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March 11, 2015

PG&E Letter DCL-15-035

U.S. Nuclear Regulatory Commission
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10 CFR 50.54(f)

Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident: Seismic Hazard and Screening Report

References:

1. NRC Letter, "Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," dated March 12, 2012

2. Electric Power Research Institute (EPRI) Report No. 1025287, "Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," dated November 2012

3. PG&E Letter DCL-13-044, "Response to NRC Request for Information Pursuant to 10 CFR 50.54(F) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukuhsima Dai-ichi Accident," dated April 29, 2013

4. NRC Letter, "Supplemental Information Related to Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Seismic Hazards Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," dated February 20, 2014

Dear Commissioners and Staff:

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to Pacific Gas and Electric Company (PG&E) directing PG&E to reevaluate the seismic hazards at Diablo Canyon Power Plant (DCPP) using present-day NRC requirements and guidance and to identify actions to address plant specific vulnerabilities associated with the updated seismic hazards. Specific requirements are outlined in Reference 1, Enclosure 1.

In response to Reference 1, and following the guidance provided in Reference 2, PG&E performed a seismic hazard reevaluation for DCPP and developed a DCPP-specific ground motion response spectrum (GMRS) for screening purposes. Enclosure 1 to this letter provides PG&E's Seismic Hazard and Screening Report. Consistent with Reference 4, the enclosed seismic hazard reevaluations are distinct from the current design and licensing bases of DCPP. Consequently, the results of these analyses - performed using present-day regulatory guidance, methodologies, and information - would not generally be expected to call into question the operability or functionality of structures, systems and components, and were not reportable pursuant to 10 CFR 50.72, "Immediate Notification Requirements for Operating Nuclear Power Reactors," and 10 CFR 50.73, "Licensee Event Report System."

The GMRS was developed through the performance of a Senior Seismic Hazards Analysis Committee (SSHAC) Level 3 seismic source characterization study and a SSHAC Level 3 ground motion characterization study, in accordance with NUREG 2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," dated April 2012, followed by a site-specific amplification study. A copy of the participatory peer review panels (PPRP) closure letters for seismic source characterization and the ground motion characterization (GMC) is provided in Enclosure 1, Appendix C. The GMC closure letter found that the DCPP SSHAC meets the expectations for a SSHAC Level 3 study but requested that additional technical justification be provided regarding the application of the directivity component of the GMC model to the DCPP site. The SSHAC Technical Integration team provided a response to the PPRP request (see Enclosure 1, Appendix C). PG&E will submit the resolution of the PPRP identified request as soon as it is completed.

As discussed in NRC Letter, "Diablo Canyon Power Plant, Unit Nos. 1 and 2 – NRC Review of Shoreline Fault (TAC Nos. ME5306 and ME5307)," dated October 12, 2012, PG&E's reevaluation used the DCPP double design earthquake (DDE) as the safe shutdown earthquake for screening purposes. PG&E's screening evaluation of the GMRS indicates that the GMRS exceeds the DDE in the 1 to 10 hertz frequency range. Therefore, DCPP screens-in for a seismic risk evaluation in accordance with Reference 2. PG&E will perform the seismic risk evaluation as required in Reference 2. In the interim, PG&E compared the GMRS to the design and licensing basis 1977 Hosgri earthquake spectrum and to the results of the long term seismic program seismic margins assessment. These comparisons demonstrate that there is reasonable assurance that the DCPP structures, systems, and components required for safe shutdown will continue to perform their intended safety function if subjected to the ground motions at the newly developed GMRS levels. PG&E will perform an update of the seismic probabilistic risk assessment (PRA), which will include high-frequency confirmation, and a spent fuel pool integrity evaluation in accordance with Reference 2.

PG&E is making a new regulatory commitment (as defined by NEI 99-04). PG&E is revising an existing regulatory commitment as shown in Enclosure 2. PG&E has determined that it is not necessary to perform an expedited seismic evaluation process as PG&E's interim evaluation provides reasonable assurance that it is safe to operate DCPP while the updated/upgraded seismic PRA is developed. Refer to Enclosure 2.

If you have any questions, or require additional information, please contact Mr. L. Jearl Strickland at (805) 781-9795.

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

Executed on March 11, 2015.

Sincerely,

Barry S. Allen

Barry S. Allen
Vice President, Nuclear Services

dmfn/50465913-3
Enclosures
cc: Diablo Distribution
cc:/enc: Marc L. Dapas, NRC Region IV Administrator
Dan H. Dorman, NRC/NRR Director
Thomas R. Hipschman, NRC, Senior Resident Inspector
Siva P. Lingam, NRR Project Manager

Pacific Gas and Electric Company

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1.0 Introduction

Following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami, the 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, on March 12, 2014, the NRC issued a request for information letter under Title 10, "Energy," of the Code of Federal Regulations, Part 50, "Domestic Licensing of Production and Utilization Facilities," Section 50.54, "Conditions of Licenses," Subsection (f), "Request for Information," (March 12, 2012 10 CFR 50.54(f) letter), to assure that these recommendations are addressed by all United States nuclear power plants (NRC 2012). The March 12, 2012 10 CFR 50.54(f) letter requests that licensees and holders of construction permits under 10 CFR 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/licensing 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 10 CFR 50.54(f) letter pertaining to NTTF Recommendation 2.1 (NRC 2012) for Diablo Canyon Power Plant (DCPP), located in San Luis Obispo County, California. In providing this information, Pacific Gas and Electric Company (PG&E) followed the guidance provided in Electric Power Research Institute (EPRI) Technical Report No. 1025287, "Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic" (EPRI 2013a).

The original geologic and seismic siting investigations for DCPP predate the issuance of Appendix A, "Seismic and Geologic Siting Criteria for Nuclear Power Plants," to 10 CFR 100, "Reactor Site Criteria" (NRC 1973). The double design earthquake (DDE), which the NRC directed PG&E to use for the response to the March 12, 2012 10 CFR 50.54(f) letter[1], was originally developed using site-specific criteria and methods, and is used for the design of Design Class I structures, systems, and components, where Design Class I is DCPP's

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1 As stated in the NRC's letter to PG&E dated October 12, 2012 (NRC 2012c), "for the purposes of the response to the March 12, 2012 request for information, the NRC staff expects PG&E to use the DDE for comparison with the reevaluated seismic hazard GMRS."

equivalent to Seismic Category I, as defined in NRC Regulator Guide 1.29, "Seismic Design Classification" (NRC 1978). In addition, the seismic design of DCPP includes the 1977 Hosgri earthquake (HE). The 1977 HE, which has significantly larger ground motions than the DDE, is also used for design and evaluation of Design Class I structures, systems, and components. Finally, in response to License Condition 2.C.(7) of the DCPP Unit 1 operating license, the Long Term Seismic Program (LTSP) earthquake (LTSPE) was developed. The LTSPE was used for DCPP's prior SPRA and SMA (1988 LTSP Final Report, PG&E 1988).

In response to the NRC's March 12, 2012 10 CFR 50.54(f) letter, and following the guidance provided in the screening, prioritization, and implementation details (SPID)[2] (EPRI 2013a) and a Senior Seismic Hazard Analysis Committee (SSHAC) process established by the NRC for western United States plants, a seismic hazard reevaluation was performed for DCPP. This included development of DCPP-specific ground motion response spectrum (GMRS). Consistent with the NRC letter dated February 20, 2014, (NRC 2014) the seismic hazard reevaluations presented herein are being performed to beyond current design/licensing basis requirements for DCPP. Therefore, the results do not call into question the operability or functionality of structures, systems, and components and are not reportable pursuant to 10 CFR 50.72, "Immediate Notification Requirements for Operating Nuclear Power Reactors," or 10 CFR 50.73, "Licensee Event Report System."

The GMRS was developed through the performance of a SSHAC Level 3 seismic source characterization study and a SSHAC Level 3 ground motion characterization study, in accordance with NUREG-2117, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," (NRC 2012b). In addition, a site-specific amplification study was performed. A copy of the participatory peer review panels (PPRP) closure letters for seismic source characterization and the ground motion characterization (GMC) is provided in Appendix C. The GMC closure letter found that the DCPP SSHAC meets the expectations for a SSHAC Level 3 study but requested that additional technical justification be provided regarding the application of the directivity component of the GMC model to the DCPP site. The SSHAC technical integration team provided a response to the PPRP request (see Appendix C). PG&E will submit the resolution of the PPRP identified request as soon as it is completed.

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2 Note: It has been recognized, and acknowledged by the NRC in public meetings (NRC 2014c and NRC 2014d), that the guidance provided in the SPID is more aligned with the seismic hazard studies associated with central and eastern United States plants, while SSHAC studies, performed in accordance with NUREG-2117 (NRC 2012b), and site-specific amplification studies, utilizing more up-to-date, modern day methodologies, are applicable to western United States plants.

DCPP's screening evaluation of the GMRS, performed in accordance with SPID Figure 1-1, indicates that the GMRS exceeds the DDE in the 1 to 10 Hz frequency range. Therefore, DCPP screens-in for a seismic risk evaluation per the requirements of the SPID. PG&E will perform a SPRA in accordance with the EPRI guidance (EPRI 2013a) and the schedule as defined in NEI's letter to the NRC, dated April 9, 2013 (NEI 2013) and confirmed in NRC's letter, dated May 7, 2013 (NRC 2013).

In accordance with the NRC's February 20, 2014 request for supplemental information from plant's that screen-in for a seismic risk evaluation (NRC 2014), PG&E has performed an interim evaluation to address the seismic safety of DCPP. This interim evaluation compared the GMRS to the design/licensing basis 1977 HE spectrum and to the results of the LTSP seismic margin evaluation. This comparison demonstrated that there is reasonable assurance that DCPP's safety related structures, systems, and components will continue to perform their intended safety function if subjected to the ground motions at the newly developed GMRS levels.

PG&E's letter to the NRC dated April 29, 2013 (PG&E 2013d), indicated that the expedited seismic evaluation process (ESEP) would be implemented for DCPP in accordance with EPRI Technical Report No. 3002000704, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic" (EPRI 2013b). However, as noted above, the interim evaluation already demonstrates DCPP's seismic safety while an updated/upgraded SPRA is being developed. No additional insights will be gained for DCPP from the implementation of the ESEP. PG&E concludes that only a SPRA will be performed, rather than the implementation of an ESEP, such that the critical skilled resources can be devoted towards an update/upgrade of the SPRA. The SPRA, which includes the high-frequency confirmation, will be performed in accordance with the EPRI guidance (EPRI 2013a) and the schedule as defined in NEI's letter to the NRC, dated April 9, 2013 (NEI 2013) and confirmed in NRC's letter, dated May 7, 2013 (NRC 2013).

PG&E's spent fuel pool (SFP) screening evaluation indicates that the GMRS exceeds the DCPP DDE in the 1 to 10 Hz frequency range. Therefore, DCPP screens-in for further review of the SFPs as required by the SPID. PG&E also performed an interim evaluation to address the seismic safety of the SFPs, which are located in the fuel handling area of the auxiliary building. Comparing the GMRS with the design/licensing basis 1977 HE spectrum and the LTSP seismic margin shows that the auxiliary building has a significant margin beyond the GMRS. Therefore, there is reasonable assurance that DCPP's SFPs will maintain their structural integrity if subjected to the ground motions at the newly developed GMRS levels. As indicated in PG&E's letter dated April 29, 2013 (PG&E 2013d), PG&E will perform additional evaluations of the SFPs in accordance with the EPRI guidance (EPRI 2013a) and the schedule as defined by the NEI's letter to the NRC, dated April 9, 2013 (NEI 2013) and confirmed in the NRC's letter dated May 7, 2013 (NRC 2013).

2.0 Seismic Hazard Reevaluation

DCPP is located on the central California coast, approximately 19 kilometers (km) (12 miles (mi.)) west of San Luis Obispo, California (Figure 2.0-1). The plant is on the southwestern margin of the Irish Hills, an area of moderate relief bordered by Morro Bay on the north, San Luis Obispo Bay on the south, and Los Osos Valley on the east. The Irish Hills are the northwestern part of the San Luis Range, which trends approximately west-northwest/east-southeast and separates the Santa Maria River Valley to the south from the Los Osos and Edna valleys to the north.

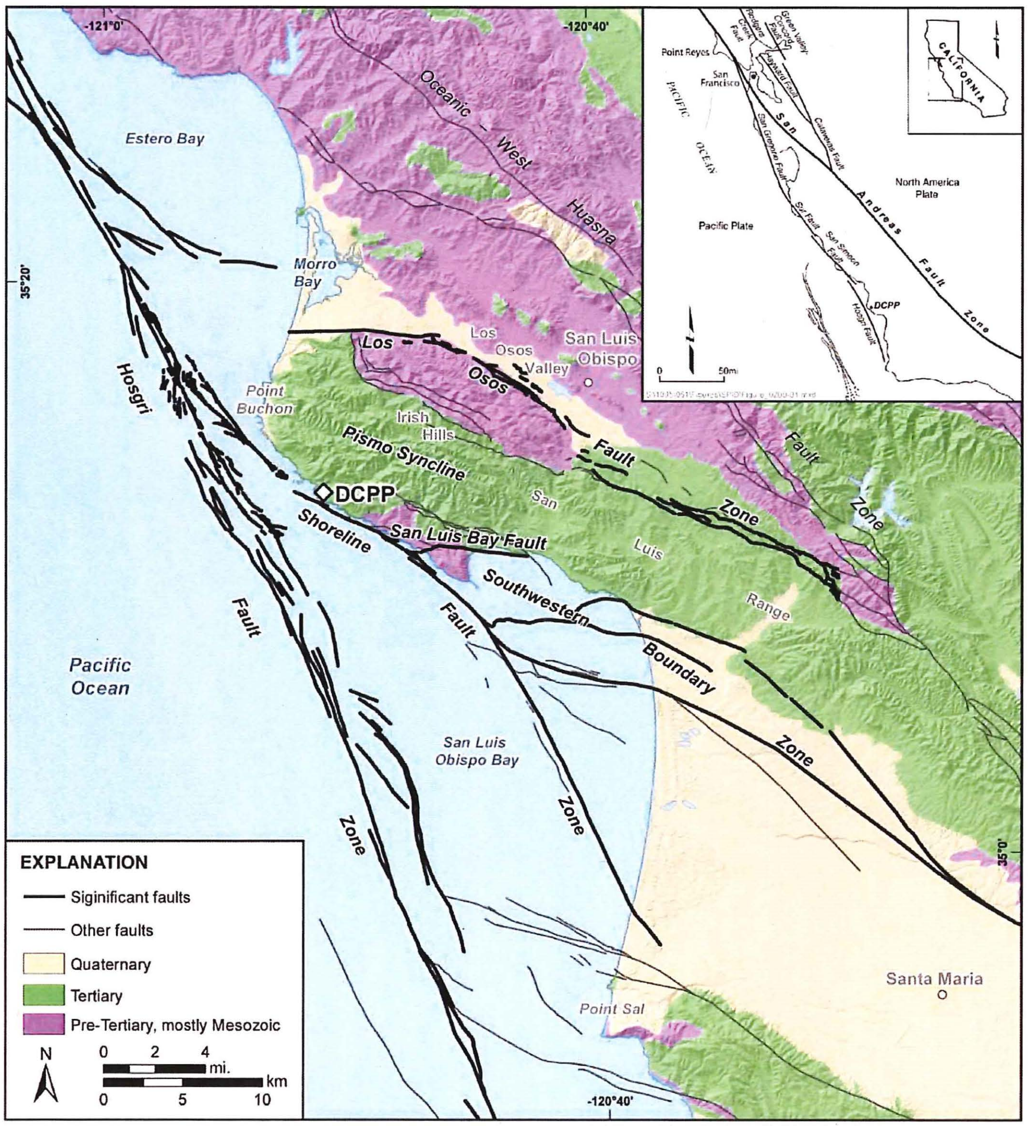

Figure 2.0-1: Simplified Geology and Faults in DCPP's Vicinity

DCPP's site region is within the broad boundary between the Pacific and North American tectonic plates. The majority of relative motion between the plates is accommodated by the right-lateral strike-slip San Andreas Fault Zone (SAFZ), located approximately 80 km (50 mi.) northeast of DCPP. Lesser rates of plate-boundary deformation are accommodated by faults and folds in the coastal and offshore areas around the site.

Historical earthquakes in the DCPP region have been moderate to large. The largest ground motion recorded at the site is a peak ground acceleration (PGA) (horizontal) of 0.042 g from the 2003 moment magnitude (**M**) 6.5 San Simeon earthquake. This ground motion is significantly lower than the ground motions from the design, licensing, and evaluation basis earthquakes (see Section 3.0 for definitions:

a) Design Earthquake (DE): An earthquake having a horizontal PGA of 0.20 g.

b) Double Design Earthquake (DDE): The DDE is defined as twice the DE and is an earthquake having a horizontal PGA of 0.40 g. The NRC staff requested that PG&E use the DDE for the GMRS comparison (NRC 2012c).

c) 1977 Hosgri Earthquake (HE): DCPP's highest-level design/licensing basis earthquake having a horizontal PGA of 0.75 g.

d) 1991 Long Term Seismic Program Earthquake (LTSPE): DCPP's review level earthquake associated with the SPRA and SMA, having a horizontal PGA of 0.83 g.

2.1 Regional and Local Geology

Bedrock in DCPP's vicinity includes highly deformed Mesozoic and Cenozoic sedimentary and volcanic rocks. Foundations of principal plant buildings are founded directly on volcaniclastic rocks of the Miocene Obispo Formation (Fm.).

2.1.1 Bedrock Stratigraphy

Basement rocks exposed in the central California coastal region generally consist of Jurassic to Cretaceous Franciscan Complex rocks (primarily mélange, metavolcanics, ophiolite, and serpentine) faulted against Cretaceous marine arkosic to lithic sandstone (Figure 2.0-1).

Overlying basement rocks in DCPP's vicinity are a sequence of Cenozoic sedimentary and volcanic rocks deposited in fault-bounded, marine to coastal sedimentary basins. Faulted and folded strata of the Pismo basin are located beneath the DCPP site and much of the San Luis Range in the Pismo syncline

(Figure 2.0-1). The base of the Pismo basin Cenozoic sequence consists of the Oligocene Rincon shale and Vaqueros sandstone, which unconformably overlie the Mesozoic basement rocks. Overlying the Oligocene strata are the Miocene Obispo and Monterey Formations and the Miocene to Pliocene Pismo Fm.. The Obispo Fm. consists of resistant zeolitized tuff, tuffaceous marine sandstone, and diabase, whereas the Monterey and Pismo Formations consist of nonvolcanic marine siltstone, chert, and porcelaneous shale.

2.1.2 Tectonic Setting

DCPP is located within a tectonic region of distributed transpressional dextral shear bordering the eastern margin of the Pacific Plate. The SAFZ, located approximately 80 km (50 mi.) northeast of DCPP, accommodates most of the relative motion between the Pacific Plate and the Sierra Nevada–Great Valley microplate. West of the SAFZ, an additional component of relative Pacific–Sierra Nevada plate motion is accommodated by slip on various Quaternary faults bounding crustal blocks and, to a lesser extent, by deformation within the blocks.

In DCPP's site vicinity, the San Luis Range and adjacent valleys and ranges are underlain by crustal blocks that together make up a larger tectonic element called the Los Osos domain (Lettis et al 2004). The Los Osos domain is a triangular structural region bounded by three Quaternary faults: the northwest-striking right-lateral oblique Oceanic–West Huasna fault zone on the east; the west-striking left-lateral oblique Santa Ynez River fault on the south; and the north-northwest-striking right-lateral Hosgri–San Simeon fault zone on the west (Figure 2.0-1).

Individual blocks within the Los Osos domain are bounded by northwest-striking reverse, oblique, and strike-slip fault zones. Crustal shortening within the Los Osos domain is accommodated primarily by reverse faulting along the block margins, producing alternating uplifted and down-dropped blocks (Lettis et al 1994, Lettis et al 2004). Additional crustal shortening and dextral shear is accommodated by a combination of reverse, oblique, and strike-slip faulting between and within blocks and by block rotation.

DCPP is located within the San Luis–Pismo block, which is topographically expressed by the San Luis Range. The San Luis–Pismo block is bounded by the Los Osos fault zone on the north, by the faults of the "southwestern boundary zone" (including the San Luis Bay, Wilmar Avenue, Los Berros, and Oceano fault zones) on the south, and by the Hosgri fault zone on the west (Figure 2.0-1).

2.1.3 Significant Faults

Faults that contribute significantly to the seismic hazard at DCPP include the Hosgri fault zone, the Los Osos fault zone, the San Luis Bay fault within the southwestern boundary zone, and the Shoreline fault (Figure 2.0-1).

2.1.3.1 Hosgri Fault Zone

The Hosgri fault zone is the southern part of the larger 410 km (255 mi.) long San Gregorio–San Simeon–Hosgri fault system (Figure 2.0-1). The location of the offshore Hosgri fault zone is known primarily from the interpretation of marine seismic-reflection data. The fault zone consists of multiple vertical to steeply dipping traces in a zone up to 2.5 km (1.6 mi.) wide directly offshore of DCPP and forms the western termination of the offshore bedrock platform associated with uplift of the San Luis–Pismo block (PG&E 1988, PG&E 1990, PG&E 2011; Willingham et al 2013). Focal mechanisms and the distribution of seismicity along the Hosgri fault zone document nearly pure strike slip on a near vertical to steeply east-dipping fault to a depth of 12 km (7.5 mi.) (McLaren and Savage 2001; Hardebeck 2010, Hardebeck 2013).

Slip rate studies provide an estimate of approximately 1 to 3 millimeters per year (mm/year) of right-lateral slip on the Hosgri fault near DCPP (Hanson and Lettis 1994; Johnson et al 2014; PG&E 2014, Chapter 3). These rates are consistent with regional geodetic data showing approximately 1 to 3 mm/year of plate-margin lateral shear in the region west of the West Huasna fault (DeMets et al 2014).

2.1.3.2 Los Osos Fault Zone

The Los Osos fault zone borders the northeastern margin of the San Luis Range (Figure 2.0-1). The south to southwest-dipping fault generally separates the uplifting San Luis–Pismo block from the subsiding or southwest-tilting Cambria block to the northeast (Lettis et al 1994). As described by Lettis and Hall (Lettis and Hall 1994), the fault zone is a 2 km (1.2 mi.) wide system of discontinuous, sub-parallel and en-echelon fault traces extending from an intersection with the Hosgri fault zone in Estero Bay on the north to an intersection with the West Huasna fault southeast of San Luis Obispo, for a distance of over 55 km (34 mi.). The slip rate of this reverse to reverse-oblique fault is estimated to be approximately 0.2 to 0.4 mm/year (PG&E 2015).

2.1.3.3 San Luis Bay Fault within the Southwestern Boundary Zone

The southwestern margin of the San Luis Range is bordered by a complex zone of late Quaternary reverse, oblique-slip and possibly strike-slip faults (Figure 2.0-1). These faults in aggregate separate the San Luis–Pismo block from the subsiding Santa Maria Valley block to the southwest (Lettis et al 1994). The zone of faults is collectively called the southwestern boundary zone, and is 4 to 10 km (2.5 to 6.2 mi.) wide and over 60 km (30 km) long (Lettis et al 1994; Lettis et al 2004). The faults generally strike west-northwest and dip moderately to steeply to the northeast. Principal structures within this fault zone include the San Luis Bay, Wilmar Avenue, Los Berros, Oceano, and Nipomo faults. The cumulative rate of vertical separation across the fault zone, based primarily on deformation of the marine terrace sequence along the coast and southwest side of the range onshore, ranges from about 0.1 to 0.3 mm/year with each fault generally having a rate of 0.04 to 0.1 mm/year (Lettis et al 1994). Within the southwestern boundary zone, the north-dipping, reverse-slip San Luis Bay fault lies closest to DCPP. The fault has an estimated slip rate of approximately 0.1 to 0.3 mm/year (PG&E 2015).

2.1.3.4 Shoreline Fault Zone

The Shoreline fault was originally identified from a seismicity lineament trending approximately N60°W to N70°W offshore and parallel to the coast in the vicinity of DCPP (Hardebeck 2010) (Figure 2.0-1). Mapping of the Shoreline fault zone at and near the seafloor was performed by PG&E (PG&E 2011; PG&E 2014, Chapters 2 and 3). The hypocentral distribution of seismicity forms a nearly vertical alignment that extends to a depth of about 8 to 10 km, and focal mechanisms indicate the fault is right-lateral strike slip (Hardebeck 2013). Hardebeck (Hardebeck 2013) interprets that to the north the Shoreline fault zone likely connects with the Hosgri fault zone, a result that is consistent with PG&E (PG&E 2014, Chapter 2). Within San Luis Obispo Bay and south of the seismicity lineament, high-resolution 3D seismic data show that the Shoreline fault zone displaces sediments of late Quaternary age providing clear geologic evidence of late Quaternary fault activity (PG&E 2014, Chapter 3). The Shoreline fault zone has an estimated slip rate of approximately 0.03 to 0.15 mm/yr (PG&E 2015).

2.1.4 Site Geology

The geology of DCPP's site area consists of Tertiary Obispo Fm. resistant tuff, volcaniclastic strata, and later-stage Obispo Fm. diabase that intruded into the Obispo Fm. volcaniclastics, Quaternary surficial deposits, and engineered fill (Figures 2.1.4-1 and 2.1.4-2). Older Cretaceous sandstone and Franciscan basement rocks are mapped on the seafloor approximately 500 meters (m) southwest of DCPP (Figure 2.1.4-1), and onshore along the coastline several km to the southeast (Figure 2.0-1; PG&E 2014, Chapter 9).

Four map-scale Obispo Fm. sub-units, or lithofacies, are recognized within the DCPP site area. From oldest to youngest, these sub-units are as follows:

a) Resistant, bedded to massive tuffaceous rocks, including possible "peperite," a near-source intrusive tuff (Tmor)

b) Bedded, shaley siltstone with tuffaceous fine sandstone interbeds (Tmofc)

c) Bedded, tuffaceous and dolomitized fine sandstone and siltstone (Tmofb)

d) Massive to jointed diabase (Tmod).

The diabase sub-unit intrudes all the other lithologies, and thus is the youngest (PG&E 2014, Chapter 9).

