	1.10E-05	4.87E-06	6.42E-07
2.00	2.16E-09	1.26E-08	3.27E-08	5.86E-07	2.21E-06	8.82E-07	8.12E-08
3.00	6.54E-10	3.85E-09	8.95E-09	1.99E-07	7.68E-07	2.97E-07	2.20E-08
5.00	1.23E-10	7.21E-10	1.56E-09	4.20E-08	1.80E-07	6.84E-08	3.77E-09

2.5 CONTROL POINT RESPONSE SPECTRA

The control point hazard curves described above have been used to develop uniform hazard response spectra (UHRS) and the GMRS. To ensure that important site response frequencies are accurately modeled, the control point response spectra are based on smoothed UHRS developed at the hard-rock boundary using the approach described by NRC (2007a) and McGuire et al., (2001). The UHRS were obtained through linear interpolation in log-log space to estimate the spectral acceleration at each oscillator frequency for the 1E-4 and 1E-5 per year hazard levels. The 1E-4 and 1E-5 UHRS, along with a design factor (DF) are used to compute the GMRS at the control point using the criteria in Regulatory Guide 1.208. ***Table 2-7*** presents the control point 1E-4 and 1E-5 UHRS and the GMRS, and ***Figure 2-7*** graphically illustrates the GMRS relative to the UHRS.

TABLE 2-7
DBNPS 5%-DAMPED UNIFORM HAZARD RESPONSE SPECTRA AND GMRS AT CONTROL POINT

FREQUENCY [Hz]	HORIZONTAL SPECTRAL ACCELERATION [g] AT THE RB FOUNDATION		
	$1x10^{-4}$ MAFE UHRS	$1x10^{-5}$ MAFE UHRS	GMRS
0.10	0.0027	0.0063	0.0032
0.13	0.0039	0.0092	0.0046
0.16	0.0056	0.0133	0.0067
0.20	0.0081	0.0192	0.0097
0.26	0.0118	0.0278	0.0141
0.33	0.0176	0.0406	0.0206
0.42	0.0266	0.0605	0.0308
0.50	0.0372	0.0832	0.0425
0.53	0.0390	0.0874	0.0446
0.67	0.0475	0.1078	0.0549
0.85	0.0570	0.1310	0.0666
1.00	0.0611	0.1416	0.0718
1.08	0.0640	0.1513	0.0764
1.37	0.0663	0.1673	0.0834
1.74	0.0616	0.1658	0.0816
2.21	0.0623	0.1789	0.0869
2.50	0.0655	0.1948	0.0940
2.81	0.0751	0.2275	0.1094
3.56	0.1072	0.3373	0.1609
4.52	0.1500	0.4892	0.2317
5.00	0.1759	0.5824	0.2750
5.74	0.2150	0.7181	0.3385
7.28	0.2648	0.8969	0.4216
9.24	0.2960	1.0126	0.4751
10.00	0.3042	1.0424	0.4889
11.72	0.2937	1.0146	0.4751
14.87	0.2627	0.9233	0.4308
18.87	0.2436	0.8609	0.4013
23.95	0.2094	0.7414	0.3455
25.00	0.2031	0.7190	0.3350
30.39	0.1908	0.6667	0.3115
38.57	0.1876	0.6446	0.3022
48.94	0.1746	0.5840	0.2752
62.10	0.1477	0.4700	0.2237
78.80	0.1221	0.3722	0.1787
100.00	0.1125	0.3507	0.1676

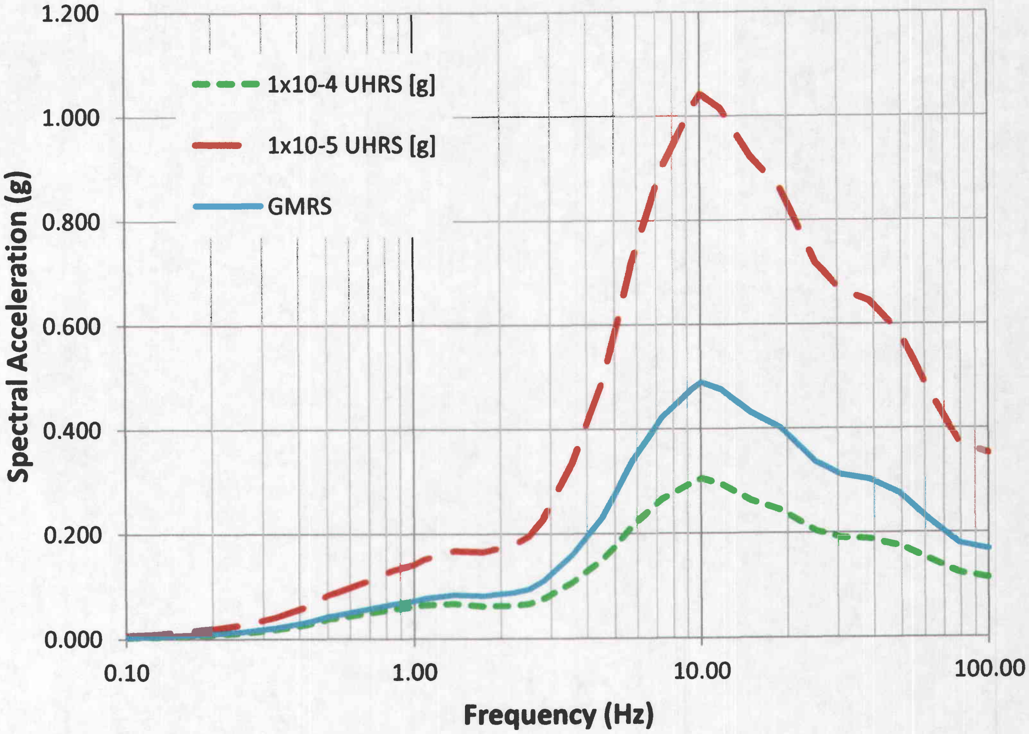


FIGURE 2-7
CONTROL POINT UNIFORM HAZARD RESPONSE SPECTRA AT MEAN ANNUAL FREQUENCIES OF EXCEEDANCE OF $1X10^{-4}$ AND $1X10^{-5}$, AND GROUND MOTION RESPONSE SPECTRUM AT DBNPS

3.0 PLANT DESIGN BASIS GROUND MOTION

The design basis for DBNPS is identified in the USAR (Toledo Edison, 2012).

3.1 SSE Description of Spectral Shape

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. Based on deterministic hazard analysis, the USAR (Toledo Edison, 2012, Appendix 2C, Section 2C.3.4, Table 2C.3-4) reports two design basis earthquakes. A Maximum Possible Earthquake (larger) is postulated primarily on the basis of structural geologic features. The ground motion associated with the Maximum Possible Earthquake is taken to represent the SSE ground motion. SSCs important to safety are designed to remain functional subject to the ground motion from the Maximum Possible Earthquake.

A second, Maximum Probable Earthquake (smaller) is postulated primarily on the basis of the historic earthquakes with qualitative consideration of the probability of occurrence. This earthquake produces vibratory ground motions used in the design of structures and equipment, whose failure would not result in the release of significant radioactivity and would not prevent reactor shutdown. The Maximum Probable Earthquake is similar to the Operating Basis Earthquake.

The SSE ground motion was developed on the basis of two postulated events; (1) a MMI VI occurring close to the site, representing the maximum possible for Lake Erie and South Central Michigan earthquakes, and (2) an MMI VII (7.5) occurring close to the site representing an event similar to the Anna, Ohio earthquake of 1937.

Using several correlations between MMI and PGA developed, for example, by Esteva et al., (1964) and Seed et al., (1969), a maximum PGA of 0.15g was estimated. The shape of the SSE horizontal spectrum derives from the 5%-damped average response spectra of several acceleration records. This shape is similar to that suggested by Newmark, et al, (1969). This PGA is taken to anchor the horizontal SSE spectrum at 5-percent damping defined by the following amplification factors:

- Acceleration region (f = 5 Hz) = 2.5
- Velocity region (f = 1 Hz) = 2.0
- Displacement region (f = 0.2 Hz) = 1.3

The 5-percent damped horizontal SSE spectral accelerations are presented in ***Table 3-1***. The corresponding vertical spectrum for the SSE is taken to be two-thirds the horizontal across the entire range of frequency. ***Figure 3-1*** presents the SSE 5%-Damped Response Spectra.

TABLE 3-1
SSE HORIZONTAL GROUND MOTION RESPONSE SPECTRUM FOR DBNPS

FREQUENCY [Hz]	SPECTRAL ACCELERATION [g]
0.10	0.004
0.37	0.060
2.31	0.374
8.00	0.374
33.00	0.150
100.00	0.150

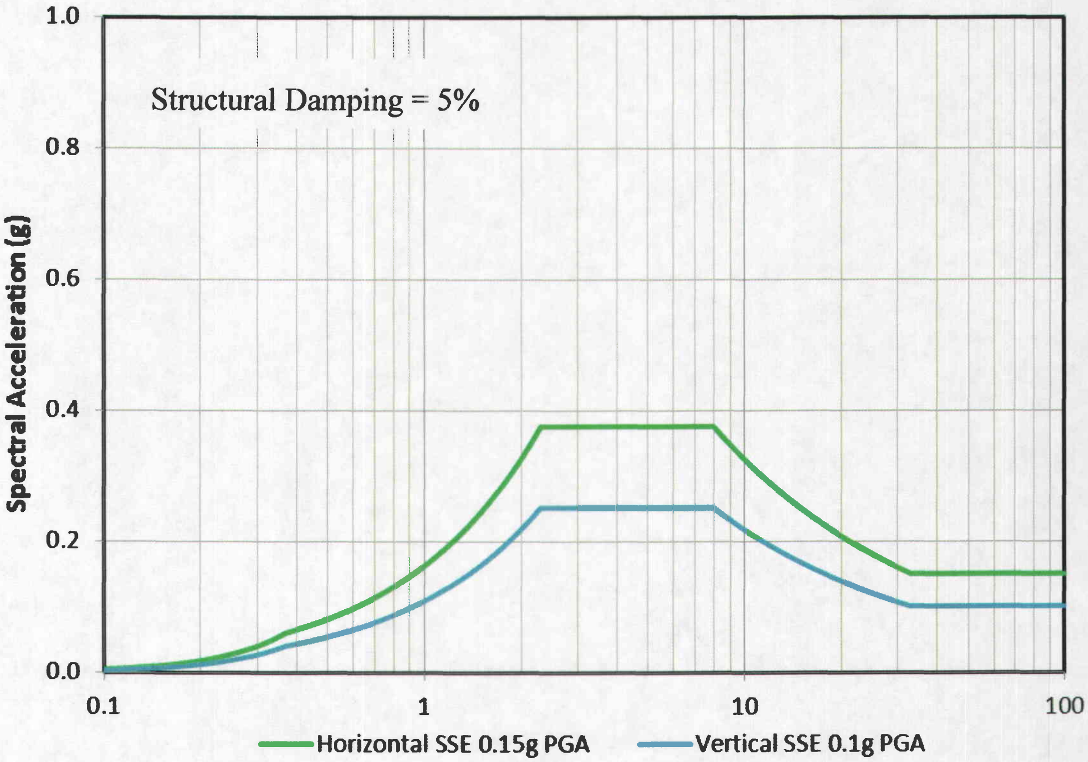


FIGURE 3-1
SAFE SHUTDOWN EARTHQUAKE GROUND MOTION SPECTRA

3.2 SSE Control Point Elevation

The horizontal and vertical SSE response spectra represent the design basis ground motion input applied at the base of the foundation levels of the DBNPS structures. At DBNPS, the top of bedrock is at EL 555 ft and the foundation elevation of the RB is 540 ft. Other major structures supported on rock are founded at somewhat higher elevations. The SSE control point elevation is taken to be the base of the RB foundation, and the SSE response spectra are, therefore, compared to the GMRS at EL 540 ft.

4.0 SCREENING EVALUATION

In accordance with the SPID, (EPRI, 2013a, Section 3), a screening evaluation was performed as described below.

The screening process determines if a seismic risk evaluation is needed. The horizontal GMRS determined from the hazard reevaluation is used to characterize the amplitude of the updated evaluation of the seismic hazard at the DBNPS Site. The screening evaluation is based upon a comparison of the GMRS with the horizontal SSE ground motion spectrum.

