BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of Pacific Gas and Electric Company, For Authorization To Establish A Rate Adjustment Procedure For Its Diablo Canyon Nuclear Power Plant; To Increase Its Electric Rates To Reflect The Cost Of Owning, Operating, Maintaining and Eventually Decommissioning Unit 1 Of The Plant; And To Reduce Electric Rates Under Its Energy Cost Adjustment Clause And Annual Energy Rate To Reflect Decreased Fuel Expense. (Electric)	Application 84-06-014 (Filed June 6, 1984, amended December 21, 1984)
And Related Matter.	Application 85-08-025 (Filed August 12, 1985)

PREHEARING BRIEF OF THE PUBLIC UTILITIES COMMISSION DIVISION OF RATEPAYER ADVOCATES

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E. As A Result Of Hosgri And PG&E's Design Errors, The Diablo Canyon Plant Had To Be Constructed and Reconstructed Three Times

Because of PG&E's failure to discover the Hosgri fault and later design errors, the Diablo Canyon plant had to be constructed and reconstructed three times.

The plant was essentially complete in 1976 at a total cost of about $1 billion when the NRC required PG&E to redesign and reconstruct it to withstand severe shaking that could occur as a result of a large earthquake on the Hosgri fault. By 1981 the plant had been redesigned and reconstructed a second time, to correct the deficiencies in the original seismic design, increasing the total cost of the plant to $2.4 billion.

During the course of the redesign to strengthen the plant to withstand an earthquake on the Hosgri fault numerous design errors were made which were not detected until 1981. From 1981 to 1985 the plant had to be redesigned and reconstructed a third time to correct the errors made in the earlier second redesign. This was a massive effort that required more engineers and construction workers than had been employed in either of the earlier construction efforts and more than doubled the cost of the plant, increasing it from $2.4 billion to $5.518 billion.

The cost impact of the need to redesign and construct the plant three times is illustrated by Figure 3.

F. The DRA's Recommended Ratemaking Disallowance Will Bring The Cost Of Diablo Canyon In Line With The Cost Of Other Nuclear Plants Begun During The Same Time Period

After carefully considering the results of its consultants findings, the DRA concluded that approximately $4.4 billion of

have been conducted ore more conservatism could have been built into the initial design at very little cost, thus providing insurance against unpleasant, extremely costly surprises.

Moreover, it was PG&E's management's responsibility to provide assurance that the plant's design met all public health and safety requirements, and that responsibility could not be abdicated in favor of a functional expert like its design consultant, Blume. Quality assurance also provides a form of insurance against the risk that a significant error might be made, and it is project management's role to instill an appropriate commitment to that objective. It was PG&E's dereliction of this responsibility that led to the massive independent design verification program.

These errors and omissions happened because PG&E management neglected to provide a reasonable level of insurance against their occurrence. The ratepayer should not be saddled with the resulting unreasonable costs.

III. DEFICIENCIES IN PG&E'S GEOSEISMIC SITING STUDIES WERE THE DIRECT CAUSE OF PROJECT DELAYS FROM 1976 TO 1981

A. The Importance Of Geoseismic Siting Studies

Geoseismic siting studies are among the most important and fundamental types of studies necessary to assure the safe design and construction of a nuclear power plant, and yet they are often among the most inconclusive of studies. More often than not, the available geologic and seismologic evidence involves significant uncertainty and allows for different interpretations over which experts can be expected to differ. As a result of the uncertainties associated with these sciences, and the public health and safety risks inherent in nuclear power development, nuclear plants sited in areas such as coastal California, where earthquakes can be expected to occur, must be designed with more than enough strength to withstand the maximum earthquake shaking

to which they could be subjected. Thorough geologic and seismologic studies are absolutely essential to determine an appropriately conservative seismic design sufficient to provide the assurance that public health and safety requires. The fundamental deficiency in PG&E's geoseismic siting studies was the company's failure to take a sufficiently conservative approach to provide this assurance.

