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MEMORANDUM FOR: George W. Knighton, Chief
Licensing Branch No. 3
Division of Licensing

FROM: Hans Schierling, Project Manager
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Division of Licensing

SUBJECT: DIABLO CANYON UNITS 1 & 2 - LONG TERM SEISMIC PROGRAM PLAN

DATE & TIME: May 22 and 23, 1985
8:30 am - 4:00 pm

LOCATION: Westinghouse Offices (May 22, 1985)
Bethesda, Maryland

Room P-118 (May 23, 1985)
Phillips Building
Bethesda, Maryland

PURPOSE: To discuss PG&E Long Term Seismic Program and NRC comments.

PARTICIPANTS: NRC

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cc: See next page

NRC Staff's Comments on Pacific Gas and Electric Company's
"Long Term Seismic Program Plan January 1985"
For Diablo Canyon Nuclear Power Plant

The NRC Staff and its consultants and advisors have reviewed the program plan for the seismic reevaluation of Diablo Canyon Nuclear Power Plant specified by the condition on the operating license of Unit 1.

Overall, the program plan displays an understanding of the current research, data, working hypotheses and methodologies necessary to carry out the proposed program. The plan is responsive to comments made by the NRC and its consultants and advisors at the four pre-plan meetings.

The overall organization and administration of the program are appropriate. The members of the Consulting Board and the Advisory Groups are selected to respond to key elements of the license condition. The consultants should provide independent state-of-the-art guidance.

The milestone summary schedule has reasonable and timely deadlines that meet the program scope. However, it appears that several segments of the plan may be overly ambitious and may eventually have to be modified to allow completion of the program within three years. In view of this and the possibility of new developments, it is important for the future program to be flexible.

As indicated in the license condition, deterministic engineering studies may be necessary. This should be assessed during the term of the program.

As a result of our review of the program plan the staff has developed the following comments and questions which should be clarified by PG&E prior to program plan approval.

Chapter 3.0 Geological Investigations

The recommendations for topical research in geology, geophysics, and related disciplines, and the extent of areal investigations from site specific to regional, are comprehensive. This broad topical and geographic approach is appropriate and important because the complex tectonic setting of Diablo Canyon, within the system of plate-margin faults and near the northern margin of Transverse Range structures, permits several different interpretations of fault geometry, mechanics, and slip rates. As the designers of the program point out, these different tectonic models lead to different earthquake source parameters and probably also to different estimates of maximum magnitude.

What seems to be lacking--or difficult to extract from the plan is: 1) a clear statement of the major issues to be examined, 2) a sense of priorities for evaluating these issues, 3) specific plans or strategies for testing or evaluating the hypotheses related to these issues, and 4) the areal extent and specifications for new data needed to evaluate specific issues.

Some typical issues mentioned or implied in the text are: the relative importance of strike slip vs. thrust displacement on the Hosgri fault; the amount, sense, and age of displacement on the Hosgri fault; the relationship of the Hosgri fault to the San Gregorio fault and to Tranverse Range structures; the potential for damaging earthquakes near the site from other possible fault sources (strike slip, near surface thrust or reverse faults, buried or folded thrust faults similar to that at Coalinga); and the relative merits and difficiencies of alternative tectonic models.

Evaluating these and similar questions are essential tasks in completing the broader goals of the program and they provide a more specific framework for the geologic investigations than do the designated tasks A and B on p. 3-12. Designing the program as a series of investigations linked to such specific

tasks (or issues) may entail some overlap in work elements but not in the actual work done. More importantly, such a design can clarify objectives, goals, and priorities; facilitate communication between all of those concerned with successful design and completion of the investigation; and permit better tracking of progress and results.

It is important to recognize that new discoveries in geology and seismology will probably continue during and after this program; some of these may raise the same kind of questions which the program plan is designed to address.

The types of studies that are planned are probably those most likely to resolve the outstanding concerns. However, to someone not familiar with the issues, these studies appear to lack focus. For example, pages 3-19 through 3-23 describe investigations (surface and at depth) in the site area on shore, offshore and in the transition area between onshore and offshoe structure. These studies are clearly responsive to one of the staff's major concern's--the possible presence of a major·thrust fault (possibly the Hosgri) beneath the site that is closer to the plant than 5.8 km used in attenuation estimates, the characteristics of that fault, and its earthquake generating capability. It is no benefit to become too focussed on a single problem, but it would make the plan more clear if the initial primary issues were referred to in the same sections as the investigations to resolve them are being described.

More detailed information should be included concerning specific data that will be used, where it will be obtained and how it will be used to resolve the issues.

