Diablo Canyon Power Plant, Unit Nos. 1 and 2 - Shoreline Fault Study.

ACTION PLAN FOR THE STUDY OF THE SHORELINE FAULT

I. INTRODUCTION

Recent processing of seismic recordings from small earthquakes (1987-2007, magnitudes <1 to 3.5) using improved earthquake location computer programs shows an alignment of epicenters along the coast offshore, approximately one km from DCPP that is suggestive of a vertical strike-slip fault at depth (~3-11 km). The seismicity alignment has a length of 15 km. If it is extended to the intersection with the Hosgri fault, the length is 24 km. In addition to the seismicity data, raw (unprocessed) aero-magnetic and marine-magnetic data that were recently collected by the USGS show a magnetic anomaly with a trend that is consistent with the seismicity alignment. Although the geophysical survey results are preliminary, taken together, the available seismicity and geophysical data suggest that there is an active fault located offshore DCPP which we call the Shoreline fault.

Based on this preliminary data, PG&E estimated magnitudes of 6.25 and 6.5 for the Shoreline fault based on rupture lengths of 15 and 24 km, respectively, and an average rupture depth of 12 km. The potential ground motion at DCPP from these two events was evaluated and was found to be lower than the current design ground motions based on a larger earthquake on the more distant Hosgri fault.

The Action Plan below is designed to collect data and conduct analyses to better constrain the characteristics of the Shoreline fault and the potential ground motions at DCPP and ground deformation west of the power block. The Plan has three objectives. The first objective is to characterize the Shoreline fault in terms of its location, geometry, activity rate, rupture characteristics, and relation to the Hosgri fault zone. The second objective is to evaluate the ancient (Tertiary) shear zone west of the power block structure for evidence of secondary deformation that may have been associated with the Shoreline fault. The third objective is to estimate potential ground motions from the Shoreline fault, including both independent rupture of the Shoreline fault and possible synchronous rupture with the Hosgri fault.

This Action Plan describes the geology, seismology, geophysics, and ground motions studies to be performed over the next 2 years to achieve the above objectives. Results from these new studies will be integrated with results from the PG&E/USGS CRADA which is developing new regional tectonic models. An updated evaluation of the seismic hazard at DCPP will be conducted by PG&E Geosciences as part of the Long Term Seismic Program (LTSP) hazard update, which is scheduled to be completed in 2011. PG&E Geosciences and their consultants will perform the majority of the work; as part of the CRADA, the USGS will perform the balance of their marine magnetic survey and evaluate additional seismicity data in the region.

II. GEOLOGIC STUDIES (G)

Purpose: Locate, if possible, the surface expression of the Shoreline fault through geologic mapping and geophysical surveys (as described in Section IV). If located, then assess the last displacements for timing and amount of displacement. In addition, evaluate whether or not the shear zone has experienced secondary ground deformation

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related to the Shoreline fault. The shear zone is considered in this context as the shears in the shale unit of the Obispo Formation that crops out west of the power block.

Task G-1 Geologic mapping between Montana del Oro and Point San Luis

This Task will update existing knowledge of the geology along the coast between Montana del Oro and Point San Luis to provide the geologic framework for interpretation of the geologic setting of the Shoreline fault.

Subtask G-1A - Review and compile the 1988-1991 LTSP and other data concerning the geology of the coast, including diver geology videos and notes.

Subtask G-1B – Map geologic contacts and faults along the coast; inspect the coast in detail for exposures of the Olson and Rattle Snake faults where recent erosion may have exposed them. Use the offshore geophysics information (Task GP-2) as a guide to where the Shoreline fault may come onshore and be exposed in the sea cliffs. This Subtask includes detailed geologic mapping to improve existing geological maps at the DCPP site, including mapping the wave-cut platforms in Diablo Cove and elsewhere.

Subtask G-1C - Use divers and/or remotely operated vehicles (ROV) to extend mapping offshore at sites identified by the LiDAR and offshore geophysics (Task GP-2) and onshore mapping. This Subtask is focused on extending mapped geologic contacts and/or strata offshore to document fault offsets, if any.

Subtask G-1D - Profile selected streams that discharge from the Irish Hills to identify breaks in slope and channel offsets related to faulting. The LiDAR data and shallow bathymetry (Task GP-2) and other pertinent data from the offshore geophysics will be used in this analysis.

Task G-2 - Evaluation of secondary deformation in the shear-zone

This Task will improve the location of the shear zone as mapped for the ISFSI FSAR and will evaluate the amount of secondary ground deformation that may have been associated with earthquakes on the Shoreline fault.

Subtask G-2A - This Subtask will evaluate the potential for secondary deformation using the methodology of Peterson et al (2004) to calculate the probabilistic fault rupture hazard for strike-slip faults and will compare these results with geologic analogs.