B. NRC Geoseismic Siting Requirements Were Minimum Standards

Utilities have always been responsible under NRC regulations to assure that public health and safety is protected in siting and designing proposed nuclear power plants. Under NRC regulations this responsibility is clearly the utility's and not the responsibility of the NRC, the USGS, or the intervenors in nuclear plant siting cases. Since at least 1959 NRC siting criteria have explicitly required utilities to evaluate geoseismic hazards. These requirements became increasingly more specific throughout the 1960s and early 1970s as the NRC reviewed the seismic safety of proposed sites, particularly sites located on the California coast such as Bodega Bay, Malibu, Bolsa Island, and Mendocino. All of these sites were abandoned primarily because of onsite or nearby earthquake faults.

As a result of these siting cases the NRC became increasingly concerned about the adequacy of nuclear plant siting standards and nuclear seismic design and recognized the need to establish more specific geoseismic siting standards. More specific standards were drafted and were discussed extensively among utility and nuclear industry representatives during the period 1967 - 1973. During this period concerns about offshore faulting were frequently discussed. PG&E was well aware of these developing regulations and the NRC and USGS concern regarding potential offshore faults. An officer of PG&E, Barton Shackelford, was in fact the chairman of a group of western

utilities formed to work informally with the AEC in developing the new regulations during this period.

The new AEC standards contained in 10 CFR 100 Appendix A and in the "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants" clearly required extensive analysis of geoseismic hazards including: 1) analysis of all faults within 20 miles of the site by using suitable geological and geophysical techniques, and 2) analysis of epicenter locations of historic earthquakes within 200 miles of the site. These regulations were interpreted even by the utilities to require extensive studies of potential offshore faulting. Moreover, the regulations clearly indicated that they were minimum standards and that additional investigations may be required for sites located in areas having complex geology or in areas of high seismicity.

C. Techniques Were Available In The 1960s For Locating Offshore Faults

Scientific techniques for identifying and evaluating offshore faults were available and were well known during the time period that PG&E was conducting both their initial geoseismic siting studies (1965 - 1968) and later studies following the discovery of the Hosgri fault (1970 - 1976).

Seismic-reflection studies were at the time, and still are, the most effective technique available for identifying offshore faults. Seismic-reflection studies were widely used by the oil industry for offshore exploration during this period. In fact, the very studies that led to the discovery of the Hosgri fault were conducted by Shell Oil Company prior to 1963. The USGS and academic institutions were also conducting offshore reflection studies during the 1960s. The availability of these techniques to locate offshore faults was fairly well known even to some intervenors. Intervenors made use of offshore data collected by

Scripps Institution of Oceanography in 1965 in opposing PG&E's plans to construct a nuclear power plant at Bodega Bay.

Offshore seismic-reflection studies were also conducted by utilities in evaluating geoseismic hazards at proposed nuclear power plant sites. Such studies were conducted by the Los Angeles Department of Water and Power at the Bolsa Island site in 1967, and by Southern California Edison at the San Onofre site in 1970. PG&E's chief consulting geologist recommended such studies at the Montezuma site in 1968, and PG&E actually conducted offshore studies at Davenport in 1970 and at Mendocino in 1971. Although such studies were not routinely done in siting every proposed coastal nuclear plant in California prior to 1970, the seismic design of every plant built without such studies, including Humboldt, San Onofre 1 and Diablo 1 and 2, was later found to be inadequate. In light of PG&E's responsibility under the law for ensuring public safety, and in light of the potential licensing and economic risks involved, reasonable prudence clearly required offshore studies.

D. Geoseismic Issues Critical To Resolve At The Diablo Site

The Diablo Canyon plant site is located on the central California coast approximately twelve miles southwest of the City of San Luis Obispo. Three to five miles offshore to the west of the plant site lies the Hosgri earthquake fault. The Hosgri fault is a major fault in excess of 90 miles in length which extends approximately from Point Piedras Blancas south to the vicinity of Point Arguello. (See Figure 5.) The fault trends in a northwest-southeast direction roughly parallel to the central California coastline. It is part of a system of large faults, commonly referred to as the San Gregorio-Hosrgri fault system, that extends from a juncture with the San Andreas fault near San Francisco southward to the Transverse Mountain Ranges northwest of Santa Barbara. (See Figure 6.) The Hosgri may have been the source of one of the largest earthquakes in California this

earthquake and concluded that it would be equivalent to 20% of the force of gravity or "0.2g". To assure an ample margin of safety for plant systems and structures critical to safety, AEC practice at the time required that these critical plant features be designed to withstand ground shaking twice the level expected from the postulated design earthquake. As a consequence, critical safety related systems and structures at Diablo were designed to withstand shaking of 0.4g.