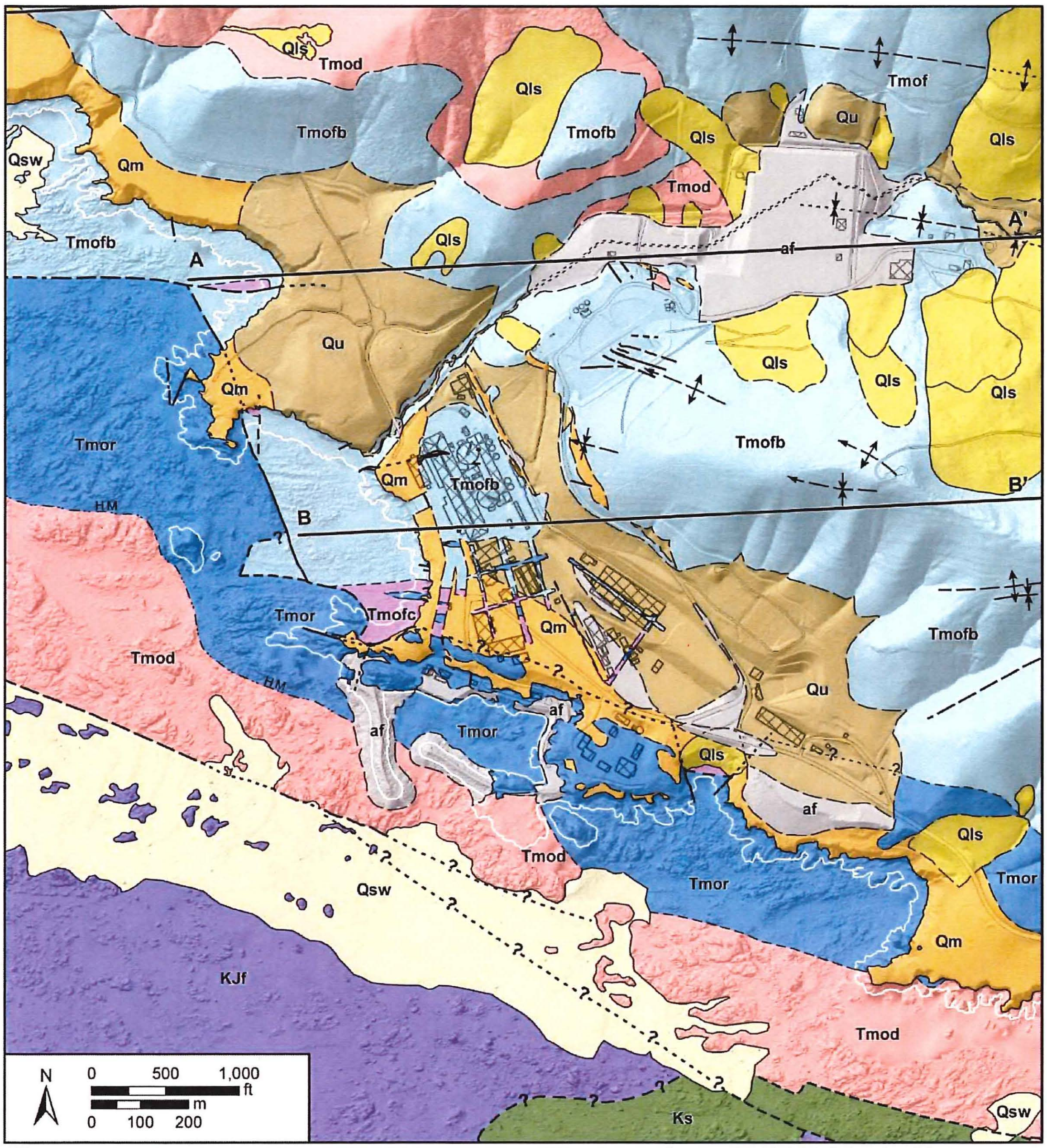

Figure 2.1.4-1: Geologic Map of DCPP's Site Area from (PG&E 2014, Chapter 9)
(Explanation of geologic units and symbols are shown on Figure 2.1.4-2)

Geologic Units

Quaternary

- **af** — **Artificial fill:** fill material emplaced locally during construction and improvement activities. Shallow fills not shown; bedrock with trenches and excavation for power block shown; filled with af.
- **Qsw** — **Sand wave deposits, offshore:** unlithified sheets of sand that form migrating marine dunes.
- **Qls** — **Landslide deposits:** unlithified masses of displaced bedrock and/or soil; may be active or inactive.
- **Qm** — **Marine terrace deposits:** unlithified to weakly lithified marine sand and gravel deposited above wave-cut platforms in the Pleistocene and commonly overlain by alluvial fan and colluvial deposits.
- **Qu** — **Quaternary deposits, undifferentiated:** unlithified silt, sand, and/or gravel; consists of alluvial fan, fluvial terrace, alluvial and colluvial deposits.

Neogene — Miocene

- **Tmod** — **Obispo Formation, diabase:** brown, aphanitic to phaneritic, intrusive in dikes and sills.
- **Tmofb** — **Obispo Formation, fine-grained sub-member b:** Bedded tuffaceous, dolomitic, fine to medium-bedded siltstone and fine sandstone.
- **Tmofc** — **Obispo Formation, fine-grained sub-member c:** Bedded shale and siltstone, very fine bedded silty shale with medium bedded, dolomitic siltstone interbeds.
- **Tmor** — **Obispo Formation, resistant member:** Bedded to massive zeolitic tuff, tuff breccia, and tuffaceous sandstone.

Jurassic/Cretaceous

- **Ks** — **Cretaceous Sandstone:** arkosic to lithic sandstone, brown, bedded, well-lithified, fine- to course-grained, includes minor shale.
- **KJf** — **Franciscan Complex, undifferentiated**

Geologic Structures

From previous mapping and GMP

- **Contact:** solid where well located, long dash where approximate, short dash where inferred, dotted where concealed, queried where uncertain.
- H M — Boundary (contact) between Obispo diabase and tuffaceous rocks interpreted from helicopter magnetic survey (PG&E, 2011). Line may not follow exact contact of rock at surface.
- **Syncline:** dashed where approximate, dotted where concealed. Arrow points in direction of plunge.
- **Anticline:** dashed where approximate, dotted where concealed. Arrow points in direction of plunge.
- **Fault:** solid where well located, long dash where approximate, short dash where inferred, dotted where concealed, queried where uncertain.

Geographical Features

- Roads
- Buildings
- Coastline (white line) at mean lower low water (approximate sea level)
- A — A' Vp Cross sections (Figure 2.3.1-3)

Figure 2.1.4-2: Explanation of Geologic Units and Symbols for Figure 2.1.4-1

DCPP is underlain by gently to steeply dipping sub-unit Tmofb, the bedded, tuffaceous and dolomitized fine sandstone and siltstone (Figure 2.1.4-1). Directly adjacent to the foundation area, this volcaniclastic sub-unit is locally unconformably overlain by Quaternary surficial units including alluvial fan sediments (mapped as part of undifferentiated Quaternary deposits (Qu)) and marine terrace deposits (Qm) (Figure 2.4.1-1). Additionally, engineered fill (af) underlies portions of the roadways and infrastructure at the DCPP site.

2.2 Probabilistic Seismic Hazard Analysis

2.2.1 Probabilistic Seismic Hazard Analysis Results

In accordance with the March 12, 2012 50.54(f) letter (NRC 2012) a site-specific probabilistic seismic hazard assessment was completed for DCPP's site. The assessment used an updated seismic source characterization (SSC) model and an updated GMC model as basic inputs. The SSC and GMC studies were undertaken to fulfill the NRC requirement that PG&E conduct a probabilistic seismic hazard assessment using SSHAC Level 3 procedures for DCPP, as specified by the NRC (NRC 2012). Thus, the SSC and GMC models were developed using processes that are appropriate for a SSHAC Level 3 study, as described in NUREG/CR-6372 (NRC 1997), and the detailed implementation guidance provided in NUREG-2117 (NRC 2012b). Both the SSC and GMC models represent new or "replacement" models according to the definitions and instructions in NUREG-2117. The SSC model describes the future earthquake potential (e.g., magnitudes, locations, and rates) for the region surrounding the DCPP site, and the GMC model describes the distribution of the ground motion as a function of magnitude, style of faulting, source-to-site geometry and reference site condition.

The DCPP SSC model includes fault and areal seismic sources out to and beyond the 320 km (200 mi.) DCPP site region. The SSC model focuses on those sources that contribute most to hazard at DCPP: the Hosgri, Los Osos, San Luis Bay, and Shoreline fault sources, called the primary fault sources, and the local areal source zone, which accounts for earthquakes that occur near DCPP but off the recognized fault sources (PG&E 2015). Uncertainty and variability in earthquake ruptures that are modeled to occur on the primary and adjacent fault sources consider alternative fault geometries and fault slip rates, and include alternative connections of adjacent fault sections across which earthquake ruptures may occur. New elements in the SSC model compared to prior SSC models include fault magnitude probability density functions that allow a fault source to rupture during more common, characteristic earthquakes and rare but permissible multi-fault, maximum earthquakes. The largest earthquake considered in the SSC model is a magnitude **M** 8.5 on the Hosgri fault source, representing an extremely rare, but plausible, rupture between offshore Point Arguello south of DCPP and the Mendocino Triple Junction offshore Cape Mendocino in northern California. The postulated rupture would include the entire 410 km (255 mi.) length of the Hosgri–San Simeon–San Gregorio fault zone and an additional 330 km (205 mi.) of the northern San Andreas fault north of San Francisco. More common characteristic earthquake magnitudes on the fault sources range between **M** 6 and **M** 7.3, with strike-slip, reverse, and reverse-oblique slip senses occurring between approximately 10 and 1 km (6 and 0.6 mi.) from DCPP at closest source-to-site distances. Another new element of the DCPP SSC model is the inclusion of uncertainty in the time-dependent nature of the earthquake occurrence rate. Instructions for implementing the SSC model are in the SSC hazard input document. Full documentation of the DCPP SSC model and the SSHAC Level 3 process is contained in the DCPP SSC Report (PG&E 2015) and is available online at www.pge.com/dcpp-ltsp.

The DCPP GMC model is derived as part of a regional study addressing the ground motion characterization for two sites located in the Southwestern United States (SWUS) (DCPP and Palo Verde Nuclear Generating Station in Arizona), for a common reference site condition with V_{S30}[3] of 760 meters per second (m/s) and kappa of 0.041 seconds (sec) (GeoPentech 2015). The DCPP GMC model for the median is derived from published ground motion prediction equations which are then reparameterized into models that use a common functional form. With a set of models based on a common functional form, the covariance structure of the model coefficients can be estimated and sampled to produce a large number of alternative ground motion prediction equations (GMPEs). This large space of ground motion models is then discretized into a smaller number of representative ground motion models. A key advantage of this approach is that the weights on the alternative models represent probabilities of the ground motion models based on the discretization of the ground motion model space. The ground motion models are optimized for large magnitudes (**M** 5.5 to **M** 7.5) strike slip and reverse events at short distances (< 10 km) that dominate the hazard at DCPP. The hanging-wall effects are captured from a suite of hanging-wall adjustment models derived from the hanging-wall scaling in the existing NGA-West2 R_{RUP}-based GMPEs.

In addition to the empirically-based models, finite fault simulations were used for three purposes: (1) to constrain the hanging-wall scaling; (2). to provide an alternative data set of large magnitude near-fault ground motions for use in the evaluation of the weights for the ground motion models; and (3) to constrain the scaling of ground motions for complex and splay ruptures that are not well constrained in the empirical data sets (complex rupture refers to a case with significant (i.e., > 15 degrees) changes in rake and dip along fault strike, and splay rupture refers to a case with two faults rupturing together). The GMC model for the standard deviation for DCPP uses the partially non-ergodic approach (Al Atik et al, 2010) in which the variability of the average site-specific amplification, not captured in the simple site scaling in the GMPEs, is removed from the within-event standard deviation. This approach provides a consistent

[3] V_{s30} is defined as the average shear-wave velocity in the first 30 m of subsoil/rock.

method for combining the uncertainty in the site-specific site amplification with the aleatory variability of the ground motion models.

Instructions for implementing the GMC model are in the GMC hazard input document. Full documentation of the DCPP GMC model and the SSHAC Level 3 process is contained in the southwestern United States GMC report (GeoPentech 2015) which is available online at www.pge.com/dcpp-ltsp.

2.2.2 Base Rock Seismic Hazard Curves

For the central and eastern United States (CEUS) sites, the base rock condition is a hard rock site condition (shear-wave velocity of 2800 m/s) (EPRI 2013c). For the western United States, the ground motion models are not well constrained for hard-rock conditions. Therefore, a reference rock condition for soft-rock (V_{S30} = 760 m/s) is used for the base rock hazard calculation.

The hazard is computed using a minimum moment magnitude of 5.0. All sources within 320 km (200 mi.) of DCPP are included in the hazard calculation, as required by Regulatory Guide 1.208 (NRC 2007). The aleatory variability is modeled using the single-station sigma approach (Al-Atik et al 2010), which removes the systematic site terms from the traditional total standard deviation. Using the single-station sigma approach requires that the epistemic uncertainty in the site-specific site terms be included. The epistemic uncertainty in the site term at each spectral frequency is included through the standard error of the empirical site term.

The hazard curves by seismic source are shown in Figures 2.2.2-1 and 2.2.2-2 for 1 and 10 Hz spectral acceleration, respectively. The digital data associated with these figures are listed in Appendix A. The sources that contribute at least 5 percent to the total hazard at 1×10^{-3} hazard level are shown individually. Only the sources that come within 15 km (9 mi.) of DCPP contribute significantly (at least 5 percent) to the total hazard at any spectral period for hazard levels of 1×10^{-3} or less. The total hazard for seven frequencies is shown in Figure 2.2.2-3.

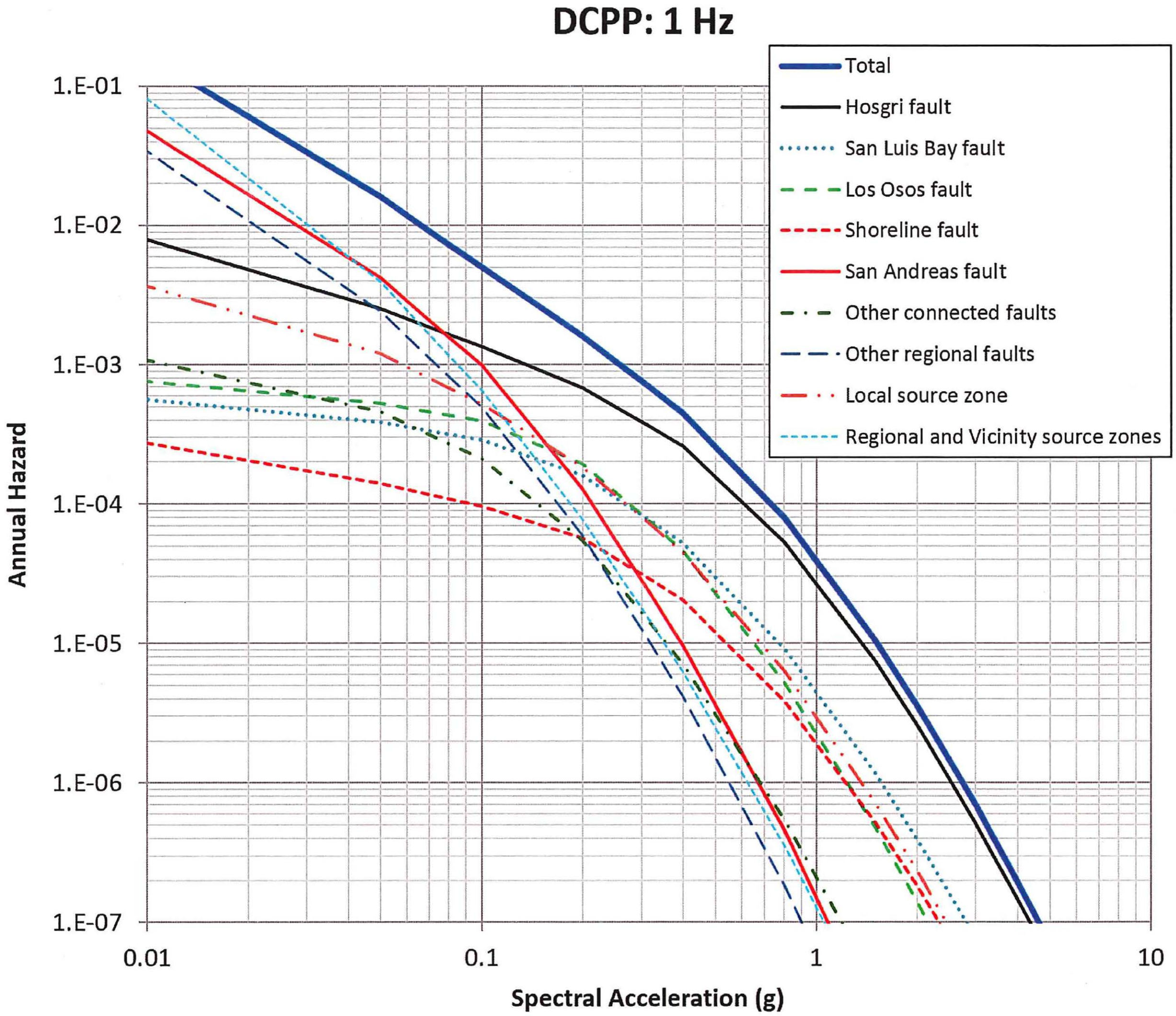

Figure 2.2.2-1: Reference Rock Hazard by Source for 1 Hz Spectral Acceleration

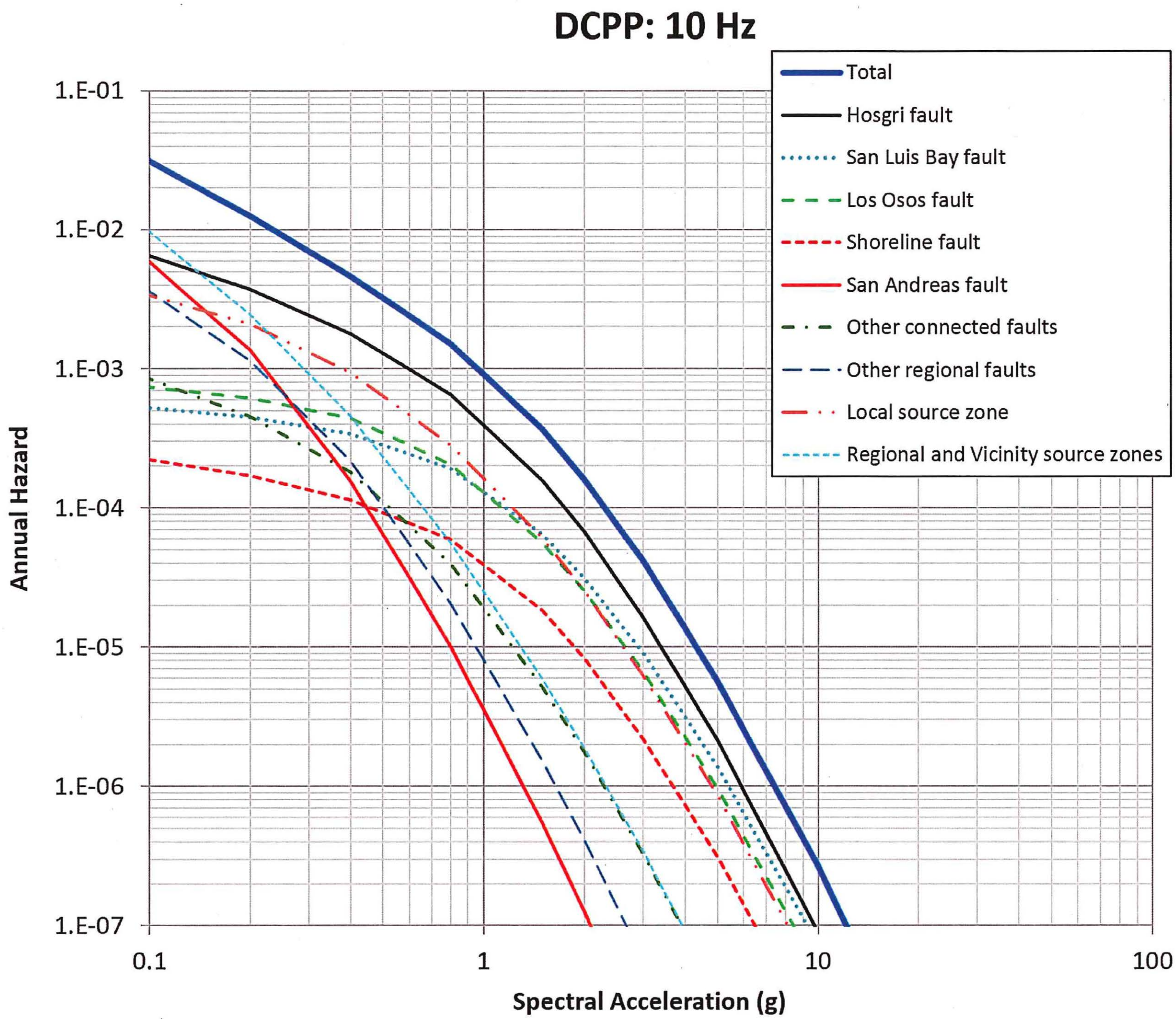

Figure 2.2.2-2: Reference Rock Hazard by Source for 10 Hz Spectral Acceleration

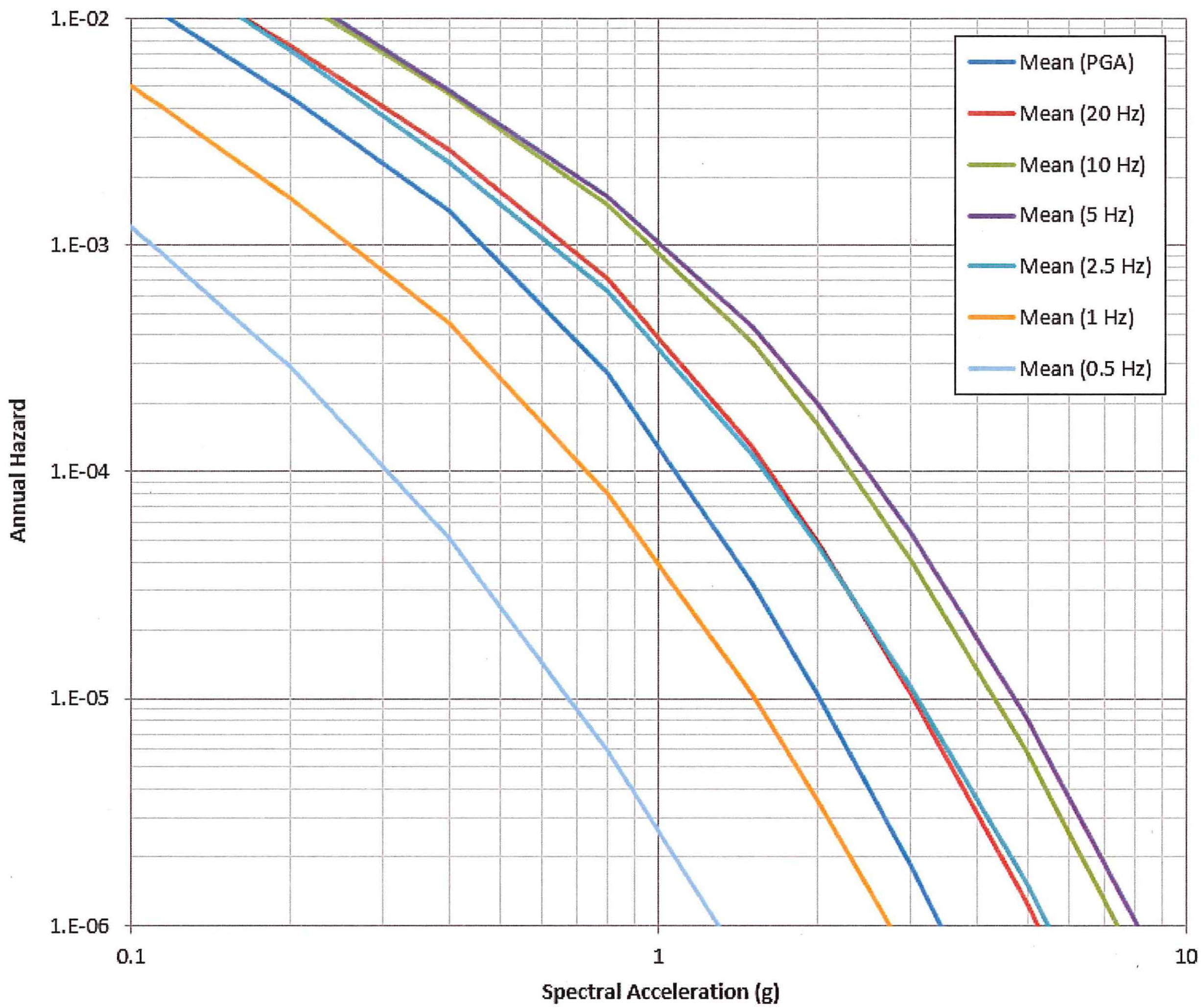

Figure 2.2.2-3: Reference Rock Mean Hazard for PGA and 20, 10, 5, 2.5, 1, and 0.5 Hz Spectral Acceleration

2.3 Site Response Evaluation

The traditional approach for site response is to develop analytical models for the site amplification relative to the reference rock site condition used for computing the hazard. An alternative empirical approach is used for DCPP to account for the recorded ground motion data at DCPP[4]. This approach relies on the observed ground motions at the site to constrain the site amplification rather than analytical models. When site specific data are available, the empirical approach is preferred over analytical modeling. The epistemic uncertainty due to the limited number of recordings is taken into account.

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4 DCPP's seismic instrumentation system, described in Section 3.7.4 of the DCPP UFSAR (PG&E 2013), includes several free-field recording instruments. Ground motion records from instrument nos. ESTA27 and ESTA28 (see Figure 2.3.2-4 for instrument locations) are used as input to the site response evaluation.

The empirical site term represents the difference from the site amplification expected for a reference V_{S30} of 760 m/s and the observed site amplification. It is estimated from recorded data after removing the average source and path terms from the observed ground motions at DCPP.

The control point for DCPP is set at one of the free-field recording instruments (ESTA28). This control point is at elevation 26 m (85 feet (ft)). The empirical site response approach estimates the site amplification at the control point. To estimate the ground motions at other locations as part of the soil-structure interaction analyses, a three-dimensional (3D) site response will be conducted in a separate study. The 3D site response will be used to compute the factors to scale the control point ground motions to other locations accounting for the lateral differences in the 3D velocity structure across the DCPP site. Equivalent one-dimensional (1D) profiles will be developed that capture the range of the amplification from the alternative 3D velocity models in order to define the inputs for the soil-structure interaction analyses.

2.3.1 Description of Subsurface Material

The volcaniclastic Tmofb subunit of the Tertiary Obispo Fm. is mapped to the bottom of the four deepest boreholes in the DCPP foundation area, as well as two deep boreholes located about 305 m (1000 ft) east-northeast of the northeastern corner of the DCPP foundation. Directly adjacent to the Tmofb subunit are other subunits of the Obispo Fm. as shown on Figure 2.1.4-1.

There is considerable rock velocity variability observed in the high-resolution 3D tomographic 5 km by 5 km (3 mi. by 3 mi.) area containing the DCPP structure foundations (PG&E, 2014, Chapter 10). A substantial portion of this variability appears to be related to volcanic intrusion and alteration of the diabase subunit. Characteristics of acoustic (Vp) seismic velocities estimated using 3D tomography from active-source seismic data collected in 2011 and 2012 (PG&E 2014, Chapter 10) are briefly discussed below and then related to first-order geology in the remainder of this section.