4.1 RISK EVALUATION SCREENING (1 TO 10 HZ)

In the 1 to 10 Hz part of the response spectrum, the GMRS exceeds the horizontal SSE (at frequencies above about 6 Hz). Therefore, the plant screens in for a risk evaluation.

The GMRS exceedance relative to the SSE spectrum above about 6.0 Hz is characterized as broad banded with spectral accelerations exceeding 0.4g at some frequencies in the 1.0 to 10 Hz frequency range. However, the SSE spectrum envelops the GMRS below 6.0 Hz. Therefore, SSCs and failure modes associated with low frequency are not affected by the GMRS. As discussed in the SPID (EPRI, 2013a), these SSCs and failure modes include flexible distribution systems, sliding and rocking of unanchored components, fuel assemblies inside the reactor vessel, soil liquefaction, and liquid sloshing in atmospheric pressure storage tanks. Accordingly, no new high confidence of low probability of Failure (HCLPF) analysis of low frequency failure modes is planned.

4.2 HIGH FREQUENCY SCREENING (> 10 HZ)

For a portion of the range above 10 Hz, the GMRS exceeds the horizontal SSE. The high frequency exceedances will be addressed in the risk evaluation discussed in ***Section 4.1*** above. Although safety equipment in DBNPS was evaluated in the A-46 program, the SSE ground motions used in this evaluation do not have significant frequency content above 10 Hz. The A-46 program verified the seismic adequacy of mechanical and electrical equipment for the plant SSE using the seismic criteria defined in the USI A-46 technical resolution (NRC Generic Letter

87-02). The USI A-46 procedures make use of earthquake experience data supplemented by test data to verify the seismic capability of equipment below specified earthquake motion bounds. Additionally, the consideration of high-frequency vulnerability of components in the IPEEE was focused on "bad actor" relays mutually agreed to by the industry and the NRC, with known earthquake or shock sensitivity. These specific model relays, designated as low ruggedness relays, were identified in EPRI Report 7148 (EPRI, 1990). Rather than considering high frequency capacity versus demand screening, "bad actor" relays were considered program outliers and were evaluated using circuit analysis, operator actions, or component replacement.

The response of components to the high frequency ground motion associated with the GMRS will be addressed as part of the on-going SPRA. EPRI Report NP-7498 (EPRI, 1991), as well as more recent studies related licensing activities for new plants (EPRI, 2007a and 2007b), summarize the basis and conclude that "...high-frequency vibratory motions above about 10 Hz are not damaging to the large majority of NPP structures, components, and equipment. An exception to this is the functional performance of vibration sensitive components, such as relays and other electrical and instrumentation devices whose output signals could be affected by high-frequency excitation."

The SPRA will utilize the information from EPRI's on-going test program to develop estimates of fragility for potential high-frequency sensitive components. The test program is expected to "... use accelerations or spectral levels that are sufficiently high to address the anticipated high-frequency in-structure and in-cabinet responses of various plants."

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 horizontal 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 (2013b) is being performed as proposed in a letter to NRC dated April 9, 2013 (NEI, 2013), and agreed to by NRC in a letter dated May 7, 2013 (ML13106A331).

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 Plant. 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, NEI letter dated March 12, 2014 (NEI, 2014), 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 (NRC, 2010a):

> 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.

DBNPS 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 DBNPS NTTF Recommendation 2.3 walkdowns, and the IPEEE program. These programs further illustrate the plant seismic capacity.

5.1 NTTF 2.3 WALKDOWNS

In response to NTTF Recommendation 2.3, FENOC completed the Seismic 2.3 walkdown for DBNPS in September 2012 (FENOC, 2012b). This walkdown identified no major anomalies. Of the IPEEE vulnerabilities identified in the report (FENOC, 2012), the walkdown sampled several and verified that they were addressed and closed. Items that were not accessible during the initial walkdown were subsequently walked down during the following refueling outage. The walkdown of these additional items identified no potentially adverse findings.

The 2.3 walkdown at one of FENOC's plants (Beaver Valley) was subsequently audited by NRC staff. The staff concurred with the process, as well as the findings and conclusions.

5.2 IPEEE DESCRIPTION AND CAPACITY RESPONSE SPECTRUM

The IPEEE for DBNPS is characterized as a reduced scope SMA using the EPRI approach. The IPEEE evaluation is based on the review level earthquake (RLE) ground motion defined by the NUREG/CR-0098 (Newmark and Hall, 1978) 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 HCLPF spectrum (IHS) is not used for screening. However, it is provided here for reference and to document the level of the BDB seismic ground motion for which the plant SSCs have been evaluated. ***Appendix B*** summarizes the elements of the IPEEE, following the IPEEE adequacy requirements in SPID Section 3.3.1 (EPRI, 2013a).

The IPEEE concludes that the plant level HCLPF, controlled by insufficient freeboard in the Borate Water Storage Tank, is 0.26g PGA. Accordingly, the 5-percent damped horizontal IHS spectral accelerations provided in Table 3-2 correspond to the 0.26g PGA RLE spectrum. The SSE spectrum and the IHS in the horizontal direction are shown on ***Figure 5-1***.

TABLE 5-1
IPEEE HORIZONTAL GROUND MOTION RESPONSE SPECTRUM FOR DBNPS

FREQUENCY [Hz]	SPECTRAL ACCELERATION [g]
0.10	0.013
0.25	0.085
1.64	0.550
8.00	0.550
33.00	0.260
100.00	0.260

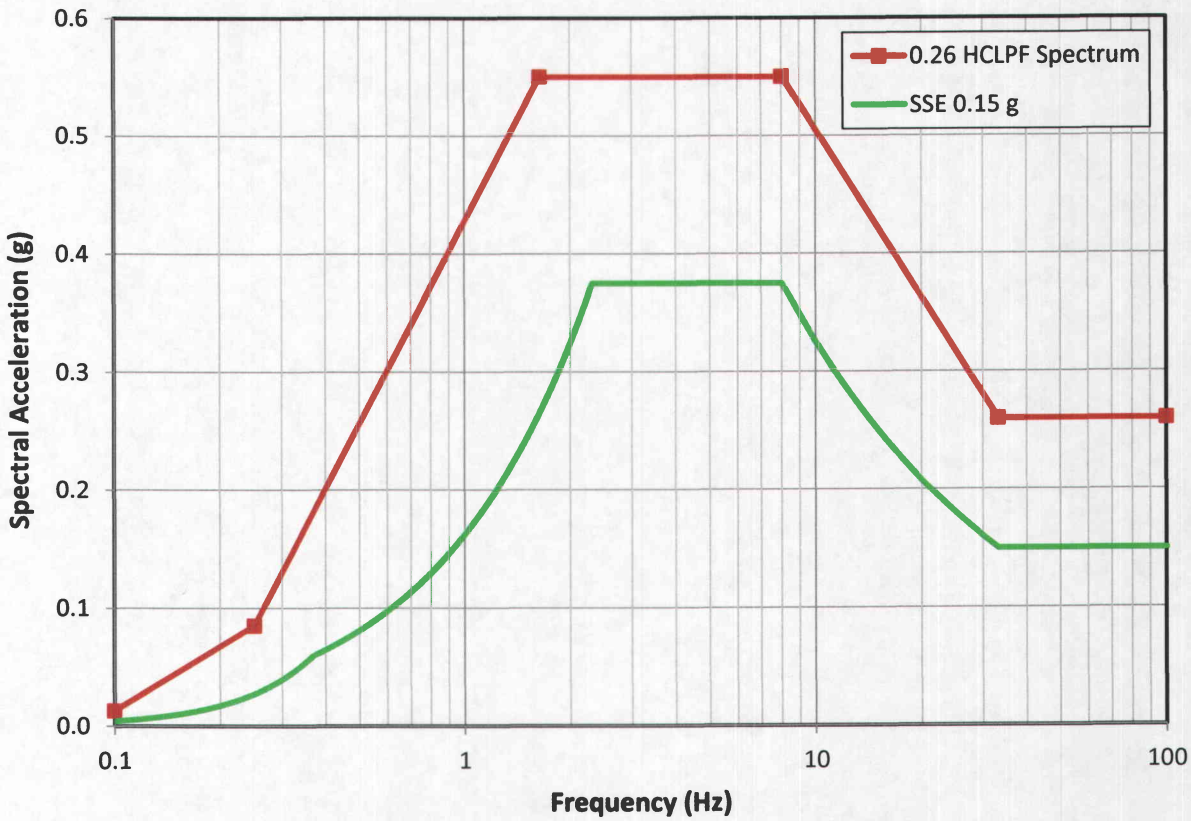


FIGURE 5-1
SSE AND IPEEE RESPONSE SPECTRA FOR DBNPS

6.0 CONCLUSIONS

In accordance with the 50.54(f) request for information letter (NRC, 2012a) a seismic hazard and screening evaluation was performed for DBNPS. This reevaluation followed the guidance provided in the SPID (EPRI, 2013a) and developed the control point GMRS for the Site. The screening evaluation compares the horizontal SSE spectrum to the control point GMRS.

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 horizontal SSE both in the 1 to 10 Hz part of the response spectrum and above 10 Hz.

Although the DBNPS IPEEE is a reduced scope SMA, and is not used for screening, this report (***Appendix B***) performs the evaluation of the completed IPEEE. It concludes that the IPEEE is of good quality and meets all other prerequisites and the adequacy requirements in accordance with the SPID. The Report compares the GMRS to the IPEEE spectrum for reference and to illustrate the robustness in the plant design relative to the design basis for new plants.

The SPRA is currently on-going and is expected to be completed in accordance with the schedule for CEUS nuclear plants provided in the April 9, 2013, letter from industry to the NRC (NEI, 2013) and agreed to by NRC in a letter dated May 7, 2013, (ML13106A331).

7.0 REFERENCES

Castagna, J.P., and M.M. Backus, 1993, "Rock Physics – The Link Between Rock Properties and AVO Response," in Eds., Offset-dependent reflectivity – Theory and Practice of AVO Analysis, Castagna, J.P., Batzle, M.L., and Kan, T.K., Investigations in Geophysics (SEG) No. 8, p. 135 – 171, 1993.

EPRI, NP-7148, "Procedure for Evaluating Nuclear Power Plant Relay Seismic Functionality," Electric Power Research Institute, December 1990.

EPRI, NP-7147-SL, "Seismic Ruggedness of Relays," and Addendums, Electric Power Research Institute, August 1991.

EPRI, NP-7498, "Industry Approach to Severe Accident Policy Implementation," Electric Power Research Institute, November 1991.

EPRI, 1991c, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)," Technical Report NP-6041-SLR1, Electric Power Research Institute, August 1991.

EPRI, 1993, "Guidelines for determining design basis ground motions." Electric Power Research Institute, Vol. 1-5, EPRI TR-102293, 1993.

EPRI, 2004, "CEUS Ground Motion Project Final Report: TR-1009684 2004," Electric Power Research Institute, December 2004.

EPRI, 2006, "Program on Technology Innovation: Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States," TR-1014381, Electric Power Research Institute, August 2006.

EPRI, 2007a, "Program on Technology Innovation: The Effects of High-Frequency Ground Motion on Structures, Components, and Equipment in Nuclear Power Plants," EPRI 1015108, Electric Power Research Institute, June 2007.

EPRI, 2007b, "Program on Technology Innovation: Seismic Screening of Components Sensitive to High-Frequency Vibratory," EPRI 1015109, Electric Power Research Institute, October 2007.

EPRI, 2013a "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, February 2013.

EPRI, 2013b, "Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," Report 3002000704, Electric Power Research Institute, April, 2013.

EPRI, 2013c, "EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project, Report 3002000717," Electric Power Research Institute, June 2013.

EPRI/DOE/NRC, 2012, "Technical Report: Central and Eastern United States Seismic Source Characterization for Nuclear Facilities," EPRI Report # 1021097, U.S. DOE Report # DOE/NE-0140, U.S. NRC NUREG-2115, Electric Power Research Institute, Palo Alto, CA, U.S. DOE, U.S. NRC, 2012.

Esteva, L. and Rosenblueth, E. (March 1964), "Espectros de temblores a distancias moderadas y grandes," Boletin Saciedad Mexicana de Ingenieria Sismica, II, No. 1.