2. Although PG&E Suspected Offshore Faults, No Studies Were Done To Evaluate The Extent Of Such Faulting

The most significant deficiency in PG&E's original siting studies was PG&E's failure to evaluate the possibility of nearby, unidentified, major faults offshore of the plant site. PG&E's chief consulting geologist, Dr. Richard H. Jahns, later admitted that the existence of the Hosgri fault was suspected in 1967 when PG&E's original siting studies were conducted:

> "In 1967 the potential existence of the Hosgri fault was suspected." (Testimony of Richard H. Jahns, ACRS Subcommittee Meeting transcript, February 18-19, 1975, at page 62. See also DRA Exhibit 11,361.)

PG&E seismologist Dr. Stewart W. Smith also suspected offshore faults at the time of the company's original siting studies.

> "California is 'laced with earthquake fault lines' and Dr. Benioff and I felt, in making the original report in 1967, that the offshore area of California was also laced with earthquake fault lines although these offshore fault lines were generally not charted at that time." (Interview of Stewart W. Smith by F.B.I., March 8-9, 1978, See DRA Exhibit 11,360 at pages 17-22).)

Even though PG&E's consultant's suspected the existence of such faults at the time of their initial siting studies, PG&E failed to conduct any offshore geophysical studies.

3. More Complete Regional Geologic Studies Would Have Indicated The Need For Offshore Studies

Offshore geophysical studies were not done during PG&E's initial siting studies and clearly should have been done, but had the geoseismic studies PG&E did do been thorough, the results would clearly have demonstrated the need for offshore investigations. PG&E's geologic studies were limited primarily to a 3000 foot by 6000 foot area in the immediate vicinity of the site. A more complete review of the regional geology in the vicinity would have shown that there was evidence of significant active faulting extending offshore toward the plant site. This information was clearly shown, for example, on a map published in 1923 by Bailey Willis in the Bulletin of the Seismological Society of America. (A copy of this map is reproduced in Figure 7.) Willis presumed active faulting extending south from Point San Simeon, but was uncertain of its length or location. Since no one had studied this offshore area prior to PG&E's initial siting studies, this evidence clearly warranted further investigation. No such investigation was done by PG&E however.

4. A Conservative Interpretation Of Seismologic Evidence Would Have Recognized The Possibility Of Offshore Faulting Nearby

A more complete review of seismologic literature would have alerted PG&E and the NRC to a northwest trending alignment of earthquake epicenters that indicated the possibility of active faulting offshore of the plant site roughly corresponding to what was later identified as the Hosgri fault. (This trend is illustrated in Figure 8.) This evidence should have been further investigated. In 1968 Robert Curry, a consulting geologist for Diablo Canyon intervenors noticed this alignment of earthquake epicenters and recognized it as a sign of possible faulting. Curry even went so far as to alert PG&E (and the CPUC as well) to this possibility and on the basis of this evidence asked how PG&E

had ruled out the possibility of significant nearby offshore faulting.

> "How has the company ruled out the possibility of nearby offshore faults of geologically recent displacement? If a Richter magnitude 7 1/2 earthquake were to occur on such a fault approximately 2000 feet south of the reactor site and ground accelerations of 0.4g or greater resulted, how would the installation be affected?" (Letter from Robert Curry to PUC Commissioner Gatov and to PG&E sent 1968.)

Unfortunately PG&E had not, and did not, investigate this possibility and could not rule out the possibility.

