PAIFIC GAS AND ELCTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

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1. **CALCULATION TITLE:** Comparison of the Response Spectra for the Shoreline and Hosgri faults with the ISFSI Long Period (ILP) Response Spectrum

2. **SIGNATORIES:**

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3. RECORD OF REVISIONS:

Rev. No.	Reason for Revision	Revision Date
0	Initial Calc	6/30/09

4. PURPOSE:

An alignment of earthquake epicenters approximately 1 km offshore of the Diablo Canyon nuclear power plant was found in November of 2008 by researchers at the USGS. This alignment is called the Shoreline fault zone by Geosciences. Per Notification 50233555 Task 1, the purpose of this calculation is to develop and document a comparison between the ISFSI Long Period Horizontal Response Spectrum (DCPP ISFSI FSAR Figure 2.6-45) and the response spectra of the Shoreline and Hosgri fault zones calculated using the new NGA attenuation relations. Geosciences interpretation of the Shoreline fault zone is described in the "Action Plan for the Study of the Shoreline Fault Zone," submitted to DCPP for the NRC (May 6, 2009). This calculation is classified as a "study", since the characterization of the Shoreline fault zone is still under development.

5. ASSUMPTIONS:

5.1. FAULT LENGTH:

Two alternative segment lengths are assumed for the Shoreline fault: 15 km and 24 km. The assumed segment lengths are based on the characterization of the Shoreline fault zone given in the Action Plan submitted to DCPP for the NRC (May 6, 2009).

The 15 km length assumption is based on PG&E's interpretation of the length of the main alignment of the earthquakes.

The 24 km length assumption is based on extending the 15 km alignment to the northwest as far as the intersection with the Hosgri fault.

5.2. SEISMOGENIC THICKNESS:

The thickness of the Hosgri fault zone is assumed to be 12 kilometers based on the most likely thickness of the Hosgri fault as characterizated in Figure 3-5: Logic Tree for the Hosgri fault zone (page 3-21) of the LTSP Final Report (1988).

The width of the Shoreline fault is assumed to be 12 kilometers based on the characterization in the Action Plan which states that there is a vertical strike-slip fault at depth of 3-11 km. The 3-11 km depth was extended to 0-12 km to be consistent with the most likely thickness of the Hosgri fault as characterizated in Figure 3-5: Logic Tree for the Hosgri fault zont (page 3-21) of the LTSP Final Report (1988).

5.3. FAULT DIP:

The Shoreline fault is assumed to have a dip of 90 degrees. This is based on the the interpretation in the Action Plan which characterizes the shoreline fault as a vertical strike-slip fault.

It is assumed that the Hosgri fault is also a vertical fault. This assumption is based on the CRADA workshop discussions at the USGS on April 1, 2009.

5.4 FOCAL MECHANISM:

It is assumed that the shoreline fault is a strike-slip feature. The basis for this assumption is the characterization in the Action Plan that describes the Shoreline fault as a vertical strike-slip fault

It is assumed that the Hosgri fault is also a strike-slip fault. This assumption is based on the CRADA workshop discussions at the USGS on April 1, 2009. This new interpretation updates the characterization in the LTSP which includes a range of source types.

5.5 HORIZONTAL COMPONENT ATTENUATION RELATIONS:

The NGA attenuation relations for horizontal response spectral values are assumed to be representative attenuation relations for shallow crustal earthquakes in active tectonic regions (eg. California). The NGA attenuation relations include: Campbell and Bozorgnia (2008), Chiou and Youngs (2008), Abrahamson and Silva (2008), Boore and Atkinson (2008) and Idriss (2008). The basis for this assumption is that these relations represent the state-of-the practice for the ground motion model for California.

5.6 MAGNITUDE-AREA SCALING RELATIONSHIPS:

The Wells and Coppersmith (1994) magnitude-area relationship for strike slip faults is used to calculate the mean characteristic earthquake values for the Shoreline fault zone. The basis for this assumption is that this relationship represents the state-of-the practice.

5.7 SHEAR WAVE VELOCITY:

It is assumed that the shear-wave velocity at the base of the powerblock can be used for the ISFSI. This assumption is based on the ISFSI SAR which shows that the ISFSI is located on the same geologic units as the powerblock (FIGURE 2.6-6).

6. INPUTS:

6.1. FAULT LENGTH:

FAULT SOURCE	MAX RUPTURE LENGTH (km)	SOURCE
Shoreline MIN	15	Assumption 5.1
Shoreline MAX	24	Assumption 5.1

6.2. SEISMOGENIC THICKNESS

FAULT SOURCE	SEISMOGENIC THICKNESS (km)	SOURCE
Hosgri	12	Assumption 5.2
Shoreline MIN	12	Assumption 5.2
Shoreline MAX	12	Assumption 5.2

6.3. FAULT DIP

FAULT SOURCE	FAULT DIP (degrees)	SOURCE
Hosgri	90	Assumption 5.3
Shoreline MIN	90	Assumption 5.3
Shoreline MAX	90	Assumption 5.3

6.4. DEPTH TO TOP OF RUPTURE (Z_{TOR}):

FAULT SOURCE	DEPTH TO TOP OF RUPTURE (km)	SOURCE
Hosgri	0	Full rupture of Hosgri (Rupture extends to the surface).
Shoreline MIN	0	Assumption 5.2 (Rupture extends to the surface).
Shoreline MAX	0	Assumption 5.2 (Rupture extends to the surface).