An additional, potentially useful study that might be carried out is a search for geological evidence of pre-historic large/great earthquakes in soft sediment within river valleys and floodplains in the onshore Santa Maria Basin

and other areas such as low, swampy areas in the Los Osos Valley and Morro Bay area.

Page 3-16, Figure 3.3-1: The rationale for selecting the irregular shaped areas and the details of what geologic structures are to be included is not clear. The program emphasis on proximity of faults, and on the very long Hosgri fault zone is valid, but the shape of the areas seems arbitrary and other faults and geologic structures should receive high priority evaluation. The use of such phrases as "having special importance" and "depend chiefly on the understanding of the seismic capability of the Hosgri Fault" suggest a low role of importance for these other faults. If the Hosgri fault is listric and/or is part of an imbricate system of faults that dip eastward in the zone between the Hosgri and the Salinian block, the close proximity to the site, length and continuity, and genetic interrelationships of these faults is very important to assessing the earthquake hazard at the site. Some related issues include the following:

(1) The possibility that the faults and folds west of the Salinian block may be part of a geologically young listric fault and related fold system. If this is true, the depths to the horizontal shears and the geographic domains for these structures would have to be determined.

(2) Should fault zones such as the Edna, West Huasna, East Huasna, Coast Range Thrust Fault, etc., be evaluated for activity, interconnections, continuity, segmentation, remote sensing character, exploratory trenching study, etc.?

(3) Should allowance be made for specific remote sensing, field, or exploratory trenching studies for the Hosgri, Miguelito, West Huasna, East Huasna, Coast Range Thrust or other faults of this region?

The interpretations should address whether the fault, reverse-fault and fold and microfold relations in this sector of the Coast Ranges are typical of the Coast Range Province, are transitional to the Transverse Ranges or belong to the Transverse Ranges. What kinds of investigations would be conducted to address these types of issues?

Sections 3.4 and 3.5 include preliminary summaries of many important concepts and sources of tectonic modelling analysis in the more recent literature. Evaluation of these is needed and a good deal of professional judgement will be required to do so. How will a tracable record be maintained to provide a basis for the results of the final analysis?

One aspect of the fold-fault studies that may be significant is flexural slip faulting. The possibility of aseismic or seismic folding or faulting as occurred at Coalinga should be considered. What kind of studies are being considered to distinguish these relations for specific structures?

One major plate tectonic discrepancy is how and where the deformation west of the San Andreas is accomodated. Are particular geodetic, plate tectonic, paleomagnetic, or other methods being considered to assess the character and amount (rate) of deformation in this section of the Coast Ranges relative to the northern Coast Ranges and the Transverse Ranges. Geologic maps suggest that deformation by folding and faulting occurs within many of the fault slices of this area, but the magnitude and style of deformation within fault slices and on faults may need to be assessed for this area. To what extent is this being considered.

Page 3-16, Figure 3.3-1 shows the line representing the main trace of the Hosgri Fault north of Point Piedros Blancas as swinging to a more northerly strike and joining the San Simeon Fault. Depicting the faults this way indicates a major intersection and continuity between the faults. Does this

represent the licensee's interpretation? Will new data be presented to support a major linkage between the Hosgri and San Simeon Faults?

Section 3.3, Page 3-24 Item (1). The first paragraph under seismic reflection data interpretations states that structural contour maps will be constructed for two horizons throughout the study area. What are these two horizons, their ages and areal extents?

Page 3-24, (1). What is meant by "Invert model" in the second paragraph?

Pages 3-25 and 3-26 (3). At the January 10, 1985 meeting, existing data within the "inner zone" was described. It consisted of deep borings and a grid of seismic reflection lines among other things. It would be useful to the staff and its advisors if this information was identified in the program plan.

Pages 3-27 and 3-28 (6) and Figure 3.3-1. Should the Outer Zone be extended farther north to include the area where the Hosgri and San Simeon Faults are shown to merge on this figure?

Page 3-30, second bullet paragraph. It is proposed to review stratigraphic studies from onshore regions adjacent to the reach of the San Andreas Fault north of its apparent juncture with San Gregorio Fault. The literature concerning this region should, of course, be reviewed but extensive studies would appear to be less fruitful than expending that time and effort in the region farther to the south. For example, studying the available data to determine the amount of right lateral strike slip faulting versus time on the San Gregorio Fault and how that amount of slip has been distributed among the Palo Colorado, Sur, San Simeon Faults, etc south of Monterey Bay; and the amount of right lateral strike slip and reverse slip that is present on the Hosgri and San Simeon faults.

