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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The Public Utilities Commission Division of Ratepayer Advocates (DRA) respectfully submits this Prehearing Brief in order to assist the Commission in understanding our findings and the evidence we will be presenting in hearings in this proceeding.

I. INTRODUCTION

A. The DRA's Independent Evaluation Of Cost Overruns And Schedule Delays At Diablo Is Of Unprecedented Scope And Depth

In May of 1984 the Commission established a special task force referred to as the "Diablo Team" for the purpose of

conducting a thorough, objective evaluation of the causes of cost overruns and schedule delays on Pacific Gas and Electric Company's (PG&E's) Diablo Canyon Nuclear Plant. This undertaking was facilitated by special legislation that provided the Commission with funds enabling the Commission staff to retain over 30 independent consulting firms with expertise in the fields of geology, seismology, seismic design, nuclear plant licensing, construction, scheduling, project management, quality assurance, finance, accounting, and law to assist in its evaluation.

Since 1984 this combined Staff/consultant team has engaged in an evaluation of unprecedented scope and depth. Well in excess of 1,000 written requests for information have been sent to PG&E, files of other involved government agencies have been researched, millions of pages of historical documents have been collected and evaluated, and numerous witnesses have been interviewed and deposed. In May of 1987 after three years of research and analysis, the DRA published 17,000 pages of testimony and supporting exhibits containing the results of its initial review.

B. The DRA's Standard Of Review Is Fully Consistent With California Law And Commission Precedent

Public Utilities Code Section 463 requires that all costs resulting from unreasonable errors or omissions in planning or construction of Diablo Canyon be disallowed for rate setting purposes. This is the standard of review required by California law and is the standard the DRA has applied in determining its recommendation in this proceeding. Moreover, the DRA has interpreted the standard of review articulated in Section 463 in the same manner the Commission did in the recent decision on the reasonableness of the costs incurred on the San Onofre 2 and 3 (SONGS 2/3) project. The DRA recognizes that, although the standard PG&E management must meet is a high standard of care, it is not a standard of perfection. The DRA has also recognized

that the standard must be applied in light of: 1) the circumstances and information available or that should have been available at the time, 2) the unique financial and safety risks inherent in nuclear plant construction, and 3) the education, training, experience, skills and management tools a reasonable manager would or should have possessed in assuming responsibility for the tasks undertaken on the project.

C. Diablo Canyon Was A Trouble Plagued Project In a Trouble Plagued Industry

In order to properly evaluate the causes of cost overruns and schedule delays incurred on the Diablo Canyon project it is necessary to understand the historical context within which the Diablo Canyon project was planned, sited, designed and constructed. Considerable time will be spent in this proceeding hearing evidence comparing the Diablo Canyon project and PG&E's management practices with other nuclear projects and other utilities and architect/engineering firms. When considered in this context it is clear that the Diablo Canyon project was a trouble plagued project compared to other projects in a trouble plagued industry.

"The magnitude of the nuclear industry's problems and management's responsibility for these problems was well summarized in a 1985 cover story in Forbes magazine:"

> "The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale. The utility industry has already invested $125 billion in nuclear power, with an additional $140 billion to come before the decade is out, and only the blind, or the biased, can now think that most of the money has been well spent. It is a defeat for the U.S. consumer and for the competitiveness of U.S. industry, for the utilities that undertook the program ..." (Forbes Magazine, February 11, 1985, Cover)

D. Comparing The Cost And Schedule Duration Of Diablo With Other Nuclear Plants Begun During The Same Period Creates A Prima Facie Case Of PG&E Management Imprudence

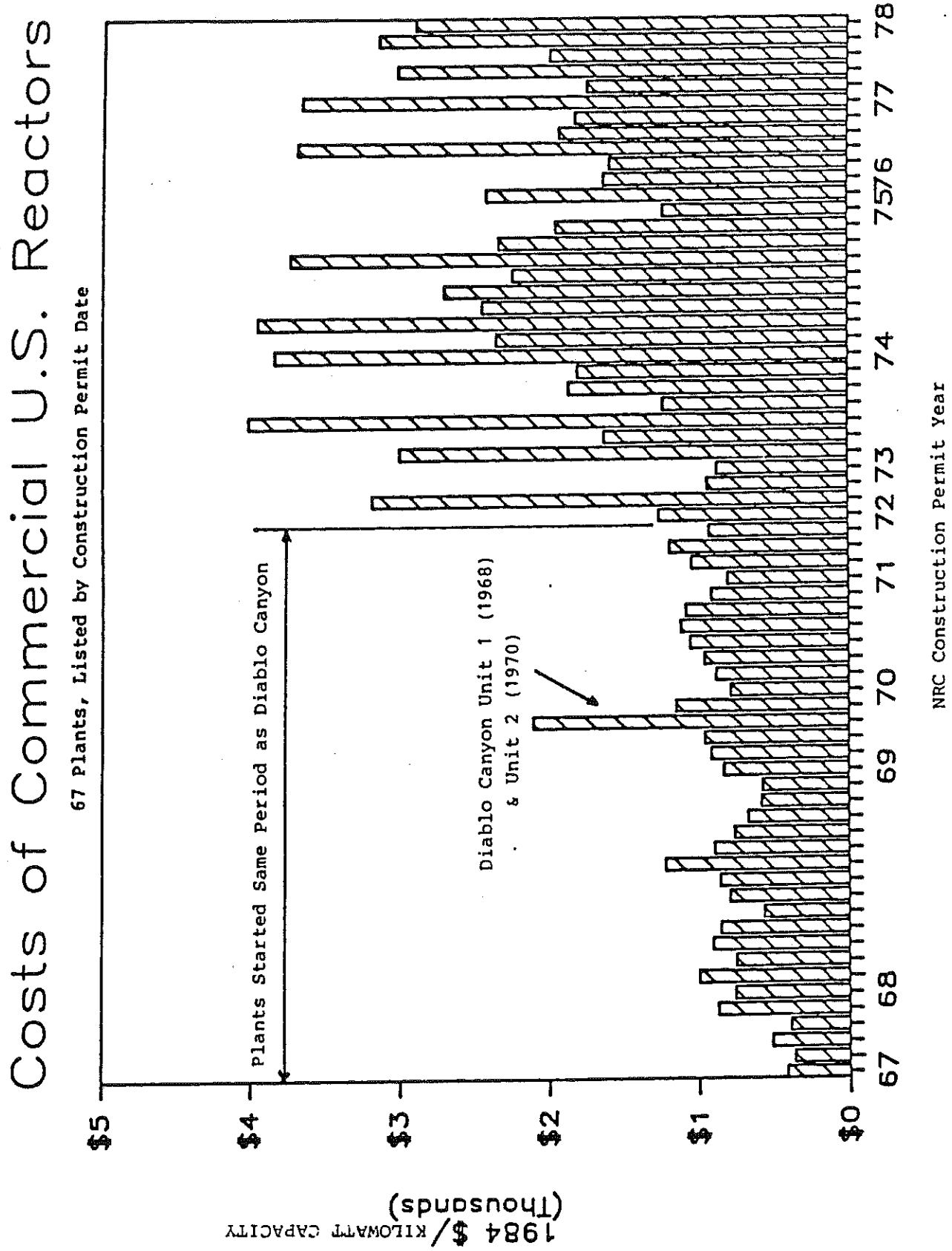
all the Comm has rejected

The trouble plagued history of the nuclear industry is one of the primary reasons that this Commission has rejected the use of industry comparisons as proof of the reasonableness of utility management of such projects. In the SONGS 2/3 decision the Commission rejected the use of industry comparisons as proof of prudence because it could not accept the comparability of nuclear plants and refused to assume that nuclear industry practices have been or can be demonstrated to be prudent. (Decision 86-10-069, pgs. 35-36.) In the opinion of the DRA, conformity with nuclear industry practices may be considered evidence of, but can not be considered proof of utility management prudence. Industry comparisons can, however, provide compelling evidence of imprudent management where it can be shown that a utility has fallen short of standard practice in this troubled industry.

Although considering the cost and schedule duration of the Diablo Canyon project against the backdrop of such a troubled industry creates an unrealistically favorable impression of PG&E management, at the same time it establishes a remarkable prima facie case of PG&E management imprudence.

The $5.18 billion cost of the plant was by far the most expensive of the nuclear plants begun during the late 1960s and early 1970s. (See Figure 1.) Diablo fares even worse when its construction schedule is compared with other plants. The construction schedule duration of Diablo was the longest of any nuclear plant that has been completed, and was more than twice as long as the average of 34 comparable plants begun during the same time period. (See Figure 2.) Given the trouble plagued history of the industry against which these comparisons have been made, and the remarkable contrast between Diablo and its contemporaries, one cannot escape the inference that the Diablo Canyon project was mismanaged to an exceptional degree.

FIGURE 1



Source: Exhibit 10,560

CONSTRUCTION

Durations of Commercial U.S. Reactors

67 Plants, Listed by CP Issue Date

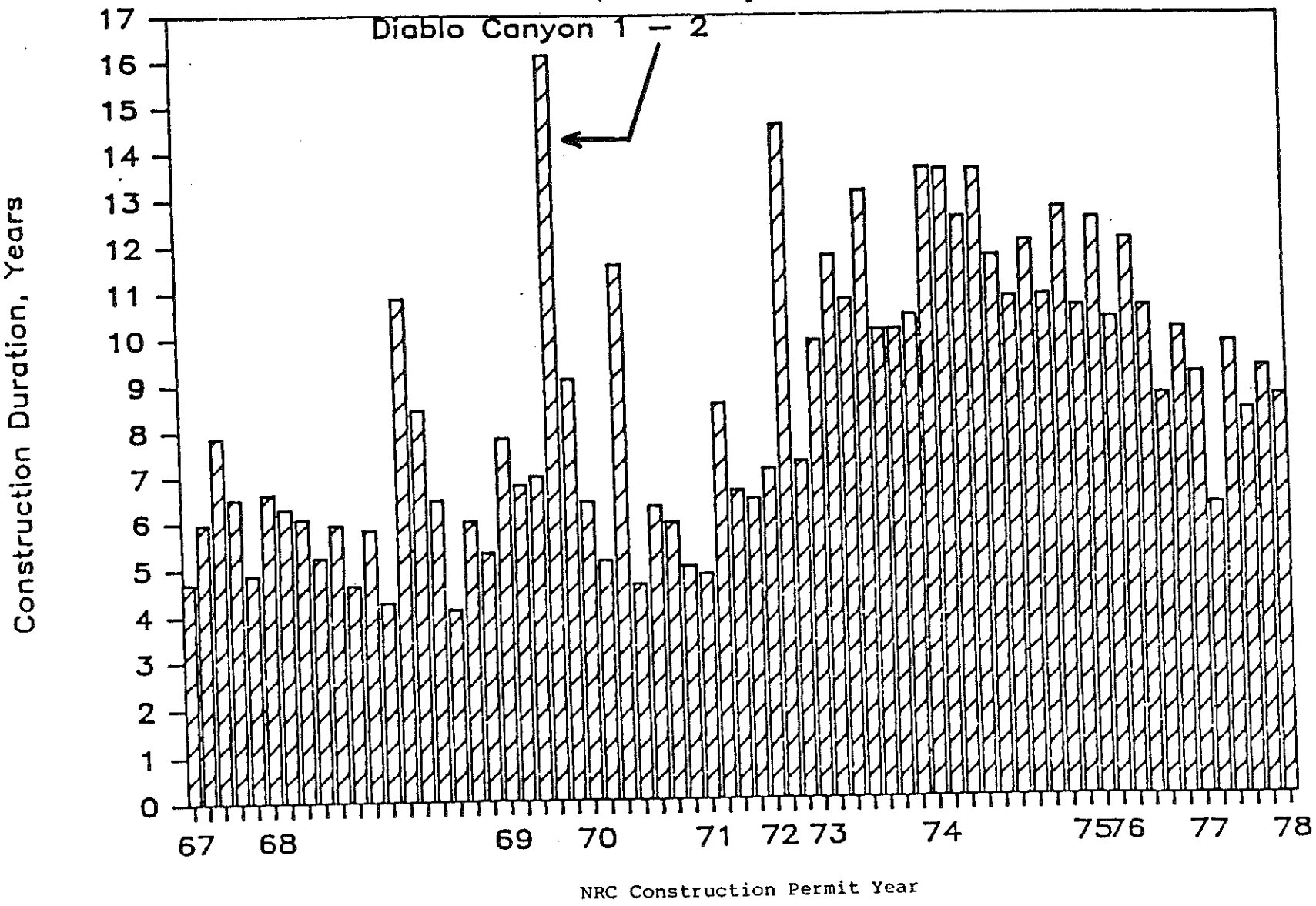


FIGURE 2

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.