6.5. FOCAL MECHANISM (F_{type}):

FAULT SOURCE	FOCAL MECHANISM	SOURCE
Hosgri	Strike Slip	Assumption 5.4
Shoreline MIN	Strike Slip	Assumption 5.4
Shoreline MAX	Strike Slip	Assumption 5.4

6.6. FAULT DOWN-DIP WIDTH (W):

FAULT SOURCE	FAULT DOWN-DIP WIDTH (km)	SOURCE
Hosgri	12	For vertical faults that rupture to the surface, fault down-dip width (W) = Seismogenic Thickness.
Shoreline MIN	12	For vertical faults that rupture to the surface, fault down-dip width (W) = Seismogenic Thickness.
Shoreline MAX	12	For vertical faults that rupture to the surface, fault down-dip width (W) = Seismogenic Thickness.

6.7. MAGNITUDE FOR HOSGRI FAULT

FAULT SOURCE	MEAN CHAR. MAGNITUDE	SOURCE
Hosgri	7.2	Safety Evaluation Report related to the operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2, Docket Nos. 50-275 and 50-323, Nureg-0675, Supplement No. 34 (1991) (page 2-32)

6.8. DISTANCE TO DCPP

FAULT SOURCE	RUPTURE DIST. (km)	SOURCE
Hosgri	R_{rup} = 4.5 R_{JB} = 4.5 R_X = 4.5	Safety Evaluation Report related to the operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2, Docket Nos. 50-275 and 50-323, Nureg-0675, Supplement No. 34 (1991) (page 2-32) (For vertical faults, $R_{JB} = R_{rup}$) (For faults that rupture to the surface, $R_X = R_{rup}$)
Shoreline MIN	R_{rup} = 1 R_{JB} = 1 R_X = 1	Notification 50233555, Task 1 (2009) (For vertical faults, $R_{JB} = R_{rup}$) (For faults that rupture to the surface, $R_X = R_{rup}$)
Shoreline MAX	R_{rup} = 1 R_{JB} = 1 R_X = 1	Notification 50233555, Task 1 (2009) (For vertical faults, $R_{JB} = R_{rup}$) (For faults that rupture to the surface, $R_X = R_{rup}$)

Where: R_{rup} is the closest distance from the rupture plane to the site (DCPP)
R_{JB} is the Joyner-Boore distance. It is the closest distance to from the surface projection of the rupture plane to the site (DCPP). R_{JB} equals zero for sites located on the surface projection of the rupture plane.
R_X is the closest horizontal distance from the top of the rupture plane to the site (DCPP).

6.9. SITE CONDITIONS:

Site condition inputs are the embedment elevation of the power block foundation (52ft 7in) and shear wave velocities from the 1978 down-hole velocity measurements. The foundation configuration of the power block structure is shown in Figure 5-2 (page 5-4) and the elevation view of section A-A' (the power block structure) is shown in Figure 5-3 (page 5-5) (Final Report of the Diablo Canyon Long Term Seismic Program, 1988). The shear wave velocity profile is shown in Figure 5-5, page 5-8 of the Final Report of the Diablo Canyon Long Term Seismic Program (1988). The values from the profile are listed in Table 6-1 below.

Elevation (ft)	Median Vs (ft/s)
52.58	3291.7
50	3291.7
50	4000
-76.67	4000
-76.67	4833.3
-98.42	4833.3

Table 6-1: Median shear wave velocities at DCPP.

6.10. GRAVITY:

The value of gravity is 1g = 981 cm/s/s to an accuracy of 1/10 of 1 percent.

6.11. ISFSI SPECTRUM:

The ISFSI Long Period (ILP) horizontal free field ground motion response spectrum is from Figure 2.6-45 in the DCPP ISFSI FSAR. Values for the spectrum are given in Table 6-13 (Table 6-14) of calculation GEO.DCPP.01.11. These values are shown in Table 6-2.

T (sec)	SA(g) 5% FN
0.010	0.830
0.025	0.830
0.030	0.830
0.040	0.964
0.050	1.110
0.075	1.454
0.100	1.772
0.125	2.084
0.150	2.084
0.170	2.084
0.174	2.084
0.178	2.085
0.200	2.086
0.230	2.120
0.250	2.135
0.270	2.125
0.300	2.105
0.333	2.084
0.400	2.084
0.445	2.084
0.500	1.795
0.600	1.541
0.750	1.383
1.000	1.199
1.500	0.931
2.000	0.713
3.000	0.465
4.000	0.343
5.000	0.265
6.000	0.173
7.000	0.123
8.000	0.090
9.000	0.068
10.000	0.054

Table 6-2: ISFSI Long Period (ILP) horizontal free field ground motion response spectrum (Fault Normal component, 5% damping).

7. METHOD AND EQUATION SUMMARY:

7.1. METHOD:

7.1.1. Magnitude

The 1994 Wells and Coppersmith magnitude-area scaling relationship for strike-slip faults is used to calculate the mean characteristic magnitude for the Shoreline fault segments.

7.1.2. Vs30

Input Table 6-1 is converted to metric units (m) and (m/s). From these values the Vs30 is calculated. The Vs30 value is the average shear wave velocity over the top 30 m below the power block foundation at DCPP.

7.1.3. $Z_{1.0}$

$Z_{1.0}$ is the depth to V_S = 1.0 km/s below the power block foundation. This value is read from the shear wave velocity profile in Figure 5-5, page 5-8 (Final Report of the Diablo Canyon Long Term Seismic Program, 1988).

7.1.4. $Z_{2.5}$

The shear wave velocity profile in Figure 5-5, page 5-8 (Final Report of the Diablo Canyon Long Term Seismic Program, 1988) is too shallow to obtain the depth to V_S = 2.5 km/s. An equation for estimating this value, given by Campbell and Bozorgnia (2007) is used.