5. A More Complete Evaluation Of Historic Epicenter Locations Would Have Revealed The Possibility Of A Magnitude 7.3 Earthquake Nearby

A more complete review of seismologic literature would have shown that there were four significantly different published epicenter locations for the 1927 earthquake, three of which were much closer to the Diablo site than the location PG&E had assumed in its reports to regulatory agencies. (Figure 8 illustrates the different published locations of the 1927 earthquake.) This information was highly significant to the siting and design of the Diablo Canyon plant. The 1927 earthquake was one of the largest earthquakes that occurred this century and even though it occurred in a sparsely populated region, it caused widespread damage onshore. The event provided PG&E with absolute, unequivocal proof of the existence of a significant fault offshore capable of very large damaging earthquakes. Even more significant was the fact that the location of the source fault of this earthquake was unknown and unmapped.

PG&E reported only the location that was furthest away from the Diablo Canyon site in its reports to regulatory agencies. This created the impression that the earthquake occurred far away from the site and could not affect the safety of the site or the

Other design formulas in widespread use in the 1960s produced dramatically different results than Blume's for nearby earthquakes. Almost any design formula in widespread use other than Blume's, would have required a higher seismic design basis for smaller earthquakes closer to the site. The possibility of a much larger shallower focus earthquake of magnitude 7.5 within 5 miles of the site would have required a significantly higher seismic design.

As a result of the way Blume's formula worked, the magnitude 6.75 earthquake assumed beneath the plant was not conservative. PG&E had absolutely no basis for assuming in the 1960s that their design was so conservative that they did not need to investigate the offshore, and they have absolutely no basis for making that claim now.

7. The USGS Did Not Evaluate The Hosgri Fault In 1970 And Did Not Conclude That Diablo Was Adequately Designed For An Earthquake On The Hosgri

The DRA has concluded that if PG&E had paid heed to the clear indications of offshore faulting available at the time, and to their own consultants' suspicions concerning offshore faulting, they could easily have discovered the Hosgri fault. In the opinion of the DRA, if this had been done, it would have been clear that the possibility of a large magnitude 7.5 earthquake on the Hosgri could not be ruled out, and the plant would have been designed to a higher seismic design basis.

PG&E has disputed this conclusion by arguing that even if they had discovered the Hosgri fault in their original siting studies it would not have affected the design of the plant. In support of this claim they have argued that the USGS discovered the Hosgri fault in 1968 and later in 1970 approved the adequacy of the design of the plant with full knowledge of the Hosgri. PG&E also alleges that prior to about 1975 seismologists and engineers believed that 0.5g was the maximum ground acceleration

possible from even the largest earthquakes. PG&E is simply mistaken. The true facts support neither of these claims.

The USGS neither discovered, nor assessed the earthquake capability of the Hosgri fault in 1970. In 1970 intervenors in the NRC Diablo Canyon proceeding took note of a swarm of small earthquakes that occurred 20 to 30 miles offshore of the plant site and noticed what they interpreted to be a northeast - southwest alignment to the epicenter locations of these earthquakes. Based upon this alignment they hypothesized the existence of an offshore fault trending directly toward the Diablo Canyon site and filed a petition with the NRC. In response to the petition, the AEC asked the USGS whether such a northeast - southwest trending fault existed. The USGS had collected limited data in this vicinity in 1968, but had never interpreted it. Upon review, the USGS concluded that the data clearly disproved the existence of any northeast trending fault. The USGS found that the structural geologic trend in the vicinity was northwest - southeast. The USGS also observed a "belt of folded and faulted strata" trending northwesterly 3 to 5 miles offshore of the plant site. (This belt corresponded to the feature mapped in more detail by Shell Oil Company that was later named the Hosgri fault.) On the basis of the clear northwesterly trend to the structures offshore of the site, the USGS concluded that no northeast - southwest trending fault extended from the epicenter region toward the site, and that the new epicenter data did not constitute any threat to the safety of the plant.

PG&E has speculated that the USGS also evaluated, and had full knowledge of the the capability and significance of the Hosgri fault at this time. This is simply not the case. The DRA has interviewed key USGS personnel involved in this review. We know what actually occurred. The truth is, USGS reviewed only the data necessary to respond to the specific question raised by the intervenors and asked of USGS by the AEC, and the question was whether a northeast trending fault existed. USGS did not investigate the continuity, length, earthquake capability, or any

other aspect of the northwest trending belt, other than its directional trend. When Shell's discovery of the Hosgri fault was later disclosed in PG&E's Final Safety Analysis Report to the AEC, the AEC and USGS reviewers immediately requested additional information from PG&E concerning this feature, and in addition, the USGS initiated its own offshore studies in the area. All of this would have been unnecessary if, as PG&E alleges, the USGS had "full knowledge" of the Hosgri in 1968.

