ENCLOSURE 1

PACIFIC GAS AND ELECTRIC COMPANY

PGandE · 77 BEALE STREET · SAN FRANCISCO, CALIFORNIA 94106 · (415) 781-4211 · TWX 910-372-6587

JAMES D. SHIFFER
VICE PRESIDENT
NUCLEAR POWER GENERATION

June 11, 1985

PGandE Letter No.: DCL-85-210

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-81
Diablo Canyon Units 1 and 2
Long Term Seismic Program Plan

Dear Mr. Denton:

The enclosure to this letter contains PGandE's responses to NRC Staff comments on the Diablo Canyon Long Term Seismic Program Plan. This Program Plan was submitted to the NRC Staff for review and approval on January 30, 1985.

The Staff's comments were forwarded to PGandE by NRC letter dated May 9, 1985. On May 22, 1985, PGandE met with the Staff and verbally responded to the comments. At that meeting, the Staff requested that PGandE provide a documented response.

These responses consist of supplemental clarifying information for items that are currently described in the Program Plan. There are no new studies or investigations proposed in these responses. As the program progresses, additional pertinent information will be identified. PGandE intends to provide the Staff with that information in progress reports and at meetings held during the course of the program.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

for J. D. Shiffer

Enclosure

cc: S. T. Algermissen
D. Bernreuter (2)
R. D. Brown
C. J. Costantino
J. Davis
R. T. Dodds
J. B. Martin
D. Perkins (3)
A. J. Philippacopoulos
M. Reich
R. P. Savio, ACRS (5)
H. E. Schierling (5)
D. B. Slemmons

~~8506190135~~ 30/90

ENCLOSURE

The NRC Staff's comments on the Diablo Canyon Long Term Seismic Program (LTSP) Plan are grouped below by chapter, numbered, and followed by PGandE's response.

Chapter 3 - GEOLOGICAL INVESTIGATIONS

Comment 1

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.

Response

With regard to the geology part of the LTSP, which responds primarily to License Condition 1, the issue being addressed is that of updating the geologic bases for determining the seismic hazard and level of vibratory ground motion appropriate for the design of the Diablo Canyon Power Plant.

Factors now recognized as considerations important to this issue include the following:

(1) Further clarification of the nature of the Hosgri fault, including its seismic capability, down-dip geometry, and relationship to other tectonic features within the Santa Maria Basin structural province.

(2) Identification, characterization, and evaluation of any and all other tectonic features in the region of the Diablo Canyon site capable of generating earthquakes which could create vibratory ground motion at the site strong enough to require consideration in assessing the seismic hazard to the plant. Such features could be represented by faults including, but not necessarily limited to, the Edna and San Miguelito faults, and faults that may be associated with the San Luis-Pismo syncline.

(3) The neotectonics of the Santa Maria Basin region.

(4) The relationship of southern Coast Ranges structures to those of the Western Transverse Ranges.

(5) The distribution of strain within the region of the boundary between the Pacific and North American plates, especially around the latitude of south central California.

Although the priorities for evaluating these factors are still being studied as part of the Phase II Scoping Study, it is expected that they will be assigned priorities approximately in the order of the listing above. The approximate areal extent of data to be used is indicated approximately on Figure 3.3-1 (Rev. 1) which is attached and Figure 3.3-2. Generalized data specifications are listed on page 3-17 and page 3-18 of the LTSP Plan. Detailed specifications are being formulated as part of the Phase II Scoping Study.

Comment 2

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 Transverse 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 deficiencies of alternative tectonic models.

Response

See response to Comment 1 above.