FENOC, 2012 "Final Report Geology and Geotechnical Information for Site Amplification Calculations Seismic Probabilistic Risk Assessment Davis-Besse Nuclear Power Station, FirstEnergy Nuclear Operating Company," Rev. 0, July 2, 2012.

FENOC, 2012b, "Davis-Besse Nuclear Power Station Near-Term Task Force Recommendation 2.3 Seismic Walkdown Report," FirstEnergy Nuclear Operating Company, August 10, 2012 (NRC ADAMS accession number ML13135A242).

FENOC, 2013 "Site Description for Davis-Besse Nuclear Power Station, Near-Term Task Force Recommendation 2.1 Partial Submittal", Davis-Besse Nuclear Power Station, FirstEnergy Nuclear Operating Company, September 12, 2013.

Goldthwait, R., G. White, and J. Forsyth, 1961, "Glacial Map of Ohio," Ohio Department of Natural Resources, Div. of Geol Survey, 1961.

Hough, J.L., 1958, "Geology of the Great Lakes," University of Illinois Press, Urbana, IL, 1958.

McGuire et al., 2001, "Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-consistent Ground Motion Spectra Guidelines", NUREG/CR-6728.

Miller, S.L.M., and R.R. Steward, 1990, "Effects of Lithology, Porosity and Shaliness on P- and S-Wave Velocities from Sonic Logs," Canadian Journal of Exploration Geophysics, Volume 26, Nos. 1 & 2, p. 94-103, 1990.

Newmark, N. H. and Hall, W. J, 1969 "Seismic Design Criteria for Nuclear Reactor Facilities," Proceedings, 4th World Conference on Earthquake Engineering, Santiago, Chile, 14 Jan 1969.

Newmark, N.H. and W.J. Hall, 1978, "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," NUREG/CR-0098.

Norris, S.E., 1975, Geologic Structure of Near-Surface Rocks in Western Ohio, Ohio Journal of Science 75(5): 225, 1975.

NEI, 2013, Letter from Pietrangelo (NEI) to Skeen (NRC) with Attachments, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," Nuclear Energy Institute, April 9, 2013.

NEI, 2014, Letter from Pietrangelo (NEI) to Leeds (NRC) with Attachments, "Seismic Risk Evaluations for Plants in the Central and Eastern United States," Nuclear Energy Institute, March 12, 2014.

NRC, 1991, "Procedural and Submittal Guidelines for the Individual Plant Examination of External Events for Severe Accident," NUREG-1407, U.S. Nuclear Regulatory Commission, Washington D.C, 1991.

NRC, 2007, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," Regulatory Guide 1.208, U.S. Nuclear Regulatory Commission, Washington, D.C., March 2007.

NRC, 2010a, "Generic Issue 199 (GI-199), Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants, Safety/Risk Assessment," U. S. Nuclear Regulatory Commission, Washington D.C., August 2010 [ML100270639].

NRC, 2012a, " Request for Information Pursuant to Title 10 Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3 and 9.3 of the Near-Term Task Forces Review of Insights from the Fukushima Dai-Ichi Accident, U. S. Nuclear Regulatory Commission, Washington D.C., March 12, 2012 (ML12053A340).

NRC, 2013, Letter from E.J. Leeds (NRC) to J.E. Pollock (NEI), "Electric Power Research Institute Final Draft Report XXXXXX, 'Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic,' as an Acceptable Alternative to the March 12, 2012, Information Request for Seismic Reevaluations," U. S. Nuclear Regulatory Commission, Washington, D.C., May 7, 2013, (ML13106A331).

NRC, 2014, Letter from E.J. Leeds (NRC) to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, "Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," U. S. Nuclear Regulatory Commission, Washington, D.C., February 20, 2014.

Pickett, G.R., (Pickett), 1963, "Acoustic Character Logs and their Applications in Formation Evaluation," Journal of Petroleum Technology, Volume 15, No. 6, p. 659-667, 1963.

Rafavich, F., C. St. C.H. Kendall, and T.P. Todd, 1984, "The Relationship between Acoustic Properties and the Petrographic Character of Carbonate Rocks," Geophysics, Volume 49, No. 10, p. 1622-1636, 1984.

RIZZO, 2012c, "Integrated Software Tool for Probabilistic Seismic Hazard Analysis and User Manual Version 1.1," Rev. 2, Paul C. Rizzo Associates, Inc., Pittsburgh, PA, April 2012.

RIZZO, 2013, "Probabilistic Seismic Hazard Analysis and Ground Motion Response Spectra, Davis-Besse NPP, Seismic PRA Project," Paul C. Rizzo Associates, Inc., Pittsburgh, PA, April 19, 2013.

Seed, H. Bolton, Idriss, I. X., and Kiefer, F. W., 1969, "Characteristics of Rock Motions During Earthquakes," ASCE, JSMFD, 95, No. SM5.

Toledo Edison, 2012 "Updated Safety Analysis Report," Davis-Besse Nuclear Power Station No. 1, Docket No: 50-346, License No: npf-3, Revision 29, December 2012.

APPENDIX A

NTTF 2.1 SITE RESPONSE ANALYSIS
DBNPS SITE

APPENDIX A – NTTF 2.1 SITE RESPONSE ANALYSIS INPUTS AND RESULTS, DAVIS BESSE NPS SITE

The following assumptions are used to develop inputs to the site response assessment:

1. Epistemic uncertainty in shear wave velocity (V_s) is modeled using three V_s profiles. The derivation of upper range (UR) and lower range (LR) V_s profiles is based on using a factor of 1.15 which is derived from a range of reasonable V_p/V_s ratios based on literature review for the type of Paleozoic rocks that exist at the site.

2. The randomized site profile realizations were generated using a natural log standard deviation of 0.25 over the top 50 ft and a value of 0.15 below a depth of 50 ft.

3. The Screening, Prioritization, and Implementation Details (SPID) (EPRI, 2013a) specifies the use of the Electric Power Research Institute (EPRI) rock degradation curves for rock units such as found at the FENOC Sites (EPRI, 2013a). These curves are used for the top 500 ft of rock. Below 500 ft, damping for the bedrock is derived consistent with kappa estimates.

4. Consistent with the SPID, kappa is estimated for each site profile. For both the lower and upper range V_s profiles, uncertainty is represented using a secondary kappa value by applying a factor of 1.5 (multiplied by 1.5 for LR profile and divided by 1.5 for UR profile). For profiles less than 3,000 ft thick the SPID document specifies use of a Q of 40 to estimate kappa; all three profiles at Davis Besse are less than 3000 ft thickness. In the top 500 ft the kappa estimates are based on using the low strain damping values from the EPRI rock curves.

5. For the secondary kappa profiles the rock damping in the top 500 ft is modified by the same factor of 1.5 used to characterize uncertainty in kappa. Below 500 ft rock damping was adjusted to preserve the total kappa for the profile.

6. ***Tables A-1 to A-7*** provide the site response inputs consistent with these assessments of uncertainty and variability.

7. ***Table A-8*** lists the resulting median amplification factors and the related ln-sigma for seven selected frequencies and 11 values of input hard rock peak ground acceleration (PGAs).

8. ***Tables A-9 to A-11*** list the resulting median amplification factors and the related ln-sigma for three loading levels associated with ***Figures 2-6 and 2-7.***

TABLE A-1
SITE RESPONSE INPUT

INPUT PARAMETER		VALUE					
Seismic Source Input		M = 6.5 with distances and depths resulting in at 11 peak ground acceleration values from 0.01g to 1.5g at the Site					
		Single-corner Table B-4 SPID	Double-corner Table B-6 SPID	Single-corner Table B-4 SPID	Double-corner Table B-6 SPID	Single-corner Table B-4SPID	Double-corner Table B-6 SPID
Source Model		Additional parameters used in the point source model found below Table B-4 SPID					
Profile		Best Estimate (P1)		Lower Range (P2)		Upper Range (P3)	
Vs		Table A-2 (P1) W = 0.40 30 Randomized Realizations		Table A-2 (P2) BE divided by 1.15 W = 0.30 30 Randomized Realizations		Table A-2 (P3) BE multiplied by 1.15 W = 0.30 30 Randomized Realizations	
Site Kappa (k1)		Total Thickness 1390 ft (k1) = .0140s (see Table A-3) W = 1.0		Total Thickness 1390 ft (k1) = .0152s (see Table A-4) W = 0.60		Total Thickness 1390 ft (k1) = .0132s (see Table A-6) W = 0.60	
Shear Modulus and Damping With (k1)	Top 500 ft	EPRI Rock	3.2% Linear damping	EPRI Rock	3.2% Linear damping	EPRI Rock	3.2% Linear damping
	501 ft to profile base	1.25% Linear damping	1.25% Linear damping	1.25% Linear damping	1.25% Linear damping	1.25% Linear damping	1.25% Linear damping
	Weight	W = 0.50	W = 0.50	W = 0.50	W = 0.50	W = 0.50	W = 0.50
Site Kappa (k2)		Not Applicable		Total Thickness 1390 ft (k2) = .0227s (see Table A-5) W = 0.40		Total Thickness 1390 ft (k2) = .0088s (see Table A-7) W = 0.40	
Shear Modulus and Damping With (k2)	Top 500 ft	Not Applicable		EPRI Rock scaled up to get low strain damping of 4.8%	4.8% Linear Damping	EPRI Rock scaled up to get low strain damping of 1.6%	1.6% Linear damping
	501 ft to profile base	Not Applicable		2.85% Linear damping	2.85% Linear damping	0.3% Linear damping	0.3% Linear damping
	Weight	Not Applicable		W = 0.50	W = 0.50	W = 0.50	W = 0.50

TABLE A-2
SHEAR WAVE VELOCITY (V_S) PROFILES

LAYER ELEVATION [ft]	PROFILE P1 [ft/s]	DEPTH [ft]	PROFILE P2 [ft/s]	DEPTH [ft]	PROFILE P3 [ft/s]	DEPTH [ft]
540	4948	0	4303	0	5690	0
528	4948	12	4303	12	5690	12
528	3970	12	3452	12	4566	12
518	3970	22	3452	22	4566	22
518	5790	22	5035	22	6659	22
508	5790	32	5035	32	6659	32
508	4071	32	3540	32	4682	32
460	4071	80	3540	80	4682	80
460	5672	80	4932	80	6523	80
370	5672	170	4932	170	6523	170
370	8782	170	7637	170	9200	170
30	8782	510	7637	510	9200	510
30	8682	510	7550	510	9200	510
-20	8682	560	7550	560	9200	560
-20	8615	560	7491	560	9200	560
-105	8615	645	7491	645	9200	645
-105	6514	645	5664	645	7491	645
-685	6514	1225	5664	1225	7491	1225
-685	5996	1225	5214	1225	6895	1225
-850	5996	1390	5214	1390	6895	1390
-850	9200	1390	9200	1390	9200	1390

TABLE A-3
KAPPA (k1) USED WITH BEST ESTIMATE PROFILE P1

V_s [ft/s] P1	THICKNESS [ft]	DEPTH TO TOP [ft]	DAMP [%] k1	Q	k1 [s]
4948	12	0	3.20	15.63	0.000155
3970	10	12	3.20	15.63	0.000161
5790	10	22	3.20	15.63	0.000111
4071	48	32	3.20	15.63	0.000755
5672	90	80	3.20	15.63	0.001016
8782	340	170	3.20	15.63	0.002478
8682	50	510	1.25	40.00	0.000144
8615	85	560	1.25	40.00	0.000247
6514	580	645	1.25	40.00	0.002226
5996	165	1225	1.25	40.00	0.000688
Half space	-	1390			0.006000
Total kappa					0.0140

TABLE A-4
KAPPA (k1) USED WITH LOWER RANGE PROFILE P2

V_s [ft/s] P2	THICKNESS [FT]	DEPTH TO TOP [ft]	DAMP [%] k1	Q	k1 [s] (Wt=0.6)
4303	12	0	3.20	15.63	0.000178
3452	10	12	3.20	15.63	0.000185
5035	10	22	3.20	15.63	0.000127
3540	48	32	3.20	15.63	0.000868
4932	90	80	3.20	15.63	0.001168
7637	340	170	3.20	15.63	0.002849
7550	50	510	1.25	40.00	0.000166
7491	85	560	1.25	40.00	0.000284
5664	580	645	1.25	40.00	0.00256
5214	165	1225	1.25	40.00	0.000791
Half space	-	1390			0.006000
Total kappa					0.0152