Page 3-32, Section 3.4. The first paragraph indicates that a generally applicable tectonic model for the region will be developed. A "most favorable" tectonic model supported by the data is desirable if achievable, but all reasonable models (also supported by the data) should be analyzed.

Page 3-33, last paragraph, Section 3.4. What is meant by "majority opinion" in the phrase "the indicated (majority opinion) slip rate on the Hosgri Fault...?"

Page 3-36, last 2 paragraphs, page 3-37, first paragraph and page 3-38, Item 2, Section 3.4. These paragraphs provide a good summary of the way tectonic models and new information should be considered.

Page 3-37, Section 3.4. The second paragraph discusses the final step in tectonic model evaluation which is to identify local structures that are relevant to assessing the risk of the site. In addition to the Hosgri fault and other large well known structures, two large folds that deform the sea floor within the Santa Maria Basin are mentioned. It would be helpful if these folds were identified and locations shown on a map or figure.

Page 3-37, Item 1, first bullet paragraph, and Page 3-43, first paragraph, Section 3.4. Can this paragraph be interpreted as a commitment to obtain new data to fill in the gaps in existing structural tectonic data? As the description of Task A (Section 3.3) does not discuss new work, what is meant by "within the scope of Task A"?

Page 3-40, Item b, Section 3.5. A possible way to gain valuable insight about the specific characteristics of faults, particularly those offshore which cannot be directly examined, would be to compare in considerable detail the offshore seismic characteristics of the San Simeon Fault with the mapable characteristics of this fault onshore. With this information the seismic

reflection characteristics of the Hosgri Fault can then be compared with the seismic reflection and mapped features on the San Simeon Fault. Similar comparisons could be made between the faults in the onshore Santa Maria Basin and their offshore counterparts.

Page 3-44, third through fifth paragraph, Section 3.5. The references to Task A, B and C and Tasks 1, 2, and 3 are confusing. A summary table that briefly indicates what each of these tasks contains would be very helpful.

Page 3-45, Section 3.5. To the list of sub-items under Task C, an additional sub-item should be included. For example, a sub-item with the topic Relationship of the fault under consideration with other faults in this area could be added.

Page 3-4, Section 3.2. The first paragraph states that detailed mapping, extensive trenching and structural analysis by Dr. R. H. Jahns during investigations for the Diablo Canyon site beginning in 1965 confirmed the absence of capable faults within the plant site and its immediate vicinity. While the absence of capable faults in the site area onshore and in the sea cliffs was confirmed the presence of low angle capable thrust faults that outcrop in the shallow water offshore or express themselves as folding near the sea floor, cannot be ruled out.

Page 3-4, third paragraph, Section 3.2. It is not clear that the Quaternary marine and nonmarine deposits and the underlying uplifted terrace bench along the coast between the Diablo Canyon site and Point San Luis have been mapped in sufficient detail to demonstrate absence of faulting or other deformation.

Page 3-27, Item (5), First bullet, Section 3.3. It is not clear what Tasks 4.b. and 4.c. refer to.

Chapter 4 Earthquake Magnitude

Pages 4-2 and 4-3. Statements are made in a number of these paragraphs that "procedures" to accomplish a certain task will be reviewed. Can references to specific procedures that will be examined be given?

Page 4-4, Section 4.2.2. Since the DBE and the analyses performed to date have been based on surface wave magnitude, it is important to be sure that the use of moment magnitude is consistent with the previous work and in and of itself does not raise any technical issues that cannot be resolved.

Page 4-5, Section 4.2.7. Why choose a 30 kilometer radius as the distance for detailed study of the seismicity pattern?

Pages 4-5 and 4-7, Section 4.2.7. During the preliminary meetings PG&E indicated that the existing capability of the local seismic network will be evaluated to determine if additional sites are needed, including possible offshore instruments. What is the status of that evaluation?

Pages 4-7 through 4-10, Section 4.3. Procedures and models for calculating earthquake magnitude are referred to in general and it is stated that they will be reviewed. It is recognized that all procedures and models that will ultimately be considered cannot be identified now. However, which specific ones are planned for use at this time?

Page 4-7, Section 4.3.1. What is meant by the definition of a unified magnitude scale for selection and rejection criteria?

Page 4-10, First paragraph and last paragraph, Sections 4.3.6 and 4.3.7. What previous studies that used slip rate for maximum earthquake characteristic

determination are being alluded to here? Reference should be made to specific weighting schemes that are being considered.

