

UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of )  
PACIFIC GAS AND ELECTRIC COMPANY ) Docket Nos. 50-275 O.L.  
(Diablo Canyon Nuclear Power ) 50-323 O.L.  
Plant, Unit Nos. 1 and 2) (Seismic Issues)

APPLICANT PACIFIC GAS AND ELECTRIC COMPANY'S  
RESPONSE TO INTERVENORS' PROPOSED FINDINGS ON IV-79



DATED: January 16, 1981

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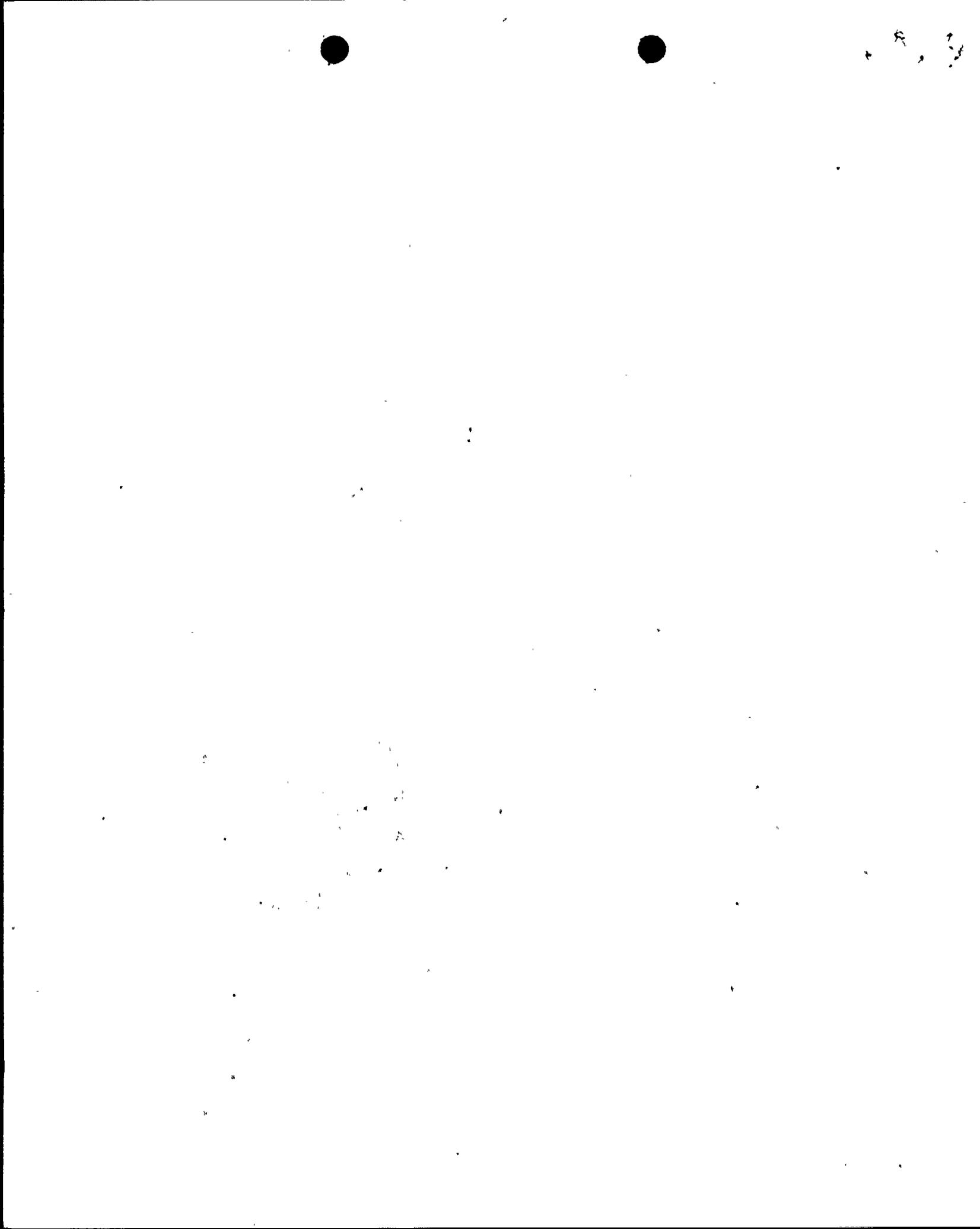


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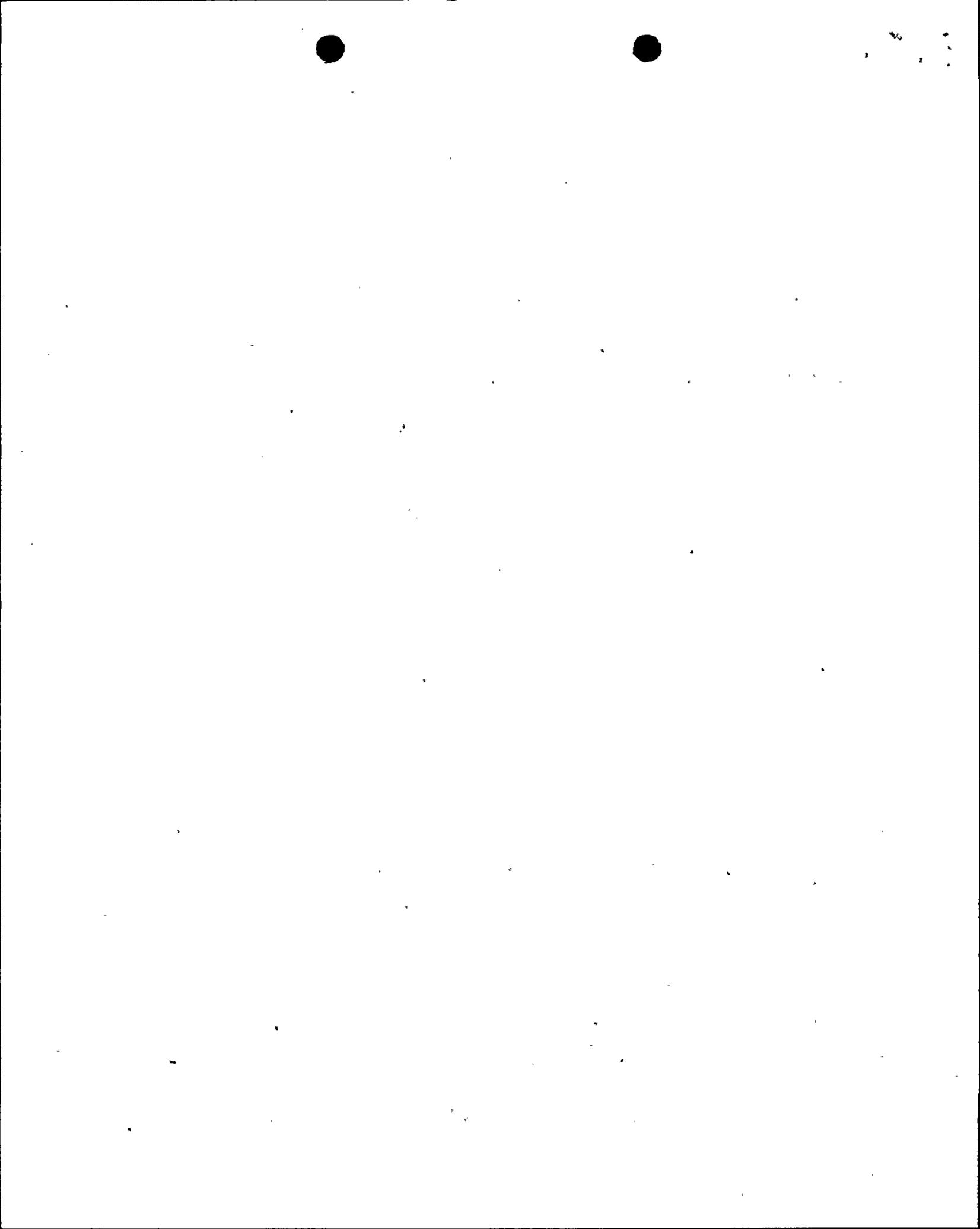


I

INTRODUCTION

Intervenors (Joint Intervenors and Governor Brown) have, under date of December 15, 1980, filed proposed findings allegedly based on the hearings held by this Board to consider the impact of the Imperial Valley earthquake of October 15, 1979 ("IV-79"). Many of their "findings" have nothing to do with IV-79 but rather are a carefully selected collection, rehash, and expansion of material from the previous hearing. It would appear that an even more fundamental tactic on Intervenors' part is to make continual comparisons of the classic apple vs. orange type. For example, Governor Brown attempts to compare  $M_S$  with  $M_L$ , instrumental with design accelerations and one definition of tau with another with equal impunity and with a failure to so inform his reader.