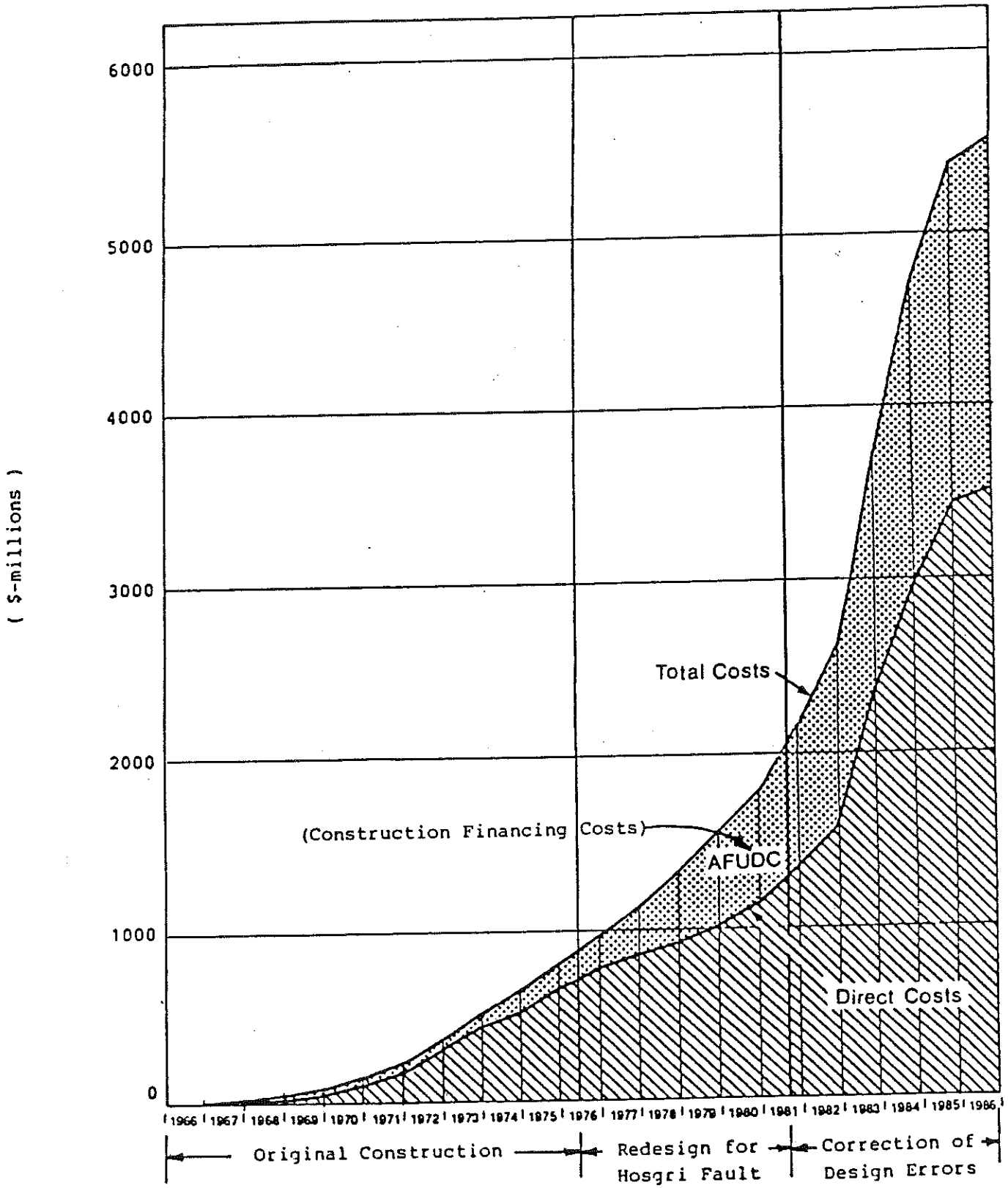
The cost impact of the need to redesign and construct the plant three times is illustrated by Figure 3.

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

Figure 3

PACIFIC GAS & ELECTRIC COMPANY
DIABLO CANYON PROJECT
CUMULATIVE COSTS
THROUGH COMMERCIAL OPERATION DATE
UNITS 1 & 2



the $5.518 billion PG&E incurred on the Diablo project was a result of unreasonable errors or omissions under Section 463 and can not lawfully be charged to ratepayers. The DRA has concluded that approximately $1.15 billion was reasonable and can be lawfully recovered from ratepayers. This $1.15 billion reasonable cost is roughly equivalent to the average cost of the 34 nuclear plants begun during the same approximate time period as Diablo Canyon. This is illustrated by Figures 4 and 1.

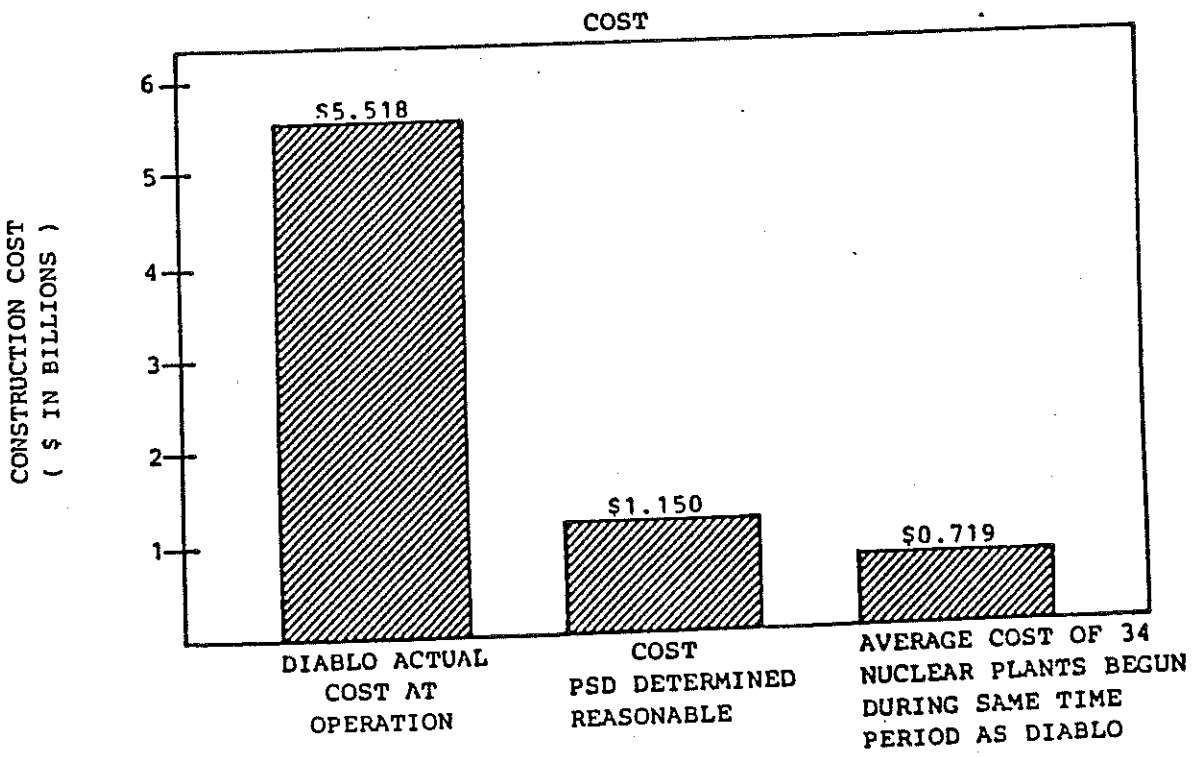
PG&E has argued that the cost of Diablo is reasonable when compared with the cost of other nuclear power plants completed in the 1980s and that Diablo is more appropriately considered a 1980's plant. On this basis PG&E argues that the DRA's recommendation in this proceeding is "out of line with any reasonable disallowance".

PG&E fails to mention, however, that when this Commission issued PG&E a certificate to construct the Diablo Canyon plant in 1967, it certificated a plant intended to operate for the benefit of California ratepayers in the early 1970's. PG&E also fails to mention the fact that in developing its recommendation the DRA calculated the cost of all reasonable plant improvements necessary to bring the plant into conformity with 1980s requirements, and has included all such costs within the amount determined reasonable. PG&E also fails to mention that the Diablo Canyon plant was essentially complete in 1976 and that at that time PG&E's actual incurred cost was very close to the amount the DRA has determined was reasonably incurred. (See Figure 3.) Finally, PG&E has failed to mention that the only reason that the plant was not licensed and in operation in the mid-1970s is because of delays that could and should have been avoided.

When all of the circumstances are considered it is clear that the only appropriate cost comparison that can be made is with plants begun during the same time period as Diablo. When

FIGURE 4

DIABLO CANYON RECOMMENDATION



considered in this light, the reasonableness of the DRA's ratemaking recommendation is undeniable.

G. DRA Has Evaluated PG&E's Fall 1987 Testimony, And Has Concluded That Its Original Conclusions On Key Issues Remain Valid And Fully Supported By Available Contemporaneous Evidence

PG&E replied to the DRA's initial review in the fall of 1987 and contested virtually every major finding and conclusion of the DRA. Since the fall of 1987 the DRA staff and consultants have been conducting a thorough evaluation of the evidence and argument filed by PG&E last fall. Due to the bulk of PG&E's response, changes in PG&E's positions on a number of issues and the number of additional witnesses offered, this evaluation has not yet been fully completed. The DRA has however evaluated all of the significant issues raised by PG&E and has concluded that its original conclusions concerning the major causes of cost overruns and schedule delays on the Diablo project are valid and well supported by available contemporaneous evidence. We have not completed our quantification of the cost of PG&E's imprudence, but our initial review indicates that this figure will probably require some revision. The results of this analysis will be filed as soon as the analysis is completed.

