EXECUTIVE SUMMARY

In November 2008, Pacific Gas and Electric (PG&E) informed the US Nuclear Regulatory Commission (NRC) that preliminary results from the Diablo Canyon Power Plant (DCPP) Long Term Seismic Program (LTSP) Update showed that there was an alignment of microseismicity subparallel to the coastline indicating the possible presence of a previously unidentified fault located about 1 km offshore of DCPP. This previously unidentified fault was named the Shoreline fault zone.

As part of the notification to the NRC in 2008, PG&E conducted an initial sensitivity study to evaluate the potential impact of the Shoreline fault zone on the seismic safety of DCPP using a seismic margin approach (PG&E, 2008). Using conservative assumptions about the total length of the fault zone, a magnitude 6.5 strike-slip earthquake at a distance of 1 km was considered. The results of this sensitivity study demonstrated that the 84th percentile ground motion from the Shoreline fault zone was lower than the 1991 LTSP/SSER34 84th percentile ground motion for which the plant had been evaluated and shown to have adequate margin (NRC, 1991). Therefore, PG&E concluded that the plant had adequate seismic margin to withstand the ground motions from the Shoreline fault zone. In early 2009, the NRC conducted an independent study of the potential impacts of the Shoreline fault zone on DCPP and also concluded that there was adequate seismic margin (NRC, 2009).

Although the initial seismic sensitivity studies showed that the plant has adequate margin to withstand ground motion from the potential Shoreline fault zone, both the NRC and PG&E recognized the need to better constrain the four main parameters of the Shoreline fault zone needed for a seismic hazard assessment: geometry (fault length, fault dip, down-dip width), segmentation, distance offshore from DCPP, and slip-rate. To address this need, PG&E conducted an extensive program in 2009 and 2010 to acquire, analyze, and interpret new geological, geophysical, seismological, and bathymetric data as part of the ongoing PG&E LTSP Update. These investigations have led to an improved understanding of the Shoreline fault zone, and its relationship to other seismic sources including the Hosgri and Southwestern Boundary fault zones. These findings are summarized in Table 1.

DETERMINISTIC GROUND MOTIONS

In addition to the updated information on the faulting in the DCPP region, updated ground motion models and methods are also available. The Next Generation Attenuation (NGA) models are used for the ground motion models with site-specific modifications calibrated from observed ground motions at the DCPP site. Using updated ground motion models, the ground motions from strike-slip earthquakes along the Hosgri fault zone have decreased and the ground motions from the reverse-slip earthquakes on the Los Osos and San Luis Bay fault zones have remained about the same relative to ground motions computed using the 1988 LTSP ground motion models. As a result, the relative importance of the faults to the hazard at DCPP has changed from the 1988 LTSP report, and the 84th percentile ground motions from these faults computed using the updated ground motion models remains bounded by the 1988 LTSP spectrum.

The magnitude of deterministic earthquakes for the Shoreline fault (M6.5) is less than the magnitudes for the Hosgri (M7.1), but due to the shorter distance, the ground motions from the 84th percentile ground motions for Shoreline fault are greater than the updated ground motions from the Hosgri fault source. Nonetheless, the ground motions from the Shoreline fault source are still bounded by the 1991 LTSP/SSER34 spectrum.

Deterministic analyses for the Hosgri, Shoreline, San Luis Bay and Los Osos fault zones, using conservative estimates of the fault dips for each fault, indicate that the 84th percentile ground motions fall below the 1977 Hosgri Earthquake (HE) Design Spectrum and the 1991 LTSP/SSER34 spectrum (Figures ES-1).

PROBABILISTIC HAZARD ANALYSIS

Probabilistic hazard calculations show that the primary contribution to the 3-8.5 Hz hazard at DCPP is from the Hosgri fault zone with the Los Osos, Shoreline, and San Luis Bay faults providing smaller contributions (Figure ES-2). The inclusion of new Ground Motion Prediction Equations and the use of the updated source characterization in the DCPP hazard model has resulted in a reduced level of the hazard as compared to the 1988 LTSP hazard at most ground motion levels, but the slope of the updated hazard is reduced so that the updated hazard crosses the 1988 LTSP hazard curve at about 3 g. These changes in the hazard curve are primarily due to the changes in the ground motion models: the NGA models with site-specific effects result in lower median ground motions for sites close to large strike-slip earthquakes, but with an increased standard deviation. Because the updated hazard curve is not enveloped by the 1988 LTSP hazard curve, the seismic core damage frequency (CDF) was reevaluated: the seismic CDF decreases from 3.8E-5 for the1988 LTSP to 2.1 E-5 for the updated models. The reduction in the seismic CDF is mainly due to the use of the NGA ground motion models with the single-station sigma approach incorporating the site-specific amplification.

