ENCLOSURE

DIABLO CANYON POWER PLANT LONG TERM SEISMIC PROGRAM

QUARTERLY PROGRESS REPORT NO. 11

PACIFIC GAS AND ELECTRIC COMPANY

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1.0 INTRODUCTION

This is the eleventh quarterly progress report for the Diablo Canyon Power Plant (DCPP) Long Term Seismic Program (LTSP). This report describes activities during the period February 1, 1988 through April 30th, 1988.

During this reporting period, Phase III activities continued in all major program elements: Geology/Seismology/Geophysics (G/S/G), Ground Motions, Soil/Structure Interaction (SSI), Fragilities, and Probabilistic Risk Assessment (PRA). The following important meetings and workshops were held during this period:

February 23-24, 1988	ACRS Subcommittee Meeting in San Francisco, CA
February 25, 1988	NRC Staff and Consultant Audit of PG&E Fragility Analysis
March 28-30, 1988	Plant Walkdown -- NRC Staff and Consultants

The following meeting is planned for May 1988:

May 11-12, 1988	NRC/PG&E Meeting on Interface Relationships among Ground Motion, SSI, and Fragilities in Rockville, MD.

2.0 GEOLOGY/SEISMOLOGY/GEOPHYSICS

2.1 GEOLOGY

During the report period, analysis of geomorphic, geophysical, and geologic data continued in order to refine the understanding of the San Luis-Pismo (SL-P) structural block and its bordering fault systems. A comparison of detailed sea cliff mapping between Point Buchon and Morro Bay with high resolution geophysical interpretations in the adjacent offshore region strongly suggests that the structural grain of the SL-P block is continuous across the coastal zone with offshore near-surface structural trends. Analysis and documentation of the San Miguelito and Edna faults, both of which lie within the SL-P block, and of the fluvial terraces along San Luis Obispo Creek, which crosses the block, were substantially completed. The undeformed nature of the fluvial terraces and lack of late Quaternary activity on these two faults provides strong evidence that the SL-P block is currently not undergoing internal deformation.

2.2 GEOPHYSICAL INVESTIGATION

Analyses of the offshore geophysical data sets continued with emphasis on the Hosgri fault zone and associated structures in the reach between Point Sal and Lopez Point. Principal structural features characterized by the analyses were: the Piedras Blancas antiform; the Hosgri fault; the offshore San Simeon fault; the structures in the step-over region

between the San Simeon and Hosgri faults; and the offshore extensions of the northwest trending structures forming the northeastern and southwestern boundaries of the San Luis-Pismo structural block. Interpretive products of these analyses included annotated copies of selected CDP seismic records, maps of near-surface structural trends, post-Late Wisconsinian sediment thickness, and sea floor geomorphic features. In addition, contour maps were constructed to illustrate the spatial characteristics of reflectors that have been interpreted by various workers as the high-angle, thrust, and listric components of the Hosgri fault zone.

Retrodeformational modeling techniques were utilized in a detailed analysis of the tectonic evolution of the Queenie structure, a topographically prominent anticlinal ridge located 50 kilometers southwest of Diablo Canyon. This structure has many characteristics of a fault-propogation fold produced by NE-SW compression. The analysis indicated that crustal shortening of 2-3% is adequate to produce the structure and that the majority of the deformation occurred between 3 and 5 million years ago.

In March 1988, PG&E received a letter from the NRC regarding a letter from Grant Lichtman of JEBCO Seismic, Inc. to the NRC. Mr. Lichtman described two recent geophysical data sets in the offshore Santa Maria basin in his letter to the NRC, and urged that interested parties review and purchase the data. The status of PG&E's review of these data is as follows:

Nekton/Merlin 1984 Survey: These data were collected along a close spaced grid primarily within the three-mile limit of state waters from the middle of San Luis Obispo Bay south to Point Arguello. PG&E consultants thoroughly reviewed these data in April 1987. Although the data were of high quality, none were purchased at the time because of the availability of other high quality data sets in the same area that PG&E wished to evaluate as well. Subsequently PG&E obtained data from two CDP seismic surveys in the same area that were conducted for the California State Lands Commision. These surveys cover the same general area with grid spacing comparable to the Nekton/Merlin survey. During this quarter PG&E has almost completed the analysis of the California State Lands Commission data. Upon completion of the analysis, PG&E will review Nekton/Merlin data or other proprietary surveys, as needed, to assess its usefulness.

JEBCO 1988 Survey: JEBCO conducted a proprietary geophysical survey outside of the three-mile limit during February 1988. This survey covered the eastern margin of the Santa Maria Basin from near Point San Luis north to offshore of Ragged Point. PG&E contacted Mr. Lichtman of JEBCO in mid-February and again in mid-April to arrange to review the data when it becomes available. The data processing is expected to be completed in late May, and a meeting is scheduled for June 7, 1988, in PG&E's offices.