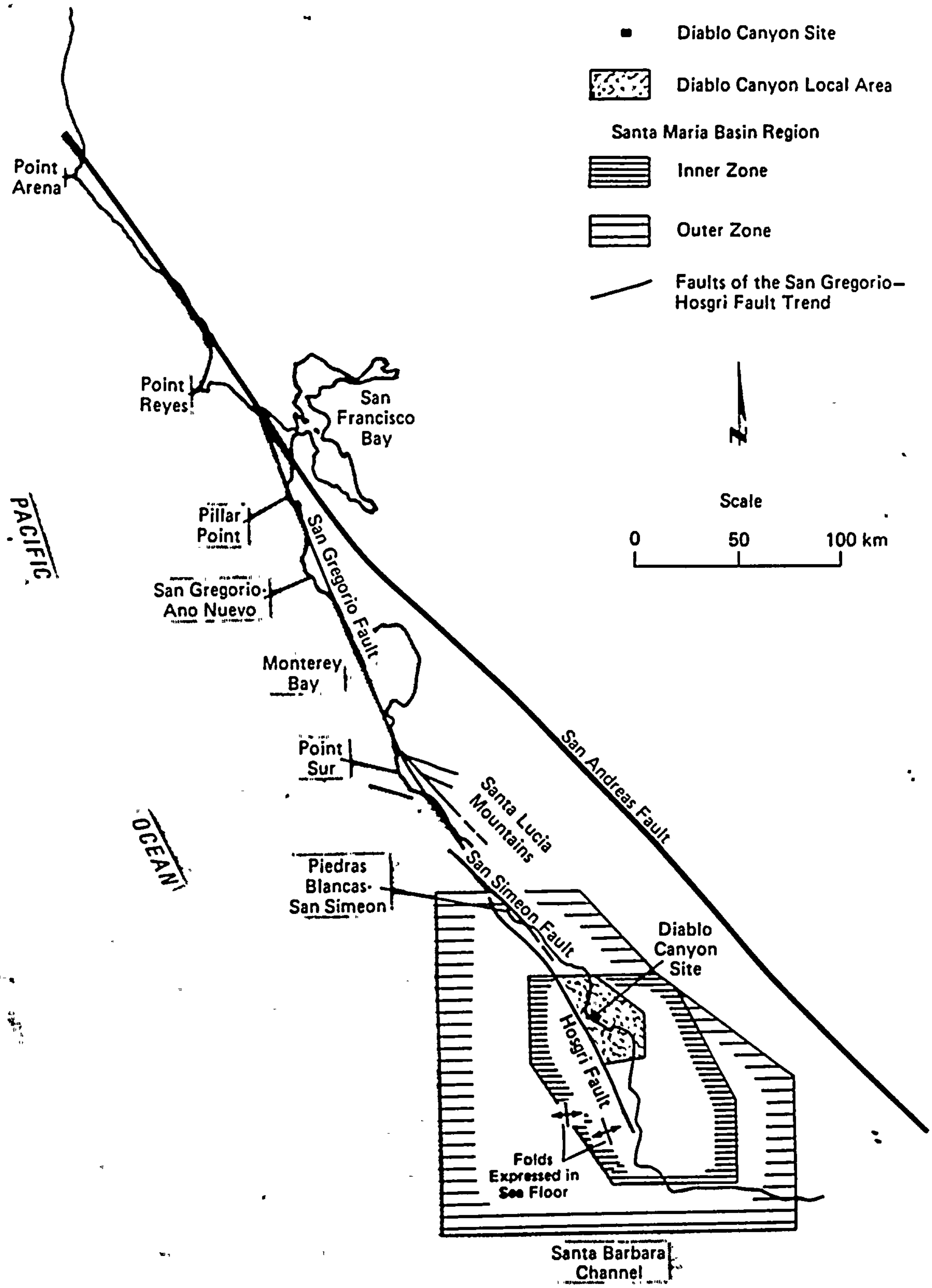
Comment 3

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.

Response

Tasks A, B (and C) were organized so as to relate to License Condition 1 (and 2). Specific priorities and design of the program will be developed as part of the Phase II Scoping Study.

The design of the program will be tested by means of a logic-tree analysis; and the logic-tree format will then be available to facilitate communication, tracking of progress and results, assessment of need for changes to the program, etc.



AREAS FOR GEOLOGIC INVESTIGATIONS

Figure 3.3-1
Rev. 1

Comment 4

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.

Response

Recognition of this fact and the need to incorporate such considerations into the program is indicated in the third paragraph, page 3-36.

Comment 5

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 onshore, offshore and in the transition area between onshore and offshore 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.

Response

These studies are intended to be responsive to the NRC Staff's concern. As the program is further developed, the specific objective of these and other studies will become clearer.

Comment 6

It is no benefit to become too focused 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.

Response

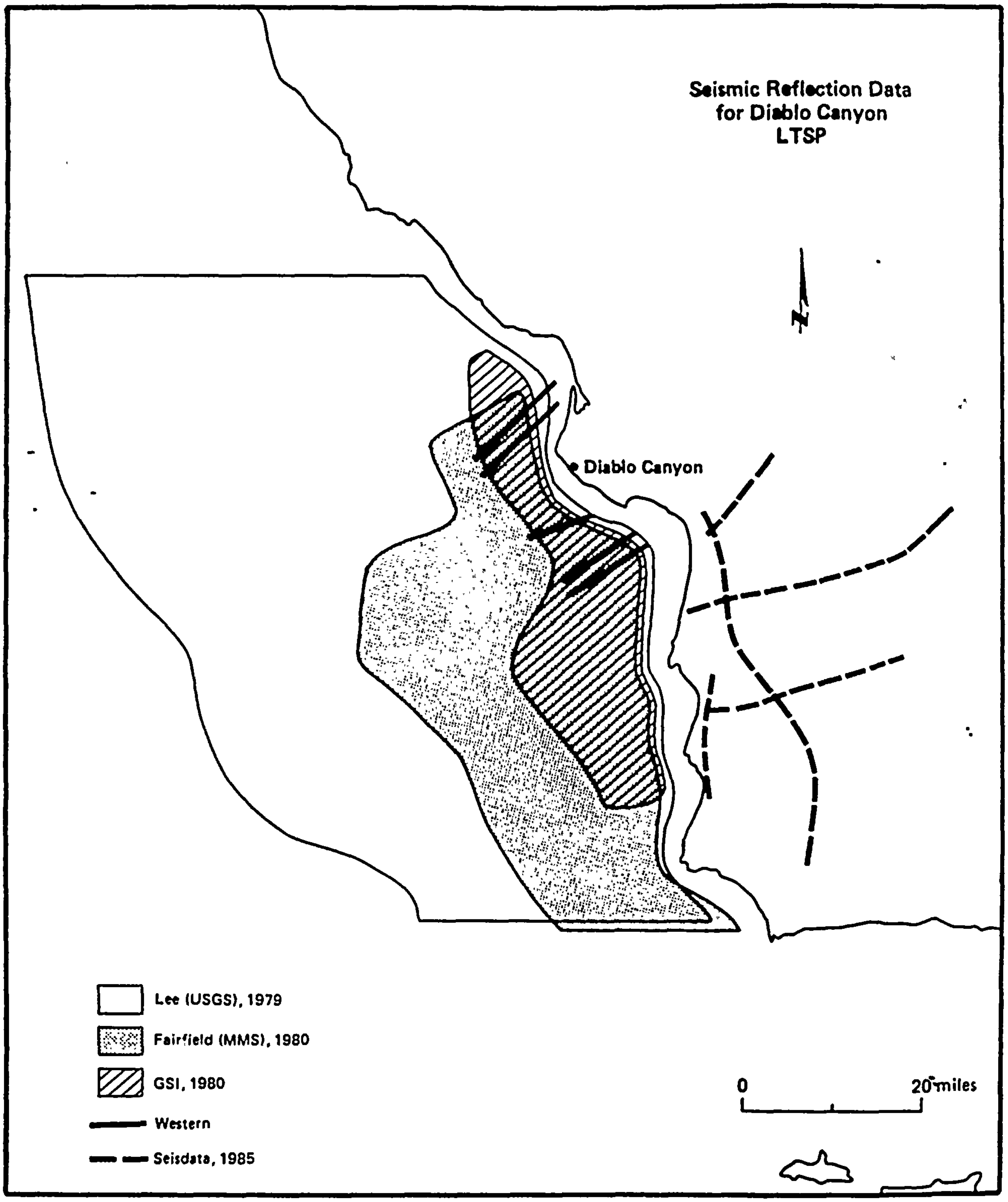
A reference matrix will be provided as the program is further developed.