SECONDARY FAULT DEFORMATION

The potential for secondary fault deformation associated with rupture of the Shoreline fault zone was evaluated using a deterministic approach. The Central segment of the Shoreline fault zone is located 300 meters southwest of the Intake structure and 600 meters southwest of the Power Block. The deterministic assessment of the geology at the DCPP site and vicinity documented the absence of late Quaternary primary or secondary surface faulting or other forms of late Quaternary tectonic deformation (e.g., tilting, folding, and subsidence) within the DCPP site that may be associated with a maximum earthquake on the nearby Shoreline fault zone. Therefore, PG&E concludes that secondary fault deformation does not affect the safety of the DCPP.

CONCLUSIONS

New seismic and ground motion data, including site-specific site amplification based on earthquake recordings at the DCPP site, have resulted in a reduction of the uncertainty in the seismic hazard at the DCPP site. Deterministic analyses for the Hosgri, Shoreline, San Luis Bay and Los Osos fault zones, using conservative estimates of the fault dips for each fault, indicate that the 84th percentile ground motions fall below the 1977 Hosgri Earthquake (HE) Design Spectrum and the 1991 LTSP/SSER34 84th percentile deterministic spectrum. Probabilistic analyses shows that the inclusion of the Shoreline fault zone contributes about 20 percent to the seismic CDF seismic, but the seismic CDF is reduced from the 1988 LTSP estimates.

The original completion date of 2011 for the LTSP Update, as stated in the Action Plan and Revised Action Plan (Appendix A-1 and A-3), has been extended to allow completion of additional studies to further refine the models presented in this report. These studies include three-dimensional (3-D) marine and two-dimensional (2-D) onshore seismic reflection profiling, additional potential field mapping, GPS monitoring, and the feasibility of installing an ocean bottom seismograph network. These activities will further refine the characterization of those seismic sources and ground motions most important to the DCPP: the Hosgri, Shoreline, Los Osos, and San Luis Bay fault zones and other faults within the Southwestern Boundary zone.

TABLE 1 Summary of Shoreline Fault Zone Parameters

PARAMETER	DESCRIPTION
FAULT LENGTH	Total Length: up to 23 km Overall Strike: N60°W to N70°W
SEGMENTATION	Three segments: North segment, ~8 km long; Central segment, ~8 km long; South segment, ~7 km long
FAULT DIP	90° based on seismicity and magnetic potential field data
DOWN DIP WIDTH	10 to 15 km from the surface
FAULTING STYLE	Right-lateral strike slip based on linear surface expression of bathymetric lineaments and focal mechanisms.
RELATIONSHIP TO OTHER STRUCTURES	Hosgri fault zone (HFZ) Rupture is inhibited from branching from the HFZ to the Shoreline fault zone North Segment dies out before, or terminates at, the HFZ. San Luis Bay fault zone (SLBFZ) Relationship to late Quaternary deformation on the SLBFZ is uncertain
SLIP RATE	Preferred slip rate: 0.2 to 0.3 mm/yr
DISTANCE FROM DCPP	Central Segment: 600 m southwest of Power Block 300 m southwest of Intake Structure
SECONDARY FAULT DEFORMATION AT DCPP SITE	A deterministic evaluation documented the absence of late Quaternary primary or secondary surface faulting or other forms of late Quaternary tectonic deformation (e.g., tilting, folding, and subsidence) within the DCPP site that might have been associated with a maximum earthquake on the nearby Shoreline fault zone.