Subtask G-2B - This Subtask will conduct detailed field investigations to improve the location of the shear zone and evaluate the amount of secondary deformation that may have been associated with the Shoreline fault. This Subtask has several elements:

a. Clean the cliffs at Diablo Cove to expose the 120,000-year-old wave-cut contact at top of rock over bedrock shears and faults in order to look for evidence of past secondary deformation.

b. Conduct local shallow seismic reflection surveys (and/or Ground Penetrating Radar) to improve the location of the shear zone and the depth of the wave-cut platforms in the area.

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c. Based on the shallow seismic reflection data (from element b), drill borings to better define the depths of the wave-cut platforms, find the depths of colluvium and marine deposits over the wave-cut platform to help locate trench sites, and delineate the extent of the shear zone south of the plant where it is covered by colluvium.

d. Excavate trenches to measure the orientation of the shears and to confirm the location of the shear zone and evidence for recent deformation (or lack thereof) observed in the cleaned cliff exposures.

III. SEISMICITY STUDIES (S)

Purpose: Analyze and document the earthquakes that make up the seismicity alignment. Studies will include quantifying uncertainties of the hypocentral locations and focal mechanisms, and studying the depth distribution and activity rate.

Task S-1: Expand the time period covered by the data set used by the USGS in their analysis of the regional seismicity and determine the locations and focal mechanisms. This Task will add earthquakes that occurred from 1980 to 1987 and from Mar 2007 to Dec 2008 to the original data set and will estimate their location and focal mechanisms using the TomoDD and HASH computer programs. This work will be performed by the USGS as part of the CRADA.

Task S-2: Provide independent reviews of USGS data analyses described in Task S-1.

Task S-3: Analyze and document the expanded data set for the Shoreline fault. After completion of Tasks S-1 and S-2, this Task will address the following parameters:

a. Hypocentral and focal mechanism uncertainties
b. Differences between 1D, 3D, hypoDD and tomoDD locations

c. Temporal and spatial development of the lineament
d. Magnitude recurrence model for the Shoreline fault based on historical seismicity
Task S-4: Evaluate the feasibility of offshore seismic stations

This Task will evaluate the feasibility of installing ocean bottom seismometers (OBS) offshore from DCPP, west of the Hosgri fault zone to improve the accuracy of past and future earthquake locations and focal mechanisms in the offshore DCPP region. Earthquakes that occur offshore, outside the PG&E and USGS seismographic on-land networks, have inherent location errors, particularly depth errors. OBSs would improve the azimuthal coverage, resulting in more accurate locations.

IV. GEOPHYSICAL STUDIES (GP)

Purpose: Conduct additional offshore geophysical studies to improve characterization of the Shoreline fault and its relation to the Hosgri fault. High priority tasks will build on the marine work done by the USGS in 2008. These tasks include GP-1 (high resolution marine magnetics), GP- 2 (nearshore geophysics), and GP-3 (scoping study for a 3-D

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seismic survey). Supplemental tasks (GP-4 through GP-6) will be considered as collaborative opportunities present themselves or the need arises.

Task GP-1: High Resolution Marine Magnetics.

Subtask GP-1A: High Resolution Marine Magnetics Data Collection: This Subtask will complete the USGS marine field work that was delayed due to equipment malfunction in 2008.

Subtask GP-1B: Marine Magnetics Data Integration and Interpretation: This Subtask will provide support for the interpretation of the high resolution marine magnetic data and integration of these data with the regional aeromagnetic survey data.

Task GP-2: Offshore Geology/Geophysics

This Task will provide uniform, high-resolution bathymetric and topographic coverage from Montana del Oro to south of Point San Luis to define the extent and character of the Shoreline fault to support Task G-1. Shallow water depths necessitate the use of various geophysical techniques to complete this Task.

Subtask GP-2A: Multi beam Bathymetry

This Task will conduct multibeam bathymetric mapping between the 30 and 5 meter contour using a shallow draft boat. This mapping will provide shallow water coverage from Point Buchon to San Luis Bay.

Subtask GP-2B: Airborne LiDAR bathymetry and coastal topography

This Task will map the coastline and surf zone using LiDAR to provide both shallow (< 5 m) bathymetry and coastal topography at a 2 meter horizontal resolution with 25 cm vertical accuracy.

Task GP-3: 3-D Seismic Survey Scoping Study

This Task will develop a scope and cost estimate for conducting a 3-D Seismic Survey within approximately 5 km of DCPP. The scope of the survey will include both onshore and offshore seismic reflection and refraction from the offshore Hosgri to the onshore Los Osos fault zone. Part of this scope will include preliminary 2-D seismic surveys to optimize the later full scale 3-D seismic survey. This Task will also include support for PG&E consultants to familiarize themselves with the LTSP and USGS CRADA datasets to develop data collection strategies that will complement and leverage previously collected information.