Comment 7

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

Response

The specific data which will be used is currently being reviewed as part of the scoping study and will be identified in progress reports; the geophysical data presently regarded as likely to be used is shown on the attached figure, "Seismic Reflection Data for Diablo Canyon LTSP," presented at the March ACRS meeting in Los Angeles. Types of data to be used are listed on pages 3-17 and 3-18 of the LTSP Plan.


Seismic Reflection Data
for Diablo Canyon
LTSP
N
Diablo Canyon
Lee (USGS), 1979
Fairfield (MMS), 1980
GSI, 1980
Western
Seisdata, 1985
0
20 miles

Comment 8

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 areas.

Response

Studies involving search for geological evidence of prehistoric large/great earthquakes in soft sediment, at points not related to recognizable tectonic features, are not presently planned since the evidence is nondiagnostic as to either the source or intensity (beyond the minimum level necessary to initiate liquefaction) of vibratory ground motion. Geological evidence of prehistoric earthquakes will, of course, be sought during any trenching studies of faulting or other suspected tectonism at specific locations which might be identified during studies such as those anticipated on page 3-27 of the LTSP Plan relating to deformation of marine and river terraces.

Comment 9

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.

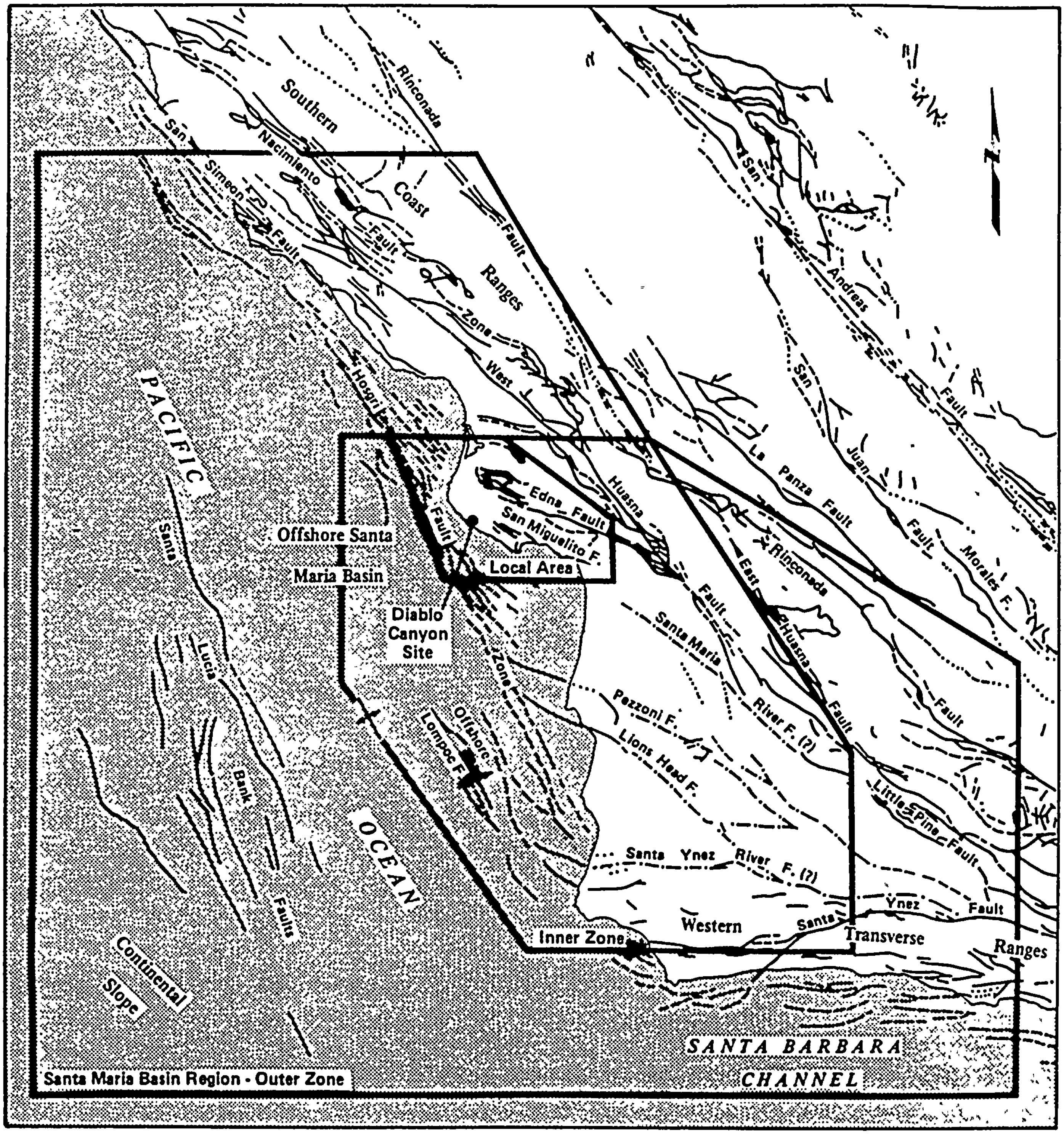
Response

The rationale for selecting study areas shown on Figure 3.3-1 was discussed at the October 1984 meeting with NRC Staff and at the March 1985 meeting with ACRS. The relationship of study area boundaries to tectonic, geographic province, and OCS lease features is shown generally on the figure, "Santa Maria Basin Region," attached hereto. A similar figure was presented at the October meeting. As noted during these presentations, the irregular-shaped areas were selected to correspond to tectonic features at progressively increasing distance from Diablo Canyon except for the west and north boundaries of the Santa Maria Basin, Inner Zone study area, which correspond to OCS Lease Sale 53 boundaries and, therefore, to a region of greater intensity of petroleum industry data and MMS data and hazards studies.