8. Seismologists, The USGS And The NRC All Knew That Ground Accelerations As High As 1.0g Were Possible From Large Earthquakes

PG&E claims that prior to 1971 seismologists and engineers believed that 0.5g was the highest ground acceleration possible from even the largest earthquakes and that as a result, even if the Hosgri fault had been discovered in PG&E's original siting studies, this discovery would not have affected the design of the plant.

Again, PG&E has its facts wrong. Seismologists recognized since at least the turn of the century that ground accelerations as high as 1.0g not only could occur, but had occurred. The preeminent seismologist Charles F. Richter described observational evidence of such high accelerations in his 1958 text "Elementary Seismology" at pages 50-54. In commenting on these observations Richter stated:

> "...there is good evidence that in the meizoseismal areas of the greatest earthquakes actual ground accelerations of the order of "g" or greater occur." (Richter, "Elementary Seismology" (1958) at p. 26)

The possibility of peak ground accelerations far in excess of 0.5g was also recognized by the USGS and AEC in the 1960s. It was precisely because of these concerns that the NRC asked PG&E to design safety related systems and structures at the proposed

2. Hamilton Knew The Hosgri Was A Significant Fault Potentially Capable Of A Very Large Earthquake As Soon As He Reviewed The Shell Data

Five months later, in late February or early March 1973, Doug Hamilton reviewed the Shell Oil Company data and discussed its interpretation with Shell geologist Ernest Hoskins. The significance of the fault was immediately apparent from the Shell data. Hamilton saw evidence that the Hosgri was recently active, and that based upon its 90 mile length, may be considered capable of a very large earthquake. Hamilton also realized that additional offshore studies were necessary to determine the full extent and significance of the fault. On April 13, 1973 he forwarded two maps containing summary information from Shell's files and Hamilton's own ideas for additional offshore geophysical studies to Dr. Jahns, PG&E's chief consulting geologist. On the upper right hand corner of one of the maps Hamilton included, for Jahns review, his estimate of the maximum earthquake potential of the Hosgri fault which he referred to at the time as "the offshore zone". The earthquake potential he estimated at the time was, "magnitude 7.5". A portion of this map containing this notation in Hamilton's own handwriting is reproduced in Figure 10.

3. The Discovery Of The Hosgri Provided A New And Compelling Reason To Reevaluate The Source Of The 1927 Earthquake

The discovery of the Hosgri fault offshore of the Diablo Canyon plant site in 1971 provided PG&E with a new and compelling reason to reevaluate the source of the 1927 earthquake. The location for this earthquake which PG&E had used in their original siting studies was on no known fault, and the Shell data indicated that the Hosgri was a long fault extending from north of the plant site south to the general vicinity of the four early mapped epicenter locations of the 1927 earthquake. Moreover,

PG&E knew that the location they had relied upon in their original siting studies was calculated in 1930 using outdated methods and was not accurate to within more than 20 miles. Dr. Smith, PG&E's consulting seismologist, had also recognized, at least since 1970, that the 1927 earthquake could have occurred on a northwest trending fault which was the trend of the Hosgri. As a result of these factors, PG&E should have realized, as soon as they learned of the Hosgri fault, that it was at least possible that the 1927 earthquake occurred on this fault. PG&E should have been very concerned. This possibility was another indication, in addition to the length of the fault, that the Hosgri may be capable of a very large earthquake. PG&E should have known that if it was possible that the 1927 earthquake occurred on the Hosgri, then for seismic design purposes PG&E would have had to assume that an earthquake of similar magnitude could recur on this fault within 3 to 5 miles of the plant site. The possibility of an earthquake of this magnitude so close to the plant raised serious doubts about the adequacy of the seismic safety of the plant.