7.1.5. Spectral Values

The horizontal response spectral values are computed using the NGA attenuation relations developed under the PEER program. The relations include: Campbell and Bozorgnia (2008), Chiou and Youngs (2008), Abrahamson and Silva (2008), Boore and Atkinson (2008) and Idriss (2008). These models provide an improvement over the older attenuation relations because they use a greatly enhanced strong motion database, data with well-document source and site parameters, and they include physics-basis in the models. They are all applicable to shallow crustal earthquakes in active tectonic regions and apply over a magnitude range of M5 – M8.5 for strike-slip and M5 – M8.0 for dip-slip, a distance range of 0 – 200 km, and spectral periods up to 10 seconds (Abrahamson and Silva, 2008).

Spectral periods (0 to 10 seconds) are calculated for each of the 5 attenuation relations. The resulting response spectra are then averaged to yield the average median horizontal spectral accelerations and the average 84th percentile horizontal spectral accelerations for the following faults: Hosgri, Shoreline MIN, Shoreline MAX.

The average horizontal response spectra for the Hosgri, Shoreline MIN and Shoreline MAX segments are compared to the ISFSI Long Period (ILP) horizontal free field ground motion response spectrum (DCPP ISFSI FSAR Figure 2.6-45).

7.2. EQUATIONS:

7.2.1. Magnitude

The Wells and Coppersmith (1994) magnitude-area scaling relationship for strike-slip faults:

$$M = 1.02 \log(A) + 3.98 \quad (1)$$

where: A is the area of the rupture plane in kilometers

7.2.2. Vs30

Vs30 is calculated with the following equation:

$$V_S 30 = \frac{30}{\sum_{i=1}^{N} \left(H_i / V_i \right)} \quad (2)$$

where: H_i = thickness of the ith layer in meters
V_i = shear wave velocity of the ith layer in meters/second

7.2.3. $Z_{2.5}$

The depth to V_S = 2.5 km/s is obtained with the equation from Campbell and Bozorgnia (2007).

$$Z_{2.5} = 0.519 + 3.595\, Z_{1.0} \quad (3)$$

7.2.4. Spectral Values

Equations for computing the spectral values are located in the following appendices:

Appendix A: Campbell and Bozorgnia (2008)
Appendix B: Chiou and Youngs (2008)
Appendix C: Abrahamson and Silva (2008)
Appendix D: Boore and Atkinson (2008)
Appendix E: Idriss (2008)

The equation for the standard deviation of the Abrahamson and Silva (2008) model contains an error in the published form (Appendix C). The correct standard deviation is included below (Abrahamson, pers comm. 2009).

$$\frac{\partial \ln Amp(T, PGA_{1100}, V_{S30})}{\partial \ln PGA_{1100}} = \begin{cases} 0 & for\ V_{S30} \geq V_{LIN} \\ \dfrac{-b(T)PGA_{1100}}{PGA_{1100}+c} + \dfrac{b(T)PGA_{1100}}{PGA_{1100}+c\left(\dfrac{V_{S30}}{V_{LIN}}\right)^{n}} & for\ V_{S30} < V_{LIN} \end{cases}$$

8. SOFTWARE:

All calculations were made by hand using excel spreadsheets. No special software was used.

9. BODY OF CALCULATION:

9.1. Magnitude

Using Eq 1 with the maximum rupture length (input 6.1) and fault down-dip width (input 6.6), the mean characteristic magnitudes for the Shoreline MIN and Shoreline MAX segments are calculated:

For the Shoreline Min:
M = 1.02 * log(15*12) + 3.98 = 6.3

For the Shoreline Max:
M =1.02 * log(24*12) + 3.98 = 6.5

9.2. Vs30

Table 6-1 is converted to metric units by multiplying the values by a coefficient of 0.3048. The metric values are listed in Table 9-1.

Elevation (m)	Vs (m/s)
16.03	1003.31
15.24	1003.31
15.24	1219.2
-23.37	1219.2
-23.37	1473.19
-30.00	1473.19

Table 9-1: Median shear wave velocities at DCPP.

The power block is at 16.03 m (52.6 ft). The base of the column over which the average shear wave velocity is calculated is at:

16.03 m – 30 m = -13.97 m

The Vs30 is an average shear wave velocity over two shear wave velocity layers with the following thicknesses (values for Table 9-1):

Layer 1: $V_1 = 1003.31$, $H_1 = 0.790$m
Layer 2: $V_2 = 1219.20$, $H_2 = 29.21$m

Using Eq 2 with the layer 1 and layer 2 values above, the Vs30 value is 1212 m/s.

9.3. $Z_{1.0}$

The depth to $V_S = 1.0$ km ($Z_{1.0}$) at DCPP is 0 meters. At the elevation of the power block base (52ft 7in), the mean shear wave velocity is 3350 ft/s (~1.0 km/s) according to Figure 5-5, page 5-8 (Final Report of the Diablo Canyon Long Term Seismic Program, 1988).

9.4. $Z_{2.5}$

Using Eq 3 with a $Z_{1.0}$ value of 0m, $Z_{2.5}$ is 0.519.

9.5. Spectral Values

Using the inputs given in Section 6 and the attenuation relationships given in Section 7 (Appendices A-E), the response spectral values are calculated for the Hosgri, and Shoreline fault segments. The resulting acceleration spectra for the 5 NGA attenuation relations are listed in Tables 9-2 through 9-7. Values obtained by averaging the NGA response spectra are shown in bold type.