The 2011-2012 active seismic acoustic-wave (Vp) travel-time and 2013 gravity data were inverted to estimate 3D Vp in a large area containing DCPP (PG&E 2014, Chapter 10). Several additional 3D Vp inversions used successively finer grid spacing and progressively smaller maximum offset arrival time data to estimate more detailed 3D Vp in the 5 km by 5 km (3 mi. by 3 mi.) volume containing DCPP. The active seismic data were also processed to produce prestack depth-migrated 3D seismic velocity volumes containing DCPP.

There is a first-order correlation between 3D Vp and geologic units (Table 2.3.1-1). The lowest seismic velocities are associated with Quaternary surficial units and the shallowest weathered regions in Tertiary rocks beneath surficial units. The highest seismic velocities are associated with massive diabase. Seismic velocities in the top 300 m vary by more than a factor of 13 in DCPP's site area. Less than half this velocity range is represented by about a factor of three range in velocities between the slowest Quaternary surficial units (Vp = 0.5 kilometers per second (km/s)) and the top of competent weathered rock (Vp = 1.5 km/s). The remaining velocity variability of about a factor of four occurs within Tertiary Obispo Fm. rocks that comprise the entire rock portion of the DCPP foundation to about 300 m below sea level or more.

Interpretation of 3D seismic-reflection data acquired in 2012 in a 3D depth-migrated volume containing the DCPP foundation indicates that there is an unconformity at elevations deeper than 300 m below sea level that separates shallow Obispo rocks from either deeper older Obispo rocks or Cretaceous sandstone (PG&E, 2014, Chapter 8). Thus the entire rock portion of the 3D DCPP foundation velocity model likely consists entirely of Tertiary Obispo Fm. rocks beneath surficial deposits.

Table 2.3.1-1: Generalized Irish Hills Vp-Geologic Unit Correlation

Bin Color (Figure 2.3.1-1)	Vp		Geologic Unit(s)
	(km/sec)	(ft/sec)	
Black	0.560	1,857	Dry soil
Dark Blue	1.120	3,675	Dry soil–weathered rock
Dark Green	1.676	5,512	Saturated soil–weathered rock
Medium Green	2.235	7,349	Typical Tertiary (all units except diabase), weathered Ks and KJf, and KJf of the northern Irish Hills
Light Green	2.794	9,186	Typical higher velocity Obispo Fm. except diabase, and KJf of the northern Irish Hills
Light Blue	3.353	11,024	Typical Ks, fast Obispo Fm. (except diabase), and KJf of the northern Irish Hills
Yellow	3.911	12,861	Typical near the top of KJf, zones around thin diabase, and KJf of the northern Irish Hills
Red	4.470	14,698	Near maximum for KJf, low diabase, and Monterey and Obispo Fm. in the hanging wall of the Edna fault
Dark Red	5.029	16,535	KJf near large-scale diabase intrusions, thin diabase, and Monterey and Obispo Fm. near the Edna fault
Purple	5.588	18,373	Exclusively diabase

Notes: Minimum velocity of the bin is listed.
Ks = Cretaceous sandstone
KJf = Franciscan complex

The 3D Vp values and their correlative geologic units shown in Table 2.3.1-1 were developed by comparing 3D Vp values to observed geologic units throughout the Irish Hills. The table illustrates that, while there probably are unique correlations between velocity and geologic unit for the fastest and slowest velocities in the DCPP foundation area, intermediate velocities can correspond to several different rock types and geologic units of various ages that exist beneath the greater Irish Hills. Thus, seismic velocity does not, in general, uniquely distinguish one rock type or formation from another. For instance, the velocity bin of ~2.2 to 2.8 km/s in Table 2.3.1-1 captures Tertiary Monterey and lower-velocity Obispo Fm. rocks as well as weathered Cretaceous sandstone (Ks) and Franciscan rocks (KJf). Unweathered, massive Obispo diabase is likely the only high-velocity rock unit that has a unique velocity signature over its maximum velocity range of 5.5–6+ km/s (Table 2.3.1-1).

Tabular and saucer-shaped high-velocity bodies are evident in east-west oriented Vp cross sections located beneath and to the north DCPP

(Figures 2.1.4-1 and 2.3.1-1) and within the high-resolution 5 km by 5 km (3 mi. by 3 mi.) tomographic model where dense seismic travel-time measurements where obtained (PG&E 2014, Chapter 10).

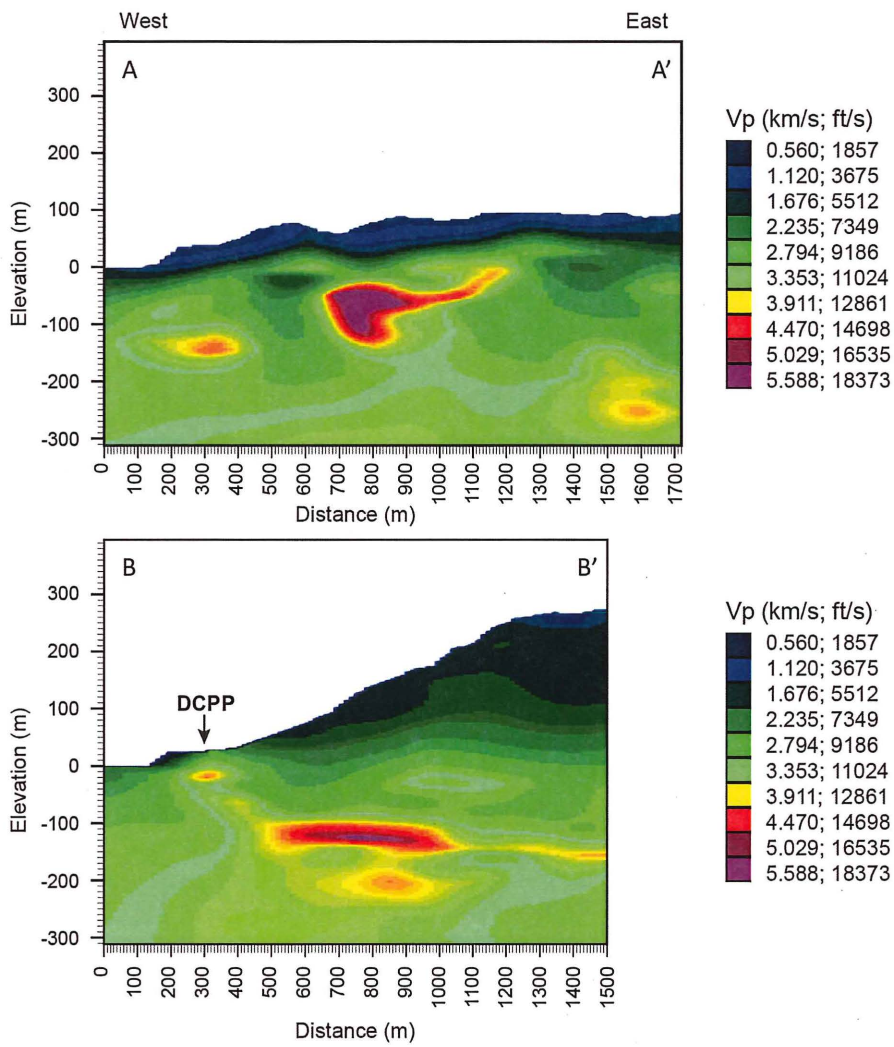

Figure 2.3.1-1: Vp Cross Sections Showing High-Velocity (yellow to magenta) Saucer-Shaped Bodies
(Vertical exaggeration is approximately 2:1. Velocities listed correspond to the top of each color bin. See Figure 2.1.4-1 for cross-section locations)

These high-velocity bodies have 3D shapes that are typically associated with saucer-shaped intrusive sills (PG&E 2014, Chapter 10). The shallow position of the saucer-shaped sills adjacent to, and beneath, some edges of DCPP's foundation area may in part explain observations of the diabase subunit exposed adjacent to the breakwater of intake cove (Figure 2.1.4-1), along the coastline southeast of DCPP, and offshore of DCPP (PG&E 2014, Chapter 9).

2.3.2 Development of Base Case Profiles and Nonlinear Material Properties

The traditional approach uses multiple base profiles and non-linear properties to capture the epistemic uncertainty in the site amplification. For the empirical site term approach used for DCPP, epistemic uncertainty is captured through the epistemic uncertainty of the empirical site terms rather than using uncertainty in the inputs to an analytical site response model.

For DCPP, we use alternative 3D models to capture the epistemic uncertainty in the lateral variation of the ground motion across the DCPP site region. The alternative 3D velocity models were selected from a large suite of alternative models such that they appropriately capture the range of the amplification at the key structures. The epistemic uncertainty in the amplification at the control point ground motion is included in the uncertainty of the empirical site factors. To avoid double counting uncertainty, only the uncertainty in the lateral variations of the site amplification due to the alternative 3D velocity is included in the 3D site response evaluation. As an example, three alternative 3D models of the shear-wave velocity are shown in Figures 2.3.2-1, 2.3.2-2, and 2.3.2-3. Figure 2.3.2-4 shows 1D profiles at the control points based on the 3D models.

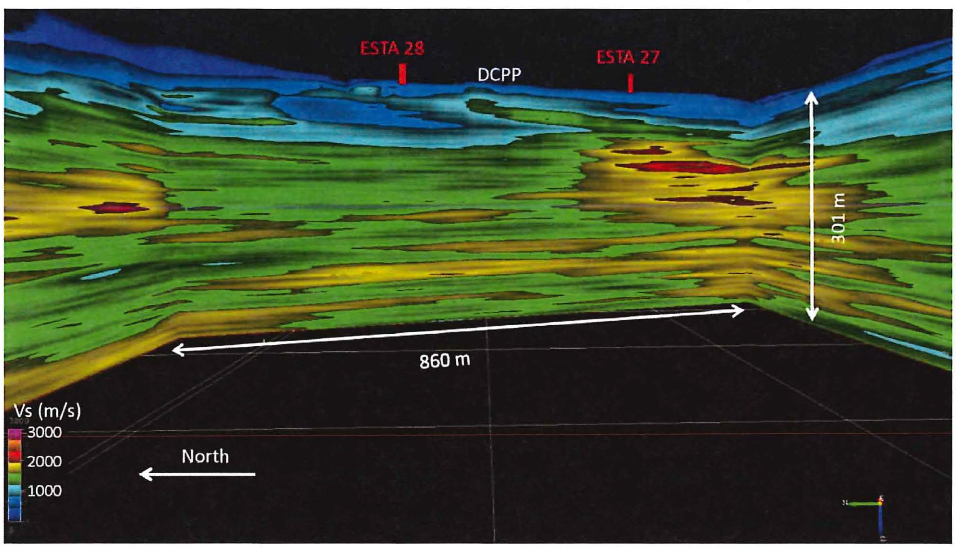

Figure 2.3.2-1: 3D Perspective of Vs-Depth Cross Section Slices through the Low-Amplification 3D Vs DCPP Site Model (Model 1). Location of Cross Section is Shown in Figure 2.3.2-4.

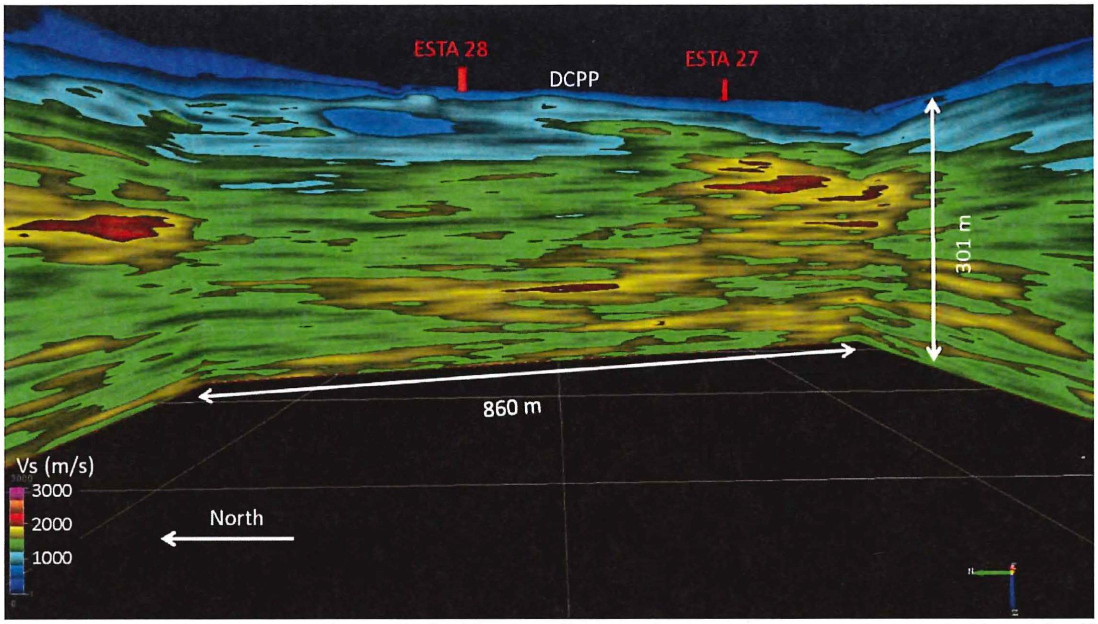

Figure 2.3.2-2: 3D Perspective of Vs-Depth Cross Section Slices through the Medium-Amplification 3D Vs DCPP Site Model (Model 2). Location of Cross Section is Shown in Figure 2.3.2-4.

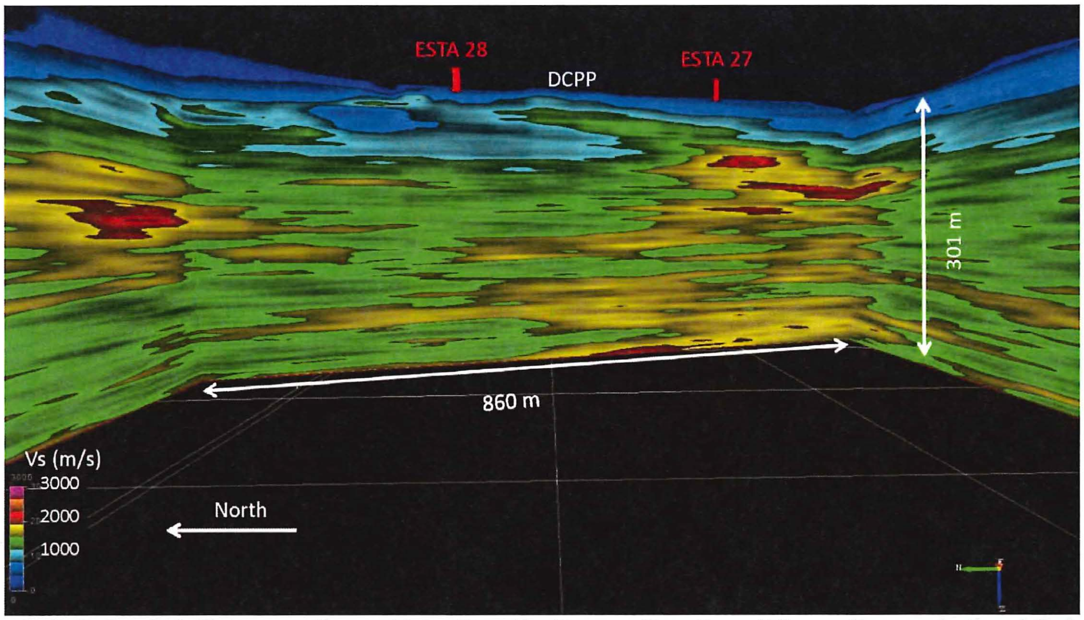

Figure 2.3.2-3: 3D Perspective of Vs-Depth Cross Section Slices through the High-Amplification 3D Vs DCPP Site Model (Model 3). Location of Cross Section is Shown in Figure 2.3.2-4.

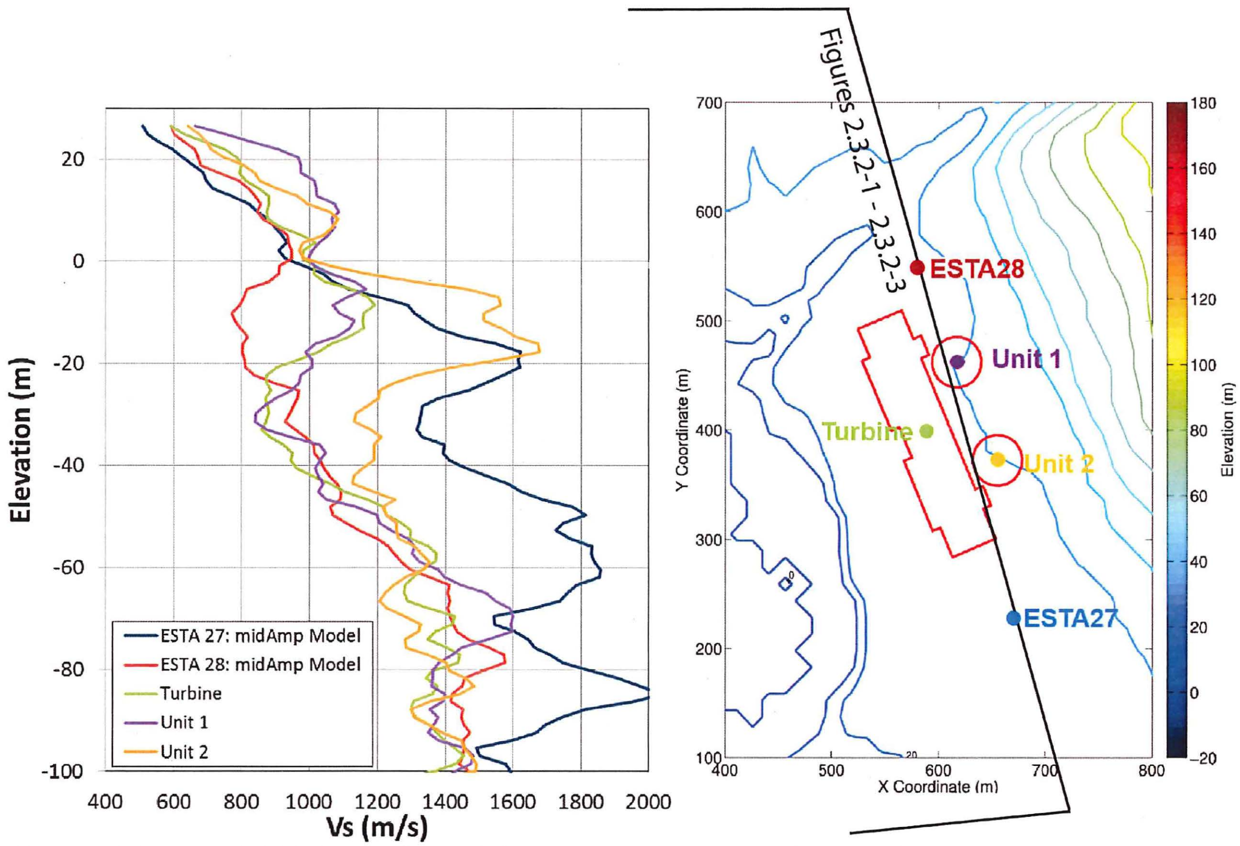

Figure 2.3.2-4: 1D Velocity Model for the Control Point (ESTA 28) and Other Locations in the Plant Area

2.3.2.1 Shear Modulus and Damping Curves

Shear-modulus curves and damping curves are not directly applicable to DCPP, since analytical modeling is not used. The non-linear site effects are implicitly included in the empirical GMPEs for V_{S30} = 760 m/s. The non-linearity in the NGA-West2 GMPEs is generally consistent with the EPRI Peninsular Range shear-modulus curves and damping curves (Kamai et al 2014). In the Kamai et al 2014 model, there is no dependence of the site amplification on the rock ground motion level (e.g. no non-linearity) for V_{S30} > 760 m/s. The NGA-West2 GMPEs also have very weak or no rock ground motion level dependence on the sites amplification for V_{S30} > 760 m/s. Therefore, the empirical site factors are applicable to high rock ground motion levels.

2.3.2.2 Kappa

The kappa values are implied in the empirical GMPEs used to develop the ground motion model and in the site-specific recordings. The GMPEs used to develop the ground motion model have average (host) kappa of 0.041 sec (Appendix M of GeoPentech 2015). The issue for DCPP's empirical approach is the applicability of this host kappa to DCPP's site. The kappa for DCPP was evaluated using the spectral shape of the 2003 Deer Canyon earthquake (Appendix L of the 2011 Shoreline fault report (PG&E 2011)) and was found to be consistent with a kappa of 0.04 sec. Empirical evaluations of the kappa scale factors (Ktenidou and Abrahamson 2015) show that the dependence of the high-frequency ground motion residuals are not strongly correlated with kappa computed from the observed ground motions. They conclude that the estimated site kappa is correlated with other parameters, which limits the observed correlation of residuals and kappa. Therefore, the kappa from the empirical GMPEs used for the ground motion model is consistent with the DCPP site kappa and an adjustment for site-specific kappa or adding additional uncertainty for kappa is not warranted.

2.3.3 Randomization of Base Case Profiles

Randomization of the base case profiles is not needed since DCPP is using the empirical site term approach.

2.3.4 Input Spectra

An input spectrum is not required since DCPP is using the empirical site term approach.

2.3.5 Methodology

The empirical site-term approach is used because site-specific empirical ground-motion data are available at DCPP. These data provide the best information on the site response because they sample the actual conditions at DCPP. In particular, the data provide a better representation of the effects of the deeper structure (top 0.5–1 km) that are important to the kappa and to the low-frequency response, which may not be captured in the analytical modeling. A disadvantage of using site-specific empirical data is the limited number of recordings; however, this limitation is addressed by estimating the epistemic uncertainty in the site response factors based on the number of recordings and the global estimate of the standard deviation of site-specific site terms.

The free-field recordings at DCPP (available from the Pacific Earthquake Engineering Research ground motion database) are used to estimate the site-specific effects on the ground motions relative to the reference-rock GMPEs. The ground motions at a site from a given earthquake reflect the event-specific source and attenuation effects in addition to the site-specific site effects. To isolate the site effects, the differences in the event-specific source and event-specific attenuation effects from the average effects captured in the GMPEs are removed. This is done by computing the mean residual at each spectral frequency over a subset of recorded ground motions from a representative distance range and then developing a source-specific estimate of the ground motion at DCPP by adding the mean residual to the median ground motion from each of the GMPEs. The mean residual for the selected data is different from the traditional event term used in developing GMPEs because it is for a limited distance range. This provides an estimate of not just the average source effect, but also the average path effect (difference from the distance scaling in the GMPEs). To avoid having the DCPP site effects influence the correction, the mean residual is computed without the DCPP data.

Ground motions from the 2003 San Simeon and 2004 Parkfield earthquakes were selected for use in this evaluation. The 2003 Deer Canyon earthquake did not have enough recordings to constrain the mean event term independent of DCPP's recordings. Therefore, the recording from the 2003 Deer Canyon earthquake is not used in this evaluation.

The mean residuals are computed for each of the five NGA-West2 GMPEs. Following the method used in the 2011 Shoreline fault report (PG&E 2011), the residuals are computed for eight recordings in the distance range of 0 to 100 km (62 mi.) for the San Simeon earthquake and for 16 recordings in the distance range of 40 to 170 km (25 to 106 mi.) for the Parkfield earthquake to capture the event term in the relevant distance ranges (35 km (22 mi.) for San Simeon and 85 km (53 mi.) for Parkfield). This mean residual is used to adjust the NGA-West2 GMPEs to the event and distance specific values (e.g. remove average source and path effects). The residuals of the free-field spectral accelerations recorded at DCPP are computed with respect to the event and distance specific spectral accelerations.

The 2003 San Simeon earthquake was recorded at one free-field instrument at DCPP (ESTA27). Following the San Simeon earthquake, additional seismic instrumentation was installed, including an additional free-field instrument (ESTA28). The 2004 Parkfield earthquake was recorded at both free-field instruments (ESTA27 and ESTA28).

The velocity profile at the location of instrument no. ESTA28 becomes similar to the power block[5] and turbine building profiles at depths of about 100 m (see Figure 2.3.2-4 above). The profile for free-field instrument no. ESTA27 shows a different gradient and does not merge with the power block and turbine building profiles at depth as seen with the profile for ESTA28. Since the profile at instrument no. ESTA28 is more consistent with the power block and turbine building profiles, this site is selected as the control point.

2.3.6 Amplification Functions

The residuals for the DCPP free-field recordings were computed (PG&E 2014, Chapter 11) for each of the five event-adjusted NGA-West2 models for a

[5] The term "power block" herein refers to the combination of the Unit 1 containment structure, the Unit 2 containment structures, and the common auxiliary building.

reference rock with V_{S30} = 760 m/s. The average residuals over the five GMPEs are shown on Figure 2.3-1. Overall, the frequency-dependent residuals are consistent between the two recordings over most of the frequency range, but there is a large difference at 0.5 hertz (Hz). In particular, the San Simeon residuals are much larger. The ESTA27 time histories from this earthquake show that the 0.5 Hz ground motion is coming from late-arriving surface waves, indicating different path effects for these two earthquakes. This is not seen in the Parkfield recordings at either ESTA27 or ESTA28. Since the low-frequency residual are not similar for both earthquakes, they are not consistent with a strong site effect. The variability of the low frequency amplification is included in the uncertainty of the site factor. The smoothed model is shown by the heavy black line and represents the DCPP site term relative to the reference free-field instrument no. ESTA28 with V_{S30} = 753 m/s.

If there was no ground motion data at a given site, then the mean site term would be zero and the epistemic uncertainty in the site term would have a standard deviation of phi_{S2S}, which is the standard deviation of the site terms from worldwide data sets. As data is recorded at the site of interest, then the mean site term can be estimated and the epistemic uncertainty reduced from the value of phi_{S2S} from global data. The source and path corrected residual at the site given an estimate of the site term. The standard error of the site terms is phi_{S2S} divided by $\sqrt{N}$, where N is the number of recordings. The uncertainty in the estimated of the source and path terms due to the limited number of recordings is added to the standard error of the site term. The standard error of the DCPP site term is listed in Table 2.3.6-1. The upper and lower ranges shown in the figure are based on ± 1.25 times the standard error and represent the 10th and 90th confidence limits.

The epistemic uncertainty in the site term has two components: the uncertainty in the estimated event-path terms for each earthquake and the variability in the single-path within-event residuals (phi0). The uncertainty in the event-path term is given by the standard error of the estimate of the mean residual of the selected subsets of recordings (8 recordings from San Simeon and 16 recordings from Parkfield). The observed ground motion at a site is a sample from a normal distribution with a standard deviation given by the single-path within-event standard deviation (called phi0). The standard deviation of the epistemic uncertainty in the site term is given by sqrt((SE1^2 + phi0^2)/4 + (SE2^2+Phi0^2)/4) where SE1 and SE2 are the standard errors of the event-path terms from San Simeon and Parkfield respectively. The value of phi0 is given by Lin et al 2011. The epistemic uncertainty is modeled using a three point distribution based on -1.64, 0, and 1.64 times the standard of the epistemic uncertainty with weights of 0.2, 0.6, and 0.0, respectively. The upper and lower ranges shown in Figure 2.3.6-1 and represent the 5th and 95th confidence limits. The central, upper, and lower ranges of DCPP's site-specific site term are listed in Table 2.3.6-1. The median amplification factors and epistemic uncertainty at the control point, using the empirical site response approach, are listed in Appendix A.