Supplemental Geophysical Tasks (as needed)
Task GP-4: Multi beam Bathymetry – from Hosgri shoreward to the 30 m depth contour

NOAA and the State of California are currently conducting multibeam bathymetric mapping of California state waters. This mapping may be extended to the Central California coast in 2009. If extended, PG&E would propose to supplement the NOAA/California multibeam mapping program through additional coverage beyond the 3 mile limit to map the Hosgri fault zone and shoreward to the 30 m depth contour.

Task GP-5: 2D High Resolution seismic survey (multi channel, Chirp)

This Task would conduct additional high resolution seismic reflection studies to augment already collected USGS marine data and to improve the resolution of marine structures in critical locations as needed.

Task GP-6: Vibrocoring for sediment age dating.

Based on marine mapping, Geosciences may identify candidate sites for age dating to constrain the rate of motion on both the Hosgri and Shoreline faults.

V. SOURCE CHARACTERIZATION OF THE SHORELINE FAULT

Purpose: Integrate of all the data from the G, S, and GP tasks and develop a set of alternative models for the characterization of the Shoreline fault in terms of its location, geometry, activity rate, rupture characteristics, and relation to the Hosgri fault zone

Task SC-1: Compile existing data on geology into a GIS data base

Create a GIS data-base for the coast and plant site that will include existing topographic maps, orthophotos, LiDAR, as well as LTSP and more recent geologic maps.

Task SC-2: Characterize the Shoreline fault

Using the GIS database, integrate the various data layers and interpret the results. Build alternative models of the location, geometry, activity rate, rupture characteristics of the Shoreline fault, and its relation to the Hosgri fault zone. Develop a logic tree structure and assign weights for the Shoreline fault characterization.

VI. GROUND MOTION STUDIES (GM)

Purpose: Evaluate the ground motions at DCPP for the case with synchronous rupture of the Hosgri and Shoreline faults using numerical simulation methods. Ground motions from independent ruptures of the Shoreline fault are adequately characterized by the existing models. These tasks will include defining the rupture characteristics for the case in which there is synchronous rupture on the Hosgri and Shoreline faults and computing the resulting ground motions at the DCPP site.

Task GM-1: This Task will use dynamic rupture models to evaluate the rupture characteristic for the generic problem of a vertical strike-slip fault with a splay fault.

Subtask GM-1A: Validate dynamic rupture models for a vertical strike-slip fault with a vertical splay fault.

The SCEC working group on dynamic rupture model code validation will add an additional validation case for a vertical strike-slip earthquake with a vertical splay fault. The working group will identify which dynamic rupture computer programs are applicable for this case.

Subtask GM-1B: Simulate a suite of ruptures on a vertical strike-slip fault with a vertical splay with a strike that is 30 degrees from the strike of the main fault.

Based on the results of Subtask GM-1A, two different computer programs will be selected and used to simulate the rupture characteristics (slip distribution, rise time, rupture velocity, and hypocenter location) for the main fault and the splay fault. This Task will also provide information on the relative rates of independent verses synchronous rupture of the main trace and the splay fault.

Subtask GM-1C: Develop kinematic source inputs.

The dynamic rupture sources from Subtask GM-1B will be converted to kinematic source models so that they can be used to simulate broadband ground motions (Task GM-2).

Task GM-2. Compute site-specific ground motions at the DCPP site using the generic kinematic sources developed in Subtask GM-1C.

The SCEC broadband simulation platform will be used to simulate the ground motions at the DCPP site from a suite of representative rupture scenarios that were developed in Subtask GM-1C.

Task GM-3. Parameterize the site-specific ground motions into a fault-specific attenuation relation for the synchronous rupture case.

The ground motion response spectra from the kinematic simulations (Task GM-2) will be parameterized into a set of attenuation equations and will be incorporated into the seismic hazard computer program.

VII. REPORT
The above results will be summarized in a report to be completed by 4th quarter 2010.
The report will address the issues investigated in this study:

• Characterization of the Shoreline fault in terms of its location, geometry, activity rate, rupture characteristics, and relation to the Hosgri fault zone.

• Evaluation of the ancient (Tertiary) shear zone west of the power block structure for evidence of secondary deformation that may have been associated with the Shoreline fault and estimate potential amount of ground deformation in the shear zone.

• Estimation of potential ground motions from the Shoreline fault, including both the independent rupture of the Shoreline fault and its synchronous rupture with the Hosgri fault.

• Summary of the feasibility studies of the Ocean-Bottom Seismometers and a 3-D seismic survey.

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