For the Hosgri median horizontal spectra, the following values are used for the variables in the attenuation relation:

M=7.2	(input 6.7)
Z_{TOR}=0	(inout 6.4)
$F_{type} = 0$	(input 6.5, $F_{type} = 0$ for strike-slip faults)
$\delta = 90$ degrees	(input 6.3)
W = 12 km	(input 6.6)
$R_{rup} = 4.5$ km	(input 6.8)
$R_{jb} = 4.5$ km	(input 6.8)
$R_X = 4.5$ km	(input 6.8)
$F_{HW} = 0$	(Not required for vertical SS faults)
$V_{S30} = 1212$ m/s	(calculation 9.2)
$Z_{1.0} = 0$ m	(calculation 9.3)
$Z_{2.5} = 0.519$ km	(calculation 9.4)
V_{S30} est. = 1	(flag for measured V_{S30} values)
$\varepsilon = 0$	(flag for calculation of median Sa (g))

For the Hosgri 84th percentile horizontal spectra, the following values are used for the variables in the attenuation relation:

M=7.2	(input 6.7)
Z_{TOR}=0	(inout 6.4)
F_{type} = 0	(input 6.5, F_{type} = 0 for strike-slip faults)
δ = 90 degrees	(input 6.3)
W = 12 km	(input 6.6)
R_{rup} = 4.5 km	(input 6.8)
R_{jb} = 4.5 km	(input 6.8)
R_X = 4.5 km	(input 6.8)
F_{HW} = 0	(Not required for vertical SS faults)
V_{S30} = 1212 m/s	(calculation 9.2)
$Z_{1.0}$ = 0 m	(calculation 9.3)
$Z_{2.5}$ = 0.519 km	(calculation 9.4)
V_{S30} est. = 1	(flag for measured V_{S30} values)
ε = 1	(flag for calculation of 84th percentile Sa (g))

For the Shoreline MIN median horizontal spectra, the following values are used for the variables in the attenuation relation:

M=6.3	(calculation 9.1)
Z_{TOR}=0	(input 6.4)
F_{type} = 0	(input 6.5, F_{type} = 0 for strike-slip faults)
δ = 90 degrees	(input 6.3)
W = 12 km	(input 6.6)
R_{rup} = 1 km	(input 6.8)
R_{jb} = 1 km	(input 6.8)
R_X = 1 km	(input 6.8)
F_{HW} = 0	(Not required for vertical SS faults)
V_{S30} = 1212 m/s	(calculation 9.2)
$Z_{1.0}$ = 0 m	(calculation 9.3)
$Z_{2.5}$ = 0.519 km	(calculation 9.4)
V_{S30} est. = 1	(flag for measured V_{S30} values)
ε = 0	(flag for calculation of median Sa (g))

For the Shoreline MIN 84th percentile horizontal spectra, the following values are used for the variables in the attenuation relation:

M=6.3	(calculation 9.1)
Z_{TOR}=0	(input 6.4)
F_{type} = 0	(input 6.5, F_{type} = 0 for strike-slip faults)
δ = 90 degrees	(input 6.3)
W = 12 km	(input 6.6)
R_{rup} = 1 km	(input 6.8)
R_{jb} = 1 km	(input 6.8)
R_X = 1 km	(input 6.8)
F_{HW} = 0	(Not required for vertical SS faults)
V_{S30} = 1212 m/s	(calculation 9.2)
$Z_{1.0}$ = 0 m	(calculation 9.3)
$Z_{2.5}$ = 0.519 km	(calculation 9.4)
V_{S30} est. = 1	(flag for measured V_{S30} values)
ε = 1	(flag for calculation of 84th percentile Sa (g))

For the Shoreline MAX median horizontal spectra, the following values are used for the variables in the attenuation relation:

M=6.5	(calculation 9.1)
Z_{TOR}=0	(input 6.4)
F_{type} = 0	(input 6.5, F_{type} = 0 for strike-slip faults)
δ = 90 degrees	(input 6.3)
W = 12 km	(input 6.6)
R_{rup} = 1 km	(input 6.8)
R_{jb} = 1 km	(input 6.8)
R_X = 1 km	(input 6.8)
F_{HW} = 0	(Not required for vertical SS faults)
V_{S30} = 1212 m/s	(calculation 9.2)
$Z_{1.0}$ = 0 m	(calculation 9.3)
$Z_{2.5}$ = 0.519 km	(calculation 9.4)
V_{S30} est. = 1	(flag for measured V_{S30} values)
ε = 0	(flag for calculation of median Sa (g))

For the Shoreline MAX 84th percentile horizontal spectra, the following values are used for the variables in the attenuation relation:

M=6.5	(calculation 9.1)
Z_{TOR}=0	(input 6.4)
F_{type} = 0	(input 6.5, F_{type} = 0 for strike-slip faults)
δ = 90 degrees	(input 6.3)
W = 12 km	(input 6.6)
R_{rup} = 1 km	(input 6.8)
R_{jb} = 1 km	(input 6.8)
R_X = 1 km	(input 6.8)
F_{HW} = 0	(Not required for vertical SS faults)
V_{S30} = 1212 m/s	(calculation 9.2)
$Z_{1.0}$ = 0 m	(calculation 9.3)
$Z_{2.5}$ = 0.519 km	(calculation 9.4)
V_{S30} est. = 1	(flag for measured V_{S30} values)
ε = 1	(flag for calculation of 84th percentile Sa (g))