TABLE A-5
KAPPA (k2) USED WITH LOWER RANGE PROFILE P2

V_S [ft/s] P2	THICKNESS [ft]	DEPTH TO TOP [ft]	DAMP [%] k2	Q	k2 [s] (WT=0.4)
4303	12	0	4.80	10.42	0.000268
3452	10	12	4.80	10.42	0.000278
5035	10	22	4.80	10.42	0.000191
3540	48	32	4.80	10.42	0.001302
4932	90	80	4.80	10.42	0.001752
7637	340	170	4.80	10.42	0.004274
7550	50	510	2.85	17.54	0.000378
7491	85	560	2.85	17.54	0.000647
5664	580	645	2.85	17.54	0.005837
5214	165	1225	2.85	17.54	0.001804
Half space	-	1390			0.006000
Total kappa					0.0227

TABLE A-6
KAPPA (k1) USED WITH UPPER RANGE PROFILE P3

V_S [ft/s] P3	THICKNESS [ft]	DEPTH TO TOP [ft]	DAMP [%] k1	Q	k1 [s] (WT=0.6)
5690	12	0	3.20	15.63	0.000135
4566	10	12	3.20	15.63	0.00014
6659	10	22	3.20	15.63	9.61E-05
4682	48	32	3.20	15.63	0.000656
6523	90	80	3.20	15.63	0.000883
9200	340	170	3.20	15.63	0.002365
9200	50	510	1.25	40.00	0.000136
9200	85	560	1.25	40.00	0.000231
7491	580	645	1.25	40.00	0.001936
6895	165	1225	1.25	40.00	0.000598
Half space	-	1390			0.006000
Total kappa					0.0132

TABLE A-7
KAPPA (k2) USED WITH UPPER RANGE PROFILE P3

V_S [ft/s] P3	THICKNESS [ft]	DEPTH TO TOP [ft]	DAMP [%] k2	Q	k2 [s] (WT=0.4)
5690	12	0	1.60	31.25	6.75E-05
4566	10	12	1.60	31.25	7.01E-05
6659	10	22	1.60	31.25	4.81E-05
4682	48	32	1.60	31.25	0.000328
6523	90	80	1.60	31.25	0.000442
9200	340	170	1.60	31.25	0.001183
9200	50	510	0.30	166.67	3.26E-05
9200	85	560	0.30	166.67	5.54E-05
7491	580	645	0.30	166.67	0.000465
6895	165	1225	0.30	166.67	0.000144
Half space	-	1390			0.006000
Total kappa					0.0088

TABLE A-8
AMPLIFICATION FUNCTIONS FOR DBNPS SITE

100 Hz SA [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)
1.02E-02	1.16E+00	9.88E-02	1.31E-02	1.02E+00	1.06E-01	2.07E-02	1.34E+00	1.15E-01	2.35E-02	1.18E+00	2.01E-01
5.45E-02	1.00E+00	1.19E-01	1.07E-01	7.89E-01	1.92E-01	1.13E-01	1.36E+00	1.22E-01	9.41E-02	1.20E+00	2.04E-01
1.15E-01	8.81E-01	1.37E-01	2.26E-01	7.45E-01	2.14E-01	2.10E-01	1.35E+00	1.24E-01	1.64E-01	1.20E+00	2.04E-01
2.52E-01	7.79E-01	1.55E-01	4.73E-01	7.15E-01	2.29E-01	4.04E-01	1.35E+00	1.26E-01	3.02E-01	1.20E+00	2.06E-01
3.97E-01	7.28E-01	1.66E-01	7.19E-01	6.97E-01	2.38E-01	5.93E-01	1.34E+00	1.30E-01	4.35E-01	1.21E+00	2.08E-01
5.48E-01	6.95E-01	1.73E-01	9.70E-01	6.84E-01	2.45E-01	7.83E-01	1.33E+00	1.33E-01	5.68E-01	1.21E+00	2.10E-01
7.03E-01	6.72E-01	1.80E-01	1.22E+00	6.73E-01	2.51E-01	9.75E-01	1.33E+00	1.37E-01	7.02E-01	1.22E+00	2.12E-01
1.10E+00	6.35E-01	1.92E-01	1.86E+00	6.48E-01	2.65E-01	1.45E+00	1.30E+00	1.49E-01	1.03E+00	1.23E+00	2.14E-01
1.51E+00	6.10E-01	2.02E-01	2.53E+00	6.28E-01	2.79E-01	1.95E+00	1.28E+00	1.63E-01	1.38E+00	1.25E+00	2.15E-01
1.95E+00	5.91E-01	2.11E-01	3.23E+00	6.10E-01	2.94E-01	2.47E+00	1.26E+00	1.78E-01	1.74E+00	1.26E+00	2.16E-01
2.37E+00	5.77E-01	2.20E-01	3.89E+00	5.94E-01	3.09E-01	2.97E+00	1.24E+00	1.91E-01	2.09E+00	1.27E+00	2.16E-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)**			
2.16E-02	8.15E-01	1.19E-01	1.46E-02	1.36E+00	1.11E-01	8.44E-03	1.16E+00	9.26E-02			
6.85E-02	8.11E-01	1.22E-01	3.72E-02	1.35E+00	1.10E-01	1.87E-02	1.16E+00	9.29E-02			
1.14E-01	8.11E-01	1.23E-01	5.86E-02	1.35E+00	1.10E-01	2.84E-02	1.16E+00	9.31E-02			
2.03E-01	8.12E-01	1.25E-01	1.01E-01	1.35E+00	1.10E-01	4.77E-02	1.16E+00	9.33E-02			
2.88E-01	8.14E-01	1.27E-01	1.41E-01	1.35E+00	1.10E-01	6.59E-02	1.16E+00	9.35E-02			
3.73E-01	8.16E-01	1.29E-01	1.81E-01	1.35E+00	1.11E-01	8.39E-02	1.16E+00	9.37E-02			
4.59E-01	8.18E-01	1.31E-01	2.21E-01	1.35E+00	1.11E-01	1.02E-01	1.16E+00	9.39E-02			
6.71E-01	8.23E-01	1.38E-01	3.20E-01	1.36E+00	1.11E-01	1.47E-01	1.16E+00	9.44E-02			
8.92E-01	8.30E-01	1.47E-01	4.23E-01	1.36E+00	1.12E-01	1.93E-01	1.16E+00	9.49E-02			
1.12E+00	8.36E-01	1.58E-01	5.31E-01	1.36E+00	1.13E-01	2.42E-01	1.16E+00	9.54E-02			
1.34E+00	8.43E-01	1.71E-01	6.34E-01	1.36E+00	1.13E-01	2.88E-01	1.16E+00	9.60E-02			

TABLE A-9
AMPLIFICATION FUNCTIONS AT SPECIFIC LOADING LEVELS FOR DBNPS SITE
100 Hz SPECTRAL ACCELERATION = 0.11g

FREQUENCY [HZ]	PROFILE P1 KAPPA 1 EPRI ROCK NONLINEAR CURVES 1-CORNER GROUND MOTION MODEL		PROFILE P1 KAPPA 1 LINEAR ROCK CURVES 1-CORNER GROUND MOTION MODEL	
	MEDIAN AF	SIGMA LN(AF)	MEDIAN AF	SIGMA LN(AF)
0.1	1.04E+00	1.43E-02	1.04E+00	1.43E-02
0.13	1.03E+00	1.07E-02	1.03E+00	1.06E-02
0.16	1.03E+00	1.04E-02	1.03E+00	1.03E-02
0.2	1.03E+00	1.22E-02	1.03E+00	1.22E-02
0.26	1.05E+00	1.66E-02	1.05E+00	1.66E-02
0.33	1.07E+00	2.46E-02	1.07E+00	2.45E-02
0.42	1.11E+00	3.75E-02	1.11E+00	3.74E-02
0.5	1.15E+00	5.18E-02	1.15E+00	5.18E-02
0.53	1.16E+00	5.74E-02	1.16E+00	5.74E-02
0.67	1.25E+00	8.35E-02	1.25E+00	8.35E-02
0.85	1.35E+00	9.86E-02	1.35E+00	9.87E-02
1	1.39E+00	8.35E-02	1.39E+00	8.36E-02
1.08	1.38E+00	6.87E-02	1.38E+00	6.87E-02
1.37	1.23E+00	4.56E-02	1.23E+00	4.59E-02
1.74	9.90E-01	6.41E-02	9.90E-01	6.44E-02
2.21	8.23E-01	4.09E-02	8.23E-01	4.13E-02
2.5	7.91E-01	4.16E-02	7.91E-01	4.23E-02
2.81	8.05E-01	9.88E-02	8.04E-01	9.97E-02
3.56	9.70E-01	1.60E-01	9.69E-01	1.60E-01
4.52	1.12E+00	1.30E-01	1.12E+00	1.34E-01
5	1.19E+00	1.81E-01	1.19E+00	1.91E-01
5.74	1.37E+00	1.73E-01	1.37E+00	1.74E-01
7.28	1.51E+00	7.40E-02	1.51E+00	8.85E-02
9.24	1.42E+00	7.03E-02	1.42E+00	8.30E-02
10	1.39E+00	6.80E-02	1.39E+00	8.21E-02
11.72	1.27E+00	6.71E-02	1.28E+00	7.82E-02
14.87	1.09E+00	7.98E-02	1.09E+00	1.00E-01
18.87	9.60E-01	8.18E-02	9.66E-01	9.90E-02
23.95	7.75E-01	9.44E-02	7.78E-01	1.07E-01
25	7.49E-01	1.03E-01	7.52E-01	1.15E-01
30.39	6.95E-01	1.27E-01	6.99E-01	1.45E-01
38.57	7.06E-01	1.08E-01	7.16E-01	1.60E-01
48.94	7.07E-01	9.34E-02	7.12E-01	1.28E-01
62.1	7.25E-01	8.10E-02	7.31E-01	1.15E-01
78.8	7.84E-01	7.20E-02	7.88E-01	9.66E-02
100	8.92E-01	7.05E-02	8.96E-01	9.16E-02

TABLE A-10
AMPLIFICATION FUNCTIONS AT SPECIFIC LOADING LEVELS FOR DBNPS SITE
100 Hz SPECTRAL ACCELERATION = 0.37g

FREQUENCY [HZ]	PROFILE P1 KAPPA 1 EPRI ROCK NONLINEAR CURVES 1-CORNER GROUND MOTION MODEL		PROFILE P1 KAPPA 1 LINEAR ROCK CURVES 1-CORNER GROUND MOTION MODEL	
	MEDIAN AF	SIGMA LN(AF)	MEDIAN AF	SIGMA LN(AF)
0.1	1.05E+00	1.64E-02	1.05E+00	1.60E-02
0.13	1.03E+00	1.21E-02	1.03E+00	1.18E-02
0.16	1.03E+00	1.15E-02	1.03E+00	1.12E-02
0.2	1.04E+00	1.31E-02	1.04E+00	1.28E-02
0.26	1.05E+00	1.73E-02	1.05E+00	1.70E-02
0.33	1.07E+00	2.51E-02	1.07E+00	2.48E-02
0.42	1.11E+00	3.80E-02	1.11E+00	3.77E-02
0.5	1.15E+00	5.24E-02	1.15E+00	5.20E-02
0.53	1.17E+00	5.80E-02	1.17E+00	5.75E-02
0.67	1.25E+00	8.42E-02	1.25E+00	8.36E-02
0.85	1.35E+00	9.93E-02	1.35E+00	9.86E-02
1	1.39E+00	8.41E-02	1.39E+00	8.35E-02
1.08	1.38E+00	6.91E-02	1.38E+00	6.86E-02
1.37	1.23E+00	4.54E-02	1.23E+00	4.60E-02
1.74	9.91E-01	6.31E-02	9.89E-01	6.47E-02
2.21	8.25E-01	4.02E-02	8.21E-01	4.13E-02
2.5	7.94E-01	4.80E-02	7.90E-01	4.29E-02
2.81	8.09E-01	1.09E-01	8.04E-01	1.01E-01
3.56	9.79E-01	1.68E-01	9.70E-01	1.61E-01
4.52	1.14E+00	1.46E-01	1.12E+00	1.34E-01
5	1.20E+00	1.90E-01	1.19E+00	1.91E-01
5.74	1.39E+00	1.75E-01	1.37E+00	1.74E-01
7.28	1.51E+00	7.75E-02	1.51E+00	8.83E-02
9.24	1.40E+00	6.64E-02	1.42E+00	8.28E-02
10	1.37E+00	6.79E-02	1.39E+00	8.23E-02
11.72	1.24E+00	7.39E-02	1.27E+00	7.92E-02
14.87	1.05E+00	7.95E-02	1.09E+00	1.01E-01
18.87	9.04E-01	9.11E-02	9.53E-01	1.02E-01
23.95	7.13E-01	1.10E-01	7.50E-01	1.15E-01
25	6.87E-01	1.15E-01	7.21E-01	1.24E-01
30.39	6.26E-01	1.28E-01	6.57E-01	1.59E-01
38.57	6.19E-01	1.13E-01	6.60E-01	1.83E-01
48.94	5.92E-01	1.10E-01	6.28E-01	1.51E-01
62.1	5.78E-01	9.19E-02	6.08E-01	1.40E-01
78.8	6.11E-01	7.69E-02	6.33E-01	1.10E-01
100	7.31E-01	7.18E-02	7.53E-01	1.00E-01