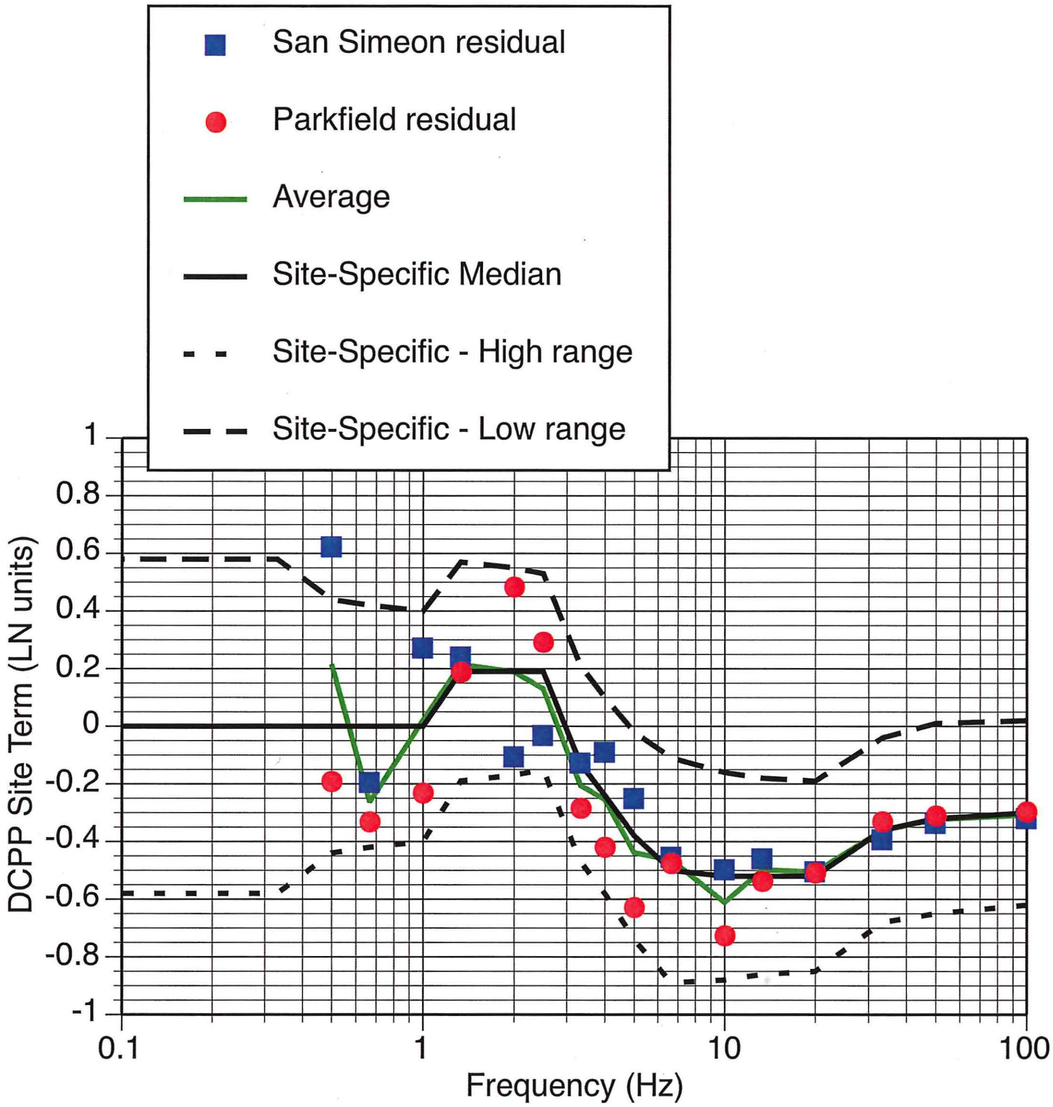

Figure 2.3.6-1: Mean Event-Specific Residuals for DCPP Relative to the ESTA28 Reference Rock Site Condition with V_{S30} = 750 m/s
Note: Epistemic uncertainty (10% and 90% confidence levels) is shown by the dashed lines

Table 2.3.6-1. DCPP Site-Specific Site Amplification Terms

Frequency (Hz)	DCPP Site Term for Control Point (ESTA28) (natural log units)			
	Standard Deviation of DCPP Site Term	Median	Upper Range	Lower Range
100	-0.20	-0.3	-0.62	0.02
50	-0.20	-0.32	-0.65	0.01
34	-0.20	-0.36	-0.68	-0.04
20	-0.20	-0.52	-0.85	-0.19
13.5	-0.21	-0.52	-0.86	-0.18
10	-0.22	-0.52	-0.88	-0.16
6.7	-0.24	-0.5	-0.89	-0.11
5	-0.22	-0.38	-0.74	-0.02
4	-0.21	-0.24	-0.58	0.1
3.3	-0.21	-0.13	-0.47	0.21
2.5	-0.21	0.19	-0.15	0.53
2	-0.22	0.19	-0.17	0.55
1.3	-0.23	0.19	-0.19	0.57
1	-0.24	0	-0.4	0.4
0.67	-0.26	0	-0.42	0.42
0.5	-0.27	0	-0.44	0.44
0.33	-0.35	0.00	0.58	-0.58
0.2	-0.35	0.00	0.58	-0.58
0.1	-0.35	0.00	0.58	-0.58

2.3.7 Control Point Seismic Hazard Curves

The mean hazard for the control point is computed using a method that is consistent with approach 3 of NUREG/CR-6728 (NRC 2001). The site term is added to the median from the ground motion models developed as part of the SSHAC ground motion characterization. Epistemic uncertainty is captured by using a logic tree for the range of the site terms. The mean hazard for the control point for seven frequencies is shown in Figure 2.3.7-1 and listed in Appendix A.

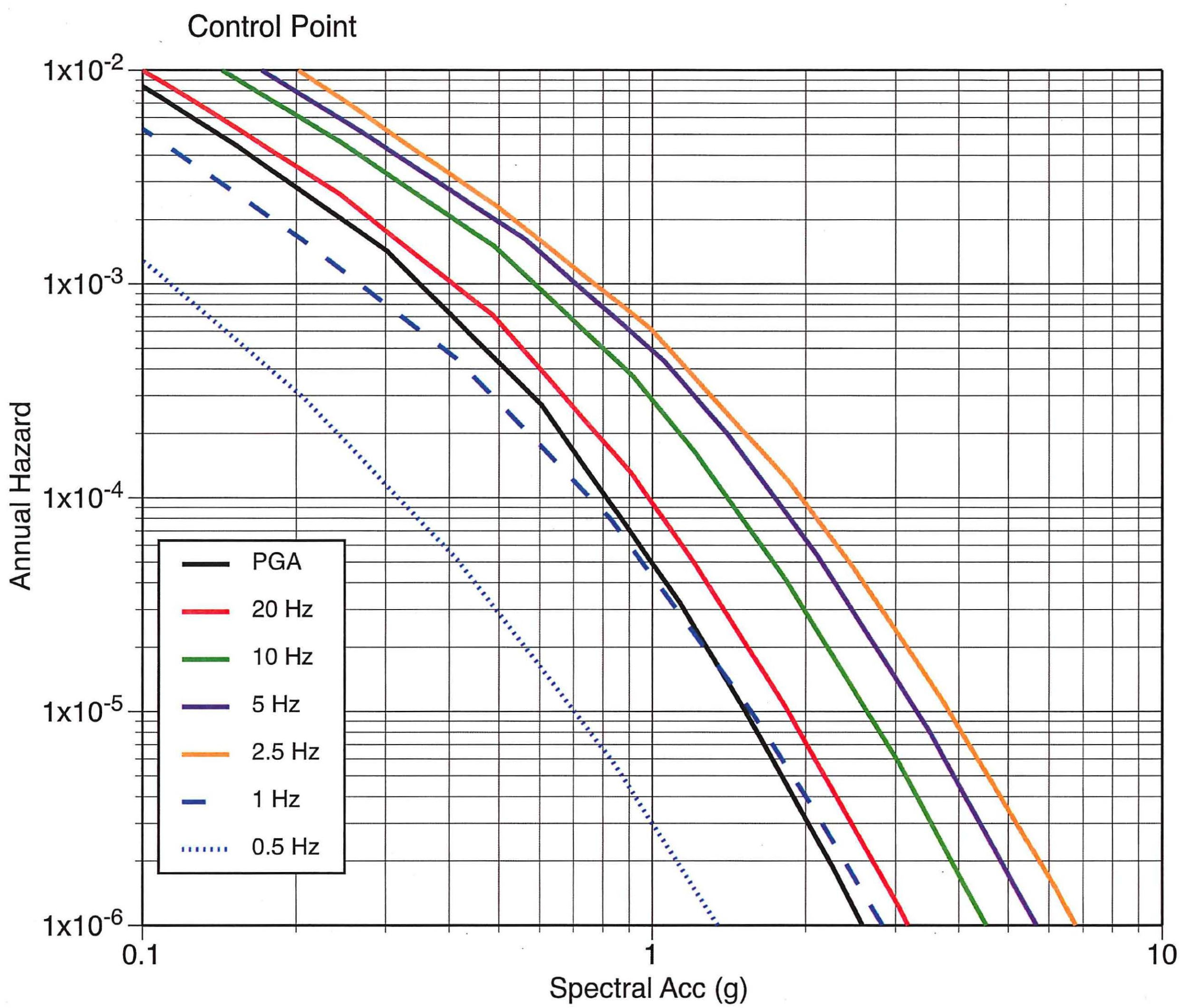

Figure 2.3.7-1 Control Point Mean Hazard Curves for PGA and 20, 10, 5, 2.5, 1, and 0.5 Hz Spectral Frequencies

2.4 Control Point Response Spectra

The uniform hazard response spectra (UHRS) for 1 x 10^{-4} and 1 x 10^{-5} hazard levels at the control point are computed from the mean hazard curves. The UHRS are plotted in Figure 2.4-1 and are listed in Table 2.4-1. The GMRS is computed following the requirements of Regulatory Guide 1.208 (NRC 2007). The GMRS is equal to the 1 x 10^{-4} UHRS at frequencies greater than or equal to 1 Hz. At lower frequencies, the GMRS is slightly greater than the 1 x 10^{-4} UHRS.

Table 2.4-1 UHRS for 1E-4 and 1E-5, and GMRS at Control Point for DCPP (5% damping)

Frequency (Hz)	Spectral Acceleration (g)		
	Control Point 1E-4 UHRS	Control Point 1E-5 UHRS	GMRS
100.00	0.812	1.525	0.812
50.00	0.832	1.564	0.832
33.33	0.882	1.659	0.882
20.00	0.983	1.849	0.983
13.33	1.236	2.295	1.236
10.00	1.405	2.640	1.405
6.67	1.613	3.054	1.613
5.00	1.740	3.305	1.744
4.00	1.785	3.373	1.785
3.33	1.714	3.236	1.714
2.50	1.960	3.830	2.010
2.00	1.634	3.186	1.672
1.33	1.200	2.469	1.282
1.00	0.755	1.566	0.812
0.67	0.478	1.017	0.525
0.50	0.318	0.703	0.360
0.33	0.188	0.408	0.210

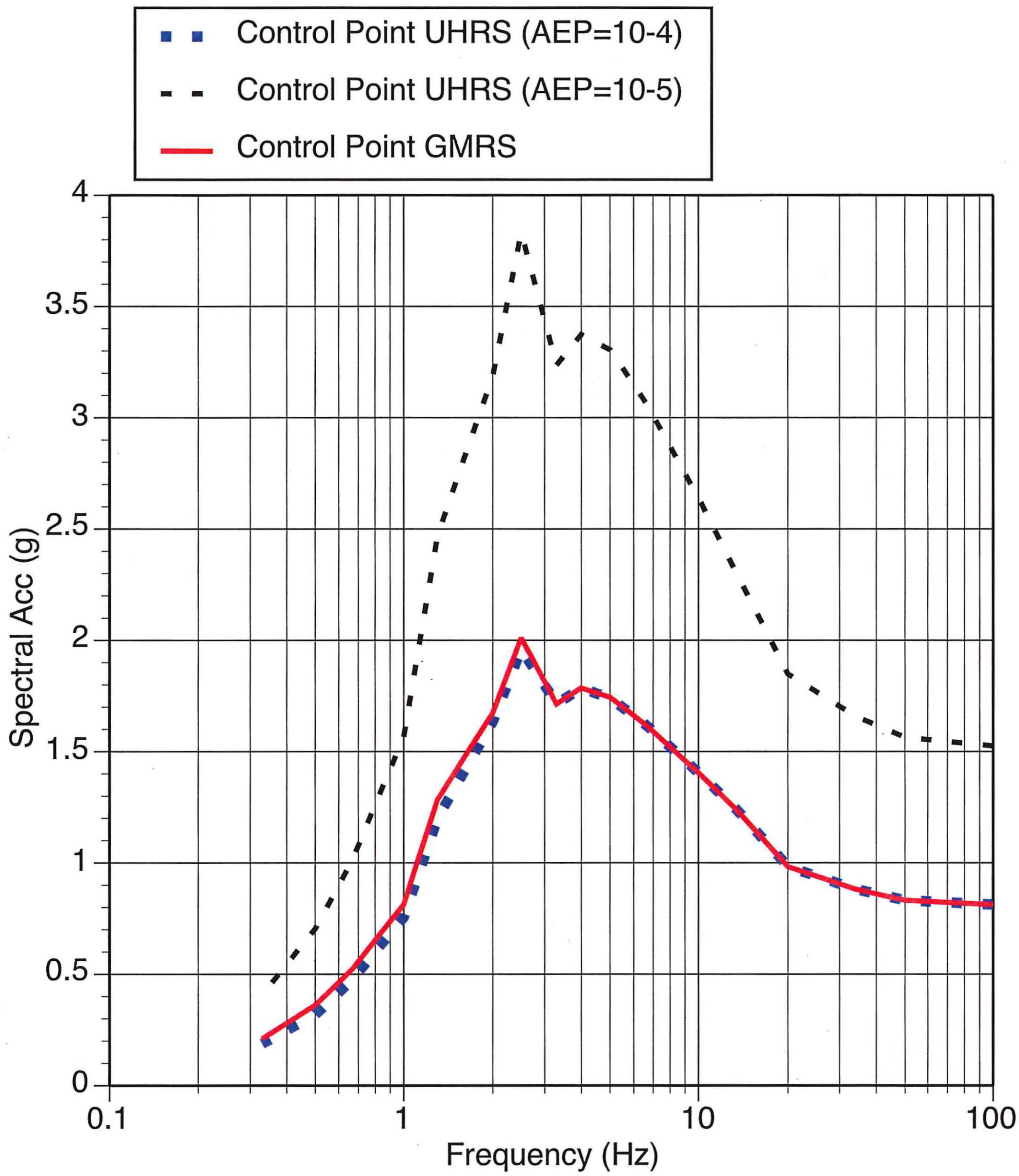

Figure 2.4-1 UHRS for 1E-4 and 1E-5, and GMRS at Control Point for DCPP

3.0 Plant Design, Licensing, and LTSP Evaluation Bases Ground Motions

The seismic design, licensing, and LTSP evaluation bases for DCPP are identified in Sections 2.5, 3.1, and 3.7 of the UFSAR, Revision 21 (PG&E 2013) the Hosgri Report (PG&E 1980), the 1988 LTSP Final Report (PG&E 1988), and the 1991 Addendum to the LTSP Final Report (PG&E 1991).

Since the development of the seismic design/licensing basis for DCPP predates the issuance of Appendix A to 10 CFR 100 (NRC 1973) site-specific criteria and methods were employed in the development of the design/licensing basis ground motions.

The seismic design, licensing, and LTSP evaluation of DCPP includes the following earthquakes:

1. <u>Design Earthquake (0.20g PGA)</u>

   The DE is defined in UFSAR Section 2.5.3.10.1 based on the maximum size earthquakes that can be expected to occur at DCPP during the life of the reactor. Four earthquakes of varying magnitudes and distances were postulated (described as Earthquake A, Earthquake B, Earthquake C, and Earthquake D in UFSAR Section 2.5.3.9.1). The postulated ground motions at DCPP for these four earthquakes were based on empirical data, with certain modifications based on input from the Atomic Energy Commission and their consultants. As described in UFSAR Section 2.5.3.10.1, Earthquakes B and D were found to be governing over Earthquakes A and C. In addition, based on meetings between PG&E, the Atomic Energy Commission, and the Atomic Energy Commission's consultants, the shape of the response spectra associated with Earthquake D was modified and the accelerations associated with Earthquake B were increased by 25 percent. After the incorporation of the modifications, the following two earthquake ground motions were selected to represent the DE for DCPP:

   (a) Earthquake D-modified, derived by modifying the S80°E component of the 1957 Golden Gate Park, San Francisco earthquake, and then normalizing to a maximum ground acceleration of 0.20 g. The smoothed response spectrum for this earthquake is shown in UFSAR Figure 2.5-21.

   (b) Earthquake B, derived by normalizing the N69°W component of the 1952 Taft earthquake to a maximum ground acceleration of 0.15 g. The smoothed response spectrum for Earthquake B is shown in UFSAR Figure 2.5-20.

Seismic design for the DE is based on the envelope of Earthquake B and Earthquake D-modified.

2. Double Design Earthquake (0.40g PGA)

   The DDE is defined in UFSAR Section 2.5.3.10.2 as an earthquake having twice the maximum ground acceleration and response spectra as those associated with the DE.

3. 1977 Hosgri Earthquake (0.75g PGA)

   The 1977 HE is defined in UFSAR Section 2.5.3.10.3 as the predicted ground motion at DCPP associated with a Richter magnitude 7.5 earthquake on the Hosgri fault at a point nearest to DCPP. There are two ground motion definitions associated with the HE:

   (a) The Newmark HE, is an earthquake developed by Dr. N. M. Newmark, having an effective maximum horizontal ground acceleration of 0.75 g. The smoothed response spectrum for the Newmark HE is shown in UFSAR Figure 2.5-30.

   (b) The Blume HE, is an earthquake developed by Dr. J. A. Blume based on empirical data associated with strong-motion time histories recorded on rock close to the epicenters, and normalized to a 0.75 g peak acceleration. The smoothed response spectrum for the Blume HE is shown in UFSAR Figure 2.5-29.

   The seismic design for the HE is summarized in Supplement No. 5 to the NRC's Safety Evaluation Report (SER) for DCPP (NRC 1976) and is based on the envelope of the loadings associated with the Newmark HE and the Blume HE. The HE is the largest ground motion considered in the seismic design of DCPP.

4. Long Term Seismic Program Earthquake (0.83 g PGA)

   The LTSPE is associated with license condition 2.C.(7) of the DCPP Unit 1 operating license, that required, in part: "PG&E shall develop and implement a program to reevaluate the seismic design bases used for the DCPP." PG&E's reevaluation effort in response to the license condition was titled the "Long Term Seismic Program."

   The LTSPE is defined in UFSAR Section 2.5.3.10.4 as the predicted ground motion at DCPP associated with a moment magnitude 7.2 earthquake on the Hosgri fault approximately 4.5 km (3 mi.) from DCPP.

The LTSP included both a SPRA and a deterministic SMA. The results of the LTSP are described in the 1988 LTSP Final Report (PG&E 1988) and the 1991 Addendum to the LTSP Final Report (PG&E 1991). The LTSP evaluation concluded that the structures, systems, and components previously qualified for the DE, DDE, and 1977 HE seismic loads remained qualified for the LTSPE. The NRC's review and acceptance of the LTSP evaluations are documented in Supplement No. 34 of the SER for DCPP (NRC 1991).

3.1 Description of Response Spectra Shapes

3.1.1 Double Design Earthquake Response Spectrum

The DDE response spectrum, which corresponds to an envelope of the 5 percent damped horizontal Earthquake B (UFSAR Figure 2.5-20) response spectrum and the 5 percent damped Earthquake D-modified response spectrum (UFSAR Figure 2.5-21), multiplied by a factor of two, is tabulated in Table 3.1.1-1 and illustrated in Figure 3.1.1-1.

Table 3.1.1-1: DDE Response Spectrum for DCPP
(5% Damping)

Period (sec)	Frequency (Hz)	Spectral Acceleration (g)
0.010	100.000	0.400
0.050	20.000	0.400
0.060	16.667	0.432
0.070	14.286	0.498
0.080	12.500	0.666
0.090	11.111	0.930
0.100	10.000	1.266
0.110	9.091	1.386
0.120	8.333	1.434
0.130	7.692	1.464
0.140	7.143	1.476
0.150	6.667	1.473
0.160	6.250	1.467
0.170	5.882	1.443
0.180	5.556	1.413
0.200	5.000	1.338
0.250	4.000	1.182
0.290	3.448	1.047
0.300	3.333	1.005
0.320	3.125	1.009
0.330	3.030	1.005
0.350	2.857	0.993
0.380	2.632	0.963
0.500	2.000	0.786
0.580	1.724	0.705
0.660	1.515	0.639
0.740	1.351	0.609
0.880	1.136	0.595
1.000	1.000	0.594

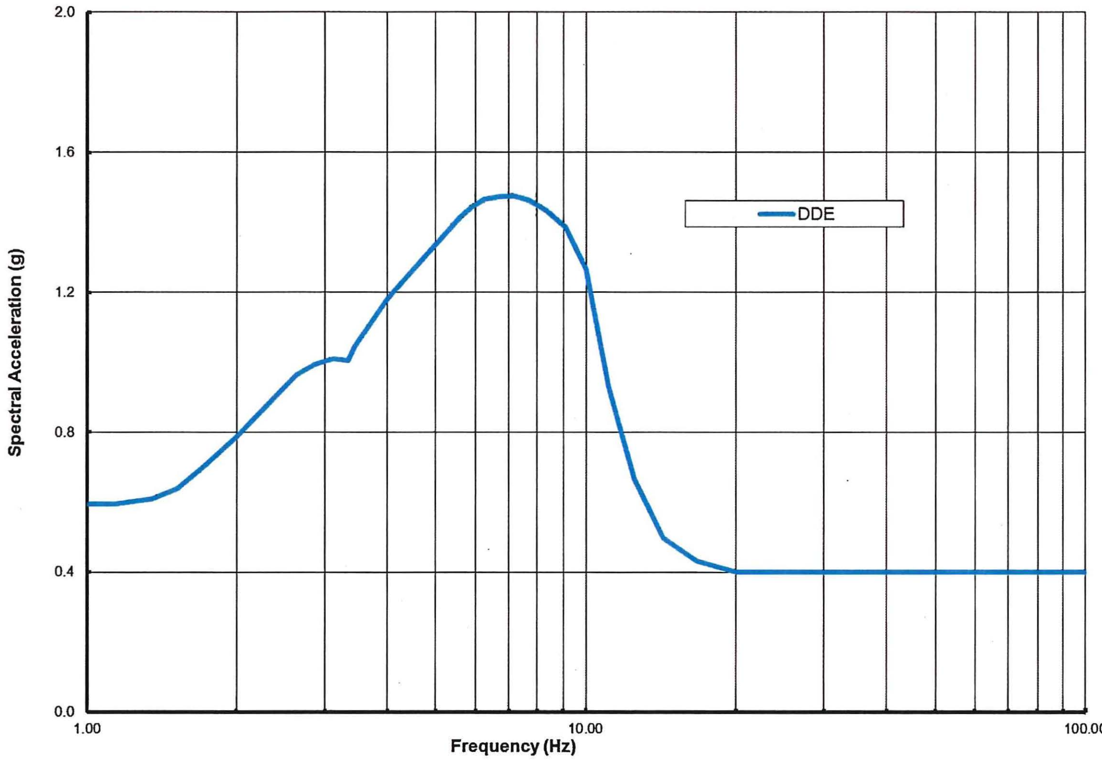

Figure 3.1.1-1: DDE Response Spectrum for DCPP
(5% Damping)

3.1.2 1977 Hosgri Earthquake Response Spectrum

The 1977 HE response spectrum, which corresponds to an envelope of the 5 percent damped horizontal Newmark HE response spectrum (UFSAR Figure 2.5-30) and the 5 percent damped horizontal Blume HE response spectrum (UFSAR Figure 2.5-29), is tabulated in Table 3.1.2-1 and illustrated in Figure 3.1.2-1.

Table 3.1.2-1: 1977 HE Response Spectrum[6] for DCPP
(5% Damping)

Period (sec)	Frequency (Hz)	Spectral Acceleration (g)
0.010	100.000	0.750
0.029	34.000	0.750
0.032	31.000	0.784
0.040	25.000	0.912
0.050	20.000	1.067
0.063	16.000	1.248
0.071	14.000	1.371
0.083	12.000	1.528
0.100	10.000	1.737
0.111	9.000	1.870
0.125	8.000	2.032
0.174	5.750	2.032
0.182	5.500	2.044
0.190	5.250	2.061
0.200	5.000	2.080
0.217	4.600	2.106
0.238	4.200	2.128
0.250	4.000	2.125
0.263	3.800	2.118
0.278	3.600	2.111
0.303	3.300	2.075
0.333	3.000	2.032
0.435	2.300	2.032
0.455	2.200	1.975
0.500	2.000	1.795
0.556	1.800	1.616
0.625	1.600	1.436
0.714	1.400	1.257
0.800	1.250	1.124
1.000	1.000	0.898
1.538	0.650	0.586
2.000	0.500	0.411

6 The spectral acceleration values represent the envelope of the Newmark HE (UFSAR Figure 2.5-30) and the Blume HE (UFSAR Figure 2.5-29). Note that the HE response spectra have been extrapolated to a minimum frequency of 0.50 Hz for this application.