A more detailed discussion of the principle causes of the cost escalation and schedule delay experienced on the project is contained in the sections which follow.

II. PG&E'S CORPORATE AND PROJECT MANAGEMENT WERE UNREASONABLE, AND THOSE MANAGEMENT FAILINGS CONTRIBUTED TO EXCESSIVE COSTS

At the most fundamental level, it was PG&E's management failures that led to Diablo Canyon's enormous cost increases and schedule delays. Although the signs were clear by the mid-1960's that the Diablo project would present management challenges and

risks several magnitudes greater than any of their previous undertakings, PG&E's senior managers took no significant steps to create the organization, plan, and controls that such a large, complex project demanded. Instead, PG&E complacently relied on the informal methods and approaches that it had used on the much smaller, more routine projects that had been the mainstay of its previous engineering and construction efforts. Neither PG&E's corporate management (the Board of Directors and the company's officers) nor those managers more directly responsible for the project gave Diablo the attention that it warranted, and that neglect was a key underlying factor in the geoseismic, design control and quality assurance deficiencies that afflicted the project.

At the very top of PG&E's management hierarchy, the Board of Directors failed to provide the leadership and direction that a major project like Diablo Canyon dictated. The Board's performance should be measured by the response to two questions: (1) what did Board members know about Diablo, and (2) what actions did the Board take at critical junctures in the project? On both of these counts, the contemporaneous record is damning to PG&E. The DRA's consultant analyzed all the materials that PG&E's witnesses say the Board reviewed and concluded that the Board failed to differentiate Diablo from other, much less significant projects and could not have monitored or evaluated Diablo Canyon in any meaningful way. In effect, although Diablo Canyon represented a major proportion of the Company's assets, it was virtually invisible to the Board. Moreover, until very late in the project, the Board was a passive onlooker to the critical decisions affecting the project. The record is clear that the Board exercised no notable role in assessing the project's plan or organization, evaluating alternatives for resolving geoseismic disputes expeditiously, or addressing the implications of the mirror image error. This dismal record cannot be judged reasonable.

PG&E's project management was equally remiss. By the mid-1960's, managers in a variety of industries agreed that the traditional functional organizational structure with largely informal (and often haphazard) planning and control was illsuited to the megaprojects that were becoming common, and their continuation entailed an unacceptable level of risk. Those managers (including some of PG&E's witnesses) responded to the needs of these large, complex projects by adopting management practices that were grounded in the well-established principles of project management -- a single focus for project decision-making and direction, comprehensive planning to integrate all of the project's elements, and systematic feedback and control as the project progresses.

For the first 17 years of the project's history, however, PG&E remained mired in the outmoded practices of a simpler, less demanding era. Opportunities to modify and evolve its management approach to meet even greater needs came and went, but PG&E's management refused to consider any change that would have impinged on its functional manager's fiefdoms or on its tradition of verbal reporting and direction based on personal relationships. That choice exacerbated the risk that critical decisions would not receive the appropriate priority and that the various project functions would not mesh. In light of the potential cost and schedule consequences, such a risk was unreasonable.

In fact, these management deficiencies provide at least a partial explanation for the project's most serious problems. PG&E now proclaims that its handling of geoseismic issues was reasonable because it deferred to its expert's evaluations. This reasoning demonstrates the fallacy of a purely functional project approach that neglects management judgment that can only be made at the project level. Only PG&E, not its geoseismic experts, could weigh the cost, schedule and public safety implications of a particular level of design conservatism. Had management accepted this responsibility, additional investigations could

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

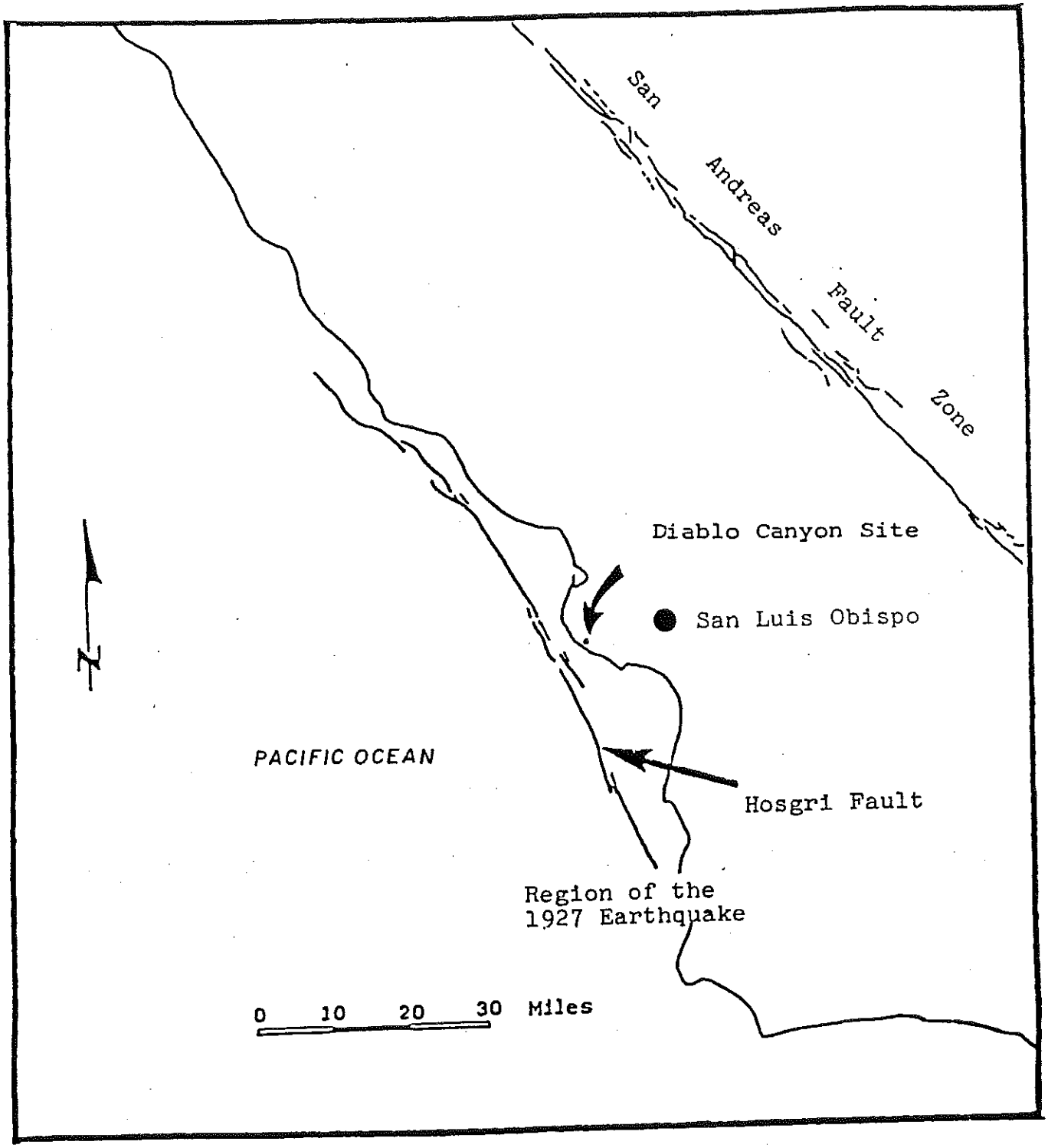
Scripps Institution of Oceanography in 1965 in opposing PG&E's plans to construct a nuclear power plant at Bodega Bay.

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

FIGURE 5



Diablo Canyon Site
And Proximity Of The Hosgri Fault
And 1927 Earthquake Epicenter

century - the magnitude 7.3 earthquake which occurred offshore to the southwest of the Diablo Canyon site in 1927.

Among the geoseismic issues critical for PG&E to resolve in siting and designing the Diablo Canyon plant were the following: 1) the significance of the Hosgri fault, and 2) the significance of the 1927 earthquake. Resolving these issues was essential in order to determine whether the Diablo site was a suitable site for the construction of a nuclear power plant, and to determine an appropriately conservative seismic design with sufficient seismic strength to assure the protection of the public health and safety.

E. Deficiencies In PG&E's Initial Geoseismic Siting Studies

PG&E has claimed that they used state-of-the-art techniques in conducting geoseismic siting studies and that they were later "negatively impacted" by the discovery of geological information obtained using new techniques. The facts clearly indicate otherwise.

PG&E's initial geologic and seismic investigations were deficient in a number of critical respects:

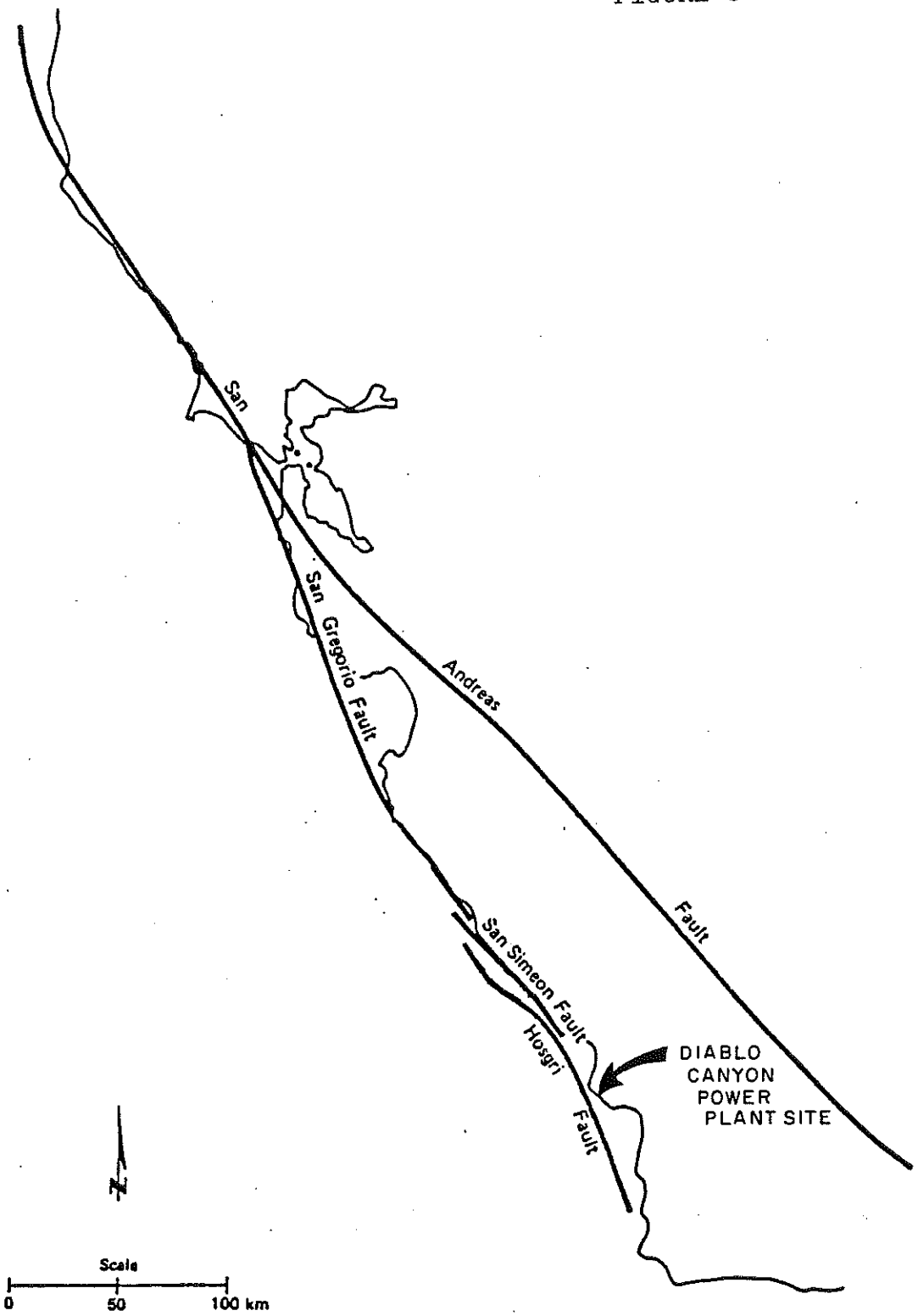
1) PG&E failed to evaluate the possibility of nearby offshore faults,

2) PG&E failed to thoroughly investigate the regional geology in the vicinity of the site,

3) PG&E failed to investigate the full extent and implications of historic seismic activity near the site, and

4) PG&E failed to evaluate the location and source of the large, magnitude 7.3 earthquake that occurred southwest of the plant in 1927.