T (sec)	SA(g) AVG	SA(g) A&S	SA(g) B&A	SA(g) C&B	SA(g) C&Y	SA(g) I
0.01	**0.34406**	0.31505	0.29284	0.34523	0.37833	0.38887
0.02	**0.35046**	0.32364	0.30006	0.35445	0.38528	0.38887
0.03	**0.37745**	0.35128	0.31770	0.39272	0.41674	0.40881
0.05	**0.45636**	0.41497	0.37258	0.51326	0.52698	0.45399
0.1	**0.66315**	0.60568	0.56701	0.73239	0.79236	0.61834
0.15	**0.74791**	0.70134	0.69310	0.77552	0.87435	0.69522
0.2	**0.75013**	0.68603	0.71627	0.77003	0.81093	0.76739
0.25	**0.69018**	0.64856	0.65117	0.67190	0.72537	0.75393
0.3	**0.62103**	0.58935	0.57822	0.59007	0.64737	0.70014
0.4	**0.52636**	0.49464	0.50098	0.50784	0.52269	0.60563
0.5	**0.43725**	0.41428	0.38353	0.43969	0.43087	0.51789
1	**0.23758**	0.26626	0.19411	0.21509	0.23221	0.28023
1.5	**0.15452**	0.18040	0.13631	0.13085	0.15356	0.17147
2	**0.10734**	0.12673	0.09792	0.09401	0.10707	0.11100
3	**0.06447**	0.07584	0.06211	0.05894	0.06372	0.06175
4	**0.04420**	0.05142	0.04334	0.04350	0.04369	0.03903
5	**0.03341**	0.03817	0.03402	0.03543	0.03220	0.02722
10	**0.01057**	0.01297	0.00991	0.01293	0.01001	0.00706

Table 9-2: Median horizontal spectral acceleration for the 5 NGA attenuation relations (Hosgri). Values obtained from averaging the NGA relations are shown in bold type.

T (sec)	SA(g) AVG	SA(g) A&S	SA(g) B&A	SA(g) C&B	SA(g) C&Y	SA(g) I
0.01	**0.59140**	0.54243	0.51576	0.58405	0.63791	0.67686
0.02	**0.60281**	0.55722	0.52847	0.60074	0.65075	0.67686
0.03	**0.65556**	0.61054	0.56517	0.67562	0.71490	0.71156
0.05	**0.80531**	0.73010	0.67147	0.90898	0.92580	0.79020
0.1	**1.19969**	1.08350	1.04146	1.33868	1.42059	1.11421
0.15	**1.35841**	1.26441	1.25535	1.41477	1.57910	1.27841
0.2	**1.36641**	1.24300	1.29991	1.38802	1.46954	1.43157
0.25	**1.26078**	1.17902	1.17705	1.20660	1.31901	1.42223
0.3	**1.14166**	1.07497	1.06205	1.05911	1.17932	1.33285
0.4	**0.97145**	0.90523	0.91559	0.90966	0.95714	1.16965
0.5	**0.81407**	0.76133	0.70940	0.79333	0.79488	1.01142
1	**0.45462**	0.49140	0.37072	0.40089	0.44349	0.56658
1.5	**0.29982**	0.33131	0.26880	0.24740	0.29783	0.35378
2	**0.21030**	0.23160	0.19719	0.17885	0.21153	0.23234
3	**0.12746**	0.13963	0.12444	0.11248	0.12886	0.13191
4	**0.08784**	0.09505	0.08710	0.08316	0.09052	0.08337
5	**0.06822**	0.07198	0.07159	0.07136	0.06803	0.05814
10	**0.02295**	0.02624	0.02207	0.02949	0.02185	0.01508

Table 9-3: 84th percentile horizontal spectral acceleration for the 5 NGA attenuation relations (Hosgri). Values obtained from averaging the NGA relations are shown in bold type.

T (sec)	SA(g) AVG	SA(g) A&S	SA(g) B&A	SA(g) C&B	SA(g) C&Y	SA(g) I
0.01	**0.39367**	0.33961	0.34926	0.40233	0.45011	0.42706
0.02	**0.40214**	0.34994	0.36136	0.41356	0.45879	0.42706
0.03	**0.43714**	0.38290	0.39641	0.46057	0.49684	0.44896
0.05	**0.54162**	0.47429	0.49512	0.60426	0.62978	0.50463
0.1	**0.77847**	0.72308	0.74825	0.78856	0.94750	0.68496
0.15	**0.84769**	0.80198	0.85710	0.81533	1.03942	0.72464
0.2	**0.81492**	0.73444	0.79416	0.81724	0.95759	0.77115
0.25	**0.72525**	0.65316	0.67573	0.72260	0.85139	0.72334
0.3	**0.63833**	0.56787	0.58361	0.63640	0.75547	0.64828
0.4	**0.52535**	0.45014	0.49005	0.55443	0.60268	0.52943
0.5	**0.42425**	0.36101	0.37049	0.46816	0.49020	0.43139
1	**0.20320**	0.20426	0.17457	0.19762	0.24398	0.19555
1.5	**0.12037**	0.12773	0.11187	0.10567	0.15094	0.10567
2	**0.07778**	0.08484	0.07324	0.06843	0.10016	0.06220
3	**0.04176**	0.04699	0.03851	0.03777	0.05525	0.03027
4	**0.02604**	0.03016	0.02153	0.02536	0.03570	0.01744
5	**0.01757**	0.01998	0.01236	0.01926	0.02492	0.01134
10	**0.00408**	0.00500	0.00223	0.00473	0.00598	0.00245

Table 9-4: Median horizontal spectral acceleration for the 5 NGA attenuation relations (Shoreline MIN). Values obtained from averaging the NGA relations are shown in bold type.