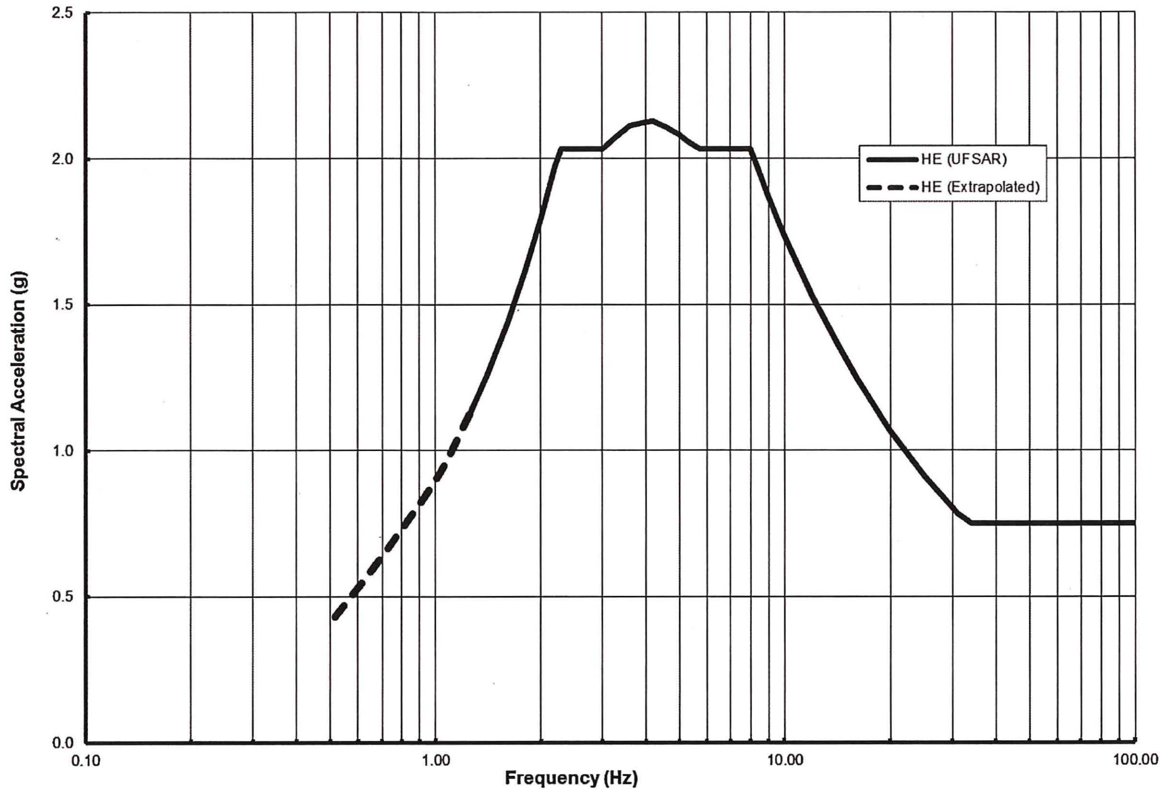

Figure 3.1.2-1: 1977 HE Response Spectrum for DCPP
(5% Damping)

3.1.3 Long Term Seismic Program Earthquake Spectrum

The 5 percent damped horizontal 84th percentile of non-exceedance 1991 LTSPE response spectrum (UFSAR Figure 2.5-33), is tabulated in Table 3.1.3-1 and illustrated in Figure 3.1.3-1.

Table 3.1.3-1: 1991 LTSPE 84th Percentile Response Spectrum for DCPP (5% Damping)

Period (sec)	Frequency (Hz)	Spectral Acceleration (g)
0.010	100.000	0.830
0.025	40.000	0.830
0.030	33.000	0.830
0.040	25.000	0.964
0.050	20.000	1.110
0.070	14.286	1.344
0.085	11.765	1.508
0.100	10.000	1.654
0.120	8.333	1.819
0.140	7.143	1.918
0.150	6.667	1.947
0.170	5.882	1.976
0.200	5.000	2.006
0.250	4.000	2.015
0.300	3.333	1.962
0.400	2.500	1.763
0.500	2.000	1.554
0.750	1.333	1.109
1.000	1.000	0.831
1.500	0.667	0.524
2.000	0.500	0.356

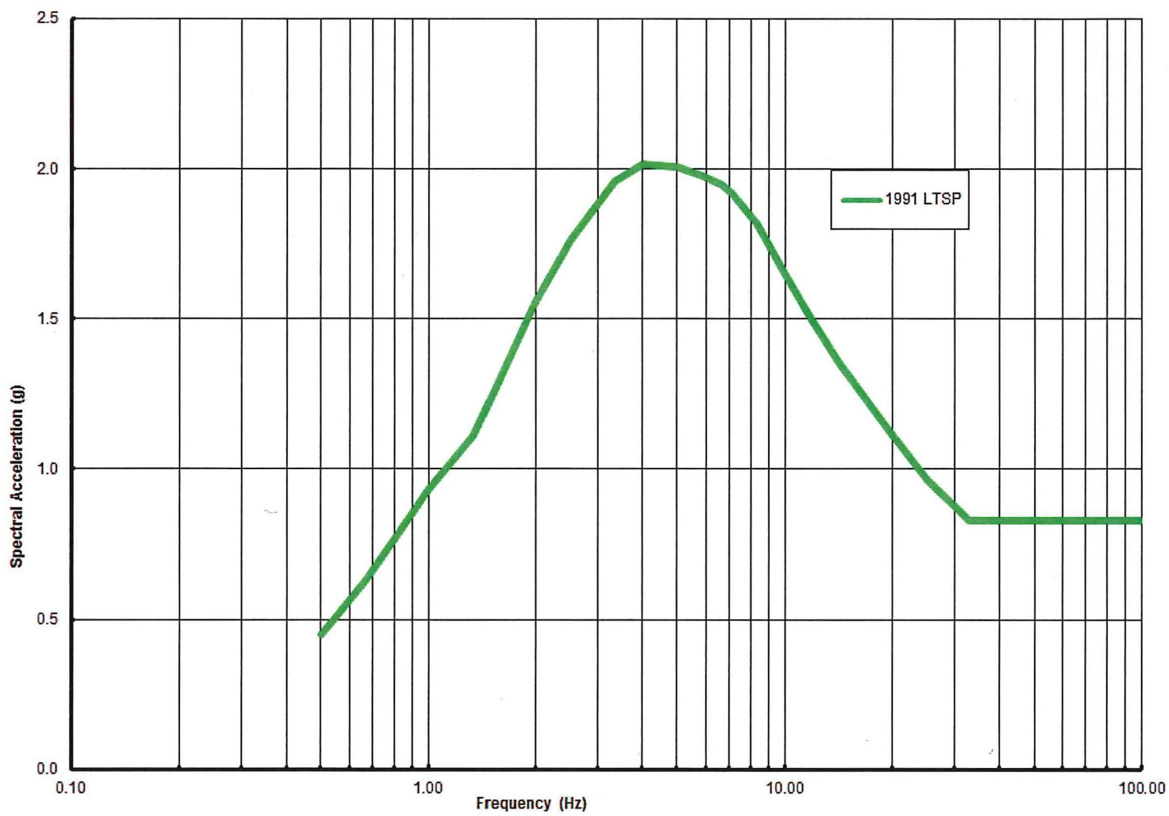

Figure 3.1.3-1: 1991 LTSPE 84th Percentile Response Spectrum for DCPP (5% Damping)

3.2 Control Point Elevation

The control point elevation for DCPP's DDE is defined based on the criteria provided in Section 2.4.2 of the SPID (EPRI 2013a).

As shown on UFSAR Figures 2.5-15, 2.5-16, and 2.5-17, all original surface materials (soil and rock) were removed from the locations of the major structures[7] and their foundations were excavated into the bedrock. Therefore, the major structures are rock-founded.

The free-field ground motions, associated with the DDE (described in Section 3.1.1) and the 1977 HE (described in Section 3.1.2), are used as input to all structures at DCPP. The UFSAR does not explicitly define a control point for the ground motions, but it can be derived from the seismic analyses of structures described in UFSAR Section 3.7. Based on a review of the seismic analyses of the major structures, as described in UFSAR Section 3.7.2.1.7, the control point for the seismic analyses is the finished grade level, which corresponds to

7 Major structures at DCPP include the containment structures, the auxiliary building, and the turbine building.

26 m (85 ft) mean sea level at the location of the major structures (see UFSAR Figure 2.5-18). This is consistent with the control point elevation associated with the site response evaluation, as described in Section 2.3.

Since the site-amplification studies associated with the GMRS (Section 2.4) are developed based on the free-field recordings of historical earthquakes affecting DCPP, the control point is specifically at the location of free-field seismic instrument no. ESTA28 (located in the yard area at elevation 26 m (85 ft), approximately 96 m (316 ft) north of the centerline of the Unit 1 containment structure and 2.4 m (8 ft) east of a north-south line passing through the centerlines of the Unit 1 and Unit 2 containment structures - see Figure 2.3.2-4). See Section 2.3.5 for additional information on the selection of the control point.

4.0 Screening Evaluation

In accordance with Section 3 of the SPID, a screening evaluation was performed, as described in the following subsections. As stated in the NRC's letter to PG&E dated October 12, 2012 (NRC 2012c), "for the purposes of the response to the March 12, 2012 request for information, the NRC staff expects PG&E to use the DDE for comparison with the reevaluated seismic hazard GMRS." Therefore, the following screening evaluations are based on the DDE.

4.1 Risk Evaluation Screening (1 to 10 Hz)

The GMRS exceeds the DDE in the 1 to 10 Hz frequency range, as shown in Figure 4.1-1. Therefore DCPP screens-in for a risk evaluation.

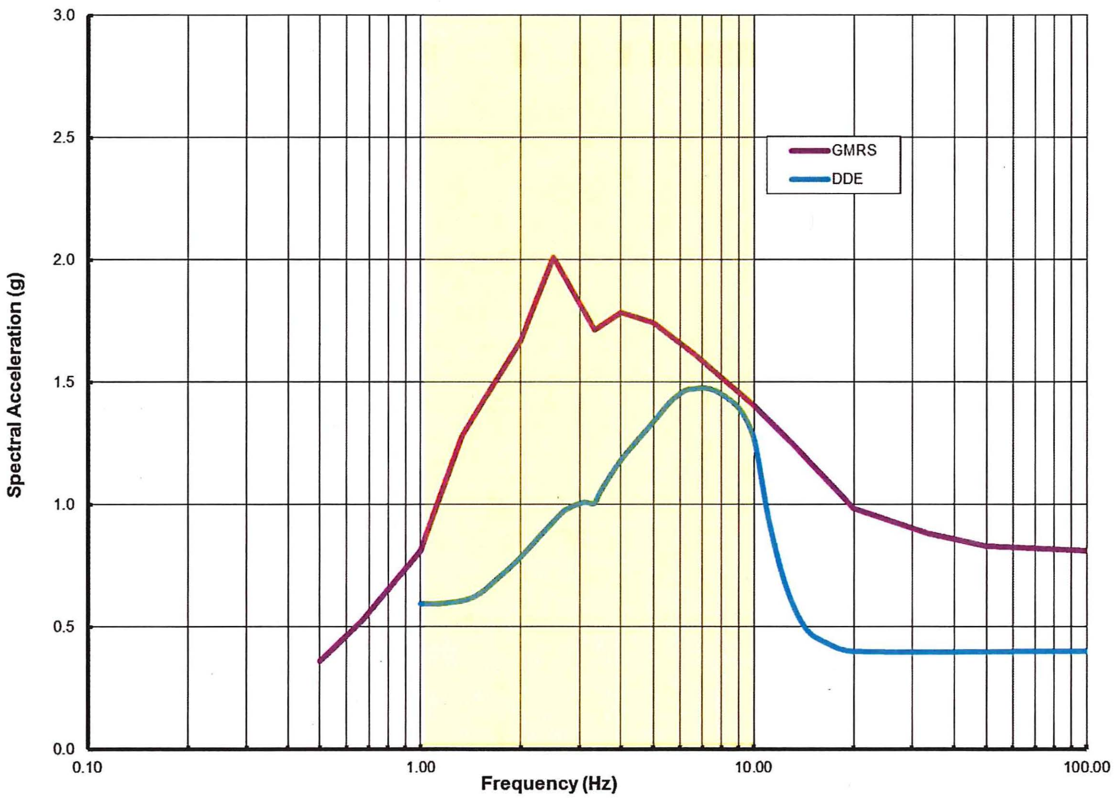

Figure 4.1-1: Comparison of GMRS and DDE Spectrum for DCPP (5% Damping)

4.2 High Frequency Screening (> 10 Hz)

The GMRS exceeds the DDE for frequencies greater than 10 Hz, as shown in Figure 4.1-1. This exceedance will be addressed in the required risk evaluation.

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

The GMRS exceeds the DDE in the 1 to 10 Hz frequency range, as shown in Figure 4.1-1. Therefore DCPP screens-in for a SFP evaluation. Note that at DCPP the SFPs are located in the fuel handling area of the auxiliary building.

5.0 Interim Evaluation

Consistent with the NRC letter dated February 20, 2014, (NRC 2014) the seismic hazard reevaluations presented herein are distinct from the current design and licensing bases of DCPP. Consequently, the results of these analyses performed using present-day regulatory guidance, methodologies, and information would not generally be expected to call into question the operability or functionality of structures, systems, and components, and are not reportable pursuant to 10 CFR 50.72 or 10 CFR 50.73.

The NRC's March 12, 2012 10 CFR 50.54(f) letter (NRC 2012) and February 20, 2014 supplemental letter (NRC 2014) request that Licensees submit an interim evaluation or actions taken or planned to address the reevaluated hazard where it exceeds the current design basis, if necessary prior to completion of the risk evaluation. PG&E's interim evaluation is based on comparisons of the beyond design basis GMRS to the design/licensing basis 1977 HE and the 1988 LTSP evaluations:

(a) 1977 HE Evaluation

All Design Class I structures, systems, and components at DCPP, including the SFPs[8], have been designed/evaluated for the design/licensing basis 1977 HE spectrum and found to meet the HE acceptance criteria (PG&E 1980 and NRC 1978b).

A comparison of the GMRS with the design/licensing basis 1977 HE spectrum is shown in Figure 5.0-1. This comparison indicates that, with the exception of an exceedance of approximately 0.09 g (7 percent) at 1.33 Hz, the GMRS is bounded by the design/licensing basis 1977 HE spectrum at all frequencies in the 1 to 10 Hz frequency range (frequency range associated with the risk evaluation screening). The exceedance is insignificant because no structure, system, or component required for safe shutdown is susceptible to the 1.33 Hz frequency (Tables 6-24 and 6-25 of PG&E 1988).

The GMRS also exceeds the design/licensing basis 1977 HE spectrum for frequencies > 24 Hz. As stated in Section 3.4 of the SPID (EPRI 2013a):

> "high-frequency vibratory motions above about 10 Hz are not damaging to the large majority of [nuclear power plant] structures, components, and equipment. An exception to this is the functional performance of vibration sensitive components, such as relays and

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[8] As indicated in Section 4.3, the SFPs are located in the fuel handling area of the auxiliary building, which is a Design Class I structure.

other electrical and instrumentation devices whose output signals could be affected by high-frequency excitations."

Therefore, in accordance with Section 3.4 of the SPID (EPRI 2013a), the results of the design/licensing basis 1977 HE evaluation demonstrate that all Design Class I structures, systems, and components are capable of resisting the ground motions associated with the GMRS with exception of the high-frequency sensitive equipment. The impact of the high-frequency exceedance is addressed as part of the LTSP evaluation, discussed below.

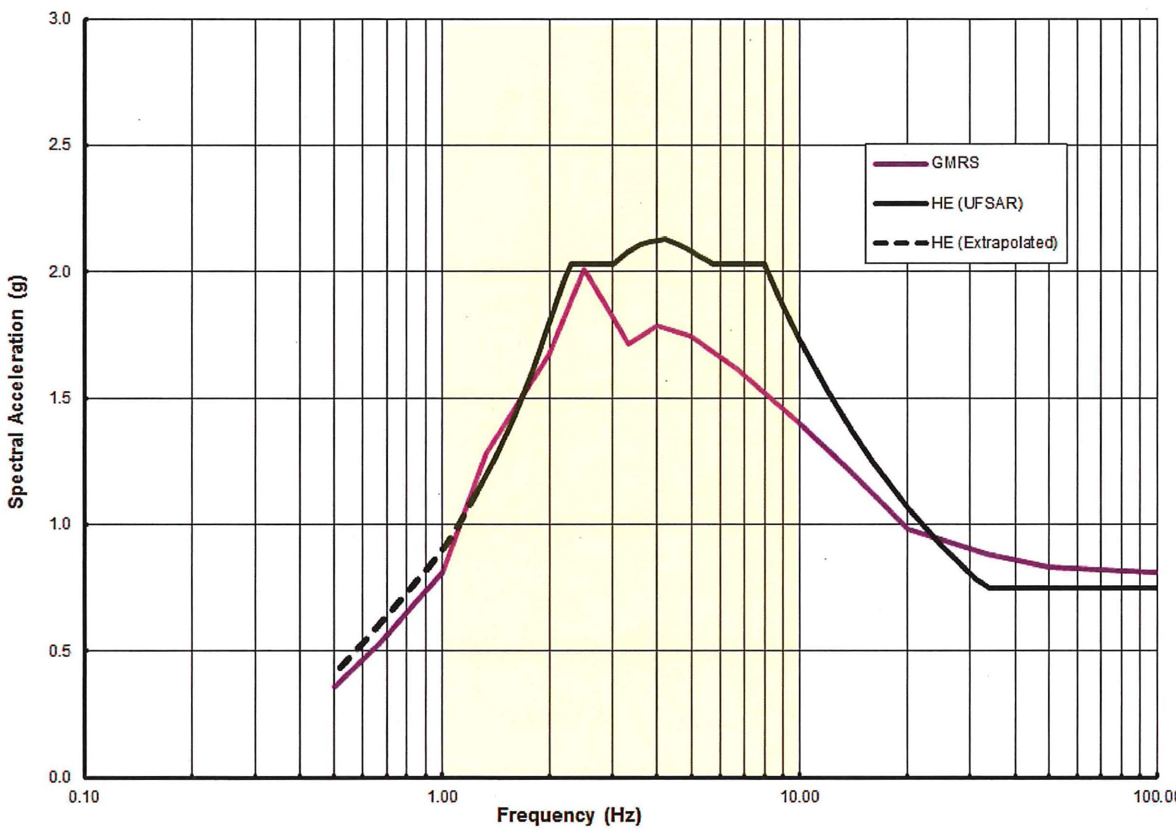

Figure 5.0-1: Comparison of GMRS and 1977 HE Design Spectrum for DCPP (5% Damping)

(b) <u>1988 LTSP Evaluation</u>

All structures[9], systems, and components required for safe shutdown[10] have been evaluated for the 1988 LTSP spectrum and found to have

9 The auxiliary building, which contains the SFPs, is included in the scope of the LTSP evaluation.

10 The safe shutdown-related structures, systems, and components addressed in the 1988 LTSP are listed in Tables 7-1 and 7-2 of the 1988 LTSP Final Report (PG&E 1988)

significant seismic margins (see Appendix B for discussion of the LTSP seismic margins).

A comparison of the GMRS with the LTSP seismic margin spectrum is shown in Figure 5.0-2. This comparison indicates that the GMRS is bounded by the LTSP seismic margin spectrum at all frequencies, including 1.33 Hz and those > 24 Hz - frequencies where the GMRS exceeds the design/licensing basis 1977 HE spectrum.

Therefore, comparing the results of the revised GMRS against the 1988 LTSP evaluation demonstrate that all structures, systems, and components required for safe shutdown, including vibration sensitive components, have a significant seismic design margin beyond the GMRS.

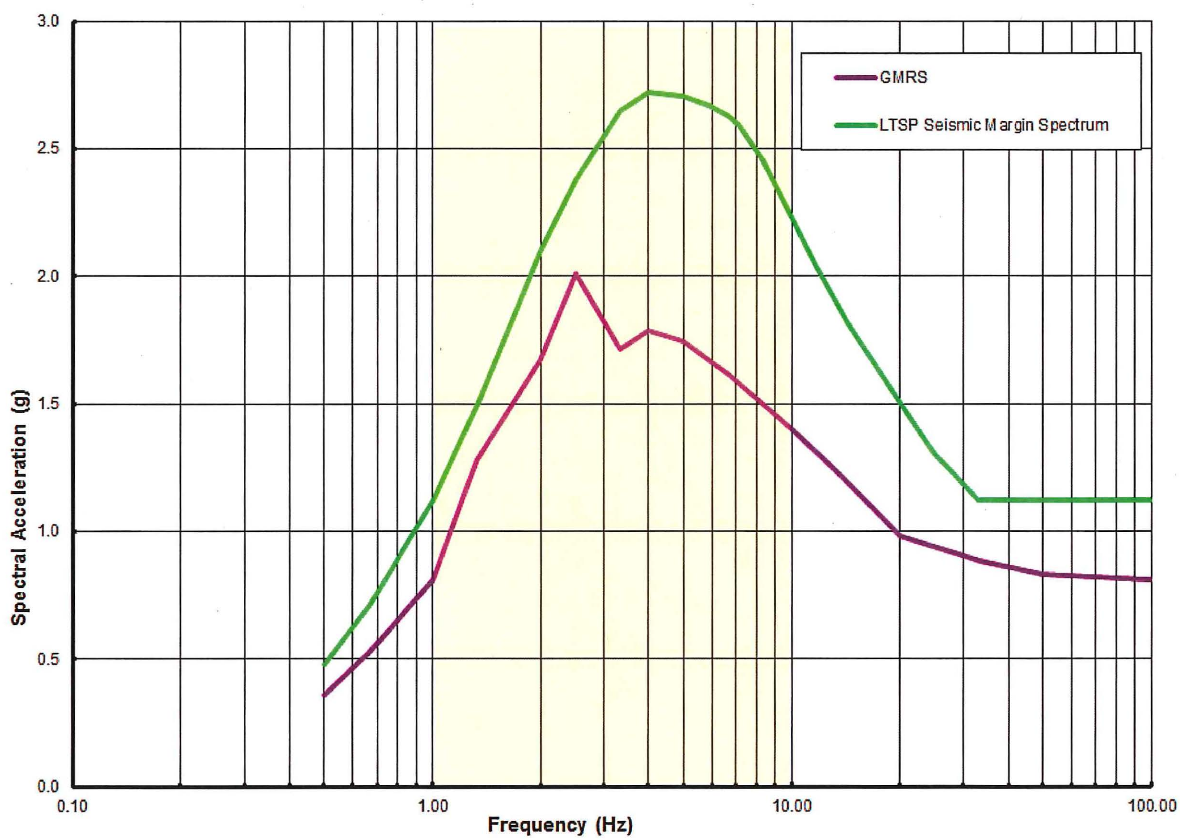

Figure 5.0-2: Comparison of GMRS and LTSP Seismic Margin Spectrum for DCPP (5% Damping)

Based on the above comparisons to the design/licensing basis 1977 HE evaluation and the 1988 LTSP evaluation, there is reasonable assurance that DCPP remains safe to operate without undue risk to the public while an updated risk evaluation is being performed.

The consideration of potential loss of the water inventory from the SFPs, as described in Section 7 of the SPID (EPRI 2013a), has been addressed as part of the NTTF Recommendation 2.3: Seismic Walkdowns, as discussed in Section 5.2. The results of these walkdowns demonstrated that the potential for loss of the water inventory from the SFPs (e.g., rapid draindown) has been adequately addressed in the design and construction of DCPP's SFPs. Further evaluations of the potential loss of the water inventory from the SFPs will be performed once an NRC-endorsed guidance has been developed.

5.1 Expedited Seismic Evaluation Process

The ESEP, as proposed in the NEI's letter to the NRC, dated April 9, 2013 (NEI 2013) and confirmed in NRC letter dated May 7, 2013 (NRC 2013), is described in EPRI Technical Report No. 3002000704 (EPRI 2013b).

The ESEP was intended as an interim measure to provide additional assurance of safety in cases where the GMRS significantly exceeds the plant design/licensing basis while additional risk evaluations (i.e., SMA, or SPRA) were being performed. However, as discussed in Section 5.0, the DCPP GMRS is bounded by other previous seismic evaluations, including the design/licensing basis 1977 HE evaluations and the 1988 LTSP evaluation. Therefore, there are no additional benefits in performing this activity in parallel with the more robust risk evaluation associated with updating/upgrading the SPRA. PG&E will devote the critical skilled resources to expediting the update/upgrade of the SPRA in order to gain additional risk insights in a timely manner.

5.2 Walkdowns to Address NRC Fukushima NTTF Recommendation 2.3: Seismic

In response to the NRC's March 12, 2012 50.54(f) letter Fukushima NTTF Recommendation 2.3: Seismic (NRC 2012), PG&E performed walkdowns of the configuration of specific equipment and components in accordance with EPRI Technical Report No. 1025286 (EPRI 2012), as endorsed by the NRC in their letter dated May 31, 2012 (NRC 2012a). The goals of these walkdowns were to (a) verify that the current plant configuration was in accordance with the licensing basis; (b) verify that the current maintenance plans were adequate to maintain the plant configuration in accordance with the licensing basis; and (c) identify any seismic vulnerabilities. The potential for loss of water inventory from the SFPs (e.g., rapid draindown) was included in the scope of these walkdowns.

The walkdowns of DCPP, Units 1 and 2, as documented in several PG&E letters to the NRC (PG&E 2012, PG&E 2012a, PG&E 2013b, and PG&E 2014a) identified a number of potentially adverse seismic conditions, which were entered into the DCPP corrective action program. The engineering evaluations of the potentially adverse seismic conditions determined that they did not adversely affect the performance of any required safety functions, including the ability to maintain the water inventory of the SFPs during a seismic event. Therefore, these walkdowns confirmed that the configuration of DCPP is within its seismic design/licensing basis and provided additional assurance of seismic safety.

The NRC has reviewed the DCPP NTTF Recommendation 2.3: Seismic walkdown submittal reports and the results of their staff assessment (NRC 2014a) concluded that sufficient information was provided by PG&E to be responsive to the requirements of their March 12, 2012 10 CFR 50.54(f) letter (NRC 2012).

6.0 Conclusions

PG&E completed a seismic hazard and screening evaluation for DCPP in accordance with the NRC's Fukushima 10 CFR 50.54(f) request for information letter (NRC 2012), and consistent with the NRC endorsed SPID guidelines (EPRI 2013a). A GMRS was developed solely for the purpose of screening for additional evaluations in accordance with the SPID. The DCPP GMRS exceeds the design and licensing basis DDE spectrum in both the 1 to 10 Hz range and above 10 Hz. Therefore, an updated risk evaluation and a SFP evaluation for potential loss of water inventory, in accordance with the SPID (EPRI 2013a) will be performed.

PG&E also compared the GMRS with the LTSP seismic margin spectrum, described in Section 5.0. The comparison shows that DCPP's structures, systems and components required for safe shutdown and the SFPs have significant design margins beyond the GMRS. In addition, the results of the Fukushima NTTF Recommendation 2.3: Seismic walkdowns, described in Section 5.2, show that the potential for loss of water inventory from the SFPs has been adequately addressed. Therefore, DCPP remains safe to operate without undue risk to the public while an updated risk evaluation and detailed SFP evaluation for potential loss of water inventory are being performed.

PG&E will perform an update to the SPRA in accordance with the EPRI guidance (EPRI 2013a) in support of the resolution of Fukushima NTTF Recommendation 2.1: Seismic. PG&E believes that since there are no additional insights to be gained from an implementation of an ESEP, PG&E will devote its resources to performing a more robust SPRA. PG&E will perform additional evaluations of the SFPs to address potential loss of water inventory in accordance with the EPRI guidance (EPRI 2013a) and any additional NRC endorsed guidance that may be issued. The completion dates for the SPRA and SFP evaluations will be based on the schedule as defined in NEI's letter to the NRC, dated April 9, 2013 (NEI 2013) and confirmed in NRC's letter, dated May 7, 2013 (NRC 2013).