Several new data sets were acquired during the quarter and are now being analyzed and integrated into the existing interpretive products. Both high-resolution and CDP reflection data sets were obtained from the California State Lands Commission covering the state waters area between Point Arguello and the Santa Maria River. These studies will concentrate on the southern reach of the Hosgri, including its interaction with the Casmalia and Lions Head faults and its possible termination in the vicinity of Point Arguello.

Detailed bathymetric data were obtained from the NOAA in the nearshore area between Point Buchon and San Luis Bay, and are being analyzed.

2.3 CENTRAL COAST SEISMIC NETWORK

Seismic activity within the region covered by the Central Coast Seismic Network continued at a low but steady level, with an average of 12 small earthquakes per month during the three-month period. On-going operation of the Network is providing an accumulation of high-quality data that are of increasing value in interpreting the current tectonics of the south-coastal California region.

The largest event recorded was a magnitude 2.5 event 10 km southeast of San Simeon Point along the coast. The San Simeon region to the north and the northwest of this event continues to be the most active locality within the area of coverage of the network, and lies at a distance of 50 to 80 km from Diablo Canyon.

The closest earthquake activity to the plant site consisted of three offshore events in March and April. The largest of the three, magnitude 2.2, occurred offshore of Point Buchon about 13 km northwest of Diablo Canyon. The two smaller events of magnitude 1.2 and 1.3 occurred 10 and 3 km, respectively, northwest of the plant site. These events occurred slightly to the east of the Hosgri fault zone at depths ranging from 7 to 12 km with focal mechanisms consistent with the complex geological structure at the western end of the San Luis-Pismo block involving both strike-slip and dip-slip faulting.

During this quarter six earthquakes ranging in magnitude from 1.4 to 2.1 occurred in the offshore area south of Point Sal and north of Point Arguello. These events lie west of the Hosgri fault zone in an area of distributed folding and faulting with geological, geophysical, and seismological evidence of recent deformation.

3.0 GROUND MOTIONS

3.1 EMPIRICAL GROUND MOTION STUDIES

Strong motion data from four recent California earthquakes (M5.3 to 6.6) were compiled. The earthquake characteristics, recording station conditions, and source-to-site distances of the available recordings were evaluated for consideration in updating and enhancing the existing strong motion data base. Additionally, work was in progress to evaluate the significance of these data in terms of predicted ground motions.

During this reporting period, ground motion input for the Phase IIIB probabilistic seismic hazards analysis was developed. This ground motion input is expressed in terms of attenuation relationships for spectral acceleration (S_A) at 5% damping for six frequencies, 2, 4, 8, 14, 25, and 33 Hz, and two frequency bands of 3-8.5 Hz, and 5-14 Hz.

Examination and reviews were made of the ground motion products provided to date as input to various engineering analyses in the LTSP. The results showed a high degree of consistency among various ground motion products.

3.2 NUMERICAL MODELING PROGRAM

The following tasks were performed during the reporting period:

3.2.1 Local Site Effects

The Fourier spectra of P and S waves from two local earthquakes recorded at stations PSE, TPB, and TPR clearly showed anomalous site response at station PSE at frequencies between 3 and 8 Hz. There is a pronounced spectral peak centered at about 6 Hz for PSE, but not for TPB and TPR. It is concluded that the response of Station PSE is not characteristic of the response of the San Luis-Pismo Syncline region.

The effect of topography on ground motions was investigated for several important records using finite difference calculations. These include the Superstition Mountain record of the November 24, 1987, Superstition Hills earthquake, and the station 1 and 2 records of the December 23, 1985, Nahanni earthquake. For the Superstition Mountain record, the ratio of mountain-top to mountain-base amplitude at high frequencies is found to be approximately 1.1, in good agreement with the amplification value observed by Malay and others (1988) during aftershocks. For the station 1 and 2 recordings of the December 23, 1985, Nahanni earthquake, the ratio of mountain-top to mountain-base amplitude at high frequencies is on the order of 1.5 to 2.0. This result is consistent with that of the small number of calculations that have been performed for shape ratios of about 0.75.

3.2.2 Saturation

The ground motion attenuation patterns of recent well-recorded earthquakes were analyzed to evaluate the saturation of peak acceleration with distance close to the fault.

Shallow strike-slip faults such as the October 15, 1979, Imperial Valley and the November 23, 1987, Elmore Ranch earthquakes show a pronounced flattening of the attenuation curves. On the other hand, the deeper events such as the July 8, 1986, Palm Springs and the October 1, 1987, Whittier Narrows earthquakes show less flattening. Our simulations for the Imperial Valley and Whittier Narrows earthquakes give attenuation relationships closely matching the empirical data in each case. The difference in the distance dependence is due primarily to the source

depth. Additional controlling effects are due to focal mechanism and the crustal structure.