T (sec)	SA(g) AVG	SA(g) A&S	SA(g) B&A	SA(g) C&B	SA(g) C&Y	SA(g) I
0.01	**0.70312**	0.62036	0.61511	0.68066	0.80065	0.79883
0.02	**0.71858**	0.63924	0.63643	0.70092	0.81749	0.79883
0.03	**0.78983**	0.71276	0.70518	0.79235	0.89910	0.83978
0.05	**0.99558**	0.90452	0.89230	1.07015	1.16702	0.94392
0.1	**1.46715**	1.40694	1.37435	1.44134	1.78671	1.32640
0.15	**1.60177**	1.56797	1.55240	1.48739	1.96911	1.43199
0.2	**1.54134**	1.43075	1.44127	1.47312	1.81560	1.54598
0.25	**1.37391**	1.26846	1.22145	1.29766	1.61558	1.46639
0.3	**1.21475**	1.10087	1.07195	1.14227	1.43240	1.32627
0.4	**0.99980**	0.86852	0.89562	0.99311	1.14294	1.09882
0.5	**0.81251**	0.69484	0.68528	0.84470	0.93237	0.90537
1	**0.39754**	0.38706	0.33339	0.36832	0.47405	0.42488
1.5	**0.23805**	0.23929	0.22060	0.19979	0.29626	0.23429
2	**0.15494**	0.15743	0.14749	0.13019	0.19968	0.13991
3	**0.08370**	0.08719	0.07716	0.07208	0.11261	0.06947
4	**0.05244**	0.05591	0.04326	0.04848	0.07450	0.04004
5	**0.03626**	0.03747	0.02601	0.03878	0.05301	0.02602
10	**0.00892**	0.01011	0.00496	0.01080	0.01312	0.00562

Table 9-5: 84th percentile horizontal spectral acceleration for the 5 NGA attenuation relations (Shoreline MIN). Values obtained from averaging the NGA relations are shown in bold type.

T (sec)	SA(g) AVG	SA(g) A&S	SA(g) B&A	SA(g) C&B	SA(g) C&Y	SA(g) I
0.01	**0.41958**	0.36279	0.37996	0.42428	0.46493	0.46594
0.02	**0.42810**	0.37383	0.39085	0.43612	0.47377	0.46594
0.03	**0.46432**	0.40904	0.42400	0.48569	0.51305	0.48983
0.05	**0.57158**	0.50239	0.51971	0.63774	0.65052	0.54756
0.1	**0.82305**	0.75919	0.78402	0.84166	0.98036	0.75004
0.15	**0.90491**	0.84829	0.92027	0.87281	1.07837	0.80483
0.2	**0.88788**	0.78616	0.90478	0.88535	0.99677	0.86631
0.25	**0.79828**	0.70761	0.78203	0.79227	0.88925	0.82026
0.3	**0.70812**	0.62129	0.68097	0.70530	0.79171	0.74131
0.4	**0.59166**	0.49877	0.58441	0.62518	0.63570	0.61424
0.5	**0.48068**	0.40396	0.44250	0.52995	0.52028	0.50672
1	**0.23553**	0.23567	0.20940	0.22572	0.26645	0.24040
1.5	**0.14219**	0.15044	0.13639	0.12174	0.16830	0.13406
2	**0.09360**	0.10140	0.09105	0.08132	0.11339	0.08085
3	**0.05178**	0.05733	0.04873	0.04804	0.06403	0.04078
4	**0.03346**	0.03734	0.02931	0.03440	0.04213	0.02412
5	**0.02355**	0.02687	0.01756	0.02744	0.02989	0.01598
10	**0.00566**	0.00673	0.00351	0.00675	0.00771	0.00361

Table 9-6: Median horizontal spectral acceleration for the 5 NGA attenuation relations (Shoreline MAX). Values obtained from averaging the NGA relations are shown in bold type.

T (sec)	SA(g) AVG	SA(g) A&S	SA(g) B&A	SA(g) C&B	SA(g) C&Y	SA(g) I
0.01	**0.74215**	0.65159	0.66920	0.71778	0.81446	0.85772
0.02	**0.75761**	0.67141	0.68837	0.73915	0.83139	0.85772
0.03	**0.83049**	0.74659	0.75425	0.83556	0.91436	0.90170
0.05	**1.03947**	0.93615	0.93661	1.12944	1.18722	1.00796
0.1	**1.53437**	1.44181	1.44005	1.53840	1.82219	1.42938
0.15	**1.69192**	1.62013	1.66681	1.59224	2.01518	1.56522
0.2	**1.66252**	1.49990	1.64204	1.59589	1.86560	1.70918
0.25	**1.49764**	1.34839	1.41359	1.42277	1.66697	1.63648
0.3	**1.33537**	1.18356	1.25077	1.26595	1.48405	1.49252
0.4	**1.11679**	0.94789	1.06806	1.11984	1.19355	1.25460
0.5	**0.91391**	0.76730	0.81847	0.95619	0.98099	1.04661
1	**0.45861**	0.44321	0.39992	0.42070	0.51517	0.51404
1.5	**0.28022**	0.28023	0.26895	0.23017	0.32923	0.29253
2	**0.18597**	0.18734	0.18335	0.15471	0.22548	0.17898
3	**0.10356**	0.10614	0.09764	0.09168	0.13020	0.09213
4	**0.06721**	0.06916	0.05890	0.06577	0.08773	0.05448
5	**0.04845**	0.05047	0.03694	0.05526	0.06346	0.03609
10	**0.01238**	0.01361	0.00782	0.01539	0.01690	0.00815

Table 9-7: 84th percentile horizontal spectral acceleration for the 5 NGA attenuation relations (Shoreline MAX). Values obtained from averaging the NGA relations are shown in bold type.

10. RESULTS AND CONCLUSIONS

RESULTS

The panel below shows the response spectra that result from the NGA attenuation relations. The left column shows the median horizontal spectral accelerations for the Hosgri, Shoreline MIN, and Shoreline MAX segments respectively. The column on the right shows the corresponding 84th percentile horizontal spectral accelerations.