FIGURE 6



Major Features of the
Tectonic Boundary
of
Coastal Central California

As a result of these deficiencies in PG&E's geoseismic studies, the original seismic design of the plant was not sufficiently conservative to assure the safety of the plant.

1. PG&E's Initial Design

PG&E's initial geoseismic siting studies appear to have been intended principally to determine two issues: 1) the maximum earthquake that could occur in the vicinity of the site for which the plant must be designed, and 2) the potential for ground rupture beneath the plant site due to surface faulting. The results of these initial siting studies were reported to the NRC in PG&E's PSAR in 1967. PG&E concluded that:

1) no major active faults were present within the power plant area;
2) the Diablo Canyon site was in an area of very low seismicity and had a very small earthquake damage history;
3) the major faults governing the maximum-size earthquake that could be expected to occur at the site area are the San Andreas fault (48 miles northwest), the Nacimiento fault (20 miles northeast), and possible aftershocks from a large earthquake on the San Andreas fault;
4) aftershocks from a large earthquake on the San Andreas Fault could occur on faults within 50 miles of the San Andreas; such aftershocks could be as large as magnitude 7.5 on any existing fault, and as large as 6.75 on faults not pre-existing.

Since the San Andreas and Nacimiento faults were some distance from the plant site, and since PG&E believed that there were no existing faults close to the site, PG&E concluded that the maximum earthquake for which the plant must be designed was an assumed magnitude 6.75 aftershock which could occur beneath the plant as a result of a large earthquake on the San Andreas fault.

On the basis of these geoseismic siting studies PG&E calculated the ground shaking expected from the assumed design

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.

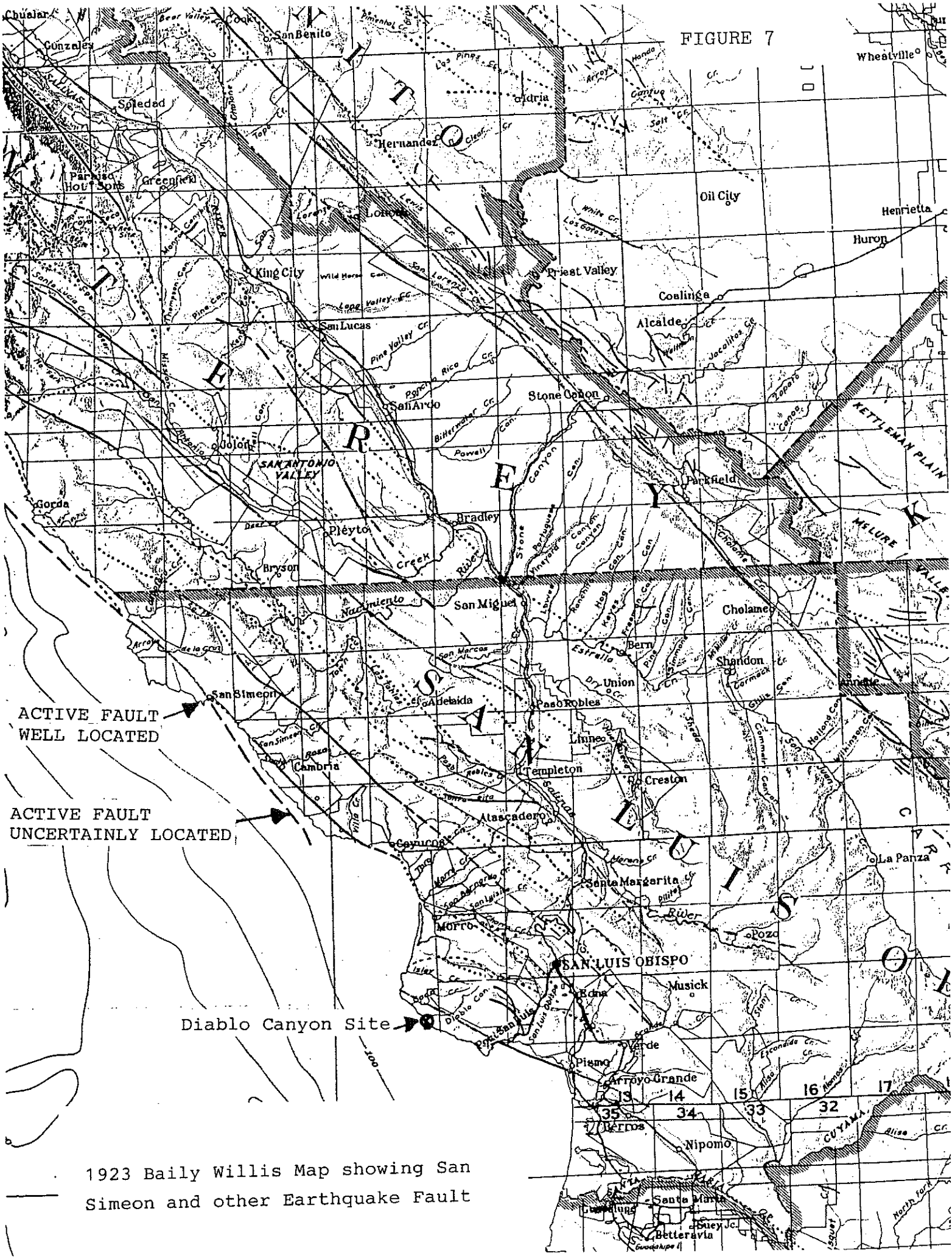
3. More Complete Regional Geologic Studies Would Have Indicated The Need For Offshore Studies

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

FIGURE 7



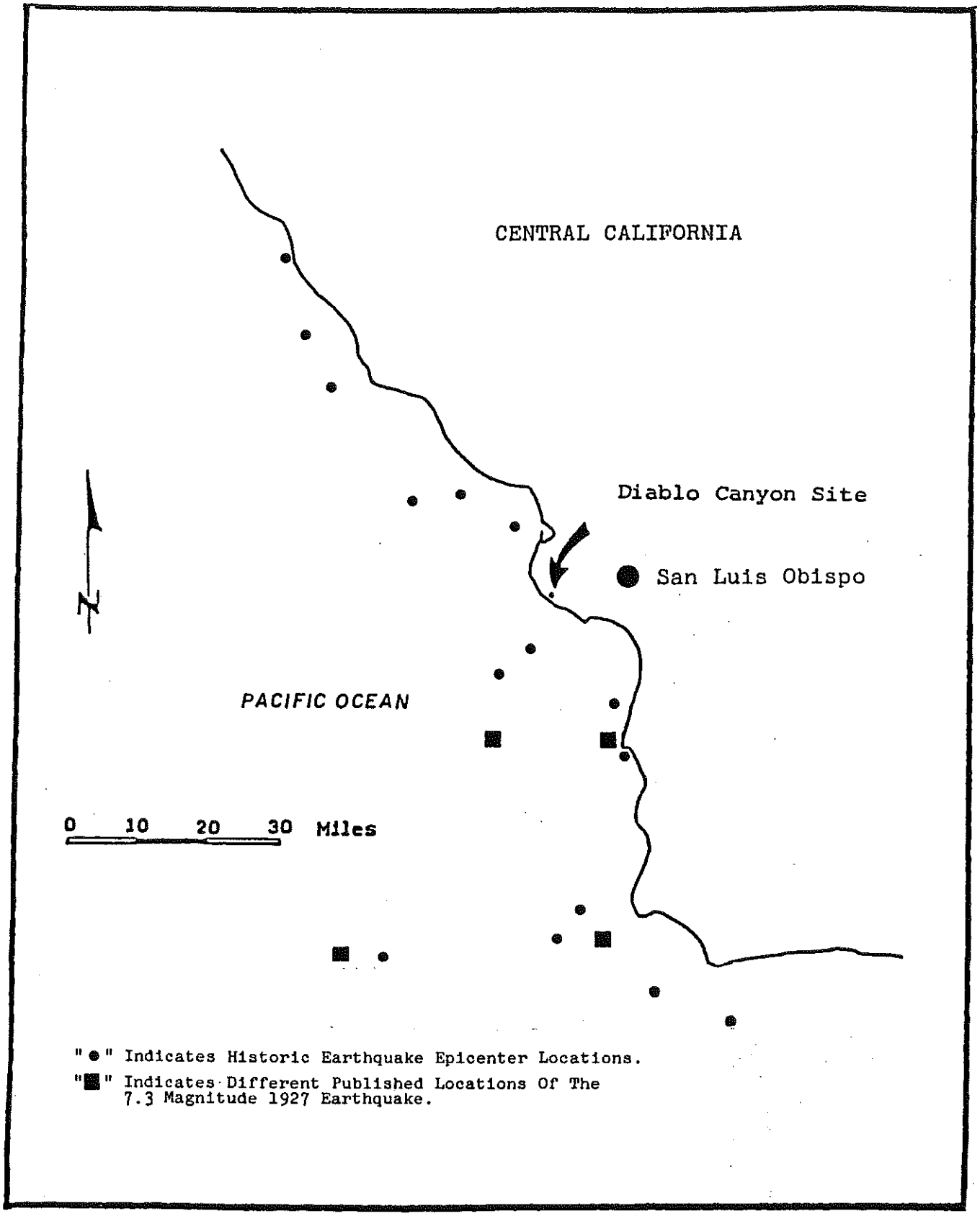
ACTIVE FAULT WELL LOCATED

ACTIVE FAULT UNCERTAINLY LOCATED

Diablo Canyon Site

1923 Baily Willis Map showing San Simeon and other Earthquake Fault

FIGURE 8



Diablo Canyon Site And Locations
Of Historic Earthquake Epicenter
Locations Known Prior To 1967

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

design of the plant. PG&E also stated that the earthquake occurred on an east-west trending fault. This assumption assured that the presumed source fault of this large earthquake would not be assumed to run anywhere near the plant site. Neither of these assumptions regarding the 1927 earthquake was in the least bit conservative.