7.0 References

7.1 Electric Power Research Institute

(a) EPRI 2012, "Seismic Walkdown Guidance for the Resolution of Fukushima Near-Term Task Force Recommendation 2.3: Seismic," Technical Report No. 1025286, dated June 2012

(b) EPRI 2013a, "Seismic Evaluation Guidance - Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," Technical Report No. 1025287, dated February 2013

(c) EPRI 2013b, "Seismic Evaluation Guidance: Augmented Approach for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," Technical Report No. 3002000704, dated April 2013

(d) EPRI 2013c, "EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project," Technical Report No. 3002000717, 2 Volumes, dated June 2013

7.2 Pacific Gas and Electric Company

(a) PG&E 1980, PG&E Report, "Seismic Evaluation for Postulated 7.5M Hosgri Earthquake - Units 1 and 2, Diablo Canyon Site," transmitted to the NRC as Amendment Nos. 50, 53, 54, 56, 59, 60, 62, 64, 66, 68, 70, 72, 75, 76, 77, 79, 82, and 83 to the Operating License Application for Diablo Canyon Power Plants Units 1 and 2," dated June 3, 1977 through June 6, 1980

(b) PG&E 1988, PG&E Report, "Final Report of the Diablo Canyon Long Term Seismic Program for the Diablo Canyon Power Plant," Enclosure to PG&E Letter DCL-88-192, "Long Term Seismic Program Completion," dated July 31, 1988

(c) PG&E 1990, PG&E Report, "Additional Deterministic Evaluations Performed to Assess Seismic Margins of the Diablo Canyon Power Plant, Units 1 and 2," Enclosure to PG&E Letter DCL-90-226, "Long Term Seismic Program Additional Deterministic Evaluations," dated September 18, 1990

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(e) PG&E 2011, PG&E Report, "Report on the Analysis of the Shoreline Fault Zone, Central Coastal California, report to the U.S. Nuclear Regulatory Commission," Enclosure to PG&E Letter DCL-11-005, "Report on the Analysis of the Shoreline Fault Zone, Central Coastal California," dated January 7, 2011

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Appendix A – Additional Seismic Hazard Curve Data

A1.0 Hazard for the Reference Rock Site

The mean hazard by source for the reference rock site are listed in Table A1.0-1 for 10 Hz spectral acceleration and in Table A1.0-2 for 1 Hz spectral acceleration. The deaggregation of the mean hazard at the 1 x 10^{-4} hazard level for 10 and 1 Hz are shown in Figures A1.0-1 and A1.0-2, respectively. The degregation shows that the hazard at DCPP at the 1 x 10^{-4} hazard level is controlled by nearby earthquakes (< 10 km) with moment magnitudes (**M**) in the **M**6 to **M**8 range.

A2.0 Hazard for the Control Point

The mean hazard for the control point and the fractiles of the hazard, that capture the epistemic uncertainty, are listed in Tables A2.0-1 through A2.0-7 for the peak acceleration and six spectral frequencies: 20, 10, 5, 2.5, 1, and 0.5 Hz.

A3.0 Site Amplification for the Control Point

The median amplification (from the reference rock site to the control point) is listed in Table A3.0-1. The epistemic uncertainty in the median amplification is quantified by the logarithmic standard deviation listed in Table A3.0-1. The non-linear effects are captured addressed by the empirical ground motion models used for the reference rock site (V_{S30} = 760 m/s and kappa = 0.041 seconds). The aleatory variability of the site response is captured by the standard deviation of the empirical ground motions. The single-station sigma approach removes the differences in the site-specific site amplification from the traditional ergodic standard deviation, but the single-station sigma approach does not remove the aleatory variability in the site amplification from the empirically-based standard deviations.

Table A1.0-1: Mean Hazard by Source for the Reference Rock Site for 10 Hz Spectral Acceleration.

10 Hz PSA (g)	Total Hazard	Hosgri fault	Shoreline fault	Los Osos fault	San Luis Bay fault	Local source zone	San Andreas fault	Other connected faults	Other regional faults
0.01	3.9E-01	2.1E-02	3.9E-04	8.3E-04	7.1E-04	4.4E-03	9.0E-02	2.1E-03	4.8E-02
0.05	7.5E-02	1.0E-02	2.7E-04	8.0E-04	5.8E-04	4.1E-03	1.9E-02	1.3E-03	9.3E-03
0.1	3.1E-02	6.5E-03	2.2E-04	7.3E-04	5.2E-04	3.4E-03	5.9E-03	8.5E-04	3.6E-03
0.2	1.2E-02	3.7E-03	1.7E-04	6.2E-04	4.5E-04	2.1E-03	1.4E-03	4.6E-04	1.1E-03
0.4	4.6E-03	1.8E-03	1.1E-04	4.4E-04	3.4E-04	9.4E-04	1.5E-04	1.8E-04	2.2E-04
0.8	1.5E-03	6.5E-04	5.9E-05	2.1E-04	1.9E-04	2.8E-04	1.0E-05	3.9E-05	2.1E-05
1.5	3.7E-04	1.6E-04	1.8E-05	5.6E-05	6.5E-05	6.0E-05	5.5E-07	5.2E-06	1.5E-06
2.0	1.6E-04	6.7E-05	8.2E-06	2.5E-05	3.1E-05	2.5E-05	1.3E-07	1.7E-06	4.1E-07
3.0	4.1E-05	1.6E-05	2.2E-06	6.6E-06	9.0E-06	6.2E-06	1.3E-08	3.3E-07	5.6E-08
5.0	5.7E-06	2.1E-06	3.1E-07	9.6E-07	1.4E-06	8.5E-07	5.9E-10	3.2E-08	3.5E-09
10.0	2.7E-07	8.9E-08	1.5E-08	4.8E-08	7.4E-08	4.0E-08	3.1E-12	9.2E-10	4.8E-11

Table A1.0-2: Mean Hazard by Source for the Reference Rock Site for 1 Hz Spectral Acceleration.

1 Hz PSA (g)	Total Hazard	Hosgri fault	Shoreline fault	Los Osos fault	San Luis Bay fault	Local source zone	San Andreas fault	Other connected faults	Other regiona l faults
0.01	1.8E-01	7.8E-03	2.7E-04	7.6E-04	5.6E-04	3.7E-03	4.8E-02	1.1E-03	3.4E-02
0.05	1.6E-02	2.5E-03	1.4E-04	5.3E-04	3.8E-04	1.2E-03	4.2E-03	4.6E-04	2.4E-03
0.1	5.0E-03	1.3E-03	9.6E-05	3.9E-04	2.9E-04	5.2E-04	9.8E-04	2.1E-04	5.0E-04
0.2	1.6E-03	6.8E-04	5.7E-05	1.9E-04	1.6E-04	1.8E-04	1.3E-04	5.4E-05	5.9E-05
0.4	4.5E-04	2.6E-04	2.1E-05	4.6E-05	5.2E-05	4.5E-05	9.7E-06	7.1E-06	4.2E-06
0.8	8.0E-05	5.4E-05	3.9E-06	5.3E-06	9.2E-06	6.5E-06	4.7E-07	5.5E-07	1.8E-07
1.5	1.0E-05	7.4E-06	5.2E-07	4.8E-07	1.2E-06	7.2E-07	1.9E-08	3.7E-08	7.2E-09
2.0	3.6E-06	2.6E-06	1.8E-07	1.4E-07	4.0E-07	2.3E-07	3.9E-09	9.4E-09	1.4E-09
3.0	6.9E-07	5.2E-07	3.6E-08	2.2E-08	7.7E-08	4.2E-08	3.5E-10	1.2E-09	1.2E-10
5.0	7.2E-08	5.4E-08	3.9E-09	1.7E-09	7.9E-09	4.0E-09	1.1E-11	7.2E-11	3.5E-12

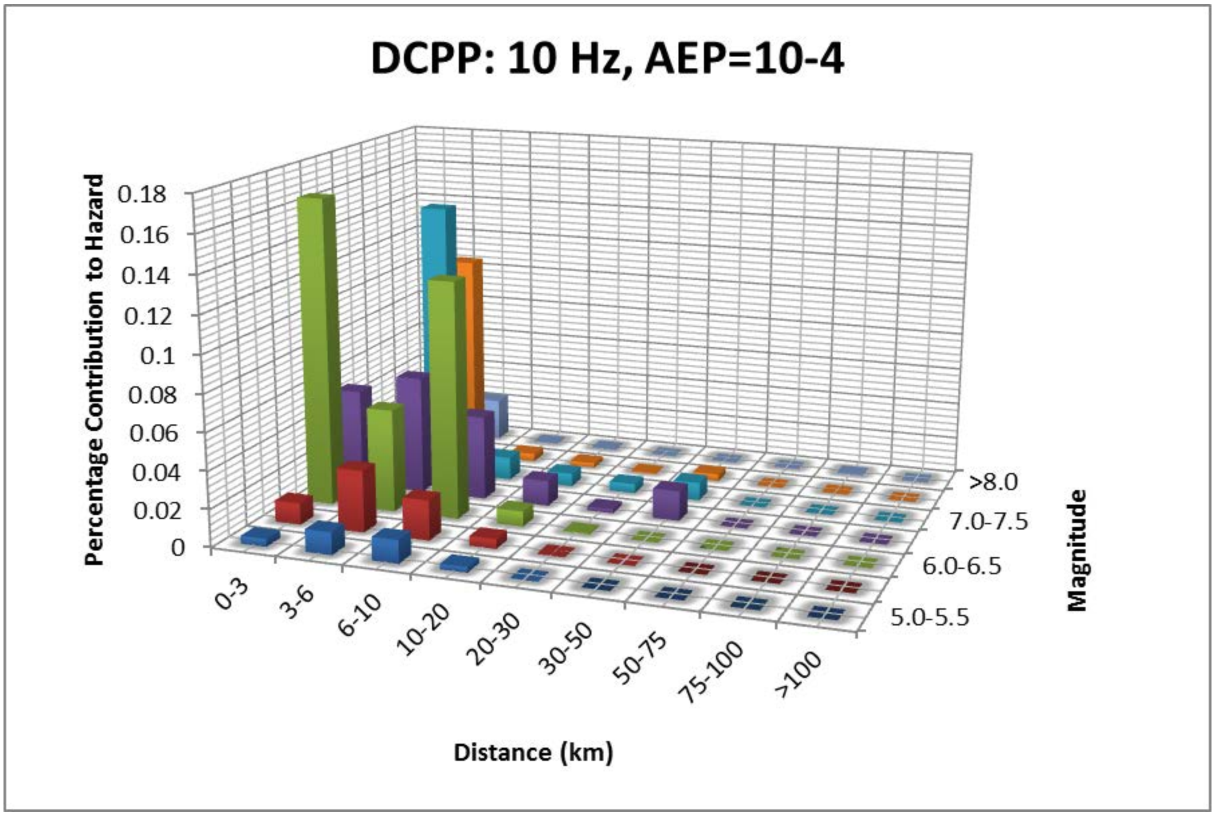

Figure A1.0-1: Deaggregation of the Reference Rock Site Hazard for 10 Hz Spectral Acceleration for the 1E-4 Hazard Level.

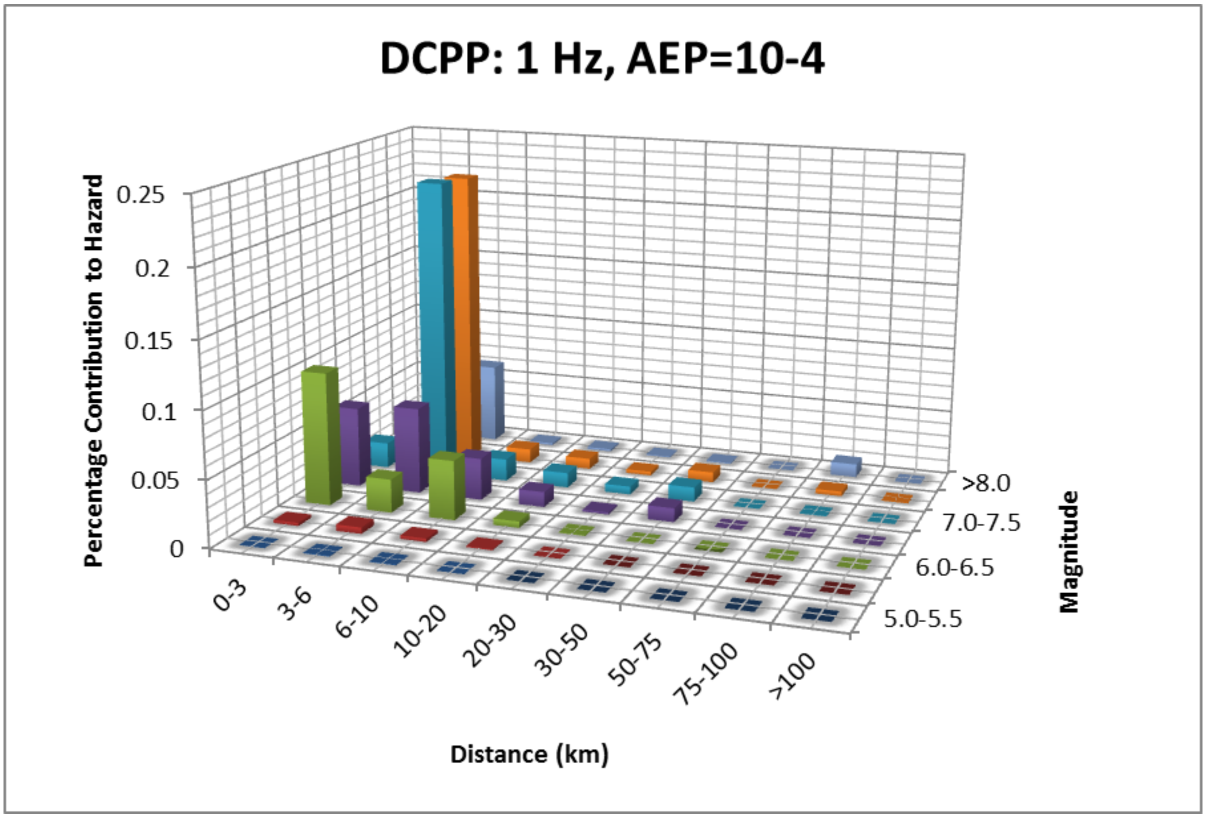

Figure A1.0-2: Deaggregation of the Reference Rock Site Hazard for 1 Hz Spectral Acceleration for the 1E-4 Hazard Level.

Table A2.0-1: Mean and Fractiles of Hazard for the Control Point for Peak Acceleration

PGA (g)	Mean	5th	16th	50th	84th	95th
0.02	7.0E-02	4.4E-02	4.9E-02	7.5E-02	1.2E-01	1.2E-01
0.05	2.3E-02	1.1E-02	1.4E-02	2.3E-02	3.5E-02	3.8E-02
0.10	8.4E-03	3.5E-03	4.6E-03	8.4E-03	1.4E-02	1.5E-02
0.15	4.6E-03	1.6E-03	2.2E-03	4.3E-03	7.2E-03	8.5E-03
0.20	2.8E-03	9.1E-04	1.4E-03	2.7E-03	4.7E-03	5.7E-03
0.25	2.0E-03	5.2E-04	8.3E-04	1.7E-03	3.3E-03	4.2E-03
0.30	1.4E-03	2.8E-04	4.9E-04	1.2E-03	2.4E-03	3.0E-03
0.40	7.3E-04	1.2E-04	2.4E-04	6.5E-04	1.5E-03	2.0E-03
0.50	4.3E-04	5.5E-05	1.2E-04	3.4E-04	8.8E-04	1.3E-03
0.60	2.8E-04	2.4E-05	5.8E-05	2.1E-04	5.5E-04	7.9E-04
0.70	1.7E-04	1.0E-05	2.7E-05	1.1E-04	3.8E-04	5.8E-04
0.85	8.6E-05	4.1E-06	1.2E-05	5.7E-05	2.2E-04	3.5E-04
1.00	4.9E-05	1.8E-06	6.4E-06	3.1E-05	1.2E-04	1.9E-04
1.20	2.6E-05	5.1E-07	2.1E-06	1.5E-05	7.1E-05	1.3E-04
1.40	1.4E-05	2.3E-07	1.0E-06	7.6E-06	3.7E-05	7.1E-05
1.60	8.2E-06	7.8E-08	4.0E-07	4.0E-06	2.3E-05	4.7E-05
1.80	4.9E-06	3.5E-08	2.0E-07	2.2E-06	1.4E-05	3.1E-05
2.0	3.2E-06	1.6E-08	9.5E-08	1.3E-06	8.9E-06	2.1E-05
2.5	1.2E-06	2.1E-09	1.6E-08	3.5E-07	3.3E-06	8.4E-06
3.0	5.0E-07	5.2E-10	3.4E-09	9.6E-08	1.3E-06	3.5E-06
4.0	1.3E-07	7.0E-11	4.3E-10	1.2E-08	2.3E-07	8.4E-07
5.0	3.8E-08	1.6E-11	1.1E-10	2.9E-09	7.2E-08	3.0E-07

Table A2.0-2: Mean and Fractiles of Hazard for the Control Point for 20 Hz Spectral Acceleration

20 Hz PSA (g)	Mean	5th	16th	50th	84th	95th
0.02	7.5E-02	4.4E-02	4.8E-02	7.1E-02	1.5E-01	1.6E-01
0.05	2.6E-02	1.3E-02	1.6E-02	2.6E-02	5.1E-02	5.5E-02
0.10	1.0E-02	4.4E-03	5.7E-03	1.0E-02	2.1E-02	2.4E-02
0.15	5.5E-03	2.1E-03	2.9E-03	5.5E-03	1.2E-02	1.4E-02
0.20	3.6E-03	1.2E-03	1.7E-03	3.6E-03	7.9E-03	9.4E-03
0.25	2.5E-03	7.1E-04	1.1E-03	2.4E-03	5.8E-03	7.0E-03
0.30	1.8E-03	4.3E-04	7.2E-04	1.8E-03	4.2E-03	5.2E-03
0.40	1.0E-03	2.0E-04	3.6E-04	1.0E-03	2.7E-03	3.5E-03
0.50	6.6E-04	7.7E-05	1.6E-04	5.7E-04	1.8E-03	2.5E-03
0.60	4.0E-04	3.8E-05	8.7E-05	3.4E-04	1.2E-03	1.8E-03
0.70	2.7E-04	2.0E-05	5.0E-05	2.3E-04	9.3E-04	1.4E-03
0.85	1.6E-04	7.9E-06	2.3E-05	1.3E-04	5.9E-04	9.6E-04
1.00	9.4E-05	3.2E-06	1.1E-05	6.7E-05	3.4E-04	6.0E-04
1.20	5.1E-05	1.3E-06	4.9E-06	3.7E-05	2.4E-04	4.4E-04
1.40	2.9E-05	4.1E-07	1.9E-06	1.8E-05	1.4E-04	2.7E-04
1.60	1.7E-05	2.1E-07	1.0E-06	1.1E-05	9.1E-05	1.9E-04
1.80	1.1E-05	7.4E-08	4.5E-07	6.1E-06	6.0E-05	1.3E-04
2.0	7.2E-06	3.8E-08	2.4E-07	3.8E-06	3.9E-05	9.1E-05
2.5	2.8E-06	9.5E-09	6.2E-08	1.3E-06	1.6E-05	4.3E-05
3.0	1.3E-06	2.0E-09	1.5E-08	4.8E-07	7.0E-06	2.0E-05
4.0	3.3E-07	2.5E-10	2.1E-09	8.5E-08	1.6E-06	5.7E-06
5.0	1.2E-07	5.9E-11	4.3E-10	2.2E-08	5.5E-07	2.4E-06

Table A2.0-3: Mean and Fractiles of Hazard for the Control Point for 10 Hz Spectral Acceleration

10 Hz PSA (g)	Mean	5th	16th	50th	84th	95th
0.02	1.1E-01	6.9E-02	7.5E-02	1.1E-01	2.1E-01	2.2E-01
0.05	4.0E-02	2.0E-02	2.3E-02	4.1E-02	7.8E-02	8.4E-02
0.10	1.6E-02	6.9E-03	8.8E-03	1.7E-02	3.3E-02	3.6E-02
0.15	9.3E-03	3.5E-03	4.7E-03	9.2E-03	1.9E-02	2.1E-02
0.20	6.2E-03	2.1E-03	2.9E-03	6.1E-03	1.3E-02	1.5E-02
0.25	4.5E-03	1.4E-03	2.0E-03	4.1E-03	9.7E-03	1.1E-02
0.30	3.3E-03	9.3E-04	1.4E-03	3.2E-03	7.1E-03	8.6E-03
0.40	2.1E-03	4.7E-04	7.9E-04	2.0E-03	4.8E-03	5.9E-03
0.50	1.4E-03	2.3E-04	4.2E-04	1.2E-03	3.4E-03	4.3E-03
0.60	9.5E-04	1.6E-04	3.0E-04	8.5E-04	2.4E-03	3.2E-03
0.70	6.7E-04	8.4E-05	1.8E-04	6.0E-04	1.9E-03	2.6E-03
0.85	4.4E-04	3.6E-05	8.5E-05	3.7E-04	1.3E-03	1.9E-03
1.00	2.9E-04	1.7E-05	4.4E-05	2.2E-04	8.8E-04	1.3E-03
1.20	1.7E-04	8.3E-06	2.3E-05	1.3E-04	6.6E-04	9.7E-04
1.40	1.0E-04	3.8E-06	1.2E-05	7.4E-05	4.3E-04	6.5E-04
1.60	6.5E-05	1.6E-06	5.6E-06	4.6E-05	3.1E-04	4.9E-04
1.80	4.4E-05	8.5E-07	3.4E-06	3.1E-05	2.2E-04	3.7E-04
2.0	2.9E-05	4.7E-07	2.0E-06	2.0E-05	1.5E-04	2.7E-04
2.5	1.2E-05	7.9E-08	4.6E-07	6.9E-06	7.2E-05	1.4E-04
3.0	6.1E-06	2.9E-08	2.0E-07	3.5E-06	3.4E-05	7.6E-05
4.0	1.7E-06	4.0E-09	3.4E-08	7.2E-07	9.4E-06	2.4E-05
5.0	6.4E-07	5.6E-10	5.3E-09	2.0E-07	3.9E-06	1.1E-05

Table A2.0-4: Mean and Fractiles of Hazard for the Control Point for 5 Hz Spectral Acceleration

5 Hz PSA (g)	Mean	5th	16th	50th	84th	95th
0.02	1.4E-01	9.6E-02	1.0E-01	1.4E-01	2.4E-01	2.5E-01
0.05	5.4E-02	2.8E-02	3.1E-02	5.6E-02	9.0E-02	9.4E-02
0.10	2.1E-02	9.5E-03	1.2E-02	2.2E-02	3.6E-02	3.9E-02
0.15	1.2E-02	4.8E-03	6.1E-03	1.2E-02	2.0E-02	2.3E-02
0.20	7.9E-03	3.0E-03	4.0E-03	7.9E-03	1.4E-02	1.6E-02
0.25	5.7E-03	2.0E-03	2.8E-03	5.3E-03	1.0E-02	1.2E-02
0.30	4.4E-03	1.4E-03	2.0E-03	4.2E-03	7.5E-03	9.0E-03
0.40	2.8E-03	7.8E-04	1.2E-03	2.7E-03	5.0E-03	6.1E-03
0.50	2.0E-03	4.8E-04	7.8E-04	1.7E-03	3.6E-03	4.5E-03
0.60	1.4E-03	3.0E-04	5.1E-04	1.3E-03	2.6E-03	3.3E-03
0.70	1.0E-03	1.9E-04	3.3E-04	8.8E-04	2.1E-03	2.7E-03
0.85	6.9E-04	1.0E-04	1.9E-04	5.8E-04	1.5E-03	2.0E-03
1.00	4.9E-04	5.9E-05	1.2E-04	3.7E-04	9.9E-04	1.4E-03
1.20	3.1E-04	2.5E-05	5.6E-05	2.4E-04	7.6E-04	1.1E-03
1.40	2.0E-04	1.5E-05	3.5E-05	1.4E-04	5.1E-04	7.5E-04
1.60	1.3E-04	7.3E-06	1.9E-05	9.4E-05	3.8E-04	5.8E-04
1.80	9.0E-05	4.2E-06	1.2E-05	6.2E-05	2.7E-04	4.3E-04
2.0	6.4E-05	1.8E-06	6.2E-06	4.2E-05	2.0E-04	3.3E-04
2.5	2.8E-05	4.9E-07	2.1E-06	1.7E-05	9.9E-05	1.8E-04
3.0	1.4E-05	1.9E-07	9.2E-07	8.6E-06	5.1E-05	9.6E-05
4.0	4.5E-06	2.7E-08	1.8E-07	2.1E-06	1.5E-05	3.2E-05
5.0	1.7E-06	3.8E-09	3.3E-08	6.6E-07	6.4E-06	1.5E-05

Table A2.0-5: Mean and Fractiles of Hazard for the Control Point for 2.5 Hz Spectral Acceleration

2.5 Hz PSA (g)	Mean	5th	16th	50th	84th	95th
0.02	2.0E-01	1.5E-01	1.6E-01	1.8E-01	2.2E-01	2.4E-01
0.05	7.4E-02	4.5E-02	4.9E-02	5.7E-02	6.9E-02	7.7E-02
0.10	2.9E-02	1.5E-02	1.7E-02	2.1E-02	2.7E-02	3.2E-02
0.15	1.6E-02	7.2E-03	8.5E-03	1.1E-02	1.4E-02	1.7E-02
0.20	1.0E-02	4.4E-03	5.3E-03	7.0E-03	9.2E-03	1.1E-02
0.25	7.1E-03	3.0E-03	3.7E-03	4.9E-03	6.7E-03	8.1E-03
0.30	5.3E-03	2.0E-03	2.5E-03	3.5E-03	4.8E-03	5.9E-03
0.40	3.3E-03	1.1E-03	1.5E-03	2.2E-03	3.1E-03	3.8E-03
0.50	2.3E-03	6.9E-04	9.3E-04	1.4E-03	2.2E-03	2.8E-03
0.60	1.6E-03	4.2E-04	5.9E-04	9.4E-04	1.5E-03	2.0E-03
0.70	1.2E-03	3.0E-04	4.3E-04	7.1E-04	1.2E-03	1.6E-03
0.85	8.3E-04	1.6E-04	2.4E-04	4.4E-04	8.2E-04	1.1E-03
1.00	6.1E-04	8.2E-05	1.3E-04	2.6E-04	5.2E-04	7.8E-04
1.20	3.7E-04	4.3E-05	7.4E-05	1.7E-04	3.7E-04	5.9E-04
1.40	2.5E-04	2.4E-05	4.1E-05	9.7E-05	2.3E-04	3.9E-04
1.60	1.8E-04	1.4E-05	2.6E-05	6.6E-05	1.7E-04	2.9E-04
1.80	1.3E-04	7.8E-06	1.5E-05	4.2E-05	1.2E-04	2.2E-04
2.0	9.4E-05	4.2E-06	9.1E-06	2.8E-05	8.3E-05	1.6E-04
2.5	4.6E-05	1.3E-06	3.3E-06	1.2E-05	4.0E-05	7.9E-05
3.0	2.4E-05	4.0E-07	1.2E-06	5.0E-06	2.0E-05	4.4E-05
4.0	8.4E-06	5.5E-08	1.9E-07	1.2E-06	5.8E-06	1.5E-05
5.0	3.5E-06	1.4E-08	5.7E-08	3.9E-07	2.4E-06	6.8E-06