This Board must satisfy itself that the Hosgri reanalysis of Diablo Canyon was based on sound engineering assumptions and judgments. That question has previously been answered in the affirmative and the remaining concern is whether information developed from IV-79 affects that decision. Applicant would respectfully submit that the record developed before this Board greatly strengthens the depth and variety of conservativeness which went into the Hosgri reanalysis.

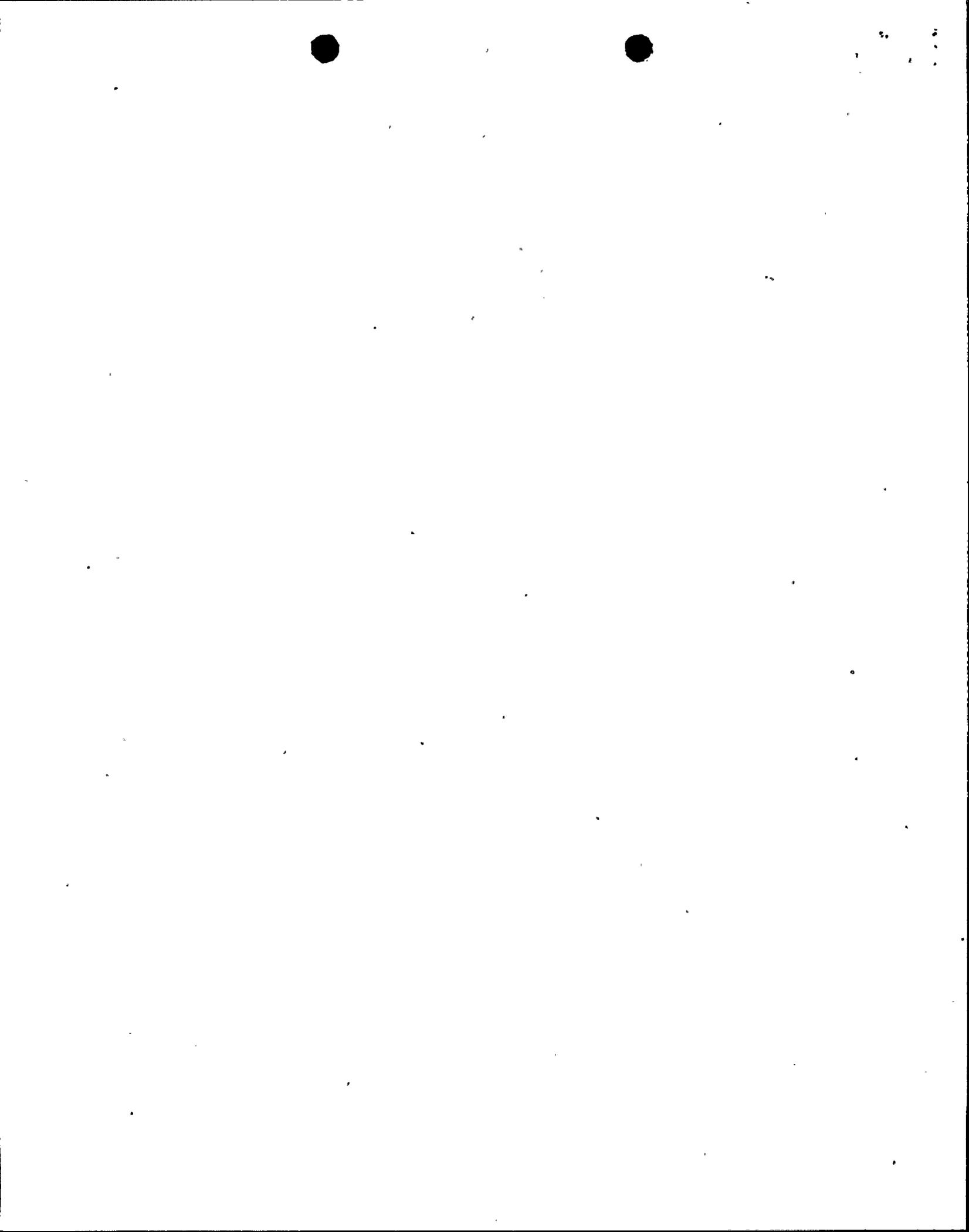


II

1927 LOMPOC EARTHQUAKE

In its partial initial decision of September 27, 1979, the Licensing Board concluded "that a 7.5 magnitude earthquake is a very conservative value for the safe shutdown earthquake" and "that the requirement imposed by the Staff that a 7.5 magnitude earthquake be used by the Applicant in its seismic analysis is reasonable and meets regulatory requirements." (LBP-79-26, 10 NRC 453, 485) This Board's question nine apparently recognized that the primary historical basis for the assignment of a 7.5 M to the Hosgri was the USGS April, 1976 position that the 7.2 M 1927 Lompoc earthquake may have occurred on the Hosgri fault. (SER Supp. 4, App. C, May 1976) At that time the USGS felt that the Applicant's position that the 1927 Lompoc earthquake occurred on the Lompoc fault was in error as "the length of the Lompoc Fault . . . appears incompatible with the magnitude of the 1927 earthquake." (Id.)

The USGS has, while not precluding the possibility that the 1927 event occurred on the Hosgri, changed its position somewhat dramatically since 1976 and the seismic hearing below. Now the USGS favors association of the 1927 earthquake with the Lompoc fault (Tr. 933) and the probability of its association with the Hosgri has been lowered (Tr. 934, 951). Significantly, new data indicates that indeed, as Applicant has always maintained, the Lompoc fault is compatible with the magnitude of the 1927 event (Tr. 931).



It is and always has been Applicant's position that the proper conservative magnitude to use in the Hosgri analysis is 6.5  $M_s$ . The use of a 7.5  $M_s$  is, even more clearly now than before, a "very conservative value" as found by the Licensing Board. In fact, the record is clear, from both below and the instant hearing, that an assignment of a 6.5  $M_s$  to the Hosgri fault would be an appropriate action for this Board to take.

### III

#### DESIGN RESPONSE SPECTRA

In discussing the design response spectra used for the Hosgri reanalysis, several important seismological and engineering concepts must be addressed. First, there is the question of what free field or instrumental accelerations should be expected from a 7.5  $M_s$  earthquake on the Hosgri fault; second, the difference between instrumental or free field and design or effective acceleration; and third, the effects of "tau" and soil structure interaction. All three of these issues were discussed below and in these hearings as IV-79 might relate to them. In each case, the ASLB findings and conclusions regarding these issues were shown to be appropriately conservative.