Chapter 4 proposes but does not emphasize that multiple methods will be used to estimate earthquake magnitudes. Methods that have been used for strike-slip faults many be different or inappropriate for reverse-slip or reverse-oblique-slip faults. This discussion does not include a complete or specific discussion of the geological and seismological methods to be used. Some of the issues that should have a greater geological input are:

(1) Are the faults and/or folds west of the Hosgri fault capable of generating strong ground motion at the site?

(2) What criteria can be used in offshore and onshore regions to determine segmentation?

(3) How will slip rate values be determined and will this be used for reverse-slip as well as strike-slip faults?

(4) Will seismological methods only be used to determine width or possible continuity of faults?

(5) Will fractional fault lengths be considered in the analysis?

(6) Will a new set of worldwide data for relevant fault types be used to correlate fault (fold?) rupture parameters and surface wave and moment magnitudes, and if so how will they be prepared?

Chapter 5 - Ground Motion (Empirical)

Page 5-1, Section 5.2.2. The California Division of Mines and Geology has developed a digitization process for strong motion seismic records which seems to circumvent some of the shortcomings of the other methods which have been used.

Page 5-2, Table 5-1. Are you planning to use the strong motion data which has recently been recorded (e.g., the magnitude 7.8 Chilean earthquake)?

Page 5-4, Section 5.3. Why only look at three frequencies (10, 5 and 1 Hertz) in the regression of response spectral ordinates? Is this adequate to characterize the shape of the response spectra? Why is the characterization of the spectra limited to 20 Hz?

Page 5.5, Section 5.3.3. What is meant by the phrase "... average bias associated with reverse fault data..."?

Page 5.7, Section 5.4.2. There has been some data collected in Japan from two-dimensional arrays, and Ralph Archuleta has been doing research with bore hole recordings. Both of these may be important to the strong ground motion analysis. Also, is there data from the PG&E array at Humbolt Bay?

Chapter 6 - Ground Motion (Numerical)

Page 6-1, Section 6. There is controversy as to the proper parameters (such as stress drop, rupture velocity, etc.) to use in modelling strong ground motion. The method developed should be flexible enough to provide sensitivity testing on all parameters.

Page 6-6, Section 6.1.2, The DELTA model which is the proposed starting model in the numerical modelling study underwent extensive review for the SONGS 1 reevaluation program. Towards the end of the review criticism centered about:

(1) Definition of uncertainty.
(2) Assumption of a constant slip function.
(3) Increased use of randomness,
(4) Estimates of Q.
(5) Rupture velocity.
(6) Fit of the model to the Imperial Valley data.

You have devoted some attention to items 1, 2, and 6. How do you intend to deal with items, 3, 4, and 5?

Chapter 7 - Soil Structure Interaction

Page 7-2, Section 7.2. Structural responses are to be computed using both the CLASSI and SASSI codes to try to assess the impact of the various assumptions on the calculations. Would it be appropriate to expend some effort at the beginning of the program to estimate the order of magnitude of the various effects on the response computed by the two approaches so the judgement can be made as to their importance?

There is a recent version of the CLASSI code that does not require that the structural base be flat but rather allows for different levels of the base. Would the use of this version result in an analysis more representative of the Diablo Canyon structures?

How do you plan to incorporate potential liftoff effects, types of structural nonlinearties that could develop in the various parts of the primary structures, and their impact on the soil structure interaction calculations?

Chapter 8 - Seismic Hazard Analysis

Page 8-1, Section 8.1. Do you plan to incorporate engineering considerations such as effective acceleration or damage causing ability of earthquakes in the seismic hazard estimation?

Page 8-1, Section 8.1. Because of the subjective nature of probabilistic assessment of seismic hazard, independent estimates from several experts are considered more appropriate than the opinion of a single analyst.

Page 8-3, Section 8.2.3. How will the results of the empirical and numerical studies of ground motion be integrated?

Page 8-3, Section 8.2.3. Will the stochastic model be used to estimate ground motion in the "deterministic" phase of the program?

Page 8-3, Section 8.2.3. It is not clear how empirical, numerical and stochastic models of ground motion will be used as input to the PRA. Will they be combined or will separate analyses be conducted?

Page 8-4, Section 8.2.4. If the proposed linear filtering of ground motion is used as input for the PRA, a sound technical basis will be needed.

Page 8-4, Section 8.2.4. Is it planned to include the uncertainly in the SSI when it is used in the probabilistic seismic hazard calculations?

We have no specific comments on the Fragility Analysis and Probabilistic Risk Assessment program plans at this time.

The ACRS has requested additional justification for limiting the PRA to a Level I assessment.

We expect that there may be additional comments on the PRA as the program develops.