Table A2.0-6: Mean and Fractiles of Hazard for the Control Point for 1 Hz Spectral Acceleration

1.0 Hz PSA (g)	Mean	5th	16th	50th	84th	95th
0.02	6.3E-02	3.0E-02	3.2E-02	6.4E-02	7.2E-02	7.5E-02
0.05	1.7E-02	6.6E-03	7.7E-03	1.4E-02	1.7E-02	1.8E-02
0.10	5.3E-03	1.7E-03	2.3E-03	4.2E-03	5.6E-03	6.2E-03
0.15	2.7E-03	6.5E-04	1.0E-03	1.9E-03	2.9E-03	3.4E-03
0.20	1.7E-03	3.1E-04	5.5E-04	1.2E-03	1.9E-03	2.3E-03
0.25	1.1E-03	1.7E-04	3.4E-04	7.6E-04	1.3E-03	1.7E-03
0.30	8.1E-04	8.2E-05	1.8E-04	4.8E-04	9.5E-04	1.3E-03
0.40	4.8E-04	2.7E-05	7.6E-05	2.5E-04	6.0E-04	8.4E-04
0.50	2.8E-04	1.2E-05	3.6E-05	1.3E-04	3.6E-04	5.4E-04
0.60	1.8E-04	4.7E-06	1.6E-05	7.1E-05	2.2E-04	3.5E-04
0.70	1.2E-04	2.4E-06	9.1E-06	4.5E-05	1.5E-04	2.6E-04
0.85	7.3E-05	9.1E-07	3.8E-06	2.3E-05	8.7E-05	1.6E-04
1.00	4.3E-05	3.4E-07	1.5E-06	1.1E-05	4.6E-05	8.8E-05
1.20	2.4E-05	1.2E-07	6.6E-07	5.8E-06	2.9E-05	5.9E-05
1.40	1.4E-05	4.2E-08	2.6E-07	2.7E-06	1.5E-05	3.3E-05
1.60	9.2E-06	1.8E-08	1.3E-07	1.5E-06	9.8E-06	2.2E-05
1.80	5.9E-06	7.7E-09	6.0E-08	8.5E-07	6.2E-06	1.4E-05
2.0	4.0E-06	3.3E-09	2.8E-08	4.8E-07	3.9E-06	9.5E-06
2.5	1.7E-06	6.7E-10	6.8E-09	1.5E-07	1.5E-06	4.2E-06
3.0	7.9E-07	1.4E-10	1.6E-09	5.0E-08	5.9E-07	1.8E-06
4.0	2.2E-07	1.3E-11	1.7E-10	6.2E-09	1.1E-07	4.4E-07
5.0	8.2E-08	2.6E-12	4.1E-11	1.5E-09	3.8E-08	1.7E-07

Table A2.0-7: Mean and Fractiles of Hazard for the Control Point for 0.5 Hz Spectral Acceleration

0.5 Hz PSA (g)	Mean	5th	16th	50th	84th	95th
0.02	2.0E-02	7.8E-03	9.0E-03	1.8E-02	2.2E-02	2.4E-02
0.05	4.5E-03	1.3E-03	1.7E-03	3.5E-03	4.7E-03	5.5E-03
0.10	1.3E-03	2.0E-04	3.4E-04	8.7E-04	1.5E-03	2.0E-03
0.15	5.6E-04	4.9E-05	1.1E-04	3.0E-04	7.0E-04	1.1E-03
0.20	3.1E-04	1.6E-05	4.0E-05	1.5E-04	4.2E-04	7.1E-04
0.25	1.8E-04	5.1E-06	1.5E-05	7.0E-05	2.5E-04	4.6E-04
0.30	1.2E-04	2.3E-06	7.5E-06	3.6E-05	1.6E-04	3.0E-04
0.40	5.6E-05	4.8E-07	2.1E-06	1.4E-05	7.5E-05	1.7E-04
0.50	2.9E-05	9.8E-08	6.2E-07	5.2E-06	3.6E-05	9.2E-05
0.60	1.6E-05	4.1E-08	2.4E-07	2.4E-06	1.9E-05	5.4E-05
0.70	1.0E-05	1.1E-08	9.1E-08	1.1E-06	1.2E-05	3.4E-05
0.85	5.5E-06	3.1E-09	2.9E-08	4.5E-07	5.4E-06	1.8E-05
1.00	3.0E-06	1.0E-09	1.1E-08	1.7E-07	2.4E-06	1.0E-05
1.20	1.5E-06	2.3E-10	3.6E-09	7.5E-08	1.3E-06	5.5E-06
1.40	8.7E-07	8.2E-11	1.2E-09	2.8E-08	5.3E-07	2.7E-06
1.60	5.2E-07	3.2E-11	5.2E-10	1.3E-08	3.0E-07	1.7E-06
1.80	3.2E-07	1.3E-11	2.3E-10	6.2E-09	1.7E-07	1.1E-06
2.0	2.1E-07	4.3E-12	8.3E-11	2.8E-09	8.9E-08	6.5E-07
2.5	8.0E-08	6.7E-13	9.3E-12	6.3E-10	2.9E-08	2.5E-07
3.0	3.6E-08	1.1E-13	1.1E-12	1.4E-10	9.6E-09	9.7E-08
4.0	9.3E-09	8.0E-15	3.8E-14	5.4E-12	1.5E-09	2.1E-08
5.0	3.2E-09	9.7E-16	2.3E-15	5.3E-13	3.9E-10	6.9E-09

Table A3.0-1: Median Amplification Factors and Epistemic Uncertainty for the Control Point Using the Empirical Site Response Approach. (Amplification is with respect to a reference rock site with V_{S30} = 760 m/s and kappa = 0.041 seconds).

Freq (Hz)	Median Amplification	logarithmic Standard Deviation (LN units)
100.00	0.74	0.20
50.00	0.73	0.20
33.30	0.70	0.20
20.00	0.59	0.20
13.30	0.59	0.21
10.00	0.59	0.22
6.67	0.61	0.22
5.00	0.68	0.22
4.00	0.79	0.22
3.33	0.88	0.22
2.50	1.21	0.22
2.00	1.21	0.22
1.33	1.21	0.23
1.00	1.00	0.24
0.67	1.00	0.26
0.50	1.00	0.27
0.33	1.00	0.35
0.20	1.00	0.35
0.10	1.00	0.35

Appendix B – Long Term Seismic Program Seismic Margin Spectrum

B1.0 Introduction

The purpose of this Appendix is to document the seismic margins associated with the 1988 Long Term Seismic Program (LTSP) evaluation of Diablo Canyon Power Plant (DCPP) (see the 1988 DCPP LTSP Final Report (PG&E 1988), the 1991 Addendum to the DCPP LTSP Final Report (PG&E 1991), and the Supplement No. 34 of the Safety Evaluation Report (SER) for DCPP (NRC 1991)). The resulting response spectrum, herein, is defined as the LTSP seismic margin spectrum.

B2.0 Long Term Seismic Program Background

License Condition No. 2.C.(7) of the DCPP Unit 1 operating license, required, in part that:

> "PG&E shall develop and implement a program to reevaluate the seismic design bases used for the DCPP."

Pacific Gas and Electric Company's (PG&E's) seismic reevaluation effort in response to the license condition was titled the "Long Term Seismic Program."

The LTSP included a seismic probabilistic risk assessment (SPRA) and a deterministic seismic margin assessment (SMA). The results of the LTSP are described in the 1988 LTSP Final Report (PG&E 1988) and the 1991 Addendum to the LTSP Final Report (PG&E 1991). The Nuclear Regulatory Commission's (NRC's) review and acceptance of the LTSP evaluations are documented in DCPP SER Supplement 34 (NRC 1991).

B2.1 LTSP Ground Motion

Site-specific free-field ground motions were developed by PG&E based on the following (PG&E 1988, Chapters 2 through 4):

(a) regional geology, seismology, geophysics, and tectonics investigations

(b) characterization of seismic source

(c) characterization of ground motions, using both empirical analysis and numerical modeling

PG&E's horizontal site-specific 1988 LTSP response spectrum is shown in Figure B2.1-1 (PG&E 1988, Figure 7-2) and tabulated in Table B2.1-1. Note that the 84th percentile response spectrum was used as input to the deterministic evaluations.

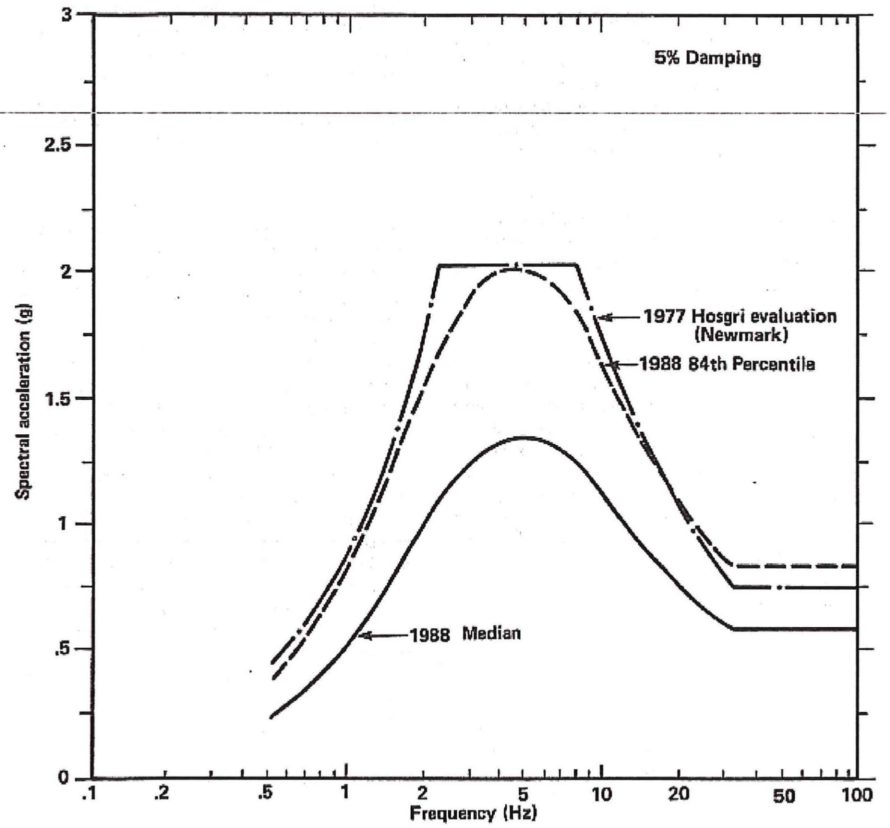

Figure B2.1-1: Horizontal 1988 LTSP Response Spectrum for DCPP
(From LTSP Final Report, Figure 7-2)

Table B2.1-1: Horizontal 1988 LTSP Response Spectrum for DCPP (5% Damping)

Period (sec.)	Frequency (Hz)	84th Percentile Spectral Acceleration (g)
0.0250	40.000	0.830
0.0303	33.000	0.830
0.0400	25.000	0.964
0.0500	20.000	1.110
0.0700	14.286	1.344
0.0850	11.765	1.508
0.1000	10.000	1.654
0.1200	8.333	1.819
0.1400	7.143	1.918
0.1500	6.667	1.947
0.1700	5.882	1.976
0.2000	5.000	2.006
0.2500	4.000	2.015
0.3000	3.333	1.962
0.4000	2.500	1.763
0.5000	2.000	1.554
0.7500	1.333	1.109
1.0000	1.000	0.831
1.5000	0.667	0.524
2.0000	0.500	0.356

B2.2 LTSP HCLPF Capacities

The high-confidence-low-probability-of-failure (HCLPF) capacities of structures, systems, and components that were found to be governing in the deterministic seismic margin assessment associated with the implementation of the LTSP are described in Chapter 7 of the 1988 LTSP Final Report (PG&E 1988) and updated in Chapter 7 of the 1991 Addendum of the LTSP Final Report (PG&E 1991).

The fragilities and HCLPF capacities for DCPP structures, systems, and components are defined based on the 5 percent damped horizontal spectral acceleration value, averaged over the frequency range of 3.0 to 8.5 Hz. This is illustrated in Figure B2.2-1 (based on Figure 7-40 from the 1988 LTSP Final Report - PG&E 1988).

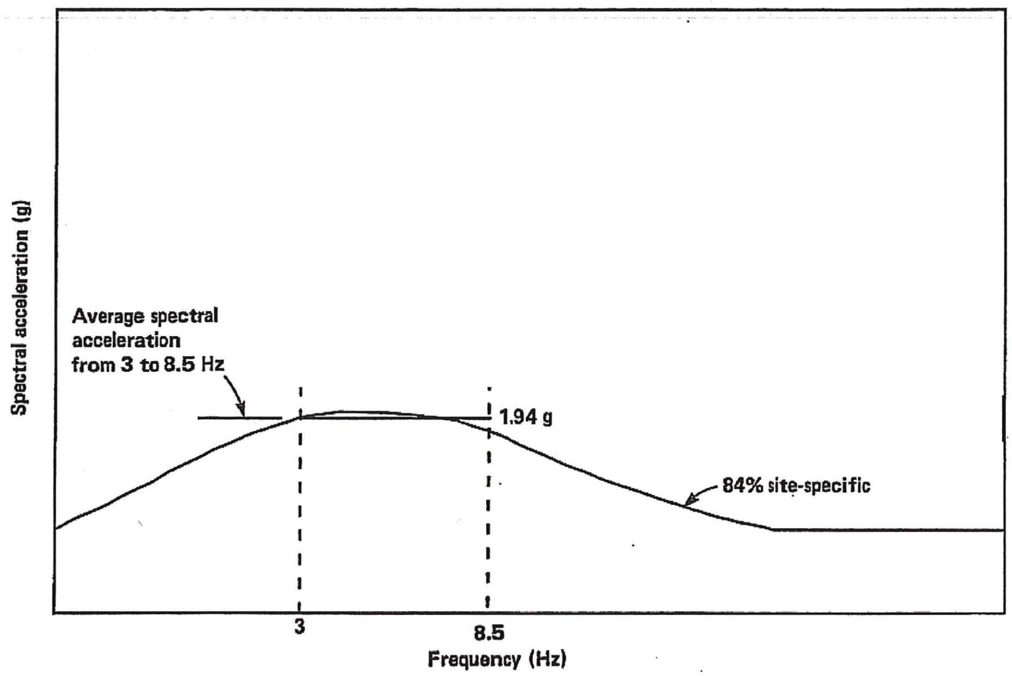

Figure B2.2-1: Frequency Range Associated with HCLPF Capacities for DCPP
(From PG&E 1988, Figure 7-40)

B3.0 Minimum Seismic Margin

As indicated in Tables 7-1 and 7-2 of the 1988 LTSP Final Report (PG&E 1988), the turbine building is the structure with the lowest HCLPF capacity and the emergency diesel generator (EDG) control panels are the component whose failure could lead to significant seismic risk to the plant with the lowest HCLPF capacity. The HCLPF capacities of these structures, systems, and components were updated by PG&E using the conservative deterministic failure margins method (PG&E 1990) and summarized in Table A7-1 of the 1991 Addendum to LTSP Final Report (PG&E 1991). The HCLPF capacities for the turbine building and the EDG control panels are listed in Table B3.0-1.

Table B3.0-1: Limiting HCLPF Capacities for DCPP
(PG&E 1988 and PG&E 1991)

SSC	84th Percentile HCLPF Capacity (g)	
Name	PG&E 1988[1]	PG&E 1991[2]
Turbine Building	2.21	2.89
EDG Control Panels	2.69	2.62

Since the average 5 percent damped spectral acceleration for the 84th percentile 1988 LTSP horizontal response spectrum is 1.94 g (see Figure B2.2-1) and the HCLPF capacity for the limiting structure, system, and components (EDG control panels) is 2.62 g, the minimum seismic margin is 2.62 g/1.94 g = 1.35.

Note that Section 3.8.1.5 of the NRC's SER associated with the 1988 LTSP (NRC 1991) states:

> "the staff generally agrees with the PG&E's statement that all components whose failure could lead to seismic risk to the plant have at least a margin of 40 percent when their HCLPF capacities are compared with the 84-percent, site-specific, ground-motion demand."

Therefore, the use of a minimum seismic margin of 1.35 is conservative relative to the NRC's conclusions for the 1988 LTSP.

B4.0 LTSP Seismic Margin Spectrum

The resulting LTSP seismic margin spectrum is the product of the 84th percentile 1988 LTSP ground motion response spectrum (Table B2.1-1) and the minimum seismic margin from Section B3.0 (1.35). The LTSP seismic margin spectrum is shown in Figure B4.0-1 and tabulated in Table B4.0-1.

1 1988 HCLPF capacities are from Tables 7-1 and 7-2 of the 1988 LTSP Final Report (PG&E 1988).

2 1991 HCLPF capacities are from Table A7-1 of the 1991 Addendum to the LTSP Final Report (PG&E 1991).

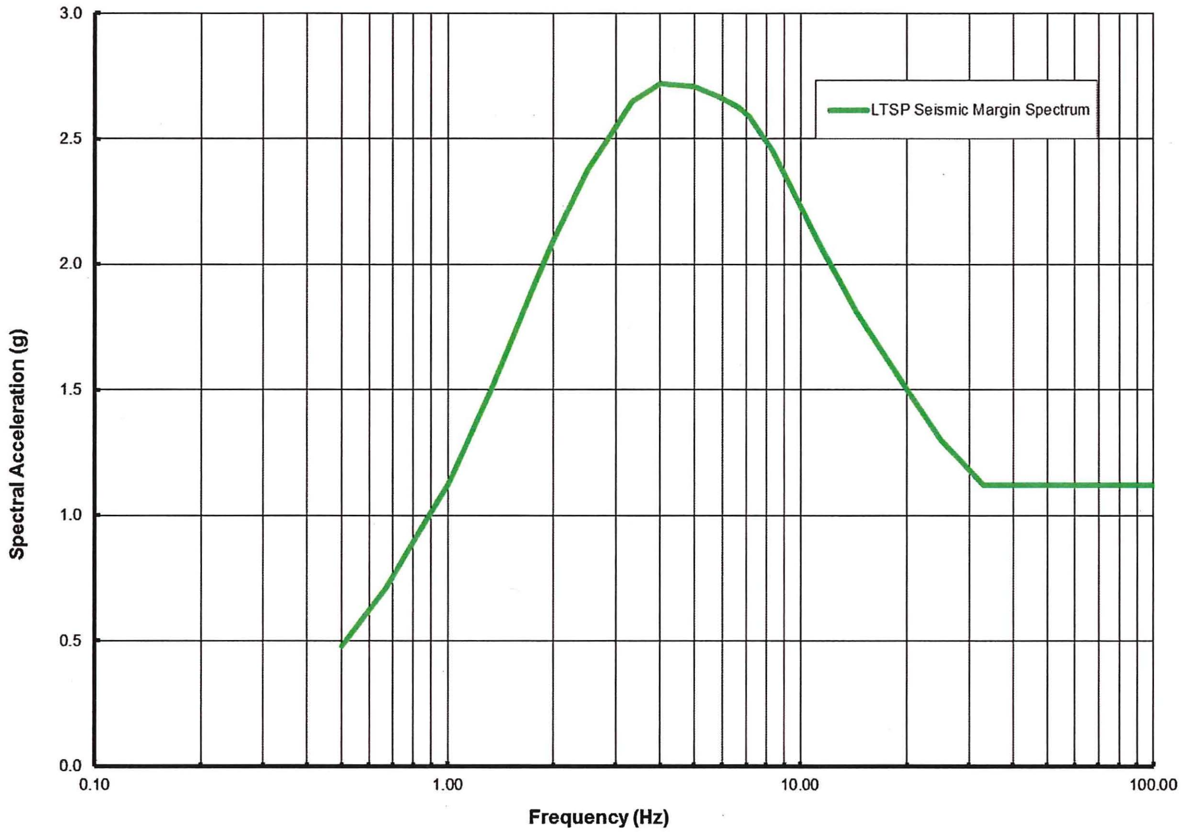

Figure B4.0-1: LTSP Seismic Margin Spectrum for DCPP
(5% Damping)

Table B4.0-1: LTSP Seismic Margins Spectrum for DCPP
(5% Damping)

Period (sec)	Frequency (Hz)	Spectral Acceleration (g)
0.0100	100.0000	1.121
0.0250	40.0000	1.121
0.0303	33.0000	1.121
0.0400	25.0000	1.301
0.0500	20.0000	1.499
0.0700	14.2857	1.814
0.0850	11.7647	2.036
0.1000	10.0000	2.233
0.1200	8.3333	2.456
0.1400	7.1429	2.589
0.1500	6.6667	2.628
0.1700	5.8824	2.668
0.2000	5.0000	2.708
0.2500	4.0000	2.720
0.3000	3.3333	2.649
0.4000	2.5000	2.380
0.5000	2.0000	2.098
0.7500	1.3333	1.497
1.0000	1.0000	1.122
1.5000	0.6667	0.707
2.0000	0.5000	0.481

B5.0 References

B5.1 Pacific Gas and Electric Company

(a) PG&E 1988, PG&E Report, "Final Report of the Diablo Canyon Long Term Seismic Program for the Diablo Canyon Power Plant," Enclosure to PG&E Letter DCL-88-192, "Long Term Seismic Program Completion," dated July 31, 1988

(b) PG&E 1990, PG&E Report, "Additional Deterministic Evaluations Performed to Assess Seismic Margins of the Diablo Canyon Power Plant, Units 1 and 2," Enclosure to PG&E Letter DCL-90-226, "Long Term Seismic Program Additional Deterministic Evaluations," dated September 18, 1990

(c) PG&E 1991, PG&E Report, "Addendum to the 1988 Final Report of the Diablo Canyon Long Term Seismic Program," Enclosure to PG&E Letter DCL-91-027, "Addendum to Long Term Seismic Program Final Report," dated February 13, 1991

B5.2 Nuclear Regulatory Commission

(a) NRC 1991, "Safety Evaluation Report related to the operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2, Docket Nos. 50-275 and 50-323, Pacific Gas and Electric Company," NUREG-0675, Supplement No. 34, dated June 1991

Appendix C – PPRP Endorsements

Diablo Canyon Seismic Source Characterization SSHAC Project Participatory Peer Review Panel Closure Letter

March 10, 2015

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245 Market St.
San Francisco, CA 94177

SUBJECT: Diablo Canyon Seismic Source Characterization SSHAC Project Participatory Peer Review Panel Closure Letter

Dear Mr. Ferre,

The Participatory Peer Review Panel (PPRP, the "Panel") for the Diablo Canyon Seismic Source Characterization (SSC) SSHAC Project (the "DCPP SSC Project") is pleased to issue this PPRP Closure Letter containing our findings with respect to the project. The four Panel members (Kevin J. Coppersmith, Steven M. Day, Neal W. Driscoll, and Thomas K. Rockwell) participated in the Project in a manner fully consistent with the SSHAC Guidance[1] for a SSHAC Level 3 study. The Panel was actively engaged in all phases and activities of the Project's implementation, including the development of the Project Plan, review of analyses performed by the Technical Integration (TI) Team to support the evaluation and integration processes, review of interim products, and review of the draft project report and the final project report.

Consistent with regulatory guidance for SSHAC projects, the role of the PPRP is to conduct a review of both the *process* followed and the *technical* assessments made by the TI Team. Accordingly, this letter documents the activities that the PPRP has undertaken in its review of the Project, its review of the adequacy of the process followed, and its findings relative to the technical adequacy of the resulting SSC model.

Consistent with SSHAC Guidance, the Panel was fully engaged in peer-review interactions with the DCPP SSC TI Team throughout the entire project performance—from development of the Project Plan through finalization the Project Report. The participatory peer review process entails the continual review of a project from its start to its completion. Thus, proper implementation requires adequate opportunity during the conduct of the study for the PPRP to understand the data, models, and methods being evaluated; the analyses performed for the study; the TI Team's integration activities that lead to SSC models and uncertainties; and the completeness and clarity of the technical

[1] Budnitz, R.J., G. Apostolakis, D.M. Boore, L.S. Cluff, K.L. Coppersmith, C.A. Cornell, and P.A. Morris (1997). *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and the Use of Experts* (known as the "Senior Seismic Hazard Analysis Committee Report", or "SSHAC Guideline"), NUREG/CR-6372, U.S. Nuclear Regulatory Commission, TIC; 235076, Washington, D.C.

NRC (2012). *Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies*, NUREG-2117, U.S. Nuclear Regulatory Commission, Washington, D.C.

justifications given in the documentation. Participatory review also involves opportunities for the PPRP to provide its reviews and comments in written and verbal form during the conduct of the project, such that the suggestions and recommendations made by the Panel can be considered by the TI Team in a timely fashion prior to completion of the work.

The meetings attended and observed by the PPRP for the DCPP SSC project are summarized in the table below. The PPRP assumed an active participant role in Workshop #3 and the PPRP Briefings.

Meeting Type	Date(s)	Topic(s)
Kick off meeting	August 25, 2011	Kick off meeting
Workshop	November 29 - December 1, 2011	Workshop #1
Working Meeting	March 28, 2012	Characteristic earthquake review
Working Meeting	April 11, 2012	Logic tree and sensitivity for magnitude PDF and earthquake recurrence
Working meeting	May 14, 2012	SSC work plan review, overall logic tree structure
Working Meeting	June 19-20, 2012	Project and Workshop #2 planning, logic tree structure, sensitivity analyses, Hosgri, Los Osos, San Luis Bay, and Shoreline logic trees
Working Meeting	October 25-26, 2012	Workshop #2 planning, logic tree sensitivity review
Workshop	November 6-8, 2012	Workshop #2
Working Meeting	December 11, 2012	Review Workshop 2, 2013 plan, data needs table
Working Meeting	February 20, 2013	2013 Schedule and Assignments, Offshore seismic stratigraphy project PE presentation
Working Meeting	September 20, 2013	Alternative fault model evaluation
Working Meeting	November 5-6, 2013	Presentation of draft SSC Model V2
Working Meeting	March 5, 2014	Rupture Models, Sam Johnson PE presentation, Recurrence model
Workshop	March 25-27, 2014	Workshop #3
Working Meeting	June 23-24, 2014	Modifications to Preliminary Fault and Deformation models, open items following Preliminary SSC Model
PPRP Briefing	July 24-25, 2014	DCPP SSC Model Final PPRP Briefing, Part 1
PPRP Briefing	October 31, 2014	DCPP SSC Model Final PPRP Briefing, Part 2, Time Dependency Model

The PPRP, collectively and individually, understood fully the SSHAC Guidance for a structured participatory peer review and the requirements for a SSHAC Level 3 project; had full and frequent access to information and interacted extensively with the TI Team throughout the project; provided peer-review comments at multiple stages; and, as documented within the final report, was fully engaged to meet its peer-review obligations in an effective way. The Panel concludes that its ongoing review and feedback interactions with the TI Team during the conduct of the DCPP SSC project activities fully met the expectations for a SSHAC Level 3 study.