The tectonic features used to define study area boundaries are the following:

(1) Local Area - west boundary is the western side of the Hosgri fault zone, east boundary is the east side of the Edna fault zone, north and south boundaries are arbitrary lines within Estero Bay and San Luis Obispo Bay, respectively.

(2) Santa Maria Basin region, inner zone - east boundary is the East Huasna fault, which defines the east limit of most of the onshore Santa Maria Basin Neogene basins; south boundary is the Santa Ynez fault, the major fault along the north side of the Western



Mapped fault, dotted where concealed.

Trend of proposed subsurface fault. (Hall, 1977; Sylvester & Darrow, 1978).

0 10 20 30 km

0 10 20 30 mi

SANTA MARIA BASIN REGION

Transverse Range structural province, west and north boundaries are tied to OCS Lease Sale 53 boundaries.

(3) Santa Maria Basin region, outer zone - east boundary is the Rinconada fault, south boundary and west boundary are arbitrary EW and NS lines drawn to encompass the southern part of the Santa Barbara Channel, the continental slope west of the Santa Lucia Bank, and the transitional region between. The outer zone north boundary is an arbitrary EW line that encompasses the region of overlap between the Hosgri and San Simeon faults.

Regions beyond the Santa Maria Basin region outer zone will not be ignored. However, studies outside the outer zone will be concentrated along the San Gregorio-Hosgri fault trend or will be directed toward evidence relating to tectonic model and plate boundary considerations.

Comment 10

Other faults and geological 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?

Response

Although the Hosgri fault is identified as "having special importance" in an evaluation of the seismic exposure of Diablo Canyon, at least because of its proximity and dimensions, the other faults within the Santa Maria Basin region will also be studied to evaluate their seismic potential. However, the relative importance of other faults is being evaluated quantitatively during the Phase II Scoping Study.

Issues regarding the nature of the Hosgri fault were anticipated by planning an area-wide study, which will include a regional grid of seismic reflection lines giving both shallow and deep crustal information, rather than concentrating only on linear zones along fault trace outcrops.

(1) This requirement is anticipated in the elements of the LTSP Plan referenced on pages 3-25 and 3-26 for Inner Zone offshore, and page 3-24 for Regional offshore basin study.

(2) Such considerations are included in applicable parts of the Inner and Outer Zone, Onshore studies identified on page 3-26, which specifies such studies for faults in the zone. Named faults are identified in the FSAR, Appendix 2.5C, and on published maps indicated in the References to Section 3 of the LTSP Plan. The principal faults in the study region are indicated on the attached revised figure "Santa Maria Basin Region."

(3) The response for (2) above also applies to this comment.

Comment 11

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?

Response

The objective of characterizing tectonic regions is recognized on page 3-13, third item, "The relationship and neotectonics of the southern Coast Ranges structures to those of the western Transverse Ranges."

Investigations to address this item are as indicated in the response to Comment 3 above; evaluation is as indicated for Task B - Tectonic Model Studies, especially as on page 3-38.

Comment 12

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 traceable record be maintained to provide a basis for the results of the final analysis?

Response

Evaluation procedures will be carried out step-by-step with documentation of each step. A logic tree exposition of the evaluation will aid in documentation.

Comment 13

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?

Response

The general types and sequence of studies envisioned for addressing this issue fall into three categories:

(1) Identification of fold and associated fault structures, mainly by using surface maps data, subsurface well data, and deep seismic reflection data.

(2) Determination of the relative activity of such fold structures, by means of analysis of geomorphic exposure, correlation of stratigraphic units to establish rate of growth, analysis of internal form as defined in (1) above, and correlation with and analysis of any associated seismicity.

(3) Evaluating the seismic capability of tectonism involved in or giving rise to the development of the fold being studied. At present it is envisioned that relationships used to evaluate earthquake magnitude and recurrence rate for faults, including ones involving dimensions of potential rupture surface and rate of deformation, will be utilized. However, this is a new field of analysis, and the appropriate approaches to be applied will evolve as the study progresses.

Comment 14

One major plate tectonic discrepancy is how and where the deformation west of the San Andreas is accommodated. 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.

Response

The studies encompassed within the LTSP geology investigation are designed to yield three-dimensional (map and subsurface) data regarding the pattern and amount of deformation in the Santa Maria Basin region (overall, and within structural subdivisions such as fault-bounded slices) and along the trend of the San Gregorio-Hosgri fault. This data will include long term or

cumulative deformation, late Quaternary deformation and, to the extent that available geodetic and seismologic data will permit, contemporary deformation. The quantitive data compiled and acquired during this program should provide a basis for an improved assessment of the distribution of deformation in the region between the "Big Bend" of the San Andreas fault and the Santa Lucia Bank fault offshore, and should enable comparisons to be made of the pattern and amount of deformation in this region relative to that in the Coast Ranges further north and the Western Transverse Ranges to the south.

Comment 15

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?