PG&E ignored an equally plausible, and much more conservative alternative possibility. Given the published information available at the time, it was equally plausible that the 1927 earthquake occurred much closer to shore and on a northwest-southeast trending fault. No one knew for sure. This alternative raised the very real possibility of the recurrence of an earthquake equal in magnitude to the 1927 earthquake very near the plant site. This was the only conservative interpretation possible. Had PG&E gone only so far as to recognize this as a possibility, additional offshore studies would have been recognized as essential.

PG&E has argued that of the four published locations, the location they used was the generally accepted location. This is true, but the location and source fault of the earthquake had never been studied in detail prior to 1968, and no one knew which location was most accurate. Moreover, no one had any particular reason to be concerned about the precise location or source of this earthquake until PG&E proposed building a nuclear power plant in the vicinity. PG&E, on the other hand, had every reason and should have had every incentive to thoroughly investigate this event crucial to the safe siting of the Diablo Canyon plant.

6. The 6.75 Earthquake PG&E Assumed In Designing The Plant Was Actually 12 Miles Away and Was Not Conservative

PG&E has also argued that none of the deficiencies DRA has cited in their original siting studies mattered because the 6.75 magnitude earthquake that PG&E assumed was possible beneath the site was an assumption so conservative that no matter what faults

might exist offshore, they wouldn't have affected the design of the plant.

Again PG&E is just plain wrong. PG&E has over simplified the actual design process they used and on the basis of this over simplification has asked the Commission to draw a conclusion patently incorrect. PG&E's seismic design consultant John A. Blume developed the design basis of the plant based upon this assumed 6.75 magnitude earthquake. When he did so, he treated it as though it were located at an equivalent horizontal distance of 12 miles. His seismic design formula treated depth the same as horizontal distance and the earthquake PG&E assumed beneath the plant was actually assumed to occur at a depth of 12 miles. This is illustrated in Figure 9. Blume's formula treated earthquake E2 in the illustration as equivalent to earthquakes D and E1.

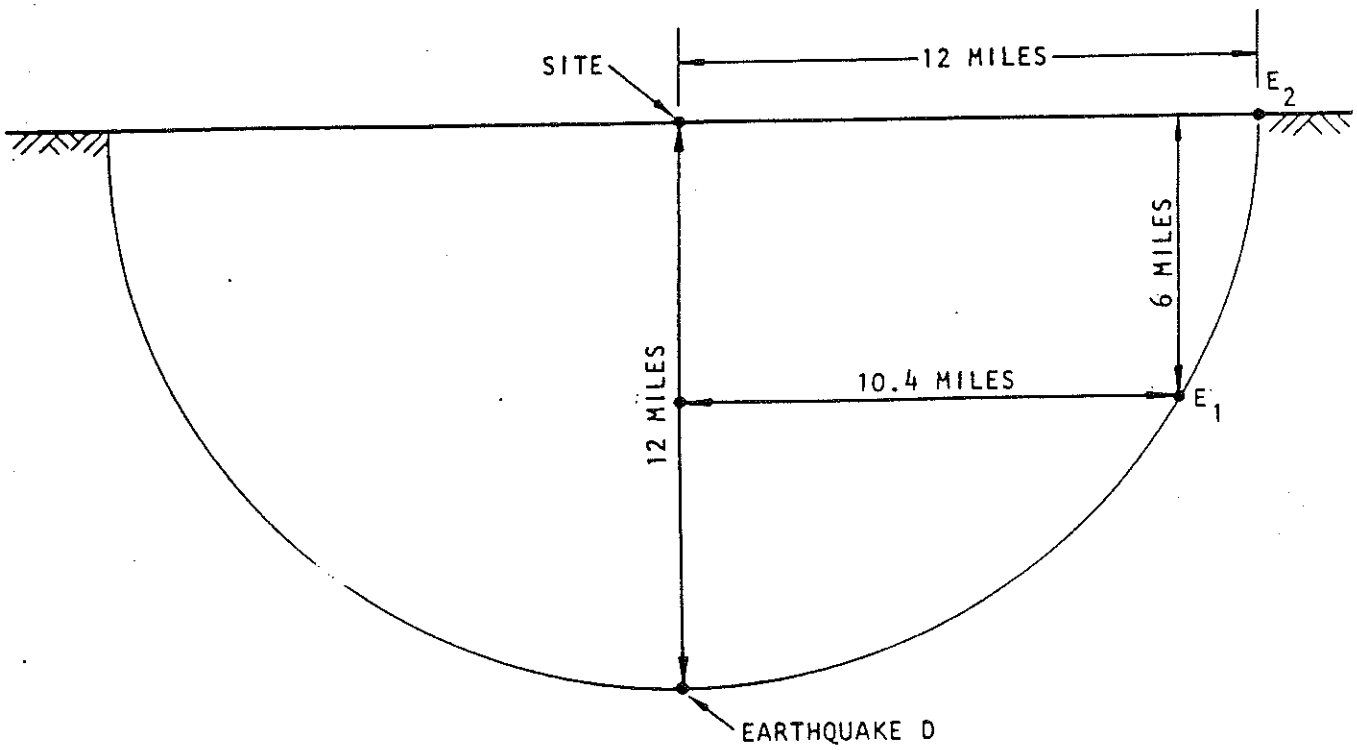


FIGURE 9 - Earthquakes Equivalent To The Assumed Earthquake Beneath The Site

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

Bodega Bay plant for ground motion of 0.67g with occasional peaks of 1.0g. PG&E's claim is clearly incorrect.

F. Deficiencies in PG&E's Response Response To The Discovery of the Hosgri Fault

Over the 8 year period from the issuance by the NRC of the construction permit in 1968 to the date the seismic design issues were finally resolved in 1976, PG&E did little to correct the deficiencies in their original geological and seismological siting studies. PG&E delayed conducting additional geoseismic studies, even though such studies were clearly warranted by the discovery of the Hosgri fault and clearly required by NRC requirements.

1. The Discovery Of The Hosgri Fault

In January 1971 a landmark article was published by two Shell Oil Company geologists, Hoskins and Griffiths, that identified significant faulting offshore of the Diablo Canyon site. The article indicated the presence of a long fault nearly 90 miles in length trending in a northwesterly direction parallel to the coastline within three to five miles of the Diablo Canyon site. This fault later became known as the Hosgri fault.

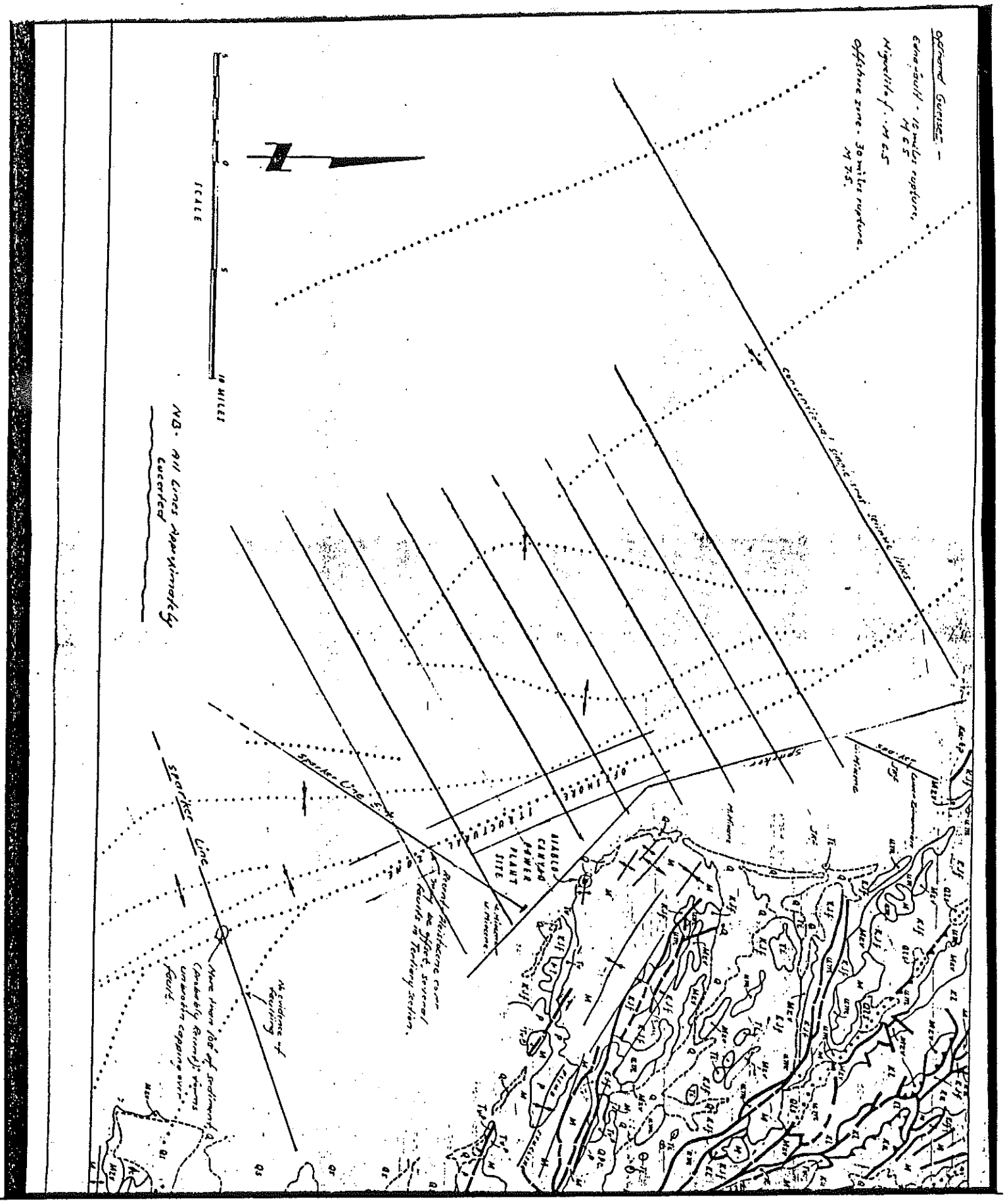
Although PG&E's chief consulting geologist, Dr. Richard Jahns read the Hoskins/Griffiths article sometime in the Spring of 1972, but he did not investigate the faulting disclosed in the article at that time or pass the information on to PG&E. The discovery apparently went unnoticed by PG&E until October 1972 when Douglas Hamilton, one of PG&E's consulting geologists, on both the Diablo Canyon and Mendocino siting cases, brought it to the company's attention. The article also indicated the presence of faulting offshore of PG&E's proposed Mendocino nuclear plant site.

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,



1973 GEOLOGIC MAP OF DIABLO CANYON
by Doug Hamilton, PG&E consultant, with
original notes of potential earthquakes

FIGURE 10

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

PG&E's Unit 1 Final Safety Analysis Report which was filed in July 1973.