1. Magnitude, Saturation, Site Conditions, Bonds Corner and PGA at Diablo Canyon.

A. Magnitude

Intervenors argue that a conservative magnitude for the IV-79 event should be 6.4 or 6.5. (Brown, at 9-12) Governor Brown

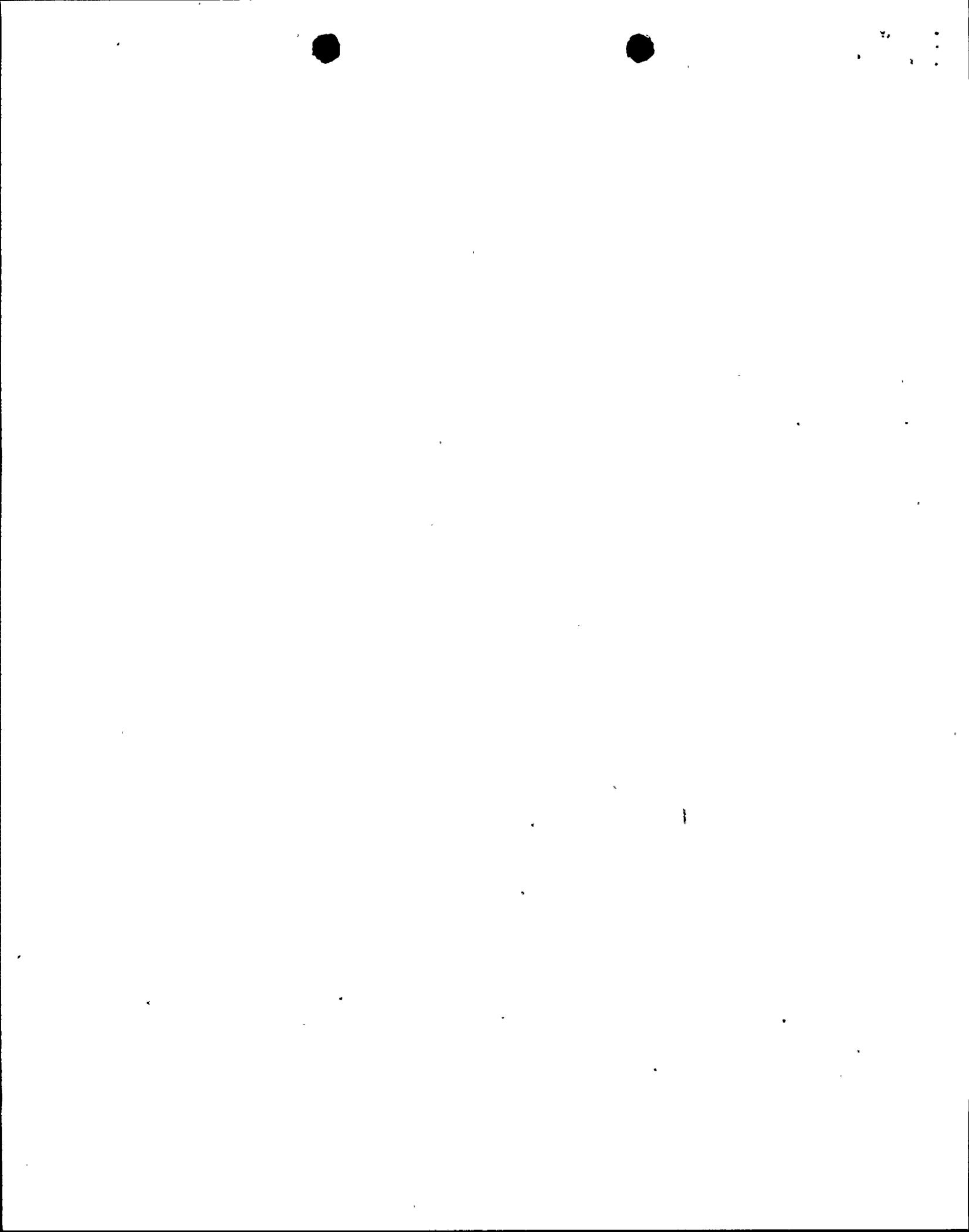


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once again resorts to a comparison of disparate concepts. There is no question that the M7.5 assigned to the Hosgri was a "surface wave" magnitude. (Luco, p. 1-2; JI Brief at p. 14-15) Similarly, there is little disagreement that the surface wave magnitude of IV-79 was 6.9. (Brune at 7; Tr. 758; Luco at 1-2; Blume at 1-2; Rothman at 4-5) Governor Brown attempts to confuse the issue by alluding to differences in calculations for the "local" magnitude which ranged from a novelly derived 6.2  $M_L$  to the generally accepted USGS 6.6  $M_L$  value (Luco, Tr. 1230) The testimony was clear that local magnitudes above 7.2 have never been assigned to an earthquake. (Luco Fig. 1-1; Brune, Tr. 765) It is simply incorrect for Governor Brown to argue that IV-79 should be viewed as having a non-specific magnitude of 6.4 or 6.5 for purposes of comparing IV-79 to the postulated Hosgri 7.5  $M_S$ . It is clear that IV-79 had an  $M_S$  of 6.9.

#### B. Magnitude Saturation

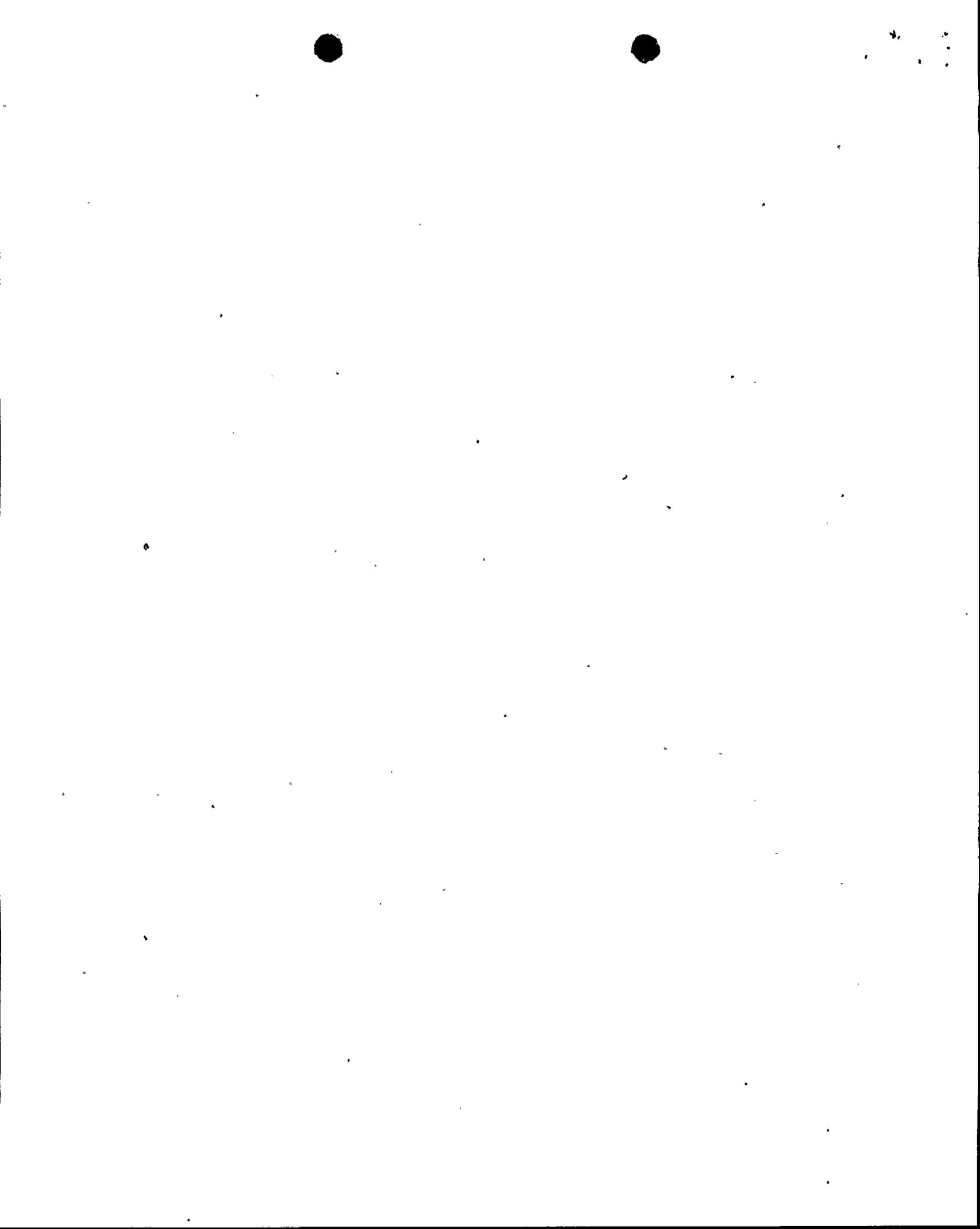
Applicant, NRC Staff and Board witnesses (Blume p. I-6; Seed I-1 to I-3; Smith I-1 to I-3; Frazier VII-13; Rothman, p. 9; Newmark p. 11-12; Trifunac, Tr. 1272-74) agree that in the near field of large earthquakes the peak ground motion saturates with increasing magnitude. Only Drs. Luco and Brune appear not to have accepted the concept of magnitude saturation. Dr. Luco offers no evidence to contradict magnitude saturation but simply indicates that in his opinion there is not sufficient data for earthquakes greater than  $M_L$  6.6 to demonstrate magnitude saturation. (Luco, Tr. 1220-21) Dr. Brune while agreeing that "flattening out" occurs, apparently reverses his opinion for this hearing over that