4. In Order To Thoroughly Evaluate The Hazard Posed By The Hosgri Fault, PG&E Should Have Promptly Conducted Offshore Studies

In order to determine whether Hamilton's estimate of the earthquake potential of the newly discovered fault was correct, and to determine whether the seismic design of the plant was adequate to withstand such an earthquake, PG&E should also have thoroughly investigated the area offshore in the vicinity of the fault. This was exactly how PG&E's consultant's on the Mendocino siting case responded to Shell Oil Company information about faulting offshore of the Mendocino site. PG&E should also have conducted a thorough investigation of the location and source fault of the 1927 earthquake. The results of such investigations should have been disclosed to the USGS and NRC no later than in

the Diablo Canyon plant that taken together span the entire 16 year construction history of the project. These construction problems were significant problems typical of the construction issues which formed the basis for the disallowance adopted by this Commission in the San Onofre 2 and 3 case. PG&E has attempted to minimize the impact of these construction issues by arguing that since there was no critical path impact for the majority of these issues, the DRA construction case is trivial. It is important, however, to bear in mind that if one were to quantify the delay associated with these issues which would have been on the critical path in the absence of Hosgri and DVP, the costs would be substantial. Figure 11 represents a summary of the "Critical Path Construction Delays with No Direct Effect On The Diablo Canyon Units 1 and 2 Commerical Operation Dates As A Result Of Subsequent Hosgri Modifications And DVP Activities." The importance and significance of these construction deficiencies should not be disregarded as insignificant simply because PG&E made other errors that resulted in concurrent project delay.

VI. APPROXIMATELY $4.4 BILLION IN PROJECT COST WAS IMPRUDENTLY INCURRED ON THE DIABLO CANYON PROJECT

Although the necessary techniques were available, PG&E failed to conduct studies to locate potential earthquake faults offshore of the Diablo Canyon site in their initial siting studies in the mid-1960's. Had they done so, the company would have discovered the Hosgri fault 3 miles offshore of the plant site. Data obtained through offshore studies would also have shown that the Hosgri fault must be considered capable of a major magnitude 7.5 earthquake. As a result of this deficiency and other deficiencies in PG&E's geoseismic siting studies, PG&E designed and built the Diablo Canyon plant to standards inadequate to safely withstand a large earthquake on the nearby Hosgri fault. In 1971 Shell Oil Company geologists published their earlier discovery of the Hosgri fault in a widely read periodical. PG&E learned of the article approximately 2 years

later. Had PG&E promptly reevaluated the design of the plant following their learning of the Hosgri fault the deficiencies in their original siting studies could have been mitigated. Instead, from 1972 through 1976 PG&E ignored or sought to minimize evidence that the Hosgri fault was a major fault capable of a very large earthquake. This concern was finally resolved in 1976 when the Atomic Energy Commission (AEC) adopted the recommendation of the U.S. Geological Survey (USGS) and required PG&E to redesign and reconstruct the Diablo Canyon plant to withstand a magnitude 7.5 earthquake on the Hosgri fault. As a result of the deficiencies in PG&E's geoseismic studies and the company's late discovery and response to the Hosgri fault, the Diablo Canyon project was delayed from approximately 1976 to 1981.

PG&E failed to adequately implement and update the company's engineering management and quality assurance procedures as these practices evolved during the 1960s and 1970s. As a consequence of these management failures, an unlabeled, unverified sketch was used to transmit critical design information from PG&E to one of the company's design consultants and an error occurred that has come to be known as the mirror image error. This error occurred in 1977 in the seismic design of the plant to strengthen it to withstand an earthquake on the Hosgri fault. The error went undetected until 1981. In the months following the disclosure of the mirror image error additional design errors and design control deficiencies were discovered which shattered the NRC's confidence in the adequacy of the plant design. As a consequence of this series of events the NRC took the unprecedented step of suspending PG&E's Operating License for Diablo Canyon and ordered an extensive Design Verification Program (DVP). As a result of the mirror image error and other design errors the completion of the Diablo Canyon project was delayed from 1981 to 1985.

Had it not been for PG&E's unreasonable errors and omissions, Diablo Canyon would have gone into operation within a time frame similar to most plants constructed in the same era.