5. PG&E's Cancellation Of Previously Planned Offshore Studies, After Their Discovery Of The Hosgri, Was Clearly Imprudent

PG&E did no investigation of either the Hosgri or the 1927 earthquake prior to filing their FSAR. When PG&E learned of the Hosgri fault in the fall of 1972, instead of promptly conducting offshore studies to fully evaluate the significance of the fault, PG&E instead cancelled previously planned offshore studies. The offshore studies which PG&E cancelled had been previously planned to comply with new NRC siting requirements for PG&E's planned Diablo Canyon Units 3 and 4. They were scheduled to be conducted in December 1972 or January 1973, and would have been conducted in the same general vicinity as the Hosgri. When the Hosgri fault was discovered these studies should have been expanded in scope rather than cancelled. Neither the offshore studies previously planned for the end of the year 1972 for Units 3 and 4, or those outlined by Hamilton in April 1973 were conducted. PG&E conducted no offshore studies whatsoever prior to filing their Diablo Canyon Unit 1 FSAR although NRC siting requirements clearly required such studies.

PG&E has claimed that the studies planned for Units 3 and 4 were cancelled because of the passage of the California Coastal Zone Conservation Act in November 1972, and not because of the discovery of the Hosgri. This argument misses the point, and in any event is contrary to the evidence DRA has obtained. Regardless of the status of the company's plans for Diablo Units 3 and 4, when the Hosgri was discovered the planned offshore studies became more important than ever to conduct. They clearly should have been conducted to determine whether Units 1 and 2 were adequately designed. Moreover, the California Coastal Act actually provided PG&E with a new incentive to expand their

studies of potential power plant sites in order to ensure that such sites were included in the Coastal Plan required to be prepared under the new act.

PG&E's failure to promptly conduct such studies following the discovery of the Hosgri fault was clearly imprudent beyond any reasonable doubt.

6. Deficiencies In PG&E's Geoseismic Studies Delayed Completion Of The Project From 1976 to 1981

Hamilton's estimate of the earthquake potential of the Hosgri fault was never disclosed to the USGS or NRC. PG&E argued against the possibility of such a large earthquake on the Hosgri for three entire years. The concerns over the adequacy of the design of the Diablo Canyon plant finally came to a head with the publication of a study in 1975 by Gawthrop under the direction of the USGS. Gawthrop re-evaluated the location of the 1927 earthquake using modern methods and demonstrated that the location PG&E had assumed was clearly in error and that this large quake could have occurred on the southern end of the Hosgri fault. PG&E responded to Gawthop's study by hiring an additional seismology consultant, E.R. Engdahl, to independently reevaluate the location of the 1927 earthquake using modern methods and to test Gawthrop's conclusion. Engdahl's results coincided with Gawthrop's and confirmed the possibility that the 1927 earthquake could have occurred on the Hosgri fault. Even after receiving Engdahl's results, however, PG&E continued to argue against the possibility of a large earthquake on the Hosgri. The seismic design concerns raised by the discovery of the fault were finally resolved in May 1976 when the NRC staff accepted the geologic interpretation of the USGS and required PG&E to redesign the plant to withstand a magnitude 7.5 earthquake on the Hosgri.

From the date PG&E learned of the Hosgri in October 1972 until May 1976 the company continued to construct the plant. By

1976 PG&E had essentially completed the plant using the original, and by then obsolete, seismic design criteria. Nearly three years of delay in resolving seismic safety and design issues raised by the discovery of the Hosgri fault and greatly increased plant costs which resulted from the necessity to redesign and reconstruct an essentially completed plant are directly attributable to deficiencies in PG&E's geoseismic studies.

IV. DEFICIENCIES IN PG&E'S ENGINEERING CONTROLS AND QUALITY ASSURANCE CAUSED THE MIRROR IMAGE AND OTHER DESIGN ERRORS, AND WERE THE DIRECT CAUSE OF PROJECT DELAY FROM 1981 TO 1985

A. PG&E's Failure to Evolve Its Engineering Controls Allowed Design Errors to Go Undetected and Contributed to the NRC's Loss of Confidence in the Design of the Plant

After years of effort by PG&E to minimize the significance of the Hosgri fault, PG&E was directed by the NRC in 1976 to redesign the safety-related components of the plant. This "Hosgri redesign" began in the late-70's, and required a substantial engineering and construction effort by PG&E consisting of both seismic reanalysis and modifications to the plant. By September 1981, the Hosgri redesign and modifications were virtually complete. On September 21, 1981, the NRC authorized a low power operating license for Unit 1. Less than one week after receiving its Unit 1 operating license, PG&E informed the NRC of the discovery of a dramatic design error, an error that is commonly referred to as the "Mirror Image Error". Numerous other design errors were later discovered, along with deficiencies in the process used to develop, distribute and control design information at Diablo Canyon.

The discovery and disclosure of these design errors and design process deficiencies resulted in the NRC losing confidence in the adequacy of the design of Diablo Canyon. As a result, on

November 19, 1981, the NRC suspended the Unit 1 low power license and ordered PG&E to conduct an Independent Design Verification Program to assure the NRC that the design of Diablo Canyon met applicable licensing requirements. When it first received its low power license for Unit 1, PG&E was projecting the cost of the completed plant to be about $2.4 billion. Instead, that cost more than doubled, to $5.518 billion, due overwhelmingly to PG&E's need to restore the NRC's confidence in the design of the plant and correct the pervasive design errors committed by PG&E during the Hosgri redesign.

In September, 1983, the Executive Director of Operations for the Nuclear Regulatory discussed the causes of the mirror image and other design errors with the NRC Commissioners. In doing so, he succinctly summarized what the DRA has independently concluded:

> "The basic cause for most of the design errors was the failure of PG&E management to recognize, at the time of the Hosgri re-evaluation in the mid-70's, the significance of the revised seismic design requirements and the attendant need to implement a vigorous and well controlled redesign effort in accordance with the requirements of its quality assurance program." (William J. Dircks, NRC, Executive Director for Operations, NRC, SECY-83-366, September 6, 1983; Subject: Diablo Canyon Unit 1 Verification Program - Staff Recommendation)

After reviewing contemporary documentation and interviewing key participants, the DRA found that PG&E management did not recognize the significance and importance of the revised seismic design requirements in effect during the Hosgri redesign. Nor did PG&E recognize the need for and implement a vigorous and well controlled redesign effort in accordance with the requirements of its quality assurance program. Once again, PG&E management failed to appreciate and understand the risks to public health and safety which must be addressed in the design and construction of a nuclear power plant. Due to these risks, an applicant for an operating license must demonstrate to the NRC that it meets all applicable licensing requirements. The

ultimate responsibility rested with PG&E to provide assurance to the NRC, that Diablo Canyon was properly designed.

The process which is intended to provide this assurance is referred to as quality assurance. Through training, documentation, reviews, inspections and appropriately structured communication, the utility must be satisfied that safety-related portions of the plant are properly designed and constructed. Quality assurance practices are intended to prevent errors where possible and to detect those that inevitably occur. A utility's quality assurance program should equip the utility with the information necessary to provide the NRC with adequate confidence in the plant's design and its ability to function safely. Despite its responsibility to provide assurance of a quality plant design, PG&E allowed its design consultants to perform the most sensitive safety-related work for the Diablo Canyon plant without requiring them to check their work for mistakes and without imposing the simple discipline required to ensure that PG&E's communications with those consultants would be clearly understood.

PG&E had committed itself to enact systems intended to provide confidence in the design of the plant. In this and other instances, however, PG&E did not enact those systems until it was too late to guard against design mistakes. Nonetheless, PG&E asserted before the NRC that it had met its responsibilities and was granted its low power operating license in September of 1981. Errors can occur on any large and complex costruction project. However, a quality assurance program is expected to minimize such errors and to detect and correct errors that do occur. Quality assurance is a critical function in a nuclear power plant because errors affecting safety-related plant components can jeopardize the public safety and can be extremely costly to correct.

PG&E has offerred the testimony of two former NRC employees, MR. Vollmer and Mr. Eisenhut, in an effort to show that the action of the NRC in suspending the Unit 1 low power

license was too harsh, that the NRC staff never thought such action was warranted, that the suspension only represented the NRC's effort to improve its own credibility. Perhaps PG&E is trying to draw attention away from the fact that the IDVP was going to occur whether or not the license was suspended. Perhaps PG&E would just as soon have this Commission forget that the NRC staff had prepared and agreed with the requirements of the IDVP and that PG&E had also agreed to its terms.

Regardless, Eisenhut and Vollmer create a misleading restatement of history. Although they were both interested in events at Diablo Canyon, neither Eisenhut nor Vollmer objected to the NRC's actions at the time. We found that senior management of the NRC -those to whom Eisenhut and Vollmer reported- supported the requirements of the IDVP. Although they claim to be offering the "NRC's" perspective of events at the time, Eisenhut and Vollmer were not in attendance at key closed meetings of the NRC at which the merits of various responses to the problems at Diablo Canyon were discussed.

Although these arguments represent an almost embarrassing effort to blame the NRC for PG&E's mistakes, the DRA has investigated PG&E's claims that the license suspension was politically motivated. We found that, if anything, contemporaneous political pressure was to expedite the commercial operation of nuclear power plants. We found that the NRC commissioners, who had previously placed great faith in PG&E's claims that the plant had been carefully designed and constructed, were deeply concerned about the potential for more safety-related errors after it became evident that Blume, a key seismic design consultant, was able to make such a fundamental mistake. When early investigations found not only more errors but quality assurance deficiencies as well, the commissioner's confidence in the design of the plant evaporated. The license was suspended so that the commissioners could personally be assured that the plant was safely designed before it began operating.

B. The Mirror Image Error Was Technically Significant and Its Discovery Led Investigators to Other Design Errors and Procedural Deficiencies

In the weeks following the discovery of the Mirror Image Error, it was disclosed that the error had occurred in March of 1977, during the Hosgri redesign. This error occurred when PG&E transmitted to its principal seismic design consultant, John Blume & Associates, a set of unverified, unlabeled sketches of the Unit 2 annulus structure[1] in place of the Unit 1 orientation. There was nothing on the diagrams that identified which unit they were applicable to. Blume personnel, therefore, incorrectly performed seismic response calculations for the Unit 1 annulus piping and other systems using the Unit 2 orientation, and returned the results of the seismic analysis to PG&E mislabeled as applicable to Unit 1. These seismic response calculations are used to determine the response to an earthquake of a structure, piping and other subsystems within a structure. PG&E, who knew that the two units are mirror images of each other, used the data for Unit 1, and then reversed it to apply to Unit 2. This error led to the incorrect calculations of the annulus areas of both units, and to the subsequent use of incorrect seismic response spectra[2] on affected subsystems, such as piping and pipe supports.