TABLE A-11
AMPLIFICATION FUNCTIONS AT SPECIFIC LOADING LEVELS FOR DBNPS SITE
100 Hz SPECTRAL ACCELERATION = 1.03g

FREQUENCY [HZ]	PROFILE P1 KAPPA 1 EPRI ROCK NONLINEAR CURVES 1-CORNER GROUND MOTION MODEL		PROFILE P1 KAPPA 1 LINEAR ROCK CURVES 1-CORNER GROUND MOTION MODEL	
	MEDIAN AF	SIGMA LN(AF)	MEDIAN AF	SIGMA LN(AF)
0.1	1.05E+00	1.82E-02	1.05E+00	1.69E-02
0.13	1.04E+00	1.35E-02	1.04E+00	1.24E-02
0.16	1.04E+00	1.27E-02	1.03E+00	1.17E-02
0.2	1.04E+00	1.41E-02	1.04E+00	1.31E-02
0.26	1.05E+00	1.82E-02	1.05E+00	1.72E-02
0.33	1.07E+00	2.60E-02	1.07E+00	2.49E-02
0.42	1.11E+00	3.90E-02	1.11E+00	3.78E-02
0.5	1.15E+00	5.35E-02	1.15E+00	5.21E-02
0.53	1.17E+00	5.92E-02	1.17E+00	5.76E-02
0.67	1.26E+00	8.58E-02	1.25E+00	8.37E-02
0.85	1.36E+00	1.01E-01	1.35E+00	9.87E-02
1	1.39E+00	8.59E-02	1.39E+00	8.34E-02
1.08	1.39E+00	7.08E-02	1.38E+00	6.85E-02
1.37	1.24E+00	4.50E-02	1.23E+00	4.61E-02
1.74	9.99E-01	6.00E-02	9.88E-01	6.48E-02
2.21	8.37E-01	4.17E-02	8.21E-01	4.13E-02
2.5	8.10E-01	6.76E-02	7.89E-01	4.31E-02
2.81	8.30E-01	1.37E-01	8.04E-01	1.01E-01
3.56	1.02E+00	1.91E-01	9.70E-01	1.61E-01
4.52	1.19E+00	1.84E-01	1.12E+00	1.35E-01
5	1.26E+00	1.99E-01	1.19E+00	1.92E-01
5.74	1.43E+00	1.75E-01	1.37E+00	1.74E-01
7.28	1.49E+00	7.55E-02	1.51E+00	8.83E-02
9.24	1.35E+00	6.90E-02	1.42E+00	8.28E-02
10	1.30E+00	7.62E-02	1.39E+00	8.25E-02
11.72	1.15E+00	8.96E-02	1.27E+00	7.96E-02
14.87	9.70E-01	8.72E-02	1.08E+00	1.02E-01
18.87	8.02E-01	1.15E-01	9.48E-01	1.04E-01
23.95	6.29E-01	1.27E-01	7.39E-01	1.19E-01
25	6.09E-01	1.27E-01	7.09E-01	1.27E-01
30.39	5.55E-01	1.17E-01	6.41E-01	1.65E-01
38.57	5.31E-01	1.10E-01	6.40E-01	1.93E-01
48.94	4.97E-01	1.20E-01	5.96E-01	1.62E-01
62.1	4.81E-01	9.64E-02	5.59E-01	1.55E-01
78.8	5.06E-01	7.96E-02	5.65E-01	1.19E-01
100	6.22E-01	7.11E-02	6.80E-01	1.06E-01

APPENDIX B

EVALUATION OF DBNPS IPEEE SUBMITTAL

APPENDIX B – EVALUATION OF DBNPS IPEEE SUBMITTAL

The Individual Plant Examination of External Events (IPEEE) performed for the Davis-Besse Nuclear Power Station (DBNPS) was a reduced-scope Electric Power Research Institute (EPRI) Seismic Margin Assessment (SMA). Therefore, in accordance with *Seismic Evaluation Guidance, Screening Prioritization, and Implementation Details* (SPID) *for the Resolution of the Fukushima Near-Term Task Force Recommendation 2.1: Seismic* (EPRI, 2013a), it is not eligible for use in screening associated with EPRI's SPID (EPRI, 2013a). Nevertheless, it is summarized here for information, and because, in combination with the A-46 program, the IPEEE findings indicate that the plant design is seismically robust and exhibits significant margins in excess of the design basis. The IPEEE was performed in accordance with the guidelines in Nuclear Regulatory Commission Technical Report, NUREG-1407 (NRC, 1991). The plant HCLPF value is reported to be 0.26g and is controlled by insufficient freeboard in the Borated Water Storage Tank.

B.1 IPEEE Prerequisites

The SPID (EPRI, 2013a) guidelines require that the following prerequisites be documented prior to the possible use of the IPEEE for screening.

1. Confirm that commitments made under the IPEEE have been met. If not, address and close those commitments.

2. Confirm whether all of the modifications and other changes credited in the IPEEE analysis are in place.

3. Confirm that any identified deficiencies or weaknesses to NUREG-1407 (NRC, 1991) in the plant specific U.S. Nuclear Regulatory Commission (NRC) Safety Evaluation Report (SER) are properly justified to ensure that the IPEEE conclusions remain valid.

4. Confirm that major plant modifications since the completion of the IPEEE have not degraded/impacted the conclusions reached in the IPEEE.

In response to Generic Letter 87-02, "Verification of Seismic Adequacy of Mechanical and Electrical Equipment in Operating Reactors, Unresolved Safety Issue A-46." Toledo Edison submitted Report Number 2316 (August 29, 1995). The Report identified several vulnerabilities which were subsequently corrected.

As part of the Near-Term Task Force (NTTF) 2.3 Seismic walkdown effort, a sample of these vulnerabilities was examined to verify that the corrective actions were implemented and documents closed. The resulting Report (FENOC, 2012) presents in Appendix G, a summary of the vulnerabilities identified in the A-46/IPEEE programs and their respective disposition. Available Seismic Evaluation Worksheets (SEWS) generated during the IPEEE walkdowns were included in the NTTF 2.3 report (FENOC, 2012b). The NTTF 2.3 walkdowns identified no potential adverse seismic conditions.

B.2 IPEEE Adequacy Demonstration

Consistent with the guidelines in NUREG -1407 (NRC, 1991), the DBNPS IPEEE accomplished a reduced scope SMA for the 0.3g Review Level Earthquake (RLE). The following paragraphs briefly summarize the IPEEE in accordance with the requirements of the SPID guidelines (EPRI, 2013a).

B.2.1 Building Seismic Analysis

The design of DBNPS is based on conservative engineering practices, which generally result in higher seismic capacity than the design peak ground acceleration (PGA) of 0.15g. Some of these factors include: conservative modeling techniques, which were based upon the limitations of the analysis performed and the "state of the art" at the time; and applying the free field seismic input motion at the base of the foundation (bedrock) without using a reduction factor. The degree of conservatism in the design basis analysis is illustrated by subsequent seismic evaluations performed at DBNPS. These include:

- Reevaluation of the seismic input motion from 0.15g to 0.20g
- Generic Letter 87-02 "Verification of Seismic Adequacy of Equipment in Older Operating Nuclear Plants."

The seismic reevaluation was based on the upgraded Maximum Possible Earthquake PGA of 0.20g in conjunction with the design basis criteria. The reevaluation determined that the systems required for safe shutdown of the DBNPS, as well as systems required for continued shutdown

heat removal, exhibit seismic margins in excess of the 0.2g PGA. NRC's SER related to the seismic reevaluation concluded that there is sufficient conservatism and margin in the piping systems, components, and supports at Davis-Besse to ensure safe shutdown and continued heat removal in the event of an earthquake having a PGA of 0.20g.

B.2.2 IPEEE Seismic Response

In-structure response spectra for use in the seismic IPEEE and Unresolved Safety Issue (USI) A-46 have been developed using median based soil properties, structural properties, and analysis assumptions. The best estimate (BE) structural models used for this analysis were based on the mathematical models used in the design seismic analysis. The two-dimensional planar models used in the design analysis were upgraded to three dimensional models to better represent stiffness offsets and mass eccentricities. These 3-D models utilized the information from the design basis models and supporting calculations as well as as-built drawings of the different structures. The raw spectra were then broadened +/ - 15 percent. The broadened spectra for each mass point degree of freedom were then enveloped for all three soil conditions.

The in-structure response spectra, as described above, are then scaled following the guidance of the Generic Implementation Program (GIP) in order to develop the 84th percentile non-exceedance spectra for use in the USI A-46. The scale factor was obtained on the basis of comparing the NUREG/CR-0098 (Newmark and Hall, 1978) 84 percent non-exceedance probability (NEP) shape anchored to the site SSE PGA of 0.15g and the IPEEE RLE spectrum. The resulting scale factor is 0.697. The same scale factor was applied to all IPEEE spectral values in order to develop ISRS for use in the A-46.

B.2.3 Screening of Components

The development of the Safe Shutdown Equipment List (SSEL) and the screening evaluations were performed following the guidelines in the GIP and EPRI NP-6041 (EPRI, 1991c). Based on the GIP, the capacity of the equipment located below about 40 ft above grade and with a natural frequency of about 8 Hz or greater is defined by a "Bounding Spectrum" characterized by a PGA of 0.33g. At building elevations in excess of 40 ft, the equipment capacities were developed based on comparing the IPEEE ISRS with amplified GIP bounding spectra.

Additionally, the IPEEE also evaluated low ruggedness relays not addressed in the A-46 program and containment performance.

B.2.4 Seismic Capability Walkdowns

The IPEEE walkdowns were combined with the A-46 walkdowns. The walkdowns were performed in accordance with the guidelines in the GIP and EPRI NP-6041 (EPRI, 1991c). The walkdowns and the subsequent seismic evaluation of active mechanical and electrical components of DBNPS confirm with a high degree of confidence that equipment included in the scope of A-46 is similar to the equipment identified in the Seismic Qualification Utility Group (SQUG) Seismic Data Base.

B.3 GMRS and IHS Comparison

The IPEEE for DBNPS is not used for plant screening evaluation. However, comparison of the IPEEE HCLPF spectrum (IHS) and the GMRS at the Reactor Building (RB) foundation level shows that the IHS substantially envelops the GMRS is the entire range of frequencies of interest.