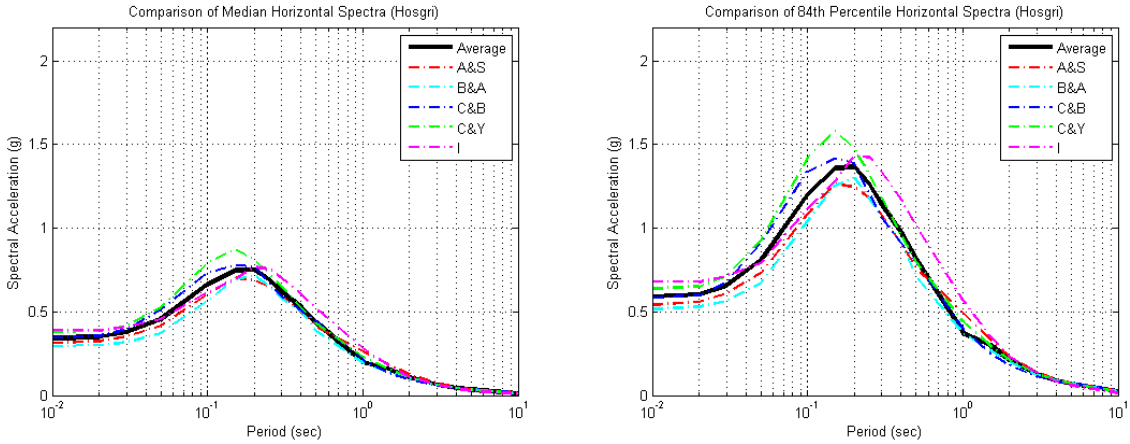

Figure 10-1a: Response spectra from the NGA attenuation relations for the Hosgri fault. The thick black spectrum is the average of the 5 individual NGA relations.

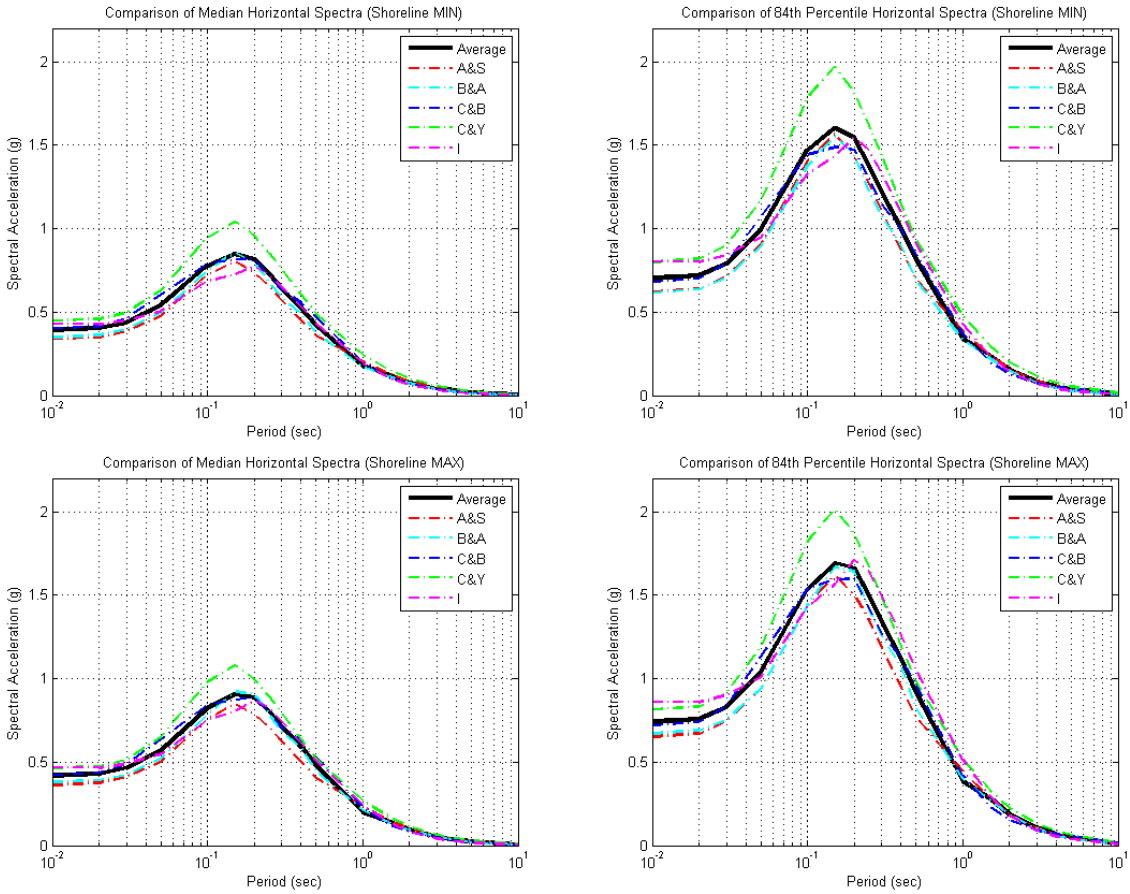

Figure 10-1b: Response spectra from the NGA attenuation relations for the Shoreline MIN and Shoreline MAX faults. The thick black spectrum is the average of the 5 individual NGA relations.

In the plots that follow, the average median and average 84th percentile response spectra are compared for the two fault zones considered, the Hosgri fault zone and the Shoreline fault zone (MIN and MAX segments). In each of the plots the average spectra are also plotted against the ISFSI Long Period (ILP) horizontal free field response spectrum (fault normal component).