After the discovery of the Mirror Image Error, more design errors were discovered. Surveying only a small portion of the plant's design, the NRC found more mistakes. Reviewing a portion

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1. The containment annulus structure, is the cyclindrical steel structure located inside the containment building supporting various piping systems, equipement, and other safety-related components. An error in the design of this interior containment structure can effect critical safety-related components and systems.
2. Seismic response spectra - seismic input to the design of piping and other subsystems within the structure.

of PG&E's quality assurance program, the NRC found that important safeguards were not in place or had not been properly enacted. In testimony before Congress[3], William Dircks, explained the NRC staff's findings:

> ...Our investigators have found that there was a lack of rigor and formality in the procedures used for verifying the accuracy of information transferred by PG&E to its consultants. These procedures did not comply with our requirements calling for the verification of design information at each stage of the process by an independent person qualified in the pertinent disciplines. Proper quality assurance controls were not employed in technical and procurement communications with service-type contractors. Nor were document controls adequate to assure that those involved in design had ready access to the most recent information available.

Proper quality assurance procedures form the foundation for confidence in the plant's design. The NRC staff's findings meant that at least part of that foundation was missing. There was no way to have confidence that some or many additional and significant design errors had not occurred and remained undetected without carefully and methodically reviewing the design itself. In Dircks' own words:

> Because of the inadequacy of QA controls over design verification, procurement and the transmittal of documents to service contractors, the acceptability of the design based on their analyses is now in question. As a result, the Staff has decided that there is sufficient reasons to review the entire process for seismic design; to review the adequacy of other plant design aspects, particularly those that were based on engineering information developed under service-type contracts; and to review the implementation of the utility QA program in these areas.

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3. Presented before the House Committee on Interiror and Insular Affairs, Subcommittee on Energy and the Environment on November 19, 1981. See Exhibit 12,756.

C. The Independent Verification Program Was Required to Restore the NRC's Confidence in the Design of the Plant

The Independant Verification Program (IDVP) required PG&E to demonstrate that safety-related structures, systems and components were properly designed and met all applicable licensing criteria. Where this could not be shown, it was necessary for PG&E to redesign that part of the plant and make all necessary physical modifications. After several months of this effort, PG&E chose to stop trying to justify its existing plant design. Instead, PG&E undertook a complete seismic reanalysis of all major structures and piping systems, including all necessary physical modifications. From this point on, the verification effort changed from a review of the adequacy of past design work to a review of PG&E's new reanalysis. PG&E was no longer willing to try to defend its earlier design work.

At first, most people thought the verification effort would only take several months. Ultimately, it took several years to complete and included PG&E's hiring of Bechtel as part of an enormous increase in its onsite engineering and construction force. There were several reasons for this expansion:

1. PG&E was often unable to produce the design documentation necessary to justify its earlier work.

2. The verification process continued to uncover errors which had to be corrected.

3. PG&E's was cited by the NRC for making a Material False Statement at a meeting with senior NRC officials concerning the independence of consultants working for PG&E during the early phases of the verification process. The company's misleading comments added to the NRC's loss of confidence in PG&E's management and lead to the institution of strict criteria to assure the independence of those undertaking the verfication effort. Those new

independence criteria added significantly to the time needed to complete the verification program.

D. PG&E's Material False Statement Dramatically Lengthened the IDVP By Prompting the NRC to Enforce Strict Procedures to Assure an Independent Review

The strict independence criteria came about largely because PG&E's senior management mislead the NRC about the company's role in the early portions of the investigation following discovery of the Mirror Image Error. PG&E senior management and attorneys met with NRC staff and at least one NRC commissioner on November 3, 1981, to discuss the verification effort. The NRC staff inquired as to the independence of a study being conducted by R.L. Cloud. In the presence of PG&E senior management and Dr. Cloud, PG&E's lawyer responded by saying:

> The report itself hasn't been prepared. If you want a copy of it before we get it, fine or simultaneously. It is an independent consultant, you know, I don't know how we can show you that more than to give you the reports when they are prepared.[4]

Later investigations found that, of the 26 PG&E employees attending the meeting, at least six knew that PG&E had already received and reviewed drafts of the report. Nonetheless, no one corrected the erroneous statement of PG&E's lawyer at the time or thereafter until confronted during an investigation. The NRC ultimately cited PG&E for having made a material false statement. NRC commissioners expressed concern about Cloud's fundamental credibility and future believability as well as PG&E's management attitudes concerning communication with the NRC.

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4. November 3, 1981 NRC meeting transcript, pp.215-217. See Exhibit 12,751.

The discovery of the Material False Statement unleashed feelings of frustration and displeasure with PG&E's management that had been developing among the NRC staff and commissioners for some time. PG&E's senior management was called before NRC officials for a candid and blunt discussion of this and other perceived management problems. In a later memorandum ,senior NRC officials summarized some of the specific management deficiencies wihch were discussed at the meeting.[5] Among other things, the memorandum cited:

> The long problems with the PG&E leadership of its Diablo Canyon project, and the clear [NRC] perception of the confusing struggle for leadership between high level [PG&E] legal managers and high level technical managers.
>
> A review of specific instances wherein high level representatives of PG&E appeared incompetent, ineffective, uninformed, ill prepared, and insulting....
>
> The apparent problems within the PG&E engineering staff including 'turf battles', lack of recognition that decisions based on engineering judgment must be documented, the reluctance to admit that errors can be made by even Senior Engineers, the strong reluctance to question work done by expert technical consultants, and the reluctance to communicate between engineering departments....
>
> The insensitivity of PG&E management to regulatory requirements and concerns. For example, the failure to implement quality assurance requirements consistent with NRC regulations with its principal service contractors until late 1977 or early 1978, and the failure to amend the Hosgri report when revised seismic design spectra were provided to them by URS/Blume in 1979.

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5. Memorandum, "Meeting with the Chairman of the Board of Directors and Two Senior Vice Presidents of PG&E," from DeYong and Engelken, NRC, to Dircks, NRC, March 12, 1982. See DRA Exhibit 12,772.

The material false statement became a very costly mistake. It was fundamental to the decision to replace Cloud with Teledyne Engineering Services as leader of the verification effort and the development of a strict protocol to assure the independence of the design review. The independence protocol required communications between PG&E and the IDVP team to be formalized in writing. Face-to-face discussions had to become public meetings. The result was a much more cumbersome and time-consuming review process than would have been necessary if PG&E had not breached the NRC's trust.

E. During the IDVP, Many Other Technically Significant Design Errors Were Discovered and Corrected

During the DVP, numerous errors in the design of Diablo Canyon were uncovered. This resulted in a 100% seismic redesign of the plant, involving extensive reanalysis, redesign and plant modifications in both Units. PG&E would have this Commission believe that this seismic redesign was all unnecessary "technological upgrades" and was "forced" upon them by the NRC. PG&E argues that, in fact, the IDVP uncovered few errors and that those errors were insignificant. This position is untenable and contrary to recorded evidence and common sense. It must be remembered that, early in the IDVP, PG&E gave up on its efforts to defend its Hosgri design work and voluntarily expanded the reanalysis. When PG&E chose to conduct a 100% seismic redesign, the IDVP stopped counting errors in the original design. At the time, PG&E called this activity Corrective Action--an effort to correct design problems. Now, PG&E prefers "technological upgrades".

There were no changes in the seismic design criteria during the DVP. This means that, during the DVP, PG&E had to meet the identical licensing criteria as before. If there had really been no errors, PG&E should have easily been able to justify that it met applicable licensing criteria and consequently assure the NRC

that the plant was properly designed. Assuring that the plant was properly designed was always a necessary part of PG&E's responsibility in order to obtain an operating license. It is always up to the applicant to demonstrate in any way it chooses, that the design of the plant meets applicable licensing criteria. The simple facts are that errors were found, PG&E could not demonstrate the adequacy of the original design and therefore PG&E had to correct the errors.

Generally, when there is any question of the adequacy of a design, an engineer will first review the original analysis to ascertain whether there are any errors in the underlying design or assumptions. If the steps of the original analysis can be clearly traced and if no underlying errors are found, the process stops there. However, if it proves impossible to verify the original design, either because of a lack of documentation, undocumented engineering judgment utilized in the original design assumptions, or discovery of poor engineering judgment utilized in the original design, reanalysis is the next step. During the reanalysis stage, the engineer essentially "sharpens his or her pencil" in order to avoid any hardware modifications. The absolute last resort, is to make hardware modifications. This is generally avoided. In PG&E's case, they were unable to verify much of their original design at the beginning of the verification effort. This was due precisely to lack of documentation for the original design and undocumented or poor engineering judgment. It is inconceivable that PG&E would have undertaken such an unprecedented redesign effort during the DVP, unless PG&E could not demonstrate the validity of its earlier work. PG&E simply could not meet its licensing requirements and was unable to assure the NRC that the design of the plant was adequate. PG&E's argument regarding technological upgrades is simply another attempt to obscure the truth. Indeed, the DRA found that these so-called "technological upgrades all involve techniques or methodology that were available either before or during the Hosgri redesign. The crucial question for this Commission to determine is why this 100% seismic redesign

occurred. The DRA will show that the 100% seismic redesign of the plant was found necessary because of PG&E's unreasonable errors.

The significant issues that affected the extensive seismic reanalysis and seismic requalification during the DVP are quite simple and easily understood. Because of errors and omissions that were committed during the Hosgri redesign, and discovered during the DVP, the mathematical models of the buildings were changed. These changes in the mathematical models of the buildings affected the seismic response spectra, which is used to design all the systems and components within and attached to a building. The generation of new response spectra for the buildings, resulted in the extensive seismic reanalysis and requalification of all systems and components. Every time there was a change in response spectra, the systems and components had to be reanalyzed, a fact that even PG&E readily admits.

These errors in the seismic design of the plant were pervasive and resulted in numerous and substantial modifications. For example, reanalysis of the piping alone, required the seismic reanalysis of approximately 27,000 pipe supports and resulted in modifications to over 55% of the pipe supports in Unit 1 and over 80% of the pipe supports in Unit 2. There were also numerous revisions to the response spectra which resulted in numerous reanalysis of the piping and pipe supports and other systems and components.

The seismic redesign effort was simply staggering. Not only did PG&E have to make corrections to mathematical models of the buildings, in some cases, they modified the building in order to accurately reflect the model. In this case, the model did not accurately represent the seismic response of the building. Substantial structural modifications were required so that the building would respond during an earthquake in the manner represented in the mathematical model. In sum, the resulting modifications were significant. Furthermore, these modifications

were made to a plant that was substantially complete, which made those modifications all the more difficult. The DRA will demonstrate conclusively that the 100% seismic redesign of Diablo Canyon during the DVP was caused by PG&E's errors and omissions. Had PG&E management appreciated the task presented them during the Hosgri redesign, and taken the appropriate steps to control the seismic design interface and had an adequate Quality Assurance program in place, these serious errors would have been avoided.

PG&E claims that the Diablo Canyon plant would have functioned safely had none of the errors been detected. Whether or not this is true, it could not have been known at the time that the license was suspended and the IDVP was initiated. Because PG&E's quality assurance effort at Diablo Canyon had been deficient, the NRC's confidence in the design of the plant could not have been restored without the IDVP. It was necessary to complete the IDVP before anyone could know that the plant could function safely. Further, because PG&E voluntarily stopped trying to defend it Hosgri design work and reanalyzed all of the safety-related design, we will never know how many errors had actually occurred. We will never know whether the plant could have performed safely without those errors being corrected.