in his earlier scientific paper which advocated magnitude saturation. (Tr. 765-70) Like Dr. Luco, Dr. Brune offered no evidence to contradict magnitude saturation in the near field of large earthquakes. Clearly, the evidence supports that peak ground motion does saturate and that free field ground motion for a magnitude  $M_s$  7.5 earthquake would not be expected to be significantly larger than the values recorded during the magnitude  $M_s$  6.9 IV-79 earthquake.

C. Site Geology Effects on Free Field Ground Motion

Since the near field IV-79 earthquake data were recorded on soil and Diablo Canyon is sited on rock, the effect of site geology on peak ground motion was discussed at some length. For peak ground velocity and lower frequency motion, it was agreed that greater motions are produced on soil than rock (Blume, III-1, III-2; Trifunac, III.1) At higher frequencies most witnesses found little or no difference in peak accelerations (Rothman, 11; Blume, III-3; Young, 26; Trifunac, III.2; Newmark, 17). Recent statistical studies in the TERA report (3-4 to 3-5) and USGS-795 (p. 17) have also found no significant difference between peak ground acceleration recorded on rock or soil. However, Applicant witness Dr. Seed concludes that acceleration values developed at rock sites would be about 30 percent higher than acceleration on deep soil (Tr. 234). When faced with the proponderance of other expert opinion against his, Dr. Seed reduced this judgmental factor to 20 percent (Tr. 1411). While Dr. Seed modestly believes he is twice as likely as everyone else to be correct, it is clear that the



weight of evidence does not support significantly higher accelerations on rock than on soil.

D. The Bonds Corner Record

Intervenors would have this Board, in direct contravention of 10 C.F.R. Part 100, Appendix A, use one spectrum from one recording station from one earthquake as the basis for finding that the basic design spectrum for Diablo Canyon is inadequate. (Brown at 2-14, 23-25.) Of course, in order for Governor Brown to make even that argument, he must argue first that the single record must be revised upward for magnitude and second that it must be revised even further upward for site conditions. (Brown at 9-12) As shown supra, the bootstrapping attempts of Governor Brown to elevate the Bonds Corner spectrum are incorrect. More important, however, is the fact that 10 C.F.R. Part 100, Appendix A, prohibits the use of a single record for design purposes and requires the use of multiple records. Governor Brown seizes on the word "maximum" and argues that the word requires an enveloping spectrum for design purposes which would bound the maximum possible instrumental or free field spectrum. Given an appreciation of the difficulties involved in draftsmanship of regulations, if such were their intent, would not the drafters of Appendix A simply have stated that the design spectrum must envelope or bound all possible instrumental or free field spectrum? There is no evidence in the record, nor could such evidence be inferred therefrom, that any nuclear facility (or any other structure) has ever been designed on the basis of a "bounding" spectrum. In fact, the generally accepted practice, as required by 10 C.F.R. §50.2, is the approach



used in the Hosgri reanalysis at Diablo Canyon. (Newmark written at 2-3, 9-10, 13-14; Blume II-1, 2)

E. Peak Ground Acceleration for Diablo Canyon

Numerous experts predicted peak ground acceleration values for Diablo Canyon assuming a  $M_s$  7.5 earthquake on the Hosgri fault. Dr. Seed estimated a mean plus one standard deviation peak ground acceleration of 0.75 g based upon his attenuation curves (Tr. 238). Dr. Smith predicted mean plus one standard deviation peak ground accelerations between 0.62 and 0.72 g based upon the TERA report (Smith I-3; TERA report I-3). Dr. Frazier used a complex earthquake model to predict a maximum peak ground acceleration of 0.75 g for the worst case rupture sequence (Governor Brown Ex. R-10). Dr. Newmark uses relationships derived by Donovan and the TERA report to predict a mean plus one standard deviation value ranging from 0.54 g to 0.78 g. In rebuttal, Dr. Seed adjusts the IV-79 peak ground acceleration data for distance, soil conditions and magnitude conditions appropriate to Diablo Canyon and predicts a mean plus one standard deviation peak ground acceleration of 0.71 g.

2. Free Field or Instrumental Versus Effective or Design Acceleration.

In the ASLB decision, a 35 percent reduction (from 1.15 g to 0.75 g) of peak instrumental ("free field") acceleration to design ("effective") acceleration was found appropriately conservative. (LBP-79-26, 10 NRC 453, 490) In this hearing, Dr. Newmark reiterated the conservatisms in the seismic design process and the



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basis for not using bounding instrumental acceleration for seismic design (Tr. 540-42). The response of the El Centro Steam Plant to the IV-79 earthquake provided further quantification of the conservatism in the actual seismic design procedures used at Diablo Canyon. See section VIII, infra. As is developed below, the 0.75 Hosgri reanalysis spectra actually represents a conservative instrumental or free field motion, without consideration of the 35 percent design or effective acceleration reduction found appropriate for seismic design.<sup>1/</sup> This value is a mean plus one standard deviation value for a 7.5  $M_s$  which has only occasionally been exceeded by any earthquake, regardless of magnitude, distance, or site conditions.