Response

The indicated figure line work was degraded somewhat during printing. The faults do not join in the area north of Point Piedras Blancas but are separated by a thick section of Neogene strata. Fault pattern there is shown in detail on Plate II(N) from FSAR Appendix 2.5E, listed in References, page 3-46. Line work representing the fault pattern north of Point Piedros Blancas is clarified on Figure 3.3-1 (Rev. 1).

Comment 16

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?

Response

It is planned that two or three horizons will be contoured as appropriate; these are, from youngest to oldest:

(1) Near top Sisquoc, Lower Pliocene, c. 3 million years

(2) Near top Monterey, Upper Miocene, c. 5 million years

(3) Acoustic basement, pre-Neogene

The Sisquoc and Monterey horizons extend through the offshore basin west of the Hosgri fault except where breached over the offshore Lompoc anticline. The horizons exist east of the Hosgri fault except where breached over the Point San Luis structural high and in the region extending north from northern Estero Bay.

Comment 17

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

Response

Item should have read "Inverse model," indicating a model developed by adjusting parameters so as to correspond to the model indicated from direct interpretation of seismic reflection lines. The purpose of this item will be to check whether unreasonable adjustments are required, which could suggest a need to reevaluate the seismic-based interpretation.

Comment 18

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.

Response

Both existing data and data planned for acquisition have been described in the meetings with the NRC Staff in October 1984 and January 1985 and with ACRS in March 1985. A figure prepared for the ACRS meeting (attached hereto) indicated distribution of "Seismic Reflection Data for Diablo Canyon LTSP." Figures presented at the October 1984 meeting with the NRC Staff indicated distribution of existing offshore seismic lines, offshore wells, and onshore wells in the Diablo Canyon local area. Data to be acquired will be identified in a Phase II Scoping Study Progress Report.

Comment 19

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?

Response

As noted in the response to Comment 15 above, the Hosgri and San Simeon faults were not meant to appear to join north of Piedras Blancas Point. The relationship between these faults in this area and elsewhere will be addressed in the San Gregorio-Hosgri fault trend study, identified on page 3-13 and shown on Figure 3.3-1 (Rev. 1).

Comment 20

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 the 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.

Response

The effort committed to this item will be apportioned generally as this comment suggests. It is believed, however, that review of the amount and distribution of plate boundry motion north of the apparent junction of the San Gregorio fault with the San Andreas fault is important both for understanding the relationship between the two faults and for evaluating the overall plate boundary relative movement.

Comment 21

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.

Response

PGandE's intention is to analyze all reasonable models as indicated on page 3-38 of the LTSP.

Comment 22

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...."?

Response

The referenced paper by Bird and Rosenstock bases the slip rate along the San Gregorio-Hosgri trend used for analysis of the distribution of crust and mantle flow in central California on a "consistency test" wherein they conclude that, since two articles (Hall, 1978 and Graham and Dickinson, 1978) agree while a third (Hamilton and Willingham, 1977) does not, the "consistent" or majority opinion is preferred for the purpose of their analysis.

Comment 23

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.

Response

Comment noted.

Comment 24

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.

Response

The location of the two large fold structures is shown on revised Figure 3.3-1 (Rev. 1).

Comment 25

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"?

Response

Items proposed within Task A do include acquisition of new data where needed. Examples include page 3-17, 2a, 5th item, "New surveys and programs carried out in support of the LTSP"; page 3-20, b(1), 2nd item, "Perform field mapping as needed to resolve discrepancies, fill gaps, and record data on microstructures"; page 3-21, 4th item, "Develop bases in local sampling and agedating ...."; page 3-22, 1st item, "If the above review and reinterpretation indicates a necessity, conduct a new multisensor survey ...."; page 3-27, 1st and 2nd items, "Reconnaissance checking and mapping ...."; and "Local detailed mapping, section measurements, and sampling."

Comment 26

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 mappable 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.

Response

PGandE plans to implement the general concept of comparing onshore and offshore faults. The onshore expression of the San Simeon fault cannot be directly compared with a comparable submerged part of either the San Simeon or the Hosgri faults, however, because of geologic dissimilarities. The onshore San Simeon fault traverses a basement uplift, and the main trace lies mostly within Franciscan rock. In contrast, the offshore part of the San Simeon fault to the north, and parts of the Hosgri fault to the south juxtapose thick sections of Neogene strata against basement. Other parts of the Hosgri fault are altogether within a Neogene section within several kilometers of the surface.

Comment 27

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.

Response

Tasks A, B, and C are identified on page 3-12. Tasks 1 and 2, as used in the referenced paragraphs, correspond to Section 3, "Geology," and Section 4, "Earthquake Magnitude."

Comment 28

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.

Response

Sub-item g, "Relationship of the fault under consideration with other faults in area" will be added.

Comment 29

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.

Response

The issue of whether low angle thrust faults could outcrop in the shallow water offshore or express themselves as folding near the sea floor is recognized. Studies to address this issue are described on pages 3-21 through 3-23 of the Program Plan and include:

(1) Review and interpretation of high resolution and deep seismic reflection geophysical data in order to identify structural features and establish the subsurface structural pattern in the area between the Hosgri fault and the site shoreline.

(2) Integration of geologic data such as dart-core and grab samples into the interpretation derived from geophysical data.

(3) Review of near surface and surface data (e.g. shallow high resolution seismic, side scan sonar, fathometer) and correlation of any observed anomalies with structural features identified in (1) above, taking special note of any evidence of warping, folding, or scarping at the sea floor or in the shallow sub-seafloor section.

(4) Evaluation of distribution of earthquake hypocenters and of focal mechanisms recorded in the area of interest.

Comment 30

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.