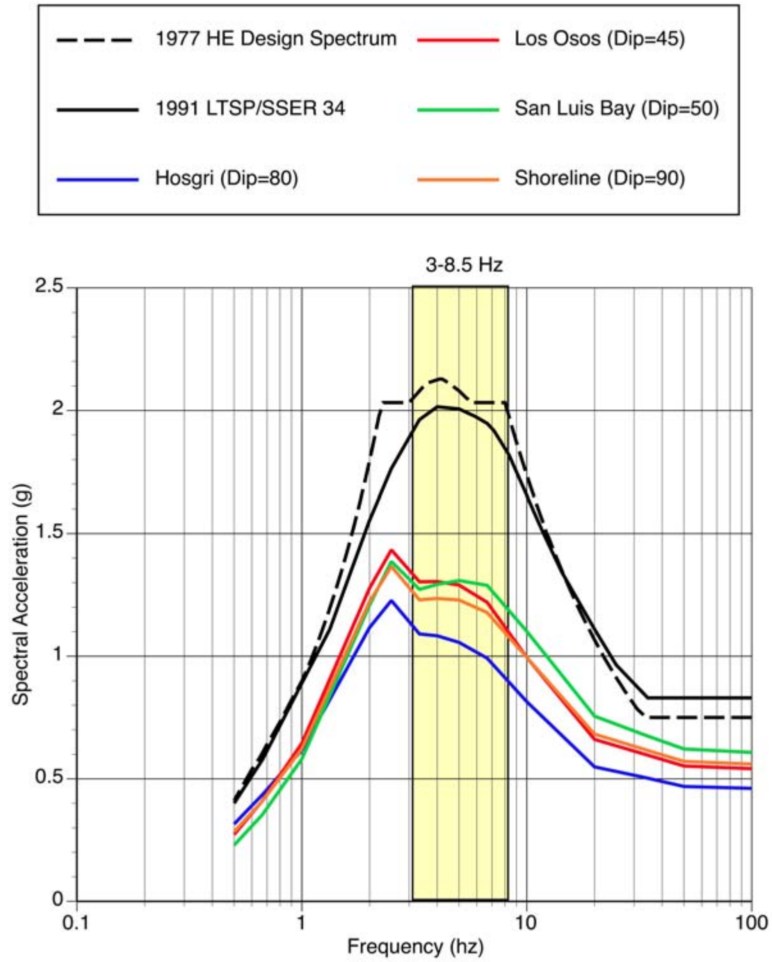

Figure ES-1. Comparison of deterministic spectra using conservative values for the dip angles on the Hosgri, Shoreline, Los Osos, and San Luis Bay faults.
The peak in the spectra at 2.5 Hz reflects the site-specific amplification of the rock at DCPP based on ground motions recorded at the DCPP site. The Shoreline fault, with M6.5 at 0.6 km, leads to a higher deterministic ground motion than new estimates for the Hosgri fault, but the ground motions are bounded by the 1991 LTSP/SSER34 spectrum and by the 1977 Hosgri Earthquake (HE) design spectrum. Ground motions from the San Luis and Los Osos faults also remain bounded by the LTSP/SSER34 spectrum, but they are now larger than the updated Hosgri ground motion. Although San Luis Bay fault is from a smaller magnitude (M6.3) at a larger distance (1.9 km) than the Shoreline fault, the spectrum for the San Luis Bay is slightly above the spectrum for the Shoreline fault due to hanging wall effects. The spectrum from the Los Osos fault (M6.8, distance=7.6 km, HW) is also similar to the spectrum from the Shoreline and San Luis Bay faults.

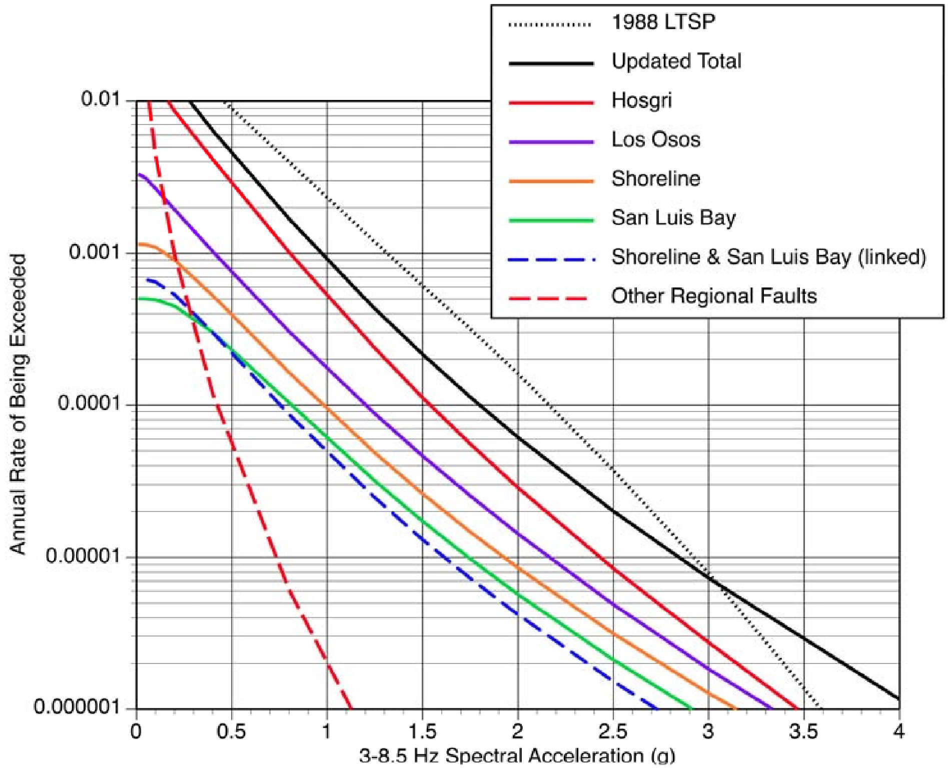

Figure ES-2. Probabilistic hazard curves for the Hosgri, Los Osos, San Luis Bay, and Shoreline fault zones.
Probabilistic seismic hazard is dominated by the Hosgri fault due to the higher rate of slip of the Hosgri compared to the other nearby faults. Hazard curves for the Los Osos, Shoreline, and San Luis Bay faults are less than the Hosgri and similar to each other.