Dr. Newmark used this 0.75 value to anchor his design spectrum. The shape of the design spectrum represents a mean plus one standard deviation for free field ground motion. (Newmark, 13-14) Dr. Newmark used the unusually high and highly disputed Pacoima Dam record to aid in determining the Diablo canyon design spectrum since this record was the strongest one available at that time. (Tr. 547-48) The strongest record in IV-79, that at the Bonds Corner Station, was shown to be equivalent to the Diablo Canyon reanalysis spectra, thus reinforcing the conservativeness of Dr. Newmark's spectrum. (Kuo, 6; Young, 21)

Dr. Seed adjusted the IV-79 data, both the mean and mean plus one standard deviation value, to magnitude, distance and site

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<sup>1/</sup>Other proceedings have also found that maximum effective acceleration was the appropriate level to be used in seismic design of nuclear power plants. (Seabrook, ALAB-561)



conditions appropriate for Diablo Canyon. (Tr. 1409-13) He then used two procedures to develop conservative free field response spectra from the adjusted IV-79 data. (Tr. 1413-15) The two procedures consist of anchoring a mean IV-79 spectral shape, computed from the 24 closest records to the fault, to a mean plus one standard deviation peak ground acceleration appropriate for Diablo Canyon design conditions and anchoring a mean plus one standard deviation IV-79 spectral shape to a mean peak ground acceleration. Both of these instrumental free field response spectra fall under the Diablo Canyon design spectrum. (Applicant's Exhibit R-20)

Dr. Blume similarly shows that the IV-79 data, when applied in the same manner in which the Diablo Canyon design spectra were produced, yield an instrumental free field response spectrum which is less than the Diablo Canyon design spectrum. (Blume II-2)

On the other hand, Governor Brown argues that the testimony of Dr. Young provides "a more meaningful comparison" of the IV-79 data. (Brown at 26) Given the actual testimony of Dr. Young at the hearing, we believe just the opposite to be true. Dr. Young demonstrated his lack of credibility in developing design spectra by advocating a 1.4 g or higher design response spectrum for Diablo Canyon (Young, 21; Tr. 1007-09) and yet previously recommended that a 0.5 to 0.6 g design response spectrum be used for an LNG facility.<sup>2/</sup> Additionally, his manipulation of the IV-79 data was

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<sup>2/</sup>Dr. Young admitted that nothing in the intervening time had occurred that would change his judgment on design levels and in his LNG report indicated that the same level of conservatism required for nuclear power plants should be applied to the LNG facility which was within 3 miles of a fault capable of a 7.5 M<sub>s</sub>.



flawed. Dr. Young anchors a mean plus one standard deviation IV-79 free field response spectra to 0.75 g assuming that 0.75 g is the mean effective peak ground acceleration. The evidence clearly shows 0.75 g to be a conservative mean plus one standard deviation instrumental free field peak ground acceleration. Dr. Luco also makes this erroneous assumption in his testimony (Luco, 2-3 to 2-6). Dr. Trifunac continues to believe that the 0.75 g Diablo Canyon design spectrum is appropriate for the Hosgri reanalysis.<sup>3/</sup>

### 3. Reductions for Tau and Soil Structure Interaction.

Intervenors argue that a reduction of the 0.75 g design spectra to account for the presence of large structures (generally termed the "tau factor") is not appropriate for the Hosgri reanalysis. In developing their argument, Intervenors attempt to follow an approach of dividing the reduction into parts, which even an expert earthquake engineer such as Dr. Newmark is unwilling to do (Tr. 682). After examining individual parts in a biased manner, Intervenors then ignore the fact that there is substantial body of data which as a whole supports the "tau" reduction and instead propose more extensive SSI analysis which is beyond the state-of-the-art, not required to justify the reduction taken and would only serve to delay these proceedings.

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<sup>3/</sup>He believes the Hosgri capable of no more than a magnitude 6.5 and therefore judges the 0.75 g design spectra sufficiently conservative (Trifunac, p. 11.1-11.2).



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Applicant and NRC Staff have maintained that large structures do not respond to earthquake motion as do free field instruments, and therefore, conservative reductions of the 0.75 g design spectra for different structures is appropriate. While the reasons for this reduction are technically complex, the Applicant has identified the principal physical phenomena, non-vertical incident waves, incoherence in ground motion and soil-structure interaction, causing these reductions. More significantly, the studies of strong motion recordings, taken in small buildings, large buildings and free field instruments and individual sets of nearby recordings in different size structures have shown that the available data demonstrate lower peak ground accelerations in large buildings over those recorded in small structures or free field instruments.

Many investigators have found lower response for large buildings to earthquake motion (ASLB hearing, p. 13; Newmark, Tr. 687; USGS-795, p. 17; TERA report, p. 3-8, 9). The available horizontal peak ground acceleration data supports an average reduction of 20 to 25 percent in large buildings as compared to small buildings or free field recordings<sup>4/</sup> (TERA report, p. 3-8) Further, comparisons of paired recordings from nearby small and large buildings indicate a mean reduction of 33 percent in peak

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<sup>4/</sup>Governor Brown (page 43) apparently agrees that such records include the tau effect but argues that since 70 percent of the free field records include this effect the free field response spectrum should be increased (Young, p. 38). The TERA report considered this issue (page 3-8) and found no significant affect on the prediction of free field PGA.



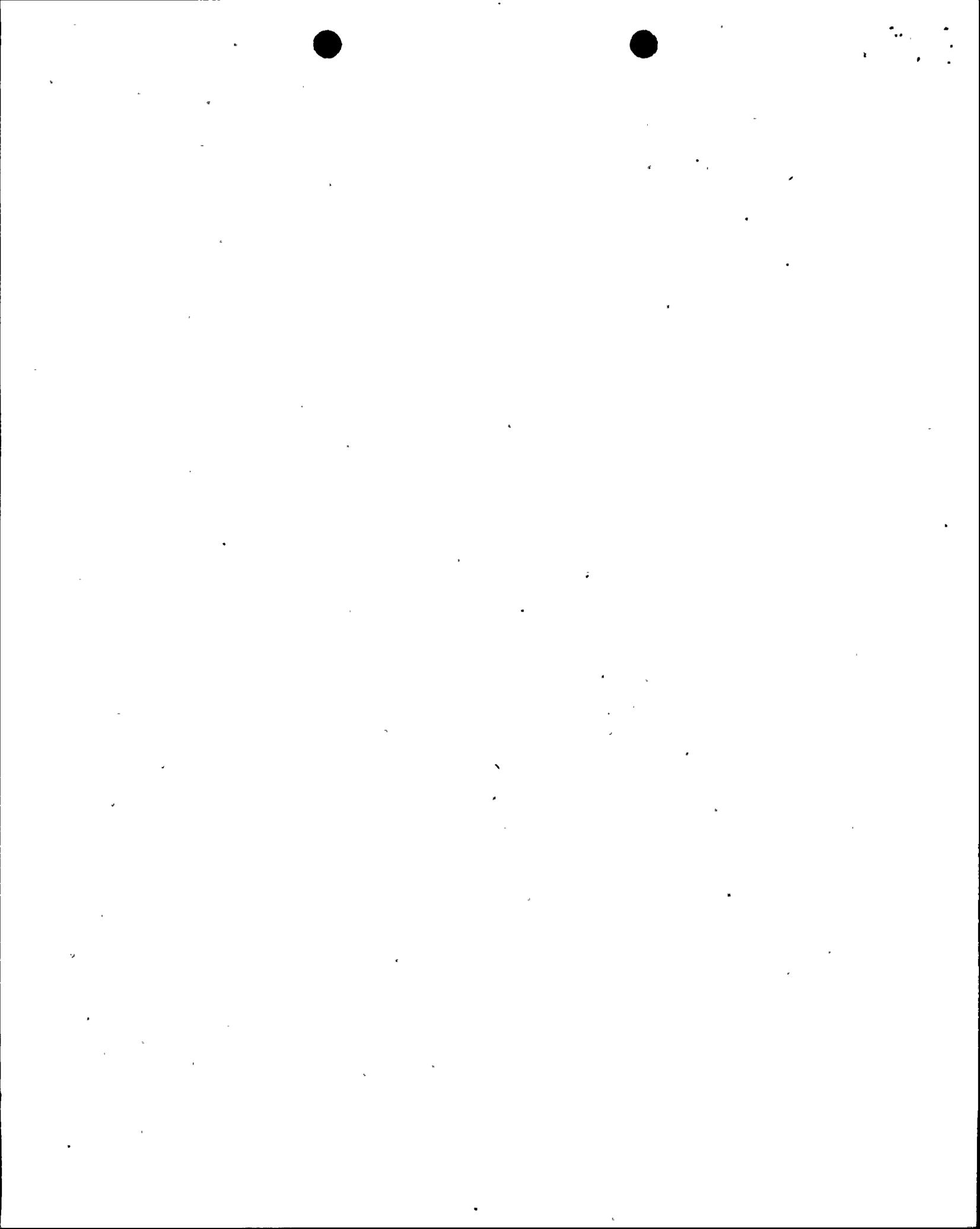
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ground acceleration for large earthquakes<sup>5/</sup> (Id., p. 3-9) USGS-795 noted (p. 17) the potential effect of large buildings in biasing downward the free field accelerations, but did not quantify this effect. These data provide quantitative justification for the "tau" reduction taken without attempting to separate the various physical phenomena.