3.2.3 Blind Tests

During this reporting period, simulations have been done for the November 23, 1987, Elmore Ranch and the November 24, 1987, Superstition Hills earthquakes. The accelerograms of the November 23, 1987, event can be satisfactorily modeled as a simple bilateral strike-slip rupture on a 12x12 km fault plane striking northeast. However, the accelerograms of the November 24, 1987, event can not be satisfactorily modeled as a single rupture over the 25 km fault segment where surface ruptures were mapped. The simulation for such a model has too short a duration. The event appears to have consisted of at least two ruptures initiating at about the same location in the northwest segment, but with a time separation of approximately seven seconds. The southeastern two-thirds of the Superstition Hills fault appears to have radiated relatively little high frequency energy.

3.2.4 Shallow Green's Functions

A procedure was implemented to more accurately compute the Green's functions for shallow fault elements. The procedure includes the receiver function in the Green's function, rather than in the aftershock recordings used as empirical source functions. This new procedure gives more accurate receiver functions at grazing angles of incidence pertaining to shallow sources.

3.2.5 Slip Distribution

A literature review of slip distribution with depth in large earthquakes was completed. The results are summarized in the form of depth profiles of average seismic moment release. In nearly all cases, the seismic moment release is relatively low in the shallowest few kilometers of the crust, and reaches a maximum in the depth range of 8 to 12 km. This suggests much greater contributions to the total ground motion amplitudes from deeper fault elements.

3.3 SPATIAL INCOHERENCE

The sensitivity of spatial incoherence to several source parameters was evaluated. The results show the following:

- Dynamic source parameters such as rupture velocity and slip velocity have relatively little effect on spatial incoherence, even though they have a strong influence on peak amplitude.

- Spatial incoherence increases as the distance to the fault decreases. This is expected from the source finiteness effect.

- Bilateral rupture produces greater incoherence than unilateral rupture, because of increased interference between arrivals from two rupture fronts moving away from each other in the case of bilateral rupture.

- Spatial incoherence increases as the fault element size decreases. This occurs because the use of smaller fault element size requires the summation of a large number of contributions, resulting in more interference.

- Measurements of spatial incoherence are not strongly dependent on the length of the time window used in the measurement.

Additional evidence supporting the spatial incoherence model developed for the LTSP has become available recently. Abrahamson (1988) analyzed the SMART1 array data for two earthquakes at very similar distances and azimuths, but having very different magnitudes. The results show greater incoherence for the larger event at all station separations analyzed, just as would be predicted from the LTSP model with added incoherence due to greater source finiteness effect.

3.4 SEISMIC HAZARDS ANALYSIS

The first meeting to update the logic trees for the Phase IIIB seismic hazards analysis was held during this reporting period. Subsequent meetings are scheduled for May 1988, and it is anticipated that the Phase IIIB seismic hazards analysis will be completed during June 1988.

3.5 STRONG MOTION INSTRUMENTATION

No earthquake triggered the strong motion instruments at the Diablo Canyon Power Plant site during February 1 to April 30, 1988.

4.0 SOIL/STRUCTURE INTERACTION

Efforts were continued to support the fragility group in providing plant responses to median site-specific ground spectra. In addition, quality assurance review and checks of the completed calculations continued.

5.0 FRAGILITIES

5.1 NRC STAFF AUDIT

An audit was conducted by the NRC Staff and its consultants on February 25, 1988. The audit included detailed review of a sample of fragility estimate calculations of certain plant structures and components. The procedures and methodology for the turbine building nonlinear analysis, as well as the auxiliary building variability study, were also discussed.

5.2 NRC PLANT WALKDOWN

The NRC Staff and its PRA and fragility consultants visited the plant on March 28 through 30, and examined the plant systems, components, and

structures that are identified as contributing to the overall risk to plant safety.

5.3 PHASE IIIB ACTIVITIES

Efforts continued in developing fragility estimates of plant structures, systems, and components by incorporating plant responses to site-specific median ground motion and the variabilities associated with the median responses. The component fragilities were reviewed for consistency with the walkdown findings. The consequences of each structure and component failure mode were discussed with system engineers to insure consistency of interpretation.

6. PROBABILISTIC RISK ASSESSMENT

Members of the NRC staff and consultants toured Diablo Canyon during the week of March 28th. All areas important to the PRA model were visited, including the containment, auxiliary, and turbine buildings. Panels were removed or opened to allow the tour groups to verify anchor points in electrical cabinets.

Work continues to verify the fragility of offsite power. Previous California earthquake experience was reviewed to determine the effect of accelerations on various types of substation equipment. The time to recovery was also investigated to determine success criteria for the station batteries.