F. The Nuclear Industry's Historical Focus on Quality Assurance Places PG&E's Engineering Control Failures in Context

In many cases before this Commission concerning the reasonableness of past actions, the greatest challenge is to establish the standard of conduct which applied at the time of the activities in question. Judging PG&E's actions related to the seismic design of Diablo Canyon raises no such problem. The design errors which prompted the verification program occurred in 1977 and later. In 1977, there were deficiencies in quality assurance which allowed the errors to occur and remain

undetected. By 1977, there had been more than a decade of dialogue between regulators and utilities, among participants in the nuclear industry and within PG&E concerning the critical importance of design control. As early as 1966, AEC Commissioner James T. Ramey was talking to utility executives about the importance of design control. In a 1968 speech, Ramey accentuated the challenges faced by those firms (such as PG&E) which were attempting to build their first nuclear plants:

> ...the consequent diffusion of project responsibilities, thrust in some instances upon insufficiently experienced organizations, gives rise to concern. This situation affords a potential for errors and omissions, particularly at the interfaces among the participants. It places a greatly increased requirement on the utility for establishing appropriate project management arrangements integrating the resources of the utility, the reactor plant supplier, the architect-engineer, and constructor. Although this change can eventually result in a utility obtaining a plant which more nearly meets its requirements, the present inexperience in the nuclear field of some utilities presages disappointments, difficulties and delays with all their cost implications....Such adverse economic ocnsequences are likely to be compounded by the general escalation of costs as reactor suppliers and vendors attempt to recover adequate profit margins and by rising interest rates, which further add to the cost of delay...
>
> This overall situation demands leadership and urgent attention by the utilities, both individually and collectively. It demands recognition that design, construction, operation and maintenance of a nuclear plant require a systematic engineering approach, utilizing the highest degree of technical competence and effective application of quality assurance programs.

The importance of design controls was recognized in the NRC's regulations governing quality control, issued in draft in 1969 and finalized in 1970.[6] These rules set forth 18 criteria for an adequate quality assurance program. The first and longest specific criterion included in those regulations is the criterion

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6. 10 CFR 50, Appendix B.

addressing design control. At least some people within PG&E recognized the significance of these new regulations even before they became final. In April, 1968, PG&E's William J. Lindblad wrote a memorandum in which he contrasted PG&E's existing quality assurance efforts with those required for Diablo Canyon by saying:

> There are a number of reasons why the nuclear units at Diablo Canyon will require a substantial extension and formalization of such a program. Among these reasons are the following:
>
> 1. There is the potential of hazard to the public should a major failure of certain plant systems occur. There Company has the primary responsibility for protecting its employees and the public from such potential hazards.
>
> 2. New safety codes permit greater allowable stresses for more economic design if the material and fabrication quality are verified to be superior.
>
> 3. The nuclear sustems use some materials, techniques and applications that are not as familiar to the Company engineers as those used in the design of previous plants.
>
> 4. Regulatory agencies, such as the AEC, will discharge their responsibilities for public safety by critically reviewing our quality assurance program.

In 1970, PG&E and other major participants in the nuclear industry formed a committee to develop concensus standards for quality assurance programs. The other participants included Bechtel, Westinghouse, Babcock & Wilcox, and several other utilities. In October 1971, recognizing the need for more detailed standards related to design control, the committee designated a working group to draft such standards. These design standards existed in draft form for several years and were finally approved in June, 1974. As a member of the committee reviewing this standard, PG&E had access to draft standards as they were developed. They participated in the concensus process that led to the final standard. In 1973, while these standards were in draft form, AEC officials (including Commissioner Larson and the directors of Regulation and Safety) came to San Francisco

to meet with utility officials from the region. The purpose was to emphasize the importance of quality assurance in the early phases of a nuclear project, particularly engineering and design control and procurement activities. Despite all of this, PG&E never incorporated the industry's design standards in its quality assurance program for the design of Diablo Canyon. Even when PG&E undertook the important task of the Hosgri seismic redesign in 1977, PG&E did not make use of the standards it had helped to develop several years earlier.

PG&E's major defense of the adequacy of its quality assurance program is that, depsite all of its quality assurance inspections, the NRC never found any problems. This is simply not true. Audits and inspections by the NRC, PG&E and outside auditors consistantly found problems with PG&E's quality assurance program and its implementation. In addition, as PG&E well knew, the NRC only audited a minute fraction of PG&E's activities related to quality assurance. All the while, people within PG&E were well aware of deficiencies in the design quality assurance program. In May of 1977 (approximately the same time when the mirror image error occurred), one of PG&E's Quality Assurance auditors (Thomas de Uriarte) responded to the fact that NRC officials did not think there were problems with PG&E's design controls by writing: [7]

> My personal opinion is that the NRC has never audited our design control very thoroughly in the past...They have concluded that interface control exists because they have run into very few design confusions or omissions, but they have never come into the General Office and performed a detailed design control audit...In digging into [one specific] problem here in the General office, an interface problem was discovered by the NRC inspector. My point in bringing this up is that that is one of the few times where a design issue has been questioned and an interface problem was found. It is my personal belief that we do have design interface control problems....this is an area perhaps we should dig into internally a little more before the NRC does.

However, PG&E did not look at its design control program thoroughly enough or soon enough. Senior management rejected a proposal by the Quality Assurance program director to conduct an audit of the entire program in 1977. Management again rejected the audit proposal in 1978. The same program deficiencies that permitted the Mirror Image Error to slip through undetected were noticed in a 1979 audit of the Blume organization. Nonetheless, the problems went unaddressed until the Unit 1 license was suspended.

PG&E was well aware that its primary challenge in its effort to restore its low power license for Unit 1, was to restore the NRC's confidence in the design of the plant. PG&E's Chief Civil Engineer R.V. Bettinger acknowledged this challenge in a December, 1981 letter to the Chairman of the California Seismic Safety Commission. Referring to the independent design verification program, initially managed by Robert L. Cloud Associates, Inc., Bettinger stated:

> We expect that this review and reverification program by R. L. Cloud Associates will be an effective means of restoring public and NRC confidence in our seismic design for Diablo Canyon.

But, in fact, the verification effort had to be expanded before confidence was restored. At the time of the the suspension of PG&E's operating license, no one knew the full scope and significance of the design errors. In order to restore that loss of confidence, it was necessary to analyze the situation fully to reverify that Diablo Canyon met its applicable licensing commitments. That determination could not have been made immediately after the license suspension, even had there been no additional design errors uncovered.

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7. PG&E internal memo to file, dated May 3, 1977, by Thomas G. de Uriarte, pp.4-5. See Exhibit 14,003.

However, additional design errors were uncovered. Each time the IDVP looked, more concerns were raised. Instead of quickly restoring the NRC's loss of confidence, the repeated discovery of additional errors raised more uncertainty regarding the design of the plant. Pervasive errors in the seismic design of the plant were found. This soon led to PG&E abandoning any attempt to justify its original design. Instead, a 100% seismic redesign was initiated by PG&E in order to restore the NRC's loss of confidence and to meet PG&E's obligation to demonstrate that the design of Diablo Canyon met all applicable licensing commitments. We estimate that the cost of restoring the NRC's confidence in the design of Diablo to be $2.4 billion dollars. We will show that these costs are the result of unreasonable errors or omissions on the part of PG&E and must be disallowed from rates pursuant to Section 463 of the Public Utilities Code.

V. CONSTRUCTION DEFICIENCIES ALSO CONTRIBUTED TO DIABLO CANYON COST ESCALATION AND SCHEDULE DELAYS

The vast majority of the cost escalation and schedule delay experienced on the Diablo project was the direct result of two significant errors: 1) PG&E's failure to discover and design the plant to accommodate the Hosgri earthquake fault, and 2) the mirror image error and other design errors. These were not, however, the only significant problems experienced on the Diablo Canyon project. They were the most publicized and had by far the most significant consequence on the cost of the project, but there were numerous other problems that would have had significant cost and schedule effects but for the fact that the schedule delays and cost increases resulting from Hosgri and mirror image error rendered concurrent delays associated with most other problems of far less incremental consequence. These problems were important to investigate, however, both because of the costs they did entail, and for the insight they provide on the adequacy of PG&E's overall management of the project.

Among the additional problems experienced on the project were eleven discrete deficiencies related to the construction of

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

FIGURE 11

CRITICAL PATH CONSTRUCTION DELAYS WITH NO DIRECT EFFECT ON THE DIABLO CANYON UNITS 1 AND 2 COMMERCIAL OPERATION DATES AS A RESULT OF SUBSEQUENT HOSGRI MODIFICATIONS AND DVP ACTIVITIES

TOPIC	DELAY
(1) Engineering Delays to Construction	459 Days to Unit 1 Interior Containment Concrete 206 Days to Unit 2 Interior Containment Concrete
(2) Reactor Vessel Installation	36 Days to Unit 1 Containment Piping
(3) Large Bore Piping	9 Months to Unit 1 Containment Piping
(4) Piping and Pipe Supports	176 Days to Unit 1 Containment Piping 235 Days to Unit 1 Auxiliary Bldg Piping
(5) Electrical Cable Installation	60 Days to Unit 1
(6) HOSGRI Modifications (Vital Tanks)	7 Months to Unit 1 Vital Tanks

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.

Diablo Canyon would have been available to serve PG&E's customers during the period for which it had been intended. By failing to bring Diablo Canyon into operation in 1976, PG&E, its shareholders and ratepayers lost valuable opportunities:

- The opportunity to avoid billions of dollars in additional construction and financial costs in an era of double digit inflation

- The opportunity to avoid encumbering ratepayers with the cost of hundreds of millions of barrels of fuel oil during the most critical years of the energy crisis.

PG&E is entitled to recover in rates the reasonable cost of the plant as it should have been completed in the 1970's. In addition, PG&E is entitled to recover the cost of necessary and reasonably constructed capital additions which have taken place since that time. The DRA has included all such cost in its rate making proposal.

The DRA has used what has become the traditional approach for determining the cost of unreasonable errors and omissions (by determining unreasonable direct costs and adding, to those, AFUDC accumulations related to the direct costs and all unreasonable delay) and found that approximately $4.4 billion was unreasonably spent. In addition, the DRA has used a more economically correct method of calculating the lost opportunities and offsetting benefits resulting from the unreasonable project delay and added direct costs. That analysis confirmed that, in this case, the AFUDC method produced a disallowance which closely reflects the net losses to ratepayers resulting from PG&E's unreasonable errors and omissions. We have confidence, therefore, that our method for calculating the disallowance produces an appropriate result.

In its response to the DRA filed testimony, PG&E has produced voluminous additional information concerning costs

related to unreasonable errors and omissions. Prior to the Quantification phase of the case, the DRA will submit revised analysis to reflect consideration of the newly submitted information.

VII. CONCLUSION

The DRA staff, consultants and attorneys look forward to having this opportunity to present the results of this reasonableness review in public hearings, and thank you for your thoughtful consideration.

Respectfully Submitted,

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Dated: June 20, 1988

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon all known parties of record in this proceeding by mailing by first-class a copy thereof properly addressed to each party.

Dated at San Francisco, California, this 20th day of June, 1988.

/s/ BESSIE J. KLAUDT

Bessie J. Klaudt