In addition to the overwhelming body of expert opinion (Newmark, Blume, Seed, Smith), Applicant has quantified several of the important physical phenomena making up the "tau factor". Applicant witness Dr. Seed, an acknowledged expert in soil structure interaction (SSI), has performed a state-of-the-art analysis of the reduction due to SSI at Diablo Canyon and concluded that spectral accelerations of the base slab above frequencies of 4, or 5 Hz would be about 20% below those of the free field motions (Seed, p. VI-6). Other witnesses have offered opinions on the magnitude of the SSI effect, but only Dr. Seed has made a special study of the effect to support his opinion. This is precisely the type of analyses recommended by Dr. Young (Young, p. 41). In fact,

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<sup>5/</sup>Governor Brown (page 43) cites testimony by Drs. Young and Trifunac of other records from closely spaced instruments that do not show evidence of the tau effect. However, a close inspection of Governor Brown's own Exhibit R-4 provides an explanation for the "counter examples". For example, the 1091 Avenue of Stars is a smaller building than 1900 Avenue of Stars (page 335 of Ex. R-4); the 222 and 234 South Figueroa buildings have their principal dimensions perpendicular to each other and 445 South Figueroa is much larger than the other two (page 335 of Ex. R-4); the 800 West 1st St. building is much larger than the Water and Power Building (page 334-35 of Ex. R-4). The note on page 3-15 of the TERA report acknowledged these and other reasons for not including these specific buildings in downtown Los Angeles.



Dr. Young expressed confidence in Dr. Seed's expertise (Tr. 1082) and indicated the acceptability of SSI results (Tr. 1093). Apparently, Dr. Young's only reservations in his review of Dr. Seed's analyses (Tr. 1108) relate to several questions he had which Intervenor, for some unknown reason, chose not to put to Dr. Seed. Whatever the case, there was no evidence in this hearing to contradict Dr. Seed's results of a 20 percent reduction in free field ground motion due to SSI.

The IV-79 data allows Applicant quantification of another aspect of the "tau factor", that being the incoherence in ground motion. Dr. Smith's analyses of the El Centro Differential Array Stations demonstrated wave incoherence reductions of 10 to 20 percent (Smith, Tr. 1396). Intervenor argue (JI p. 35-39; Brown, p. 39-42) that Dr. Smith's analysis should not serve as a basis for the "tau reduction" because the reduction is not uniform but frequency dependent, the surface shearwave velocity site effects would reduce the incoherence at Diablo Canyon by 1/9, and the fact that the analysis is based on only one set of data. The first objection is based upon a total lack of understanding of the record below and at the instant proceeding. The "tau reduction" was always frequency dependent with no reduction beyond 2 or 3 Hz (Newmark, Tr. 682; ASLB Blume written testimony, p. 43; Newmark written testimony, p. C-15). Therefore, Dr. Smith's results are consistent with the frequency dependent "tau reduction" applied in the Hosgri reanalysis. The second objection that was raised by Dr. Luco is based totally on his assumption that the cause of all



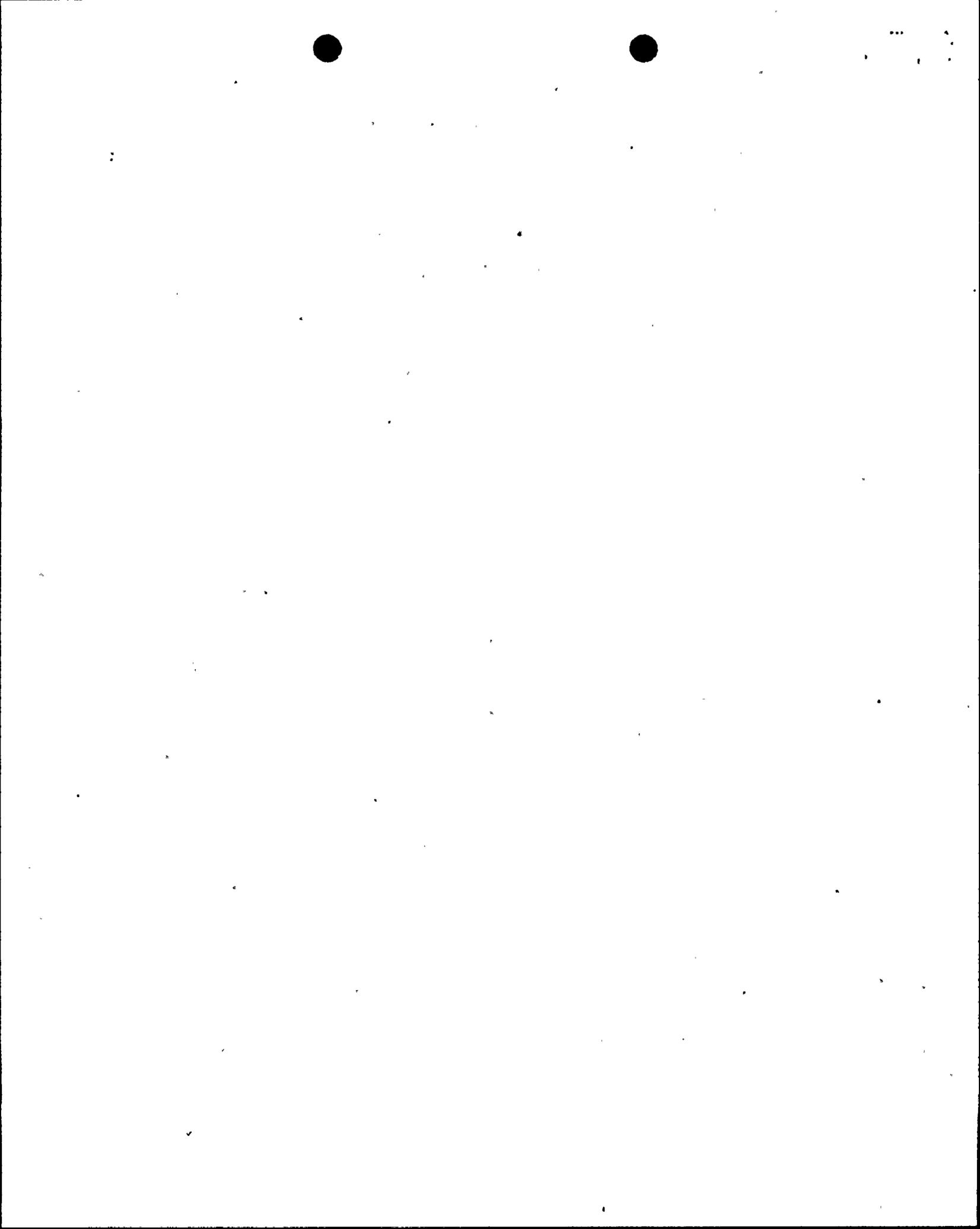
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incoherence can be related to surface shear waves generated by a point source since with this assumption the velocity difference between Imperial Valley and the Diablo Canyon site are the greatest. Incoherence can result from nonhomogeneities any where along the travel path of the seismic waves and incoherence can result from the fact that the source of the seismic waves was obviously not a point, but extended many kilometers (even in Dr. Brune's concentrated tone of energy release model). Intervenors' objection that Dr. Smith's analysis relies upon only one set of data is specious in that they ignore all the other data (e.g., that in the TERA report discussed above) which supports a reduction in free field accelerations and runs counter to their own argument that the Newmark spectrum is not conservative based solely on one recording (Bonds Corner).