APPENDIX C
REACTOR BUILDING MEAN AND FRACTILE SEISMIC HAZARD
DBNPS SITE

APPENDIX C - REACTOR BUILDING MEAN AND FRACTILE SEISMIC HAZARD

TABLE C-1
100 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

SPECTRAL ACCELERATION [g]	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	5TH	16TH	50TH	84TH	95TH
0.01	4.44E-03	2.06E-03	2.65E-03	4.02E-03	6.28E-03	8.28E-03
0.02	1.67E-03	5.93E-04	7.87E-04	1.38E-03	2.45E-03	3.99E-03
0.03	9.11E-04	2.69E-04	3.69E-04	6.82E-04	1.40E-03	2.52E-03
0.04	5.87E-04	1.50E-04	2.12E-04	4.12E-04	9.11E-04	1.78E-03
0.05	4.14E-04	9.28E-05	1.37E-04	2.80E-04	6.51E-04	1.34E-03
0.06	3.06E-04	6.27E-05	9.48E-05	2.02E-04	4.87E-04	1.01E-03
0.07	2.35E-04	4.57E-05	6.99E-05	1.53E-04	3.78E-04	7.78E-04
0.08	1.86E-04	3.51E-05	5.42E-05	1.20E-04	3.02E-04	6.16E-04
0.09	1.51E-04	2.78E-05	4.36E-05	9.61E-05	2.47E-04	5.00E-04
0.10	1.25E-04	2.26E-05	3.60E-05	7.90E-05	2.04E-04	4.13E-04
0.20	3.37E-05	5.61E-06	9.68E-06	2.23E-05	5.46E-05	1.08E-04
0.25	2.12E-05	3.41E-06	5.89E-06	1.43E-05	3.46E-05	6.57E-05
0.30	1.43E-05	2.21E-06	3.84E-06	9.70E-06	2.36E-05	4.36E-05
0.40	7.40E-06	1.02E-06	1.86E-06	5.02E-06	1.25E-05	2.24E-05
0.50	4.31E-06	5.28E-07	1.00E-06	2.89E-06	7.37E-06	1.31E-05
0.60	2.70E-06	2.95E-07	5.74E-07	1.78E-06	4.68E-06	8.30E-06
0.70	1.78E-06	1.72E-07	3.43E-07	1.15E-06	3.11E-06	5.61E-06
0.80	1.22E-06	1.04E-07	2.13E-07	7.67E-07	2.15E-06	3.98E-06
0.90	8.72E-07	6.49E-08	1.37E-07	5.29E-07	1.54E-06	2.93E-06
1.00	6.42E-07	4.21E-08	9.17E-08	3.77E-07	1.14E-06	2.22E-06
2.00	8.12E-08	1.93E-09	5.08E-09	3.38E-08	1.40E-07	3.54E-07
3.00	2.20E-08	2.31E-10	6.95E-10	6.50E-09	3.50E-08	1.14E-07
5.00	3.77E-09	1.32E-11	4.76E-11	6.98E-10	5.30E-09	2.43E-08

TABLE C-2
25 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

SPECTRAL ACCELERATION [g]	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	5TH	16TH	50TH	84TH	95TH
0.01	7.12E-03	3.75E-03	4.65E-03	6.60E-03	9.64E-03	1.21E-02
0.02	3.31E-03	1.50E-03	1.94E-03	2.97E-03	4.73E-03	6.32E-03
0.03	1.95E-03	7.89E-04	1.04E-03	1.70E-03	2.83E-03	4.03E-03
0.04	1.29E-03	4.83E-04	6.39E-04	1.09E-03	1.90E-03	2.86E-03
0.05	9.21E-04	3.22E-04	4.32E-04	7.57E-04	1.38E-03	2.17E-03
0.06	6.94E-04	2.27E-04	3.11E-04	5.58E-04	1.05E-03	1.72E-03
0.07	5.44E-04	1.68E-04	2.34E-04	4.30E-04	8.28E-04	1.40E-03
0.08	4.41E-04	1.30E-04	1.83E-04	3.44E-04	6.76E-04	1.16E-03
0.09	3.66E-04	1.04E-04	1.48E-04	2.83E-04	5.66E-04	9.76E-04
0.10	3.10E-04	8.48E-05	1.22E-04	2.39E-04	4.84E-04	8.34E-04
0.20	1.03E-04	2.39E-05	3.68E-05	7.74E-05	1.68E-04	2.81E-04
0.25	7.14E-05	1.62E-05	2.55E-05	5.39E-05	1.16E-04	1.92E-04
0.30	5.24E-05	1.18E-05	1.87E-05	4.01E-05	8.47E-05	1.39E-04
0.40	3.15E-05	6.89E-06	1.13E-05	2.47E-05	5.10E-05	8.11E-05
0.50	2.08E-05	4.44E-06	7.35E-06	1.65E-05	3.40E-05	5.27E-05
0.60	1.46E-05	3.03E-06	5.07E-06	1.16E-05	2.41E-05	3.67E-05
0.70	1.06E-05	2.15E-06	3.63E-06	8.49E-06	1.78E-05	2.69E-05
0.80	8.01E-06	1.57E-06	2.67E-06	6.36E-06	1.35E-05	2.03E-05
0.90	6.18E-06	1.17E-06	2.01E-06	4.88E-06	1.05E-05	1.58E-05
1.00	4.87E-06	8.89E-07	1.54E-06	3.83E-06	8.30E-06	1.26E-05
2.00	8.82E-07	1.15E-07	2.19E-07	6.49E-07	1.56E-06	2.53E-06
3.00	2.97E-07	2.84E-08	5.77E-08	2.02E-07	5.42E-07	9.30E-07
5.00	6.84E-08	4.24E-09	9.33E-09	4.22E-08	1.29E-07	2.37E-07

TABLE C-3
10 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

SPECTRAL ACCELERATION [g]	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	5TH	16TH	50TH	84TH	95TH
0.01	1.13E-02	6.73E-03	8.07E-03	1.08E-02	1.47E-02	1.74E-02
0.02	5.31E-03	2.77E-03	3.42E-03	4.97E-03	7.29E-03	8.97E-03
0.03	3.33E-03	1.59E-03	2.03E-03	3.07E-03	4.72E-03	5.97E-03
0.04	2.31E-03	1.02E-03	1.34E-03	2.10E-03	3.34E-03	4.33E-03
0.05	1.71E-03	7.16E-04	9.40E-04	1.54E-03	2.51E-03	3.34E-03
0.06	1.32E-03	5.29E-04	6.96E-04	1.17E-03	1.96E-03	2.68E-03
0.07	1.05E-03	4.06E-04	5.38E-04	9.15E-04	1.58E-03	2.21E-03
0.08	8.64E-04	3.20E-04	4.28E-04	7.42E-04	1.30E-03	1.87E-03
0.09	7.23E-04	2.58E-04	3.49E-04	6.15E-04	1.09E-03	1.61E-03
0.10	6.15E-04	2.12E-04	2.89E-04	5.19E-04	9.27E-04	1.40E-03
0.20	2.03E-04	5.40E-05	7.97E-05	1.60E-04	3.22E-04	4.99E-04
0.25	1.40E-04	3.43E-05	5.22E-05	1.09E-04	2.28E-04	3.55E-04
0.30	1.03E-04	2.39E-05	3.72E-05	7.93E-05	1.70E-04	2.66E-04
0.40	6.29E-05	1.39E-05	2.22E-05	4.83E-05	1.06E-04	1.63E-04
0.50	4.22E-05	8.96E-06	1.48E-05	3.27E-05	7.05E-05	1.08E-04
0.60	3.02E-05	6.17E-06	1.03E-05	2.36E-05	5.00E-05	7.67E-05
0.70	2.25E-05	4.47E-06	7.50E-06	1.77E-05	3.75E-05	5.75E-05
0.80	1.74E-05	3.36E-06	5.69E-06	1.37E-05	2.91E-05	4.45E-05
0.90	1.37E-05	2.60E-06	4.45E-06	1.07E-05	2.32E-05	3.54E-05
1.00	1.10E-05	2.06E-06	3.54E-06	8.55E-06	1.88E-05	2.87E-05
2.00	2.21E-06	3.17E-07	5.81E-07	1.62E-06	3.91E-06	6.23E-06
3.00	7.68E-07	8.67E-08	1.68E-07	5.36E-07	1.38E-06	2.31E-06
5.00	1.80E-07	1.30E-08	2.76E-08	1.12E-07	3.30E-07	6.09E-07

TABLE C-4
5 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

Spectral Acceleration [g]	Annual Frequency of Exceedance					
	Mean	5th	16th	50th	84th	95th
0.01	9.27E-03	5.43E-03	6.51E-03	8.97E-03	1.21E-02	1.42E-02
0.02	3.69E-03	1.86E-03	2.34E-03	3.49E-03	5.12E-03	6.23E-03
0.03	2.07E-03	9.40E-04	1.22E-03	1.92E-03	2.98E-03	3.72E-03
0.04	1.32E-03	5.53E-04	7.31E-04	1.20E-03	1.95E-03	2.50E-03
0.05	9.17E-04	3.61E-04	4.85E-04	8.21E-04	1.38E-03	1.81E-03
0.06	6.74E-04	2.51E-04	3.44E-04	5.98E-04	1.02E-03	1.37E-03
0.07	5.18E-04	1.84E-04	2.56E-04	4.55E-04	7.91E-04	1.08E-03
0.08	4.11E-04	1.39E-04	1.96E-04	3.58E-04	6.32E-04	8.72E-04
0.09	3.34E-04	1.08E-04	1.55E-04	2.89E-04	5.17E-04	7.22E-04
0.10	2.77E-04	8.60E-05	1.25E-04	2.38E-04	4.32E-04	6.09E-04
0.20	7.91E-05	1.94E-05	3.00E-05	6.44E-05	1.28E-04	1.93E-04
0.25	5.24E-05	1.20E-05	1.91E-05	4.22E-05	8.56E-05	1.31E-04
0.30	3.72E-05	8.05E-06	1.32E-05	2.98E-05	6.14E-05	9.36E-05
0.40	2.14E-05	4.25E-06	7.18E-06	1.71E-05	3.59E-05	5.44E-05
0.50	1.37E-05	2.57E-06	4.40E-06	1.09E-05	2.34E-05	3.54E-05
0.60	9.44E-06	1.67E-06	2.92E-06	7.40E-06	1.64E-05	2.47E-05
0.70	6.84E-06	1.14E-06	2.04E-06	5.28E-06	1.20E-05	1.82E-05
0.80	5.14E-06	8.08E-07	1.48E-06	3.92E-06	9.05E-06	1.38E-05
0.90	3.98E-06	5.91E-07	1.10E-06	3.00E-06	7.02E-06	1.08E-05
1.00	3.15E-06	4.44E-07	8.37E-07	2.35E-06	5.57E-06	8.66E-06
2.00	5.86E-07	5.12E-08	1.07E-07	3.90E-07	1.08E-06	1.81E-06
3.00	1.99E-07	1.18E-08	2.68E-08	1.17E-07	3.76E-07	6.74E-07
5.00	4.20E-08	1.24E-09	3.31E-09	1.88E-08	7.97E-08	1.61E-07