Response

The Diablo Canyon FSAR, Appendix 2.5C, Plate VIII shows mapped sectors of the sea cliff exposure of the terrace deposits - rock section. The entire sea cliff exposure has been mapped, and the maps will be incorporated into the LTSP.

Comment 31

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

Response

"Task 4.b." refers to item 4-b-(3) of Task A. "Task 4.c" refers to Item 4-c-(5) of Task A. Item 4-b-(3), "Offshore-Onshore Transition" study program is outlined on page 3-22; this program will be extended to include all of the Inner Zone offshore-onshore interface, as indicated on page 3-27.

Chapter 4 - EARTHQUAKE MAGNITUDE

Comment 1

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?

Response

The term "procedures" is used on page 4-2, in Section 4.2.1, in reference to total fault length. Fault length is defined as the maximum length whereby the fault is considered a discrete structural entity. Fault length will be assessed on the basis of all relevant geologic, geophysical, and seismologic data.

At other locations on pages 4-2 and 4-3, "procedures" refers to various empirical and analytical approaches to estimating maximum earthquake magnitude. These include:

- Total length (Slemmons, 1982)
- Rupture length [fractional (Slemmons, 1982)]
- Rupture length (segmentation) (Schwartz and Coppersmith, 1985)
- Rupture length (Slemmons, 1982; Bonilla and others, 1984)
- Rupture area (Wyss, 1979)
- Maximum displacement per event (Slemmons, 1982; Bonilla and others, 1984)
- Moment magnitude (Hanks and Kanamori, 1979)
- Slip rate (Smith, 1976; Anderson and Luco, 1983)

All of these techniques will be examined for use in magnitude estimation. As noted in the program plan, these magnitude estimation techniques, and others, involve assumptions and conditions (such as fault type and testonic environment) that will be reviewed.

A key issue in the process of magnitude estimation is establishing consistency among magnitude estimates, since multiple techniques and analyses will be used.

Comment 2

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.

Response

A consistent approach will be used throughout the study in the use of magnitude scales and values, particularly in relating magnitude to ground motion.

Comment 3

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

Response

The intent is to focus on the region of coastal California closest to DCPP, and to use these data as part of the evaluation of fault behavior. Similar data at distances greater than 30 kilometers may be used as needed for fault evaluations pertinent to regional issues.

Comment 4

Pages 4-5 and 4-7, Section 4.2.7. During the preliminary meetings PGandE 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?

Response

The status of PGandE's evaluations is as follows:

(1) Preliminary comparisons have been performed of the accuracy of earthquake locations and focal depths, for (1) the existing USGS stations and (2) the existing stations supplemented by assumed station configurations, both onshore and offshore. These comparisons have shown that there is a significant advantage to providing additional stations.

(2) Based on the evaluations to date, PGandE has made a decision to provide additional stations. One scheme being considered is the installation of 12-15 on-land stations. In addition, PGandE is evaluating the feasibility of installing additional instruments in the offshore area.

(3) PGandE will finalize plans and begin procurement of the network equipment during the next few months.

Comment 5

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?

Response

See response to Comment 1 in Chapter 3.

Comment 6

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

Response

A consistent approach will be used throughout the study in the use of magnitude scales and values, as noted in response to Comment 2 above.

Comment 7

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.

Response

Smith (1976) and Anderson and Luco (1983) use slip rate as related to maximum magnitude values. A weighting scheme being considered is called a "logic tree," whereby individual parameters and models can be assigned a weight that reflects the relative confidence in that parameter. Logic trees are being used in seismic source characterization for maximum earthquake estimation (Coppersmith and Youngs, 1982; 1983).

Comment 8

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.

Response

See response to Comment 1 above.

Comment 9

Some of the issues that should have a greater geological input are:

a. Are the faults and/or folds west of the Hosgri fault capable of generating strong ground motion at the site?

b. What criteria can be used in offshore and onshore regions to determine segmentation?

c. How will slip rate values be determined and will this be used for reverse-slip as well as strike-slip faults?

d. Will seismological methods only be used to determine width or possible continuity of faults?

e. Will fractional fault lengths be considered in the analysis?

f. 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?

Response

a. These will be evaluated to assess whether or not they are potential seismic sources, and if they are capable of generating strong ground motion at the site.

b. Fault segmentation will be assessed using the concepts and bases that have been developed along many well-studied fault zones (e.g. Schwartz and Coppersmith, 1984; 1985). Criteria that may be used include: differences in timing of events, differences in elapsed time between events, differences in slip rate, intersections with transverse structures, changes in strike, changes in structural complexity, changes in geometry or sense of slip, and variations in seismicity patterns.

c. Slip rates will be estimated using late Quaternary and Holocene displacement, horizontal and vertical components of slip (see Chapter 3), and comparison with longer term geologic rates. Slip rates will be assessed for both strike-slip and dip-slip faults.

   For maximum magnitude assessments, techniques described by Smith (1976), Anderson and Luco (1983), and possibly others will be considered for use with reverse-slip as well as strike-slip faults.

d. In addition to seismological methods, map pattern, segmentation, and geophysical/structural contours will be considered to assess possible continuity. For evaluation of fault width, crustal structure models, and evidence for brittle/ductile transitions will be included.

e. Yes, such as methods proposed for strike-slip faults by Slemmons (1982).

f. No. The presently available worldwide data set and associated regressions will be used. These are summarized in references given in response to Comment 1 of Chapter 4 and attached here. Attention will be given to the applicability of these regressions to the tectonic environment and fault types being considered.

Response to Comment 9.f

REFERENCES

Anderson, J. G., and Luco, J. E., 1983, Consequences of slip rate constraints on earthquake recurrence relations, Bull. Seism. Soc. Amer., v. 73, no. 2, pp. 471-496.