#### IV

#### FOCUSING

Governor Brown and Joint Intervenors, as a result of a biased selection of portions of the record, attempt to show that focusing could result in significantly amplified seismic motion at the Diablo Canyon site. However, there is agreement among all the experts that the IV-79 records do not show any significant effects of focusing. (Brune written at 8; Edwards VII-2; Frazier VII-4; Rothman written at 13, 14; Tr. 452, 626) Thus the data from IV-79 cannot possibly provide any basis for a conclusion that significant effects of focusing will occur at Diablo Canyon. Governor Brown's



arguments to the contrary are sophistry.<sup>6/</sup>

1. The Significance of Focusing Is Speculative at Best.

At the hearing below, and in this proceeding, there was agreement that focusing occurs in all earthquakes. (ASLB Tr. 7951, 8075; Edwards VII-3; Rothman 13) Joint Intervenors' witness in the proceeding below time and again stated how inadequate the data base was, how more near source strong motion records were needed to "prove" the significance of focusing, and that the reason the significance of focusing does not appear in the records is that there have not been enough records. (Brune ASLB testimony 3-18; ASLB Tr. 7929, 7945, 7946, 7956, 7978, 8129) At the hearing below, Dr. Brune testified as to the location and the type of instrumentation necessary to "capture" the significance of focusing:

"Well, basically I would put a dense array<sup>7/</sup> of strong motion and other types of instruments around the fault, so I could measure the radiation at a large number of difference places. (ASLB Tr. 8029)

\* \* \*

"To really be certain about the mechanism, you would need an array of stations that covered the fault up and down the fault, both directions of rupture propagation, some near the fault, some far away. (ASLB Tr. 8030)

\* \* \*

"Q. And we're not likely to know without a good deal more pertinent data?

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<sup>6/</sup>Joint Intervenors offered no findings on focusing but incorporated Governor Brown's. (JI Proposed Findings 3 (fn.))

<sup>7/</sup>This turned out to mean 20 or 30. (ASLB Tr. 8030)



"A. Yes. There's a possibility that we could get it in a relatively short time because we have deployed a large number of instruments recently.

"Q. You are now at the point of waiting for a big earthquake to occur near your instruments?

"A. That's correct." (ASLB Tr. 8129)

Dr. Brune got half of his wish. The IV-79 earthquake occurred and produced an extensive set of near field strong motion records near his instruments. (Blume I-1; Seed I-1; Tr. 1403) However, it was agreed that these many records show no significant effects of focusing. (Brune written at 8; Edwards VII-2; Frazier VII-4; Rothman 13, 14; Tr. 452, 626) Dr. Brune speculated the reason the effects of focusing were not significant in the IV-79 earthquake may have been due to the earthquake having been a series of multiple events rather than a continuous rupture (Tr. 627), a condition precedent he failed to mention at the hearing below before his hoped for data was generated. Dr. Frazier testified that he did not imply that the energy release occurred along a more or less continuous rupture in reaching his conclusion that the effects of focusing in IV-79 did not significantly increase peak acceleration. (Tr. 294-95) In any event since the most heavily instrumented "big" earthquake in history failed to show any significant effects of focusing, one certainly cannot say that there will be significant effects from the phenomenon at Diablo Canyon, but must conclude that whatever focusing did occur did not result in abnormally high PGA values and did not alter the broader tendency toward saturation of PGA values in the near-field.



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(Edwards VII-3; Frazier VII-4; Tr. 294) Clearly, since the IV-79 records contained no evidence of focusing which caused significantly higher peak accelerations, they cannot be used to predict significant effects of focusing at Diablo Canyon.

2. There Is No Mechanical Basis for Predicting Significant Effects from Focusing to Occur at Diablo Canyon.

In the proceeding below, Dr. Brune speculated that focusing might occur at the site as a result of a bend in the Hosgri fault about 27 Km from the site. (Brune ASLB testimony 3-13; ASLB Tr. 8023, 8024) At one point Dr. Brune conceded that the bend was too far away to be effective (ASLB Tr. 8104) and later he simply declined to state a probability of focusing even occurring at Diablo Canyon other than to say that such a probability was "low". (ASLB Tr. 8143-8145)

At the hearing before the Appeal Board, PGandE witness Edwards testified that the rupture focusing phenomenon was not

" . . . relevant to the Diablo Canyon site . . . [because] the portion of the Hosgri fault trace (+5°) is so far from the site . . . that any amplification by high frequency focusing would be eliminated through material damping of the high frequency radiation. (Edwards VII-4.)"

This finding remains uncontroverted in the record. In any event, Brown mischaracterizes Mr. Edwards' testimony by implying that Edwards was the one who suggested lining up a portion of the Hosgri Fault. This concept was introduced by Dr. Brune below (ASLB testimony 3-13; ASLB Tr. 8007-08) and Mr. Edwards was only responding to what was in the record. Mr. Edwards does not, as