TABLE C-5
2.5 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

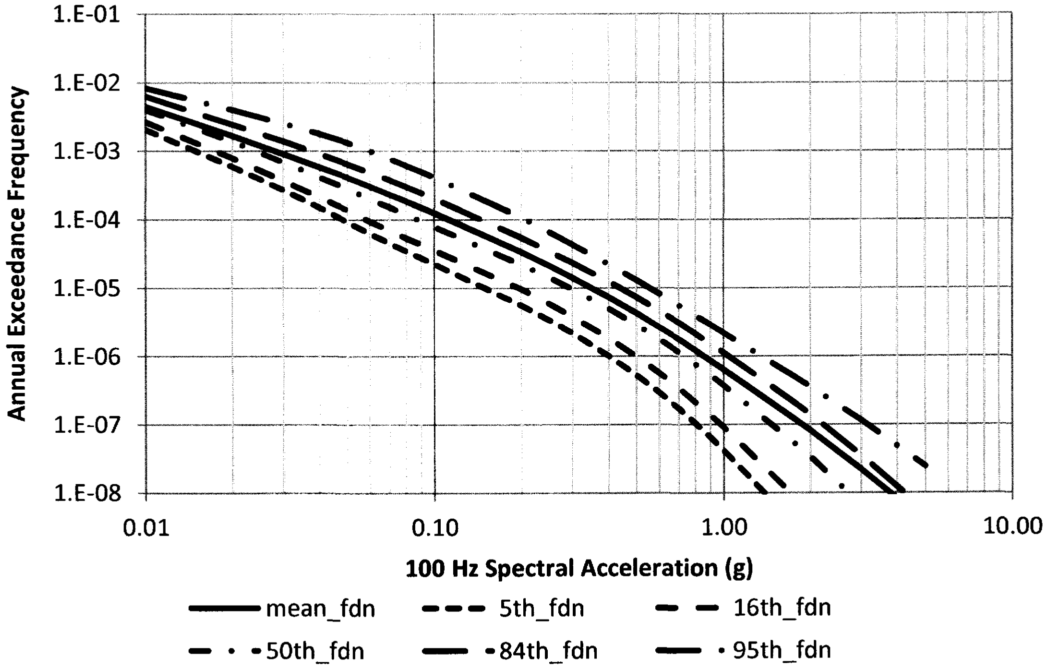
Spectral Acceleration [g]	Annual Frequency of Exceedance					
	Mean	5th	16th	50th	84th	95th
0.01	3.75E-03	1.94E-03	2.43E-03	3.58E-03	5.11E-03	6.13E-03
0.02	1.18E-03	4.82E-04	6.44E-04	1.07E-03	1.74E-03	2.22E-03
0.03	5.24E-04	1.86E-04	2.62E-04	4.64E-04	8.05E-04	1.07E-03
0.04	2.86E-04	8.95E-05	1.31E-04	2.49E-04	4.50E-04	6.10E-04
0.05	1.77E-04	5.02E-05	7.51E-05	1.52E-04	2.85E-04	3.94E-04
0.06	1.20E-04	3.14E-05	4.76E-05	1.01E-04	1.97E-04	2.76E-04
0.07	8.62E-05	2.12E-05	3.25E-05	7.06E-05	1.45E-04	2.05E-04
0.08	6.49E-05	1.50E-05	2.34E-05	5.22E-05	1.11E-04	1.59E-04
0.09	5.06E-05	1.10E-05	1.74E-05	4.02E-05	8.73E-05	1.27E-04
0.10	4.06E-05	8.34E-06	1.34E-05	3.19E-05	7.04E-05	1.03E-04
0.20	9.42E-06	1.29E-06	2.37E-06	6.70E-06	1.71E-05	2.68E-05
0.25	5.83E-06	6.77E-07	1.34E-06	3.99E-06	1.08E-05	1.71E-05
0.30	3.91E-06	3.96E-07	8.13E-07	2.60E-06	7.23E-06	1.18E-05
0.40	2.06E-06	1.64E-07	3.62E-07	1.30E-06	3.84E-06	6.46E-06
0.50	1.23E-06	7.83E-08	1.87E-07	7.32E-07	2.35E-06	4.03E-06
0.60	8.00E-07	4.15E-08	1.03E-07	4.52E-07	1.55E-06	2.72E-06
0.70	5.51E-07	2.40E-08	6.11E-08	2.98E-07	1.07E-06	1.95E-06
0.80	3.96E-07	1.46E-08	3.82E-08	2.05E-07	7.67E-07	1.44E-06
0.90	2.94E-07	9.23E-09	2.49E-08	1.45E-07	5.66E-07	1.10E-06
1.00	2.24E-07	6.01E-09	1.68E-08	1.05E-07	4.30E-07	8.53E-07
2.00	3.27E-08	2.56E-10	9.35E-10	9.85E-09	5.98E-08	1.41E-07
3.00	8.95E-09	2.74E-11	1.12E-10	1.78E-09	1.51E-08	4.05E-08
5.00	1.56E-09	1.16E-12	6.04E-12	1.63E-10	2.20E-09	7.42E-09

TABLE C-6
1 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

SPECTRAL ACCELERATION [g]	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	5TH	16TH	50TH	84TH	95TH
0.01	3.94E-03	1.96E-03	2.55E-03	4.00E-03	5.29E-03	6.05E-03
0.02	1.19E-03	4.00E-04	5.62E-04	1.07E-03	1.85E-03	2.37E-03
0.03	5.59E-04	1.50E-04	2.21E-04	4.67E-04	9.34E-04	1.29E-03
0.04	2.94E-04	6.79E-05	1.03E-04	2.32E-04	5.06E-04	7.36E-04
0.05	1.69E-04	3.52E-05	5.48E-05	1.28E-04	2.97E-04	4.49E-04
0.06	1.05E-04	2.01E-05	3.21E-05	7.72E-05	1.87E-04	2.88E-04
0.07	6.93E-05	1.23E-05	2.01E-05	4.97E-05	1.24E-04	1.94E-04
0.08	4.79E-05	7.96E-06	1.32E-05	3.37E-05	8.68E-05	1.37E-04
0.09	3.45E-05	5.40E-06	9.10E-06	2.38E-05	6.30E-05	9.98E-05
0.10	2.57E-05	3.80E-06	6.47E-06	1.73E-05	4.72E-05	7.52E-05
0.20	4.07E-06	2.99E-07	6.24E-07	2.20E-06	7.45E-06	1.40E-05
0.25	2.31E-06	1.26E-07	2.87E-07	1.14E-06	4.22E-06	8.45E-06
0.30	1.48E-06	6.11E-08	1.50E-07	6.75E-07	2.70E-06	5.67E-06
0.40	7.50E-07	1.82E-08	5.17E-08	3.00E-07	1.39E-06	3.08E-06
0.50	4.46E-07	6.65E-09	2.19E-08	1.59E-07	8.15E-07	1.90E-06
0.60	2.91E-07	2.81E-09	1.05E-08	9.17E-08	5.23E-07	1.27E-06
0.70	2.01E-07	1.32E-09	5.48E-09	5.62E-08	3.59E-07	8.90E-07
0.80	1.46E-07	6.68E-10	3.10E-09	3.66E-08	2.57E-07	6.54E-07
0.90	1.09E-07	3.62E-10	1.85E-09	2.49E-08	1.90E-07	4.97E-07
1.00	8.38E-08	2.07E-10	1.15E-09	1.74E-08	1.44E-07	3.87E-07
2.00	1.26E-08	3.26E-12	3.29E-11	1.10E-09	1.71E-08	5.59E-08
3.00	3.85E-09	2.28E-13	3.27E-12	1.82E-10	4.36E-09	1.56E-08
5.00	7.21E-10	0.00E+00	1.09E-13	1.28E-11	5.99E-10	2.39E-09

TABLE C-7
0.5 HZ SPECTRAL ACCELERATION MEAN AND FRACTILE SEISMIC HAZARD AT DBNPS RB FOUNDATION LEVEL

SPECTRAL ACCELERATION [g]	ANNUAL FREQUENCY OF EXCEEDANCE					
	MEAN	5TH	16TH	50TH	84TH	95TH
0.01	1.55E-03	4.64E-04	6.83E-04	1.42E-03	2.51E-03	3.03E-03
0.02	4.27E-04	7.60E-05	1.21E-04	3.20E-04	7.74E-04	1.13E-03
0.03	1.76E-04	2.33E-05	3.91E-05	1.17E-04	3.32E-04	5.34E-04
0.04	8.47E-05	9.26E-06	1.61E-05	5.18E-05	1.62E-04	2.74E-04
0.05	4.57E-05	4.34E-06	7.75E-06	2.62E-05	8.76E-05	1.53E-04
0.06	2.69E-05	2.27E-06	4.20E-06	1.46E-05	5.19E-05	9.25E-05
0.07	1.69E-05	1.29E-06	2.46E-06	8.72E-06	3.29E-05	5.95E-05
0.08	1.12E-05	7.78E-07	1.53E-06	5.54E-06	2.19E-05	4.04E-05
0.09	7.75E-06	4.95E-07	9.94E-07	3.70E-06	1.52E-05	2.88E-05
0.10	5.59E-06	3.27E-07	6.74E-07	2.57E-06	1.09E-05	2.13E-05
0.20	7.47E-07	1.58E-08	4.15E-08	2.33E-07	1.23E-06	3.31E-06
0.25	4.06E-07	5.67E-09	1.60E-08	1.06E-07	6.23E-07	1.89E-06
0.30	2.57E-07	2.31E-09	6.91E-09	5.50E-08	3.70E-07	1.23E-06
0.40	1.29E-07	5.01E-10	1.66E-09	1.91E-08	1.67E-07	6.22E-07
0.50	7.64E-08	1.42E-10	5.13E-10	8.17E-09	8.94E-08	3.70E-07
0.60	4.96E-08	4.67E-11	1.86E-10	3.98E-09	5.20E-08	2.39E-07
0.70	3.42E-08	1.71E-11	7.61E-11	2.15E-09	3.28E-08	1.63E-07
0.80	2.47E-08	6.54E-12	3.40E-11	1.24E-09	2.19E-08	1.15E-07
0.90	1.85E-08	2.48E-12	1.62E-11	7.48E-10	1.51E-08	8.34E-08
1.00	1.42E-08	9.39E-13	8.14E-12	4.72E-10	1.07E-08	6.19E-08
2.00	2.16E-09	0.00E+00	6.94E-14	1.73E-11	8.62E-10	6.76E-09
3.00	6.54E-10	0.00E+00	2.44E-15	2.05E-12	1.68E-10	1.58E-09
5.00	1.23E-10	0.00E+00	0.00E+00	9.59E-14	1.62E-11	1.93E-10



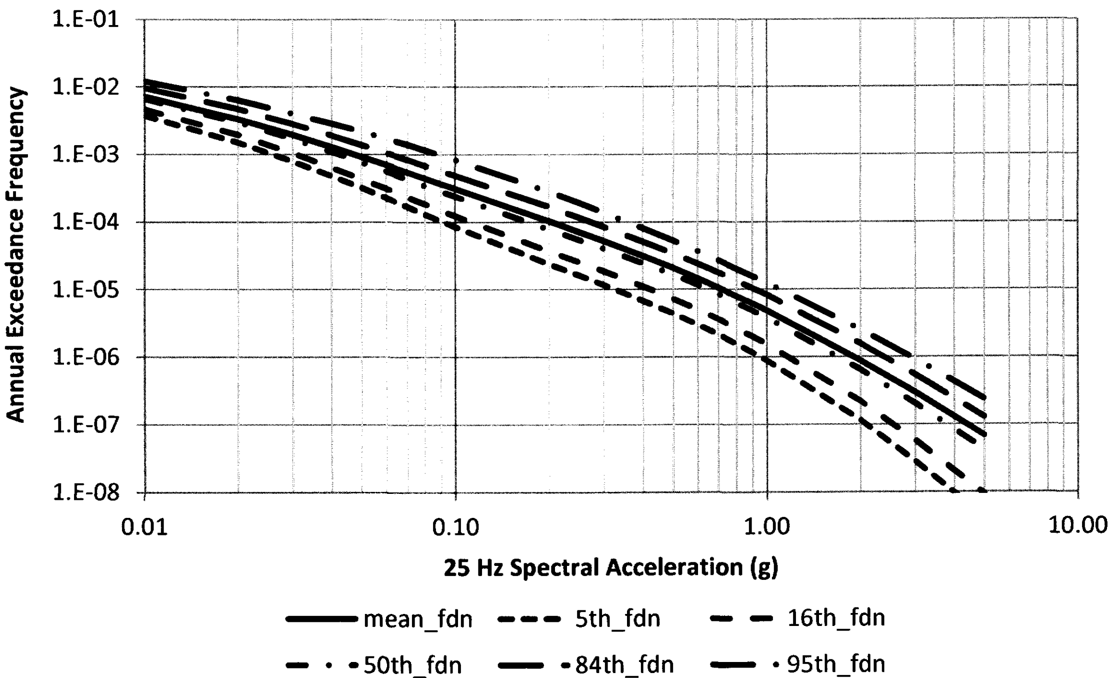
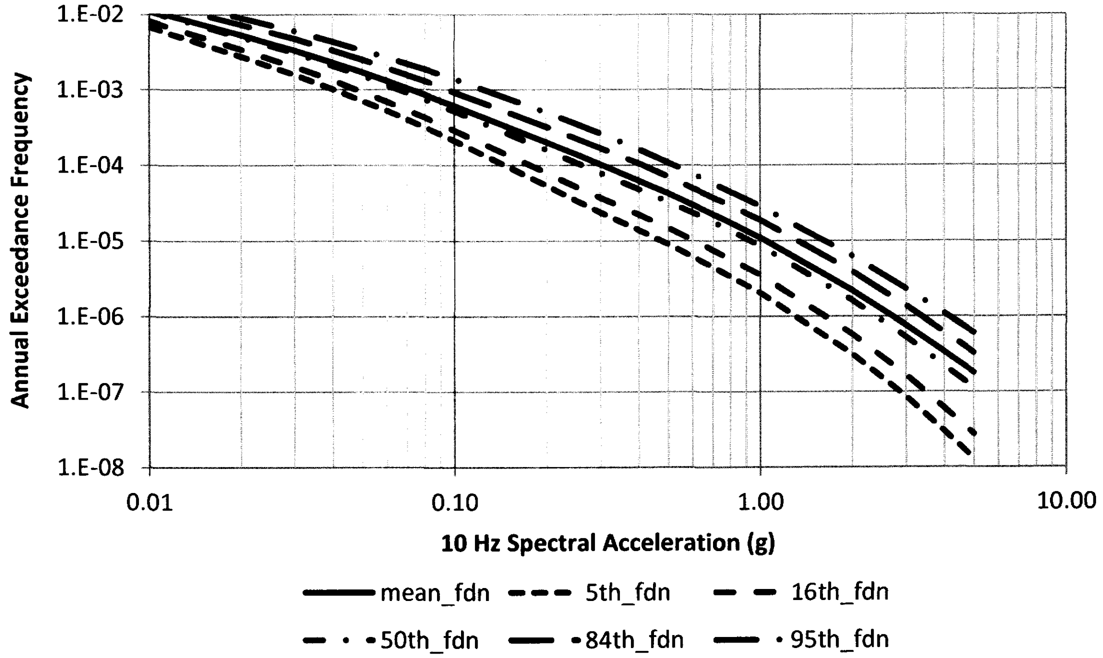