Bonilla, M. G., R. K. Mark, and J. J. Lienkaemper, 1984, Statistical relations among earthquake magnitude, surface rupture length, and surface fault displacement, Bull. Seism. Soc. Amer., v. 74, no. 6, pp. 2379-2411.

Coppersmith, K. J., and Youngs, R. R., 1982, Probabilistic earthquake source definition for seismic exposure analyses, Earthquake Notes, v. 53, no. 1, p. 67.

Coppersmith, K. J., and Youngs, R. R., 1983, Source characterization for seismic hazards analyses within intraplate tectonic environments, Earthquake Notes, v. 54, no. 1, p. 7.

Hanks, T. C., and H. Kanamori, 1979, A moment magnitude scale, J. Geophys. Res., v. 84, pp. 2348-2350.

Schwartz, D. P. and Coppersmith, K. J., 1985, Seismic hazards: new trends in analysis using geologic data, Active Tectonics, National Research Council Publication, (in press).

Slemmons, D. B., 1982, Determination of design earthquake magnitudes for microzonation, Proceedings of Third International Earthquake Microzonation Conference, v. 1, pp. 119-130.

Smith, S. W., 1976, Determination of maximum earthquake magnitude, Geophys. Res. Letters, v. 33, pp. 351-354.

Wyss, M., 1979, Estimating maximum expectable magnitude of earthquakes from fault dimensions, Geology, v. 7, pp. 336-340.

Chapter 5 - GROUND MOTION (EMPIRICAL)

Comment 1

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.

Response

PGandE plans to consider the CDMG procedure and other procedures, as appropriate.

Comment 2

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)?

Response

All available strong motion data, which is appropriate to the conditions being analyzed will be considered. Factors to be considered include earthquake size, site conditions, faulting type, and tectonic setting.

Comment 3

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?

Response

Regression analyses of response spectral ordinates will be performed at a sufficient number of frequencies to characterize the spectra at all relevant frequencies.

Comment 4

Page 5-5, Section 5.3.3. What is meant by the phrase "...average bias associated with reverse fault data..."?

Response

Each subset of strong motion data exhibits differences in average values and variances. These differences can be related to characteristics of the subset, such as type of faulting (reverse/strike-slip), site conditions (rock/soil), etc. The term "average bias of the reverse fault data" refers to these differences.

Comment 5

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 PGandE array at Humboldt Bay?

Response

The NRC has been conducting a multifacted ground motion study involving SSI data inputs and related structural analyses. A NUREG regarding the "Empirical Data on Spatial Variations of Ground Motion" is presently under review. This study includes Japanese 2-d array data, McGee Creek (near Mammoth) downhole data as analyzed by Archuleta, and other data sets from U.S. and international sources. This NUREG and its companion volumes should be available to be utilized in the LTSP project work. This data will be considered as part of the future analysis.

The PGandE microseismic array at Humboldt Bay is designed to accurately locate small earthquakes, but is not suitable for strong motion analyses. Data recorded by the Humboldt Bay strong motion instrumentation will be considered with other strong motion data.

Chapter 6 - GROUND MOTION (NUMERICAL)

Comment 1

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

Response

Sensitivity testing will be provided in the methods used.

Comment 2

Page 6-6, Section 6.1.2. The DELTA model which is the proposed starting model in the numerical modeling 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.

Response

These issues related to numerical modeling are recognized. Quantifying model parameters such as randomness, Q, and rupture velocity will be performed using physical bases derived from local observations and knowledge about past earthquakes. Further definition of the methods and parameters of the modeling study will be considered during Phase II.

Chapter 7 - SOIL-STRUCTURE INTERACTION

Comment 1

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?

Response

As explained at page 7-20, Section 7.3.5, parametric studies will be performed, as necessary, to investigate the sensitivity of analytical SSI responses to variation of parameters and various effects due to the two approaches. Such parametric studies will be conducted at the beginning of the SSI program in order to assess the response sensitivities to parametric variations and to differences in approaches. After having performed the parametric studies to show consistency of results by the two approaches, and their limitations, only one approach may be chosen as the representative approach for the final calculation of the SSI response as mentioned on page 7-21, Section 7.3.6.

Comment 2

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?

Response

The version most suited to meeting the SSI objectives will be used. At the beginning of the SSI program, an investigation will be made of the availability and capabilities of the more recent versions of the CLASSI code. The version referred to in the Program Plan is the version currently operational on the system and presently available to PGandE. As mentioned at page 7-20, Section 7.3.5, parametric studies will be performed to investigate the sensitivity of soil-structure interaction response to the effects of embedment which includes the effect of different levels of structural base.

Comment 3

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

Response

As explained at page 7-21, Section 7.3.5, the potential effect of structural base uplifting on soil-structure interaction (SSI) responses will be considered separately, where necessary, using a nonlinear time-history analysis technique which is capable of simulating the nonlinear base overturning moment versus base rotation relationship due to base uplifting. Examples of the nonlinear technique that can be used are those given in References 11 and 12 at page 7-22. Previous studies on seismic base uplifting as reported, for example, Reference 11 at page 7-22, have shown that the effect of base uplifting on the gross SSI response motion is only important when the base uplifting is substantial. The nonlinear analysis technique to be used will be capable of calculating modified SSI response motions due to the base uplifting effect, if necessary. From the modified SSI response, the effect on the structural force redistribution can then be calculated as necessary using a psuedo-static structural model.

It may be noted that significant base uplifting can occur only when the free-field seismic ground motion is very intense. The seismic hazard analysis may show that the probability of such an intense ground motion is very low, and the probabilistic risk assessment may show that the risk consequence is very small. In such cases, the effect of base uplifting may not be of practical significance.