SSHAC *Process* Review

Fundamentally, the question of whether or not a project follows a proper SSHAC Level 3 process is answered by comparing the process used with the process outlined generally in the SSHAC implementation guidance issued by the NRC. NRC (2012, Table 4-1) identifies the essential steps in a SSHAC Level 3 study that define the minimum required activities:

1. Select SSHAC Level
2. Develop Project Plan
3. Select project participants
4. Develop project database
5. Hold workshops (minimum of three, focused on available data, alternative models, and feedback)
6. Develop preliminary model(s) and Hazard Input Document (HID)
7. Perform preliminary hazard calculations and sensitivity analyses
8. Finalize models in light of feedback
9. Perform final hazard calculations and sensitivity analyses
10. Develop draft and final project report
11. Participatory peer review of entire process

Review of the project documentation, as well as ongoing participatory peer review throughout the project, leads to the conclusion that the essential steps of a SSHAC Level 3 process have been followed in the DCPP SSC Project. For example, a Project Plan was issued at the start of the project that outlined the project activities and the roles and responsibilities of all project participants; a major effort was devoted to developing a project database that was accessible to the TI Team; three topical workshops were held to identify available data, to discuss alternative methods and models, and to present feedback based on preliminary interpretations; preliminary models were developed and seismic hazard calculations conducted to provide additional feedback to the TI Team; draft and final reports were developed that documented the process followed and the technical assessments made; and a peer review process was conducted that included both participatory aspects and late-stage reviews (e.g., review of the draft report).

In light of due consideration of the essential elements of a SSHAC process and the specific manner in which the DCPP SSC Project was conducted, the Panel concludes that the project performed all essential steps consistent with current state-of-practice guidance for a SSHAC Level 3 process.

As explained in NUREG-2117 (NRC, 2012), the SSHAC process consists of two important activities, described as follows:

"The fundamental goal of a SSHAC process is to carry out properly and document completely the activities of evaluation and integration, defined as:

- *Evaluation*: The consideration of the complete set of data, models, and methods proposed by the larger technical community that are relevant to the hazard analysis.
- *Integration*: Representing the center, body, and range of technically defensible interpretations in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods)."

These activities are essential to any SSHAC study and the Panel has followed the DCPP SSC Project closely to ensure that both activities have been adequately conducted. A third key activity of a SSHAC process is the *documentation* phase, which ensures that all evaluation and integration activities are properly supported and captured in the written record.

During the *Evaluation* phase of the DCPP SSC Project, the TI Team considered new data, models, and methods that have become available in the technical community in recent years. Importantly, the TI Team evaluated the wealth of onshore and offshore data that have recently been collected as part of the AB 1632 studies required by the State of California, as well as numerous data collection activities conducted by federal and state researchers such as the USGS and California Geological Survey. Workshop #1 was devoted to reviewing these disparate datasets and to identifying which data could be used to develop the SSC model. Continuing the *evaluation* process, Workshop #2 focused on alternative methods and models that pertain to the hazard-significant SSC issues. Significant representation of these alternative viewpoints was made by the participation of resource and proponent experts at the workshop. The Panel concludes that the TI Team conducted an adequate evaluation process.

The *Integration* phase of the project entails the building of the SSC model to capture current knowledge and uncertainties. Care was given in the model-building process to appropriately distinguish between epistemic uncertainties and aleatory variability. The TI Team conducted multiple working meetings and other interactions to ensure that the center, body, and range of technically defensible interpretations were included in the SSC model. Importantly, the Team also received appropriate communications from the Project Technical Integrator (PTI) regarding the required elements of the SSC model needed for consistency with the ground motion models being developed in parallel as part of the Southwest United States Ground Motion Characterization Project. A preliminary SSC model was developed prior to Workshop #3 and hazard calculations were conducted for purposes of sensitivity analysis feedback. At Workshop #3, the PPRP was given the opportunity to provide their feedback on the preliminary model and to challenge the TI Team with respect to the technical justifications for their SSC model assessments and associated uncertainties. The TI Team used the feedback gained from the hazard calculations and PPRP comments to prioritize their efforts in the final SSC model development process. The tectonic complexity of the DCPP study region requires a complex SSC model to completely and appropriately capture current knowledge and uncertainties. Efforts were made to simplify the models when it could be shown that detailed characterization would not lead to significant differences in the hazard results. The Panel concludes that such simplifications were justified and appropriate.

In support of the *Documentation* phase of the project, the TI Team developed a comprehensive Draft Report that was provided to the PPRP for detailed review. To ensure that schedule constraints for the project were met, the report was provided to the PPRP in major installments consisting of multiple chapters and appendices. The role of the Panel's review was specifically to ensure that all *evaluation* and *integration* activities were described completely, and that the SSC model was adequately justified technically. Written comments were provided by the PPRP to the TI Team and, after revision of the report in light of those comments, written responses by the Team were provided to the PPRP to ensure proper closure of each comment.

Based on the review of the *evaluation* and *integration* activities conducted by the TI Team, as well as the *documentation* of these activities in the PSHA report, the PPRP concludes that the SSHAC process has been adequately conducted.

SSHAC *Technical* Review

The role of the PPRP in the review of the technical aspects of the project is specified in NUREG-2117 (USNRC, 2012) as follows:

> "The PPRP fulfills two parallel roles, the first being technical review. This means that the PPRP is charged with ensuring that the full range of data, models, and methods have been duly considered in the assessment and also that all technical decisions are adequately justified and documented.
>
> The responsibility of the PPRP is to provide clear and timely feedback to the TI/TFI and project manager to ensure that any technical or process deficiencies are identified at the earliest possible stage so that they can be corrected. More commonly, the PPRP provides its perspectives and advice regarding the manner in which ongoing activities can be improved or carried out more effectively. In terms of technical review, a key responsibility of the PPRP is to highlight any data, models or proponents that have not been considered. Beyond completeness, it is not within the remit of the PPRP to judge the weighting of the logic-trees in detail but rather to judge the justification provided for the models included or excluded, and for the weights applied to the logic-tree branches."

Consistent with this NRC guidance, the PPRP reviewed at multiple times during the project the TI Team's evaluations of data, models, and methods, as well as the Team's development and technical justification for the SSC model. These reviews included conference calls, post-workshop meetings, written comments, and the review of drafts of the PSHA report. Through these reviews, the PPRP communicated feedback to the TI Team regarding data and approaches that did not appear to have been considered, suggestions for methods being used within the technical community that should be evaluated by the Team, and recommendations for ways that the documentation could be improved to strengthen the discussion of the technical bases for the assessments.

Requirements for a successful *integration* or model-building phase of a SSHAC Level 3 process are that it is informed by a complete evaluation of all relevant data, models, and methods during the *evaluation* phase of the project, that all assessments are technically defensible, and that the developed models are thoroughly documented so as to be transparent to users. During the course of the integration process, the TI Team found that the available set of methods or model elements were not sufficient to properly and completely represent current knowledge and uncertainty in some components of the model. In those cases, the TI Team developed a refined set of model elements or concepts that—although they are not radically different from current practice—provide approaches that the Team concluded were more effective in modeling technical aspects than available tools. For example, the SSC model includes a series of fault geometry models and rupture sources that span the range of credible interpretations of available data. Key aspects of these rupture sources are assessed based on a consideration of constraints from geologic, geomorphic, geophysical, and seismological data.

A strong requirement of the SSHAC Guidance is that all elements of the SSC model must be completely documented and adequately justified technically. This is particularly true of new model elements that have not enjoyed the benefit of use on multiple projects or that have not been subject to peer review within the larger technical community. Particularly in those cases, the PPRP must ensure that the model elements are sufficiently justified and adequately defended in the project documentation. This has been the case in the DCPP SSC Project. Examples of new approaches include the use of a slip rate allocation approach to characterizing rupture sources, incorporating new magnitude frequency distributions, and the adoption of a non-Poisson temporal model. To review these concepts and applications to the SSC model, the PPRP was present as observers at workshops where these concepts were presented, provided written comments in response to those workshops, asked questions and provided feedback in a workshop environment regarding the adequacy of the technical justification for the models, participated in briefings and conference calls related to the topics, and provided detailed written comments related to the draft project report. Based on this process of participatory review throughout the course of the project, the PPRP concludes that the bases for the SSC model elements are technically defensible, and that the technical assessments and process for arriving at the model elements are adequately documented.

Throughout the course of the PPRP review, the TI Team was responsive to the questions, comments, and suggestions made by the PPRP relative to the technical aspects of the project. Therefore, the Panel concludes that the technical aspects of the projects have been adequately addressed and all written comments provided by the Panel, including those made following each workshop and those pertaining to the Draft Report, are hereby considered to be closed.

Conclusion

Based on our observation of the completeness and professional standard by which the evaluation and integration activities were conducted, the Panel concludes that the data, models, and methods within the larger technical community have been properly evaluated, and that the center, body, and range of technically defensible interpretations have been appropriately represented in the SSC model. Accordingly, the Panel concludes that both the process and technical aspects of the DCPP SSC assessment fully meet accepted guidance and current expectations for a SSHAC Level 3 study.

We appreciate the opportunity to provide our review of the project.

Sincerely,

DCPP PPRP Members

Kevin J. Coppersmith, Chair

Steven M. Day

Neal W. Driscoll

Thomas K. Rockwell

Participatory Peer Review Panel Closure Letter, Southwest United States Ground Motion Characterization Level 3 SSHAC Project

and

TI Team – PM Response to PPRP Closure Letter

PPRP CLOSURE LETTER

March 10, 2015

Dr. Carola Di Alessandro
SWUS Project Manager
GeoPentech, Inc.
525 N. Cabrillo Park Drive, Suite 280
Santa Ana, CA 92701

Subject: Participatory Peer Review Panel Closure Letter, Southwest United States Ground Motion Characterization Level 3 SSHAC Project

Dear Dr. Di Alessandro:

The Participatory Peer Review Panel (PPRP, also referred to herein as the "Panel") for the Southwest United States (SWUS) Ground Motion Characterization (GMC) Project is pleased to issue this PPRP Closure Letter. Herein we describe our participation in the SWUS GMC SSHAC Level 3 project and present our findings. Pursuant to the guidelines for a SSHAC Level 3 study (NUREG/CR-6372; NUREG-2117), the PPRP was engaged at all stages of the project, including review of the final Project Plan, Workshop agendas and participant lists; the planning of the evaluation and model integration activities; and review of the project documentation. Throughout the project, the Panel reviewed and provided regular feedback on both the process followed, and the technical assessments made, by the Technical Integrator (TI) Team. By this letter the Panel documents the activities it has performed in the course of its review, its assessment of the process followed relative to SSHAC Level 3 expectations, and its assessment of the technical rationale underlying the GMC model.

The PPRP issued a previous letter dated February 24, 2015. In that letter, the Panel noted that there were limitations in the completeness and clarity of the project documentation. Those limitations were noted as exceptions to the Panel's finding that the project successfully met SSHAC Level 3 expectations. Since that time, the TI Team has produced a final report, designated Rev2, addressing the final set of comments from the Panel (PPRP Submittal No. 3, February 20, 2015). The Panel has reviewed Rev2 (including a short addendum supplied to the PPRP in draft form on March 9 which the TI Team has assured in writing will be incorporated in the final version) and finds that all material concerns have been adequately addressed and are now closed, apart from one remaining exception that will be described at the end of the SSHAC Process Review section below. Two GMC models were developed for application to Diablo Canyon Power Plant (DCPP) and Palo Verde Nuclear Generating Station (PVNGS), respectively. The exception applies only to the GMC model for DCPP, and is not relevant to the case of PVNGS.

PPRP Activities in Support of the SWUS GMC Review

In a SSHAC Level 3 study, the PPRP fulfills two roles. The first is that of technical review, in which the Panel ensures that the full range of data, models and methods are considered and that technical decisions and judgments are adequately justified and documented. The second is that of process review, under which the Panel ensures that the study maintains conformity with the SSHAC Level 3 guidelines. To fulfill these roles, the Panel requires adequate opportunities to gain understanding of the data being used, the analyses being performed, the TI Team's evaluations of data and models, and the technical justifications for the TI Team's model decisions. The table below summarizes the formal project activities in which the Panel participated. Fulfilling these roles also requires the Panel to provide regular feedback to the TI Team during the course of the project. In addition to verbal feedback during Working Meetings and Workshops, the Panel provided written comments and recommendations at key stages of the project. Those written submittals are also noted in the table.

Date	PPRP Activity
June 21, 2012	Working Meeting #1 (Planning). All PPRP members attended.
July 18, 2012	Working Meeting #2 (Planning). All PPRP members attended.
August 27, 2012	Kick-off Meeting. All PPRP members attended.
September 17, 2012	PPRP submittal of written comments on the Project Plan.
October 8, 2012	Working Meeting #3. PPRP representatives attended as observers.
November 3, 2012	PPRP submittal of written comments on revised Project Plan.
November 29, 2012	PPRP submittal of PPRP endorsement letter for Project Plan.
December 10, 2012	Working Meeting #4. PPRP representatives attended as observers.
February 11, 2013	Working Meeting #5. PPRP representatives attended as observers.
March 19-21, 2013	Workshop #1: Critical issues and Data Needs. All PPRP members attended as observers. The PPRP provided verbal feedback to the TI Team at the end of each day of the Workshop
April 12, 2013	Working Meeting #6. PPRP representatives attended as observers.
April 21, 2013	PPRP submittal of written comments on Workshop #1.
May 23, 2013	Working Meeting #7. PPRP representatives attended as observers.
June 24, 2013	Working Meeting #8. PPRP representatives attended as observers.
July 16, 2013	Working Meeting #9. PPRP representatives attended as observers.
August 21, 2013	Working Meeting #10. PPRP representatives attended as observers.
October 2, 2013	Working Meeting #11. PPRP representatives attended as observers.
October 15, 2013	Working Meeting #12. PPRP representatives attended as observers.
October 22-24, 2013	Workshop #2: Proponent Models and Alternative Interpretations. All PPRP members attended as observers. The PPRP provided verbal feedback to the TI Team at the end of each day of the Workshop.
November 26, 2013	Working Meeting #13. PPRP representatives attended as observers.
December 3, 2013	PPRP submittal of written comments on Workshop #2.
January 2, 2014	Working Meeting #14. PPRP representatives attended as observers.
January 28-29, 2014	Special Working Meeting. All PPRP members attended as observers.
March 3, 2014	Working Meeting #15. PPRP representatives attended as observers.
March 10-12, 2014	Workshop #3: Preliminary GMC Models and Hazard Feedback. All PPRP members attended as participants. The PPRP provided verbal feedback to the TI Team at the end of each day of the Workshop.
March 24, 2014	Working Meeting #16. PPRP representatives attended as observers.
April 21, 2014	PPRP submittal of written comments on Workshop #3.

May 14, 2014	PPRP Closure Pre-Briefing. All PPRP members attended as participants.
July 17-18, 2014	PPRP Closure Briefing. All PPRP members attended as participants.
December 13, 2014	Submittal No. 1 of PPRP written review comments on SWUS GMC Report: Comments on SWUS GMC Report Rev.0, Chapters 7, 10, 11, 12, 13, and Appendices L, M, N, and R.
December 16, 2014	Teleconference, PPRP and TI Team, to discuss the PPRP written review comments, Submittal No. 1.
January 5, 2015	Submittal No. 2 of PPRP written review comments on SWUS GMC Report: Comments on SWUS GMC Report Rev.0, Chapters 6, 8, 9, 14, and Appendices H, I, J, K, O, and Q.
January 7, 2015	Teleconference, PPRP and TI Team, to discuss the PPRP written review comments, Submittal No. 2.
January 26, 2015	Teleconference, PPRP and TI Team, to discuss the main modifications introduced in SWUS GMC Report Draft Rev.1.
February 9, 2015	Teleconference, PPRP and TI Team, to discuss observations from PPRP partial review of SWUS GMC Report Draft Rev.1.
February 16, 2015	Teleconference, PPRP and Project Manager to discuss project completion schedule.
February 20, 2015	Submittal No. 3 of PPRP written review comments on SWUS GMC Report: Comments on SWUS GMC Report Draft Rev.1.
February 24, 2015	Submittal of Closure Letter based on Draft Rev.1

The PPRP finds that the level of ongoing review it was able to undertake, and the opportunities afforded the PPRP to provide feedback to the TI Team, met the expectations for a SSHAC Level 3 study. Interactions with the TI Team provided ample opportunity for the Panel to gain an understanding of the technical bases for the TI Team's evaluations. The Panel also was given adequate opportunity to query the TI Team, especially in Workshop #3 and in the Pre-Closure Briefing and Closure Briefing, to assess the justification provided for their model decisions. The TI Team provided written responses to each formal PPRP submittal, and in nearly every case the PPRP and TI Team subsequently discussed the comments and replies in a conference call or Working Meeting.

SSHAC Process Review

NUREG-2117 describes the goal of a SSHAC process as being "to carry out properly and document completely the activities of evaluation and integration, defined as:

> Evaluation: The consideration of the complete set of data, models and methods proposed by the larger technical community that are relevant to the hazard analysis.
> Integration: Representing the center, body, and range of technically defensible interpretations in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods)."

During the *Evaluation* activities, the TI Team considered new data, models and methods that have been introduced within the technical community since the previous seismic hazard studies were conducted for nuclear power plants in California and Arizona. The

3

Team evaluated newly available ground motion databases, ground motion prediction equations (GMPEs), and ground motion simulation techniques. Notably, the TI Team evaluated methods for the representation of non-Gaussian aleatory variability, as well as newly available methods for the visualization and characterization of epistemic uncertainty in ground motion prediction.

The PPRP finds that the TI Team's evaluation and the documentation thereof are consistent with the expectations for a SSHAC Level 3 study, apart from the specific reservation noted at the end of this section.

The *Integration* phase entails thoroughly documenting the technical bases for all elements of the GMC model, to provide assurance that the center, body and range of technically defensible interpretations have been captured. The TI Team used a new statistical technique to generate a suite of representative models for median ground motion prediction that collectively represent the epistemic uncertainty in ground motion more broadly than do the published GMPEs alone. This technique is combined with a new method to select and weight the predictions of the expanded suite of models. The TI Team's method for assigning weights is based on consideration of appropriate data sets and numerical simulations, with adequate justification. The TI Team's model for aleatory variability and weighting of alternative aleatory models is also adequately justified.

The PPRP finds that the TI Team's GMC model integration and the documentation thereof are consistent with the expectations of a SSHAC Level 3 project, apart from the specific reservation noted in the next paragraph.

The Panel finds that the TI Team's evaluation of directivity models has limitations. The TI Team make use of a simplified directivity model to save computational time, and the final report adequately describes that model, how it is used, and some of its limitations. However, because the simplified model is unpublished, it is also necessary for the TI Team to document that the simplified model is appropriate for the purpose for which it is applied, in the sense that it gives results that are essentially consistent with the published and peer-reviewed model that it is intended to approximate. The final report (in the March 9 addendum) documents the performance of the simplified model through comparison with results from a hazard calculation that uses the full, published directivity model. At hazard levels of 10^{-4} and above, the full model calculation confirms the conclusion obtained using the simplified model. At hazard levels below 10^{-4}, however, the difference in calculated hazard between the full model and the simplified model increases with decreasing hazard level. This increasing trend has not been satisfactorily explained, has not been explored beyond the single fault case provided in the March 9 addendum, and has not been quantified in terms of impact on equal-hazard spectra at hazard levels of 10^{-5} and lower. Because the key rationale for the zero weighting of the directivity branch in the GMC model for periods longer than 0.5 s (the period range where the directivity effect applies) is the weak sensitivity of hazard to the directivity effect calculated using the simplified model, the PPRP finds that this weighting lacks sufficient technical justification.

SSHAC Technical Review

NUREG-2117 describes the PPRP's technical review role as follows:

> "The PPRP fulfills two parallel roles, the first being technical review. This means that the PPRP is charged with ensuring that the full range of data, models, and methods have been duly considered in the assessment and also that all technical decisions are adequately justified and documented.
>
> The responsibility of the PPRP is to provide clear and timely feedback to the TI/TFI and project manager to ensure that any technical or process deficiencies are identified at the earliest possible stage so that they can be corrected. More commonly, the PPRP provides its perspectives and advice regarding the manner in which ongoing activities can be improved or carried out more effectively. In terms of technical review, a key responsibility of the PPRP is to highlight any data, models or proponents that have not been considered. Beyond completeness, it is not within the remit of the PPRP to judge the weighting of the logic-trees in detail but rather to judge the justification provided for the models included or excluded, and for the weights applied to the logic-tree branches."

As summarized in the table above, the PPRP reviewed the TI Team's evaluations of data, models and methods on multiple occasions, and through various means, including written communications, in-person meetings, teleconferences, and review of the project report. The Panel was given adequate opportunity to question the TI Team concerning details of their analysis, and provided feedback verbally and in writing. The TI Team was responsive to the technical input from the Panel. The TI Team's responses included evaluating additional data sets suggested by the Panel, undertaking additional analyses to address specific Panel technical questions or concerns, and examining and assessing alternative technical approaches suggested by the Panel.

The PPRP therefore concludes that it has been afforded an adequate basis for technical assessment of the TI Team's evaluations and model integration. As noted above in the final paragraph of the SSHAC Process Review section, the evaluation of directivity effects has been inadequate and may constitute a technical limitation of the study. Apart from that reservation, the PPRP finds that the project meets technical expectations for a SSHAC Level 3 study.

Conclusion

On the basis of its review of the SWUS GMC project, the PPRP finds that the project meets, with respect to both process and technical standards, the expectations for a

SSHAC Level 3 study, with the reservation cited above. That reservation pertains specifically to application of the directivity component of the GMC model to the DCPP site.

Sincerely,

Steven M. Day
Chair, PPRP

Kenneth W. Campbell
Member, PPRP

Brian Chiou
Member, PPRP

Thomas K. Rockwell
Member, PPRP

TI TEAM – PM RESPONSE TO PPRP CLOSURE LETTER

The PPRP letter identifies a limitation of the study due to the use of the Watson-Lamprey directivity model for the sensitivity studies that supported the TI Team judgment that directivity had only a small effect on the low-frequency ground-motion hazard at DCPP. The Watson-Lamprey model provides a simplified method to include the directivity in the CY14 model in a more efficient manner by randomizing over the hypocenter locations and developing site-specific adjustments to the median and standard deviation of the ground motion for the common-form models. The limitation is related to the differences in the computed hazard if the directivity model from CY14 is applied directly into the hazard rather than using the Watson-Lamprey implementation of the CY14 directivity scaling.

This limitation does not apply to PVNGS as there are no faults within 40 km of the site in the PVNGS SSC. The directivity model of CY14 reduces the directivity effects to zero for distances greater than 40 km, so there would be no directivity effects if the CY14 model was applied directly to the hazard calculations for the PVNGS site.

For DCPP, the differences between the directivity effects computed using the CY14 model directly and using the Watson-Lamprey model are discussed in Section 6.5 of this report. Including directivity for randomized hypocenter locations leads to additional variability of the low-frequency ground motion. This variability is combined with the total standard deviation. The key issue is if the standard deviation, developed from residuals from GMPEs that generally do not include directivity as a predictive parameter, should be reduced to account for the expected improved fit to the data if directivity parameters are included in the model. That is, should the additional aleatory variability be added to the standard deviation from the GMPEs or should it be added to a reduced standard deviation model that accounts for an improved fit if directivity parameters are included in the GMPE model.

The Watson-Lamprey model assumes that the standard deviations from the published GMPEs include the effects of variability due to directivity, and therefore, applies a reduction to standard deviation before adding the directivity effect on the standard deviation. If this reduction is not applied, then there will be an increase in the total standard deviation which leads to an increase in the hazard at low hazard levels. Section 6.5 shows examples of the effect on the hazard for these two alternatives. Developing a directivity model that is consistent with the median and standard deviation of the GMPEs remains an area of research.

The directivity sensitivity studies in this report that used the Watson-Lamprey model were for a period of 2 seconds. At this period, the reduction to the standard deviation in the Watson-Lamprey model is zero. Therefore, the conclusions from the hazard sensitivity for directivity are not affected by the approach of using a reduction to the standard deviation before adding the directivity effects. This remains an issue for periods longer than 3 seconds, but the Watson-Lamprey model is not applied in the final GMC model.

At a period of 3 seconds, using either approach leads to a small effect on the hazard at the 1E-4 hazard level as shown in Section 6.5. The directivity effect is primarily a standard deviation effect. If the directivity effect is applied to the full standard deviation (without reduction), then there is a potential increase of 2% to 8% for the ground motion at the 1E-4 to 1E-6 hazard level for T = 3 seconds. This increase reflects the effect of the increased standard deviation. The range of total standard deviation models developed in Chapter 13 of this report for a period of T = 2 seconds leads to a broad range (15% to 25%) for 1E-4 to 1E-6, as shown in the hazard sensitivity results in Section 14. The same range of epistemic uncertainty will apply for T = 3 seconds. The TI Team agrees that implementation of directivity into ground-motion models needs further research and that there is uncertainty in the effect of directivity on the total standard deviation, but, given that the potential range of the directivity effects is well within the range captured by the epistemic uncertainty in the total sigma logic tree, the TI Team judges that total sigma logic tree adequately captures the potential range of the standard deviation including directivity effects. The limitation noted by the PPRP does not significantly affect the range of the standard deviation of the ground-motion model for application to DCPP.

Regulatory Commitments

PG&E is making the following regulatory commitment in this submittal:

Commitment	Due Date
PG&E will submit the resolution of the PPRP identified request as soon as it is completed.	To be determined

In this submittal, Pacific Gas and Electric Company (PG&E) is revising the regulatory commitment made in PG&E Letter DCL-13-044, "Response to NRC Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Seismic Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," dated April 29, 2013.

PG&E committed to follow the guidance provided in NEI letter, "Proposed Path Forward for NTTF Recommendation 2.1: Seismic Reevaluations," dated April 9, 2013, with two clarifications. The guidance provided in the NEI letter was to utilize the Electric Power Research Institute Report No. 1025287, "Seismic Evaluation Guidance: Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," dated November 2012 for the performance of the seismic reevaluations.

This commitment indicated that PG&E will perform the ground motion response spectrum comparison. PG&E's interim evaluation in preparation for the seismic probabilistic risk assessment (SPRA), as described in Enclosure 1, provides reasonable assurance that it is safe to operate DCPP while the updated/upgraded SPRA is being developed. As a result, performance of an expedited seismic evaluation process is not necessary.