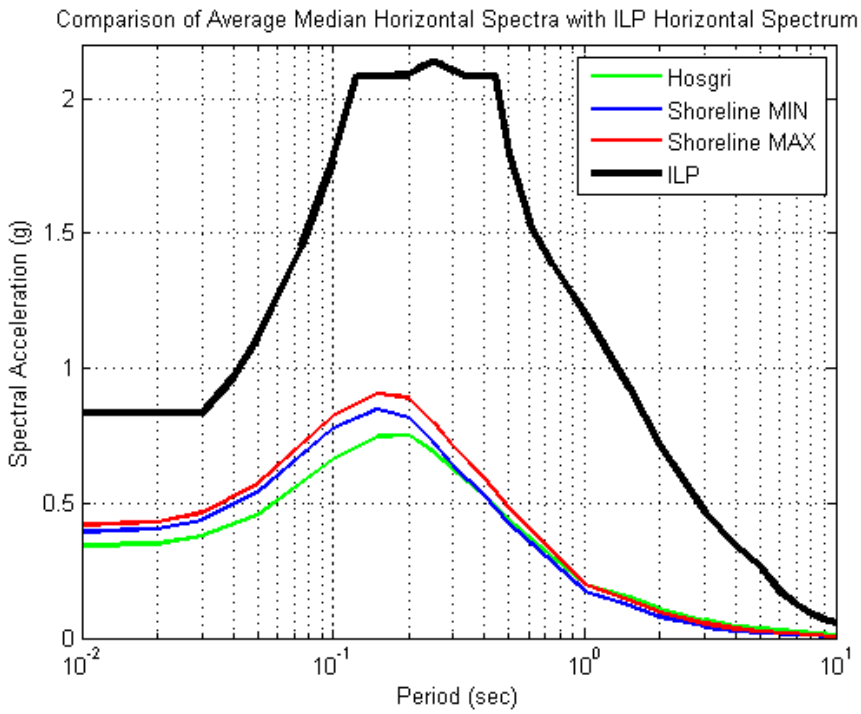

Figure 10-2: Average median horizontal response spectra from the 5 NGA attenuation relations with the horizontal ILP spectrum. The yellow box shows the period range the

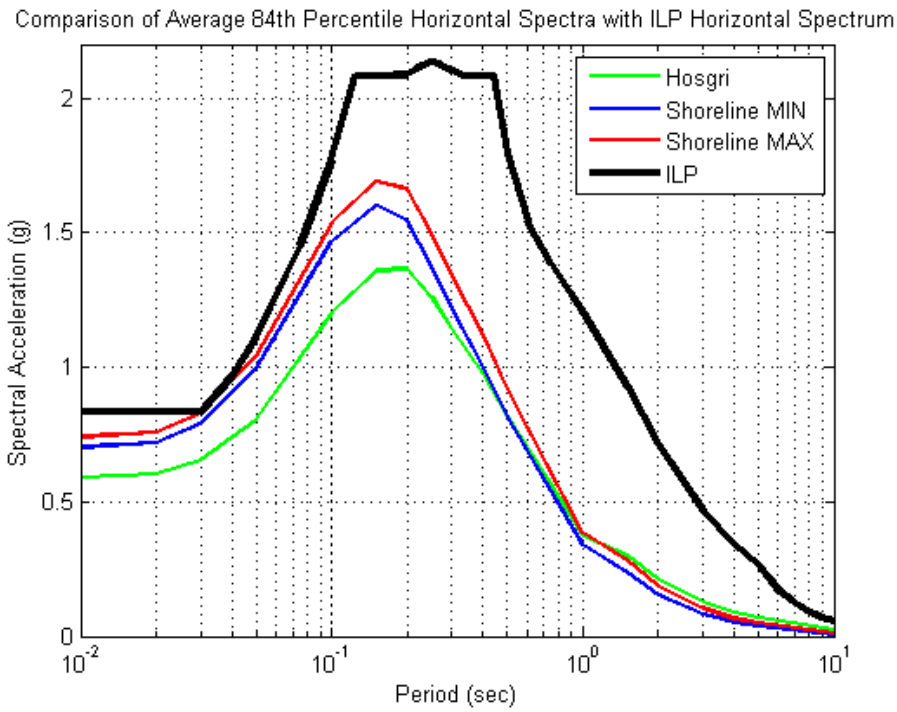

Figure 10-3: Average 84th percentile horizontal response spectra from the 5 NGA attenuation relations with the horizontal ILP spectrum.

CONCLUSIONS

A comparison of the new NGA attenuation relations for the median and 84th percentile ground motions shows that the Shoreline MIN segment results in higher deterministic ground motions at DCPP than the predicted deterministic ground motions from the Hosgri fault zone at periods less than 0.5 seconds. Ground motions for the Shoreline MAX segment result in higher ground motions at DCPP than the predicted ground motions from the Hosgri fault zone at periods less than 1 second. In each of these comparisons, the updated Hosgri spectrum based on new NGA models is used.

A comparison with the ISFSI Long Period (ILP) horizontal free field response spectrum shows that all of the sources evaluated with the new NGA attenuation relations are enveloped by the ILP spectrum. One exception occurs at T = 0.03 seconds, where the mean 84th percentile spectral accelerations for the Shoreline MAX segment very slightly exceed the ILP spectrum.

11. LIMITATIONS

The deterministic comparisons do not account for the activity rate of the fault. The larger deterministic ground motions computed for the Shoreline fault as compared to the updated Hosgri spectrum does not imply that the Shoreline is the dominate fault in terms of contribution to risk (e.g. core damage frequency) at DCPP.

12. IMPACT EVALUATION

These results are classified as a study. The impacts of this analysis are undetermined.

13. REFERENCES

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14. ATTACHMENTS

Attachment A: NGA Ground Motion Model for the Geometric Mean Horizontal Component of PGA, PGV, PGD and 5% damped Linear Elastic Response Spectra for Periods Ranging from 0.01 to 10 s

Attachment B: An NGA Model for the Average Horizontal Component of Peak Ground Motion and Response Spectra

Attachment C: Summary of the Abrahamson & Silva NGA Ground-Motion Relations

Attachment D: Ground-Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods between 0.01 and 10.0 s

Attachment E: An NGA Empirical Model for Estimating the Horizontal Spectral Values Generated By Shallow Crustal Earthquakes

Attachment F: Action Plan for the Study of the Shoreline Fault Zone