Other structural nonlinearities will be accounted for by assessing whether the effects are local, i.e., affecting only local structural force redistribution without significantly changing the gross structural frequencies and modal participation factors. These localized effects will be assessed on a case-by-case basis by using psuedo-static structural models. If the nonlinear effect is global, i.e., affecting the gross structural frequencies and participation factors, the effect will be simulated by using an equivalent linear structural model coupled with the foundation model for a revised SSI response calculation as explained at page 7-20, Section 7.3.5.

Chapter 8 - SEISMIC HAZARD ANALYSIS

Comment 1

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?

Response

These concepts may be utilized to some degree in hazards estimations. However, the specific use in such cases will be justified by analyses incorporating various effects, such as, nonlinear structural response, strong motion duration, and non-stationarity of the ground motion, as appropriate.

Comment 2

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.

Response

Several experts will be used to assess geological and seismological inputs to the seismic hazard analysis.

Comment 3

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

Response

The empirical and numerical ground motion studies will be integrated by comparing predictions from these studies for specific magnitudes and distances, understanding the causes of dissimilarities, if any, (using feedback from the respective investigators) and synthesizing the different predictions into a small number of simple formulations that can be weighted (based on justifications provided by each investigator) and used in the hazard analysis.

Comment 4

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

Response

It is currently anticipated that the stochastic model will be used only in the seismic hazard analysis input to the PRA, to provide an additional model for efficient calculation of non-stationary characteristics of ground motion.

Comment 5

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?

Response

Empirical, numerical, and stochastic models of ground motion will be used by conducting separate seismic hazard analyses, one (or possibly several) for each type of ground motion estimate. The results will be pooled into a typical multi-curve seismic hazard analysis for the PRA. Accordingly, the overall results will be obtained by including results from all ground models considered.

Comment 6

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.

Response

If linear filtering of ground motion is used to represent the effects of soil-structure interaction in the PRA, a sound technical basis will first be established. The basis for justification will depend on the overall importance to the seismic hazard analysis: if the effect of SSI, in comparison to other factors in the hazard and PRA analysis is small, a more approximate analytical model can be accepted and justified to represent it, than if the SSI effect is dominant. The justification of the technique to calculate SSI effects for deterministic analyses will be made separately.

Comment 7

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

Response

Uncertainty in the SSI effect will be included explicitly in the seismic hazard analysis if it contributes significantly to overall uncertainty in the seismic hazard results or PRA results.

Chapter 10 - PROBABILISTIC RISK ASSESSMENT

Comment 1

The ACRS has requested additional justification for limiting the PRA to a Level 1 assessment.

Response

PGandE believes that a Level 1 PRA will satisfy the fourth element of the seismic licensing condition which requires that "PGandE shall assess the significance of conclusions drawn from the seismic reevaluation studies in elements 1, 2, and 3, utilizing a probabilistic risk analysis and deterministic studies as necessary..."

As recommended by the fourth element, PRA was chosen as a tool to use in assessing the significance of conclusions drawn from the seismic reevaluation studies. A Level 1 PRA will give a clear indication of whether the seismic initiator is dominant relative to plant damage, i.e., core melt. Furthermore, a Level 1 PRA will allow determination of major contributors to core melt.

The establishment of whether the seismic initiator dominates core melt and the determination of major contributors to core melt will allow for assessment of the significance of conclusions drawn from the first three elements of the seismic licensing condition.

As part of the Level 1 efforts, PGandE will be determining the frequencies of plant damage states. A plant damage state is a category to which sequences can be assigned. This assignment is made in such a way that, when assembling the risk model, a manageable number of end states is being assembled, rather than the millions of end states that would be assembled if each individual scenario was accounted for.

There is a correlation between accident sequence and the ultimate consequences, and this correlation is factored into how the plant damage states are defined. Thus, there are insights and general conclusions concerning consequences that can be drawn from Level 1 results.

When a thorough understanding of the Level 1 PRA tool has been gained, and when the current controversy concerning Level 2 core and containment analyses has been resolved, the merits and cost-effectiveness of extending the PRA to Level 2 and/or 3 will be evaluated. This evaluation and possible extension will be performed outside of the Long Term Seismic Program.

ENCLOSURE 2

The ACRS has asked the staff and PG&E to address the suitability of performing a Level 1 probabilistic risk assessment (PRA) rather than a Level 2 PRA in the Diablo Canyon seismic reevaluation program. PG&E's response to that request is contained in an enclosure to PG&E Letter No.: DCL-85-210 from James D. Shiffer to Harold R. Denton, dated June 11, 1985. The following is the staff's response to that request.

The purpose of the PRA is to assess the significance of the differences, if any exist,.between the existing seismic design basis of Diablo Canyon and that obtained from the seismic reevaluation program and to identify any possible "weak links" in the plant.

The Level 1 PRA provides a systematic examination of the plant and its operation. This results in estimated core damage frequencies for various potential plant damage states, such as, early core melt with no containment cooling and containment failure prior to containment cooling. This systematic characterization of the potential severe accident sequences provides a framework for judging the signifiance of a particular aspect of the study. The staff's accumulated experience has indicated that potential off-site consequences are only significant for containment failure prior to core melt and for core melts with no containment cooling. Previous siting study work on consequences at reactor sites, NUREG/CR-2723, can be used to obtain an estimate of off-site consequences without conducting an exhausative consequence/containment failure analysis. This is a very appropriate approach since the thrust of the license condition is to obtain a better understanding of the seismic aspects of the plant/site and not a quantitative investigation of risk.

Another reason for limiting the effort to a Level 1 PRA is the state of flux in the containment analysis area due to the evolving source term studies. It would be a questionable expenditure of resources to perform a consequences analysis in this environment which could have the potential to misorient the program away from the plant/site features to generic analysis problems that would not and should not be resolved in this particular forum.