FIGURE C-1
DBNPS MEAN AND FRACTILE HAZARD CURVES AT RB FOUNDATION LEVEL (SA AT 100 HZ AND 25 HZ)



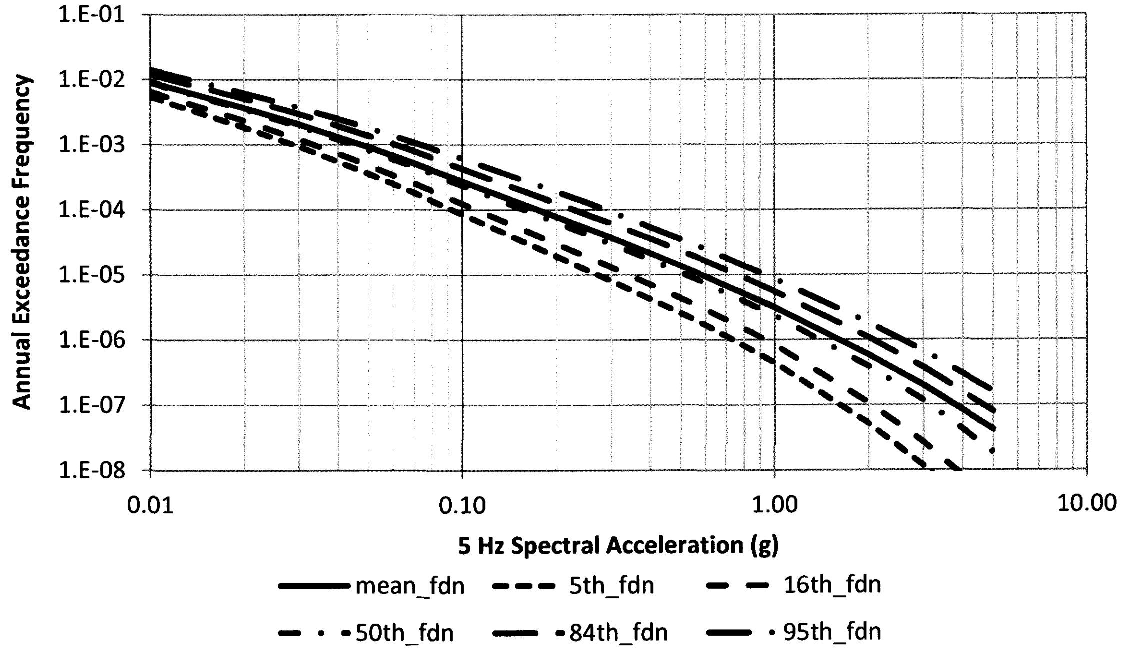
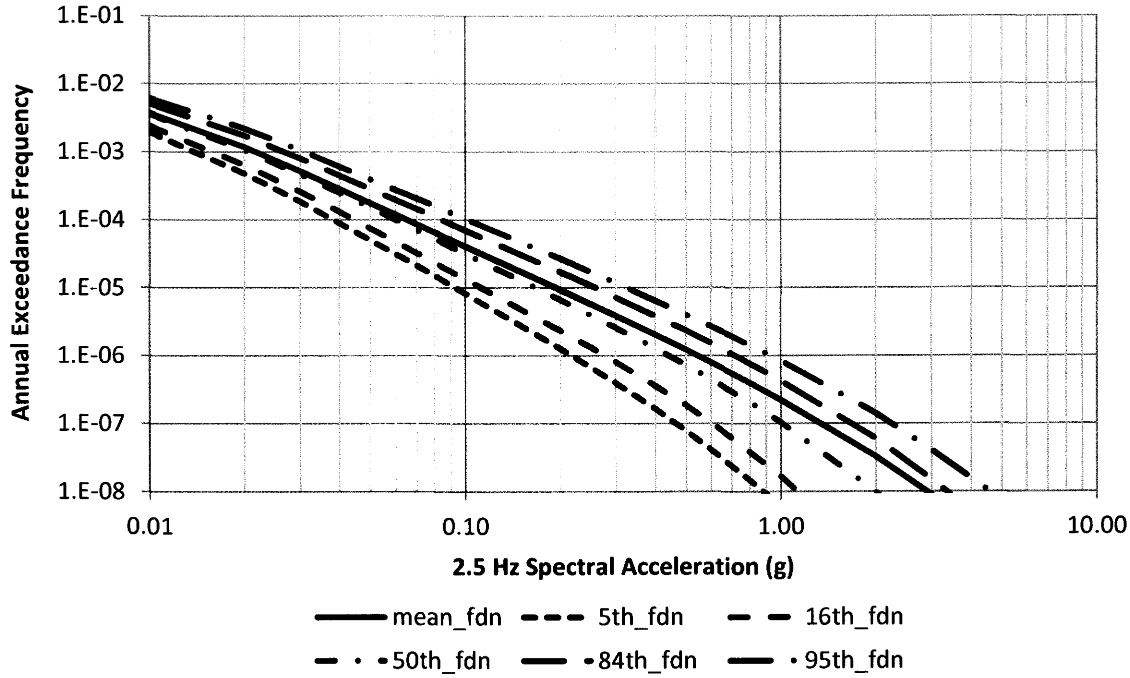


FIGURE C-2
DBNPS MEAN AND FRACTILE HAZARD CURVES AT RB FOUNDATION LEVEL (SA AT 10 HZ AND 5.0 HZ)



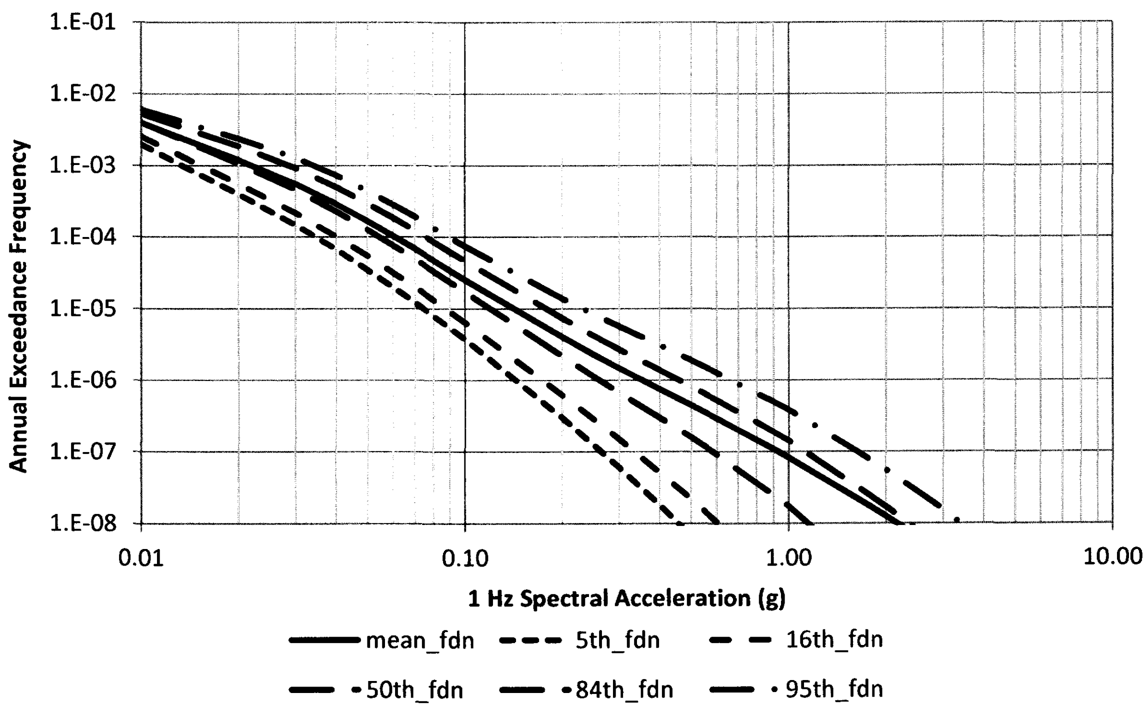


FIGURE C-3
DBNPS MEAN AND FRACTILE HAZARD CURVES AT RB FOUNDATION LEVEL
(SA AT 2.5 HZ AND 1.0 HZ)

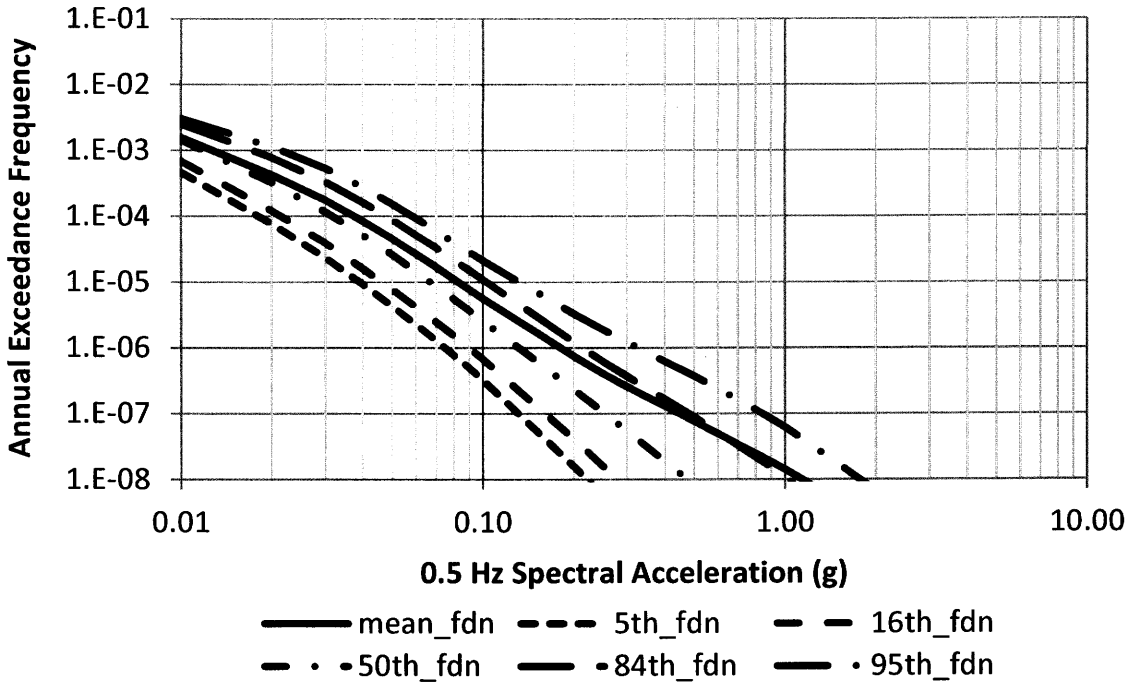


FIGURE C-4
DBNPS MEAN AND FRACTILE HAZARD CURVES AT RB FOUNDATION LEVEL
(SA AT 0.5 HZ)