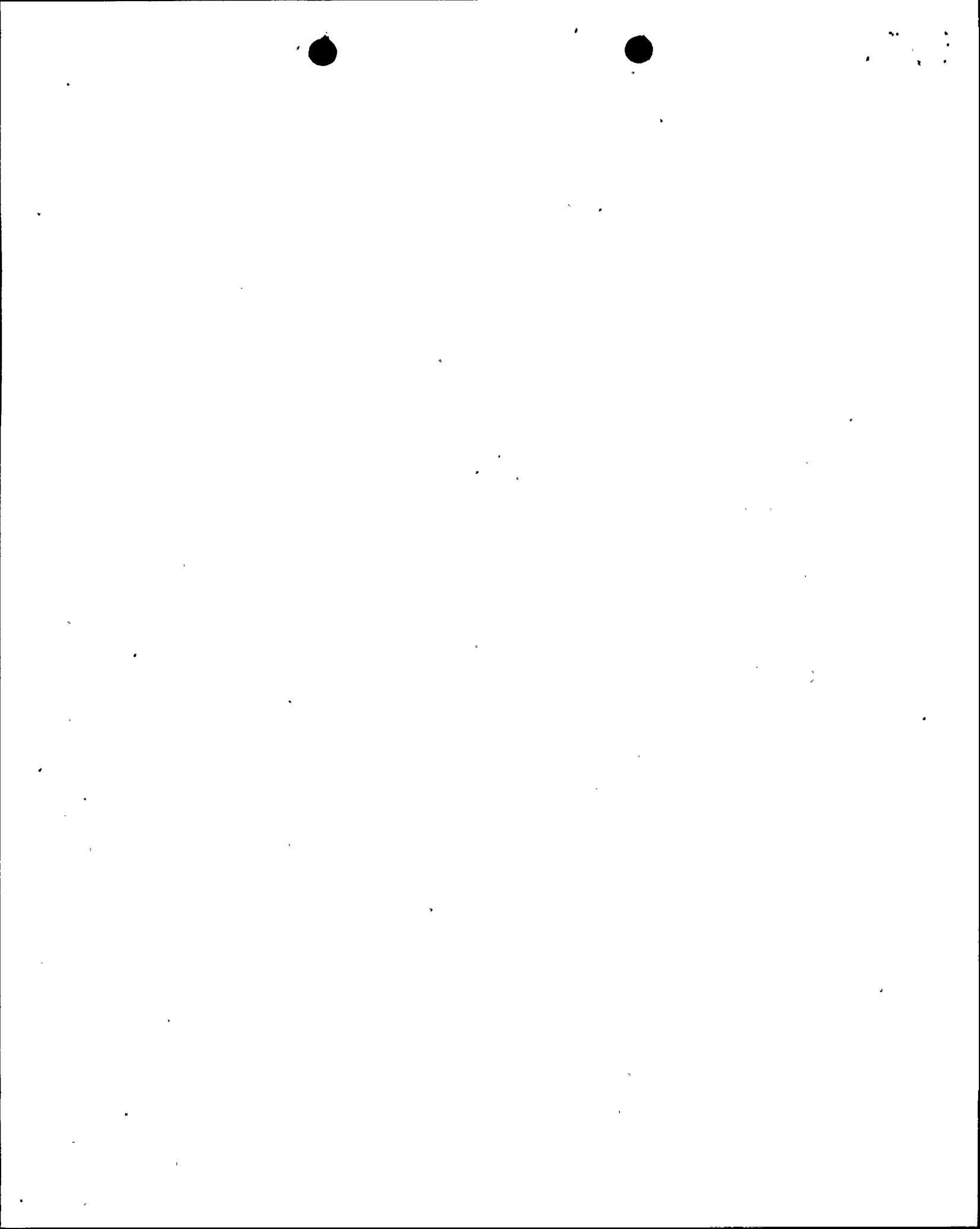


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stated by Brown, deny the existence of focusing. (Edwards VII-1, VII-3; Tr. 448) He is simply refuting Dr. Brune's mechanical attempt to "force" it on the Diablo site. At the time of the Edwards testimony Dr. Brune had not yet expounded his new theory of one highly disputed minor "splay" being a possible source of focusing at Diablo Canyon.

In his Appeal Board testimony, Dr. Brune turned his attention to a minor splay or strand shown on Joint Intervenors' Ex. R-10 (withdrawn from the record, Tr. 361) and testified that this minor feature could be the source of focusing at the site. (Tr. 648) The map upon which the feature was depicted was in evidence in the proceeding below. (Figure 35 to Hamilton testimony) The particular splay shown on that map does not appear on the official USGS map of the area (Tr. 939), and USGS witness Devine testified that the splay does not exist. (Tr. 939-40) Applicant witness Frazier testified that in his opinion a splay such as the one in question could not independently be capable of generating more than a magnitude 3 earthquake. (Tr. 317) Applicant witness Hamilton, author of the map upon which the splay is depicted, testified that the splay in question, if it exists, is restricted to the block of ground on the east side of the Hosgri fault and that it shows no evidence of direct linkage to, or participation with, major earthquake generating movements on the Hosgri. (Tr. 322)

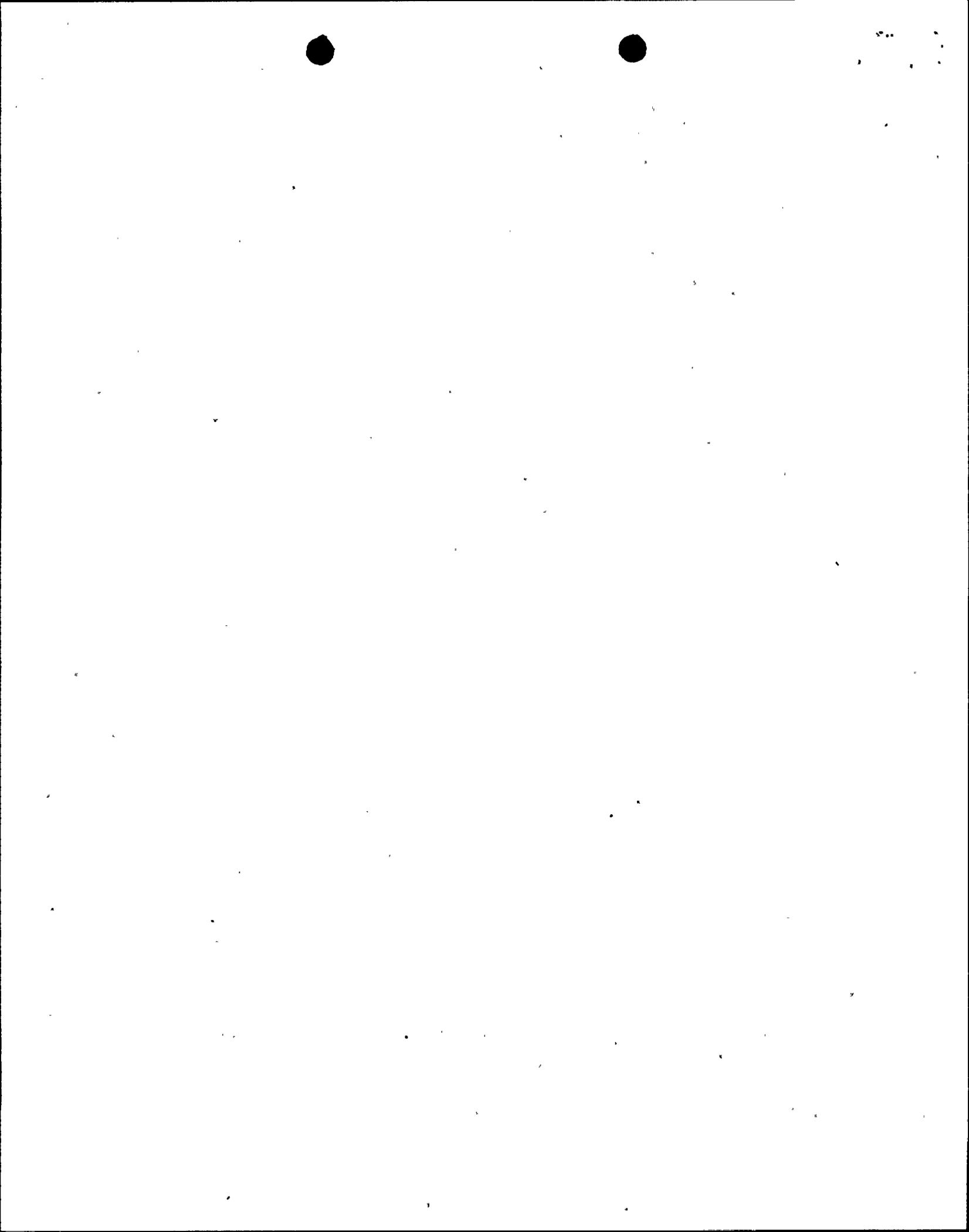
Finally, Dr. Brune's novel theory of primary zone of energy release argues against the significance of the splay. In



the first place, according to Dr. Brune the IV-79 "primary zone of energy release" corresponds to the zone of maximum displacement along the fault and is about 10 kilometers long. (JI Ex. R-12; Tr. 613, 854) Such a zone could not occur on the splay because the splay is not long enough and does not have that much cumulative past offset. (Tr. 322-24) Movement along the Hosgri fault would be expected to go past features such as this. (Id.) Also, if the midpoint of the zone of primary energy release occurs directly offshore of the site (which is the hypothesis imposed), thereby producing the maximum acceleration at the site, rupture focusing necessarily would propagate away from the site. (Tr. 1366) If there were unilateral rupture, as postulated by Dr. Brune, the motion at the site would have been much lower, illustrating defocusing. (Tr. 1366, 1367)

3. Modeling Shows No Significant Effects of Focusing at Diablo Canyon.

In the proceeding below and in this proceeding, Dr. Brune recommended that a model be prepared showing different types of faulting under various parameters. (Brune written at 2-6; ASLB written at 3-18) At this hearing, Dr. Brune agreed that modeling supplied a useful technique for earthquake analysis. (Tr. 631, 821) PGandE witness Dr. Frazier developed such a model which, as might be expected, Dr. Brune finds completely unsatisfactory because the parameters Dr. Frazier chose were not conservative enough for Dr. Brune or Dr. Brune did not understand them. (Tr. 631-33, 637, 647-49, 821, 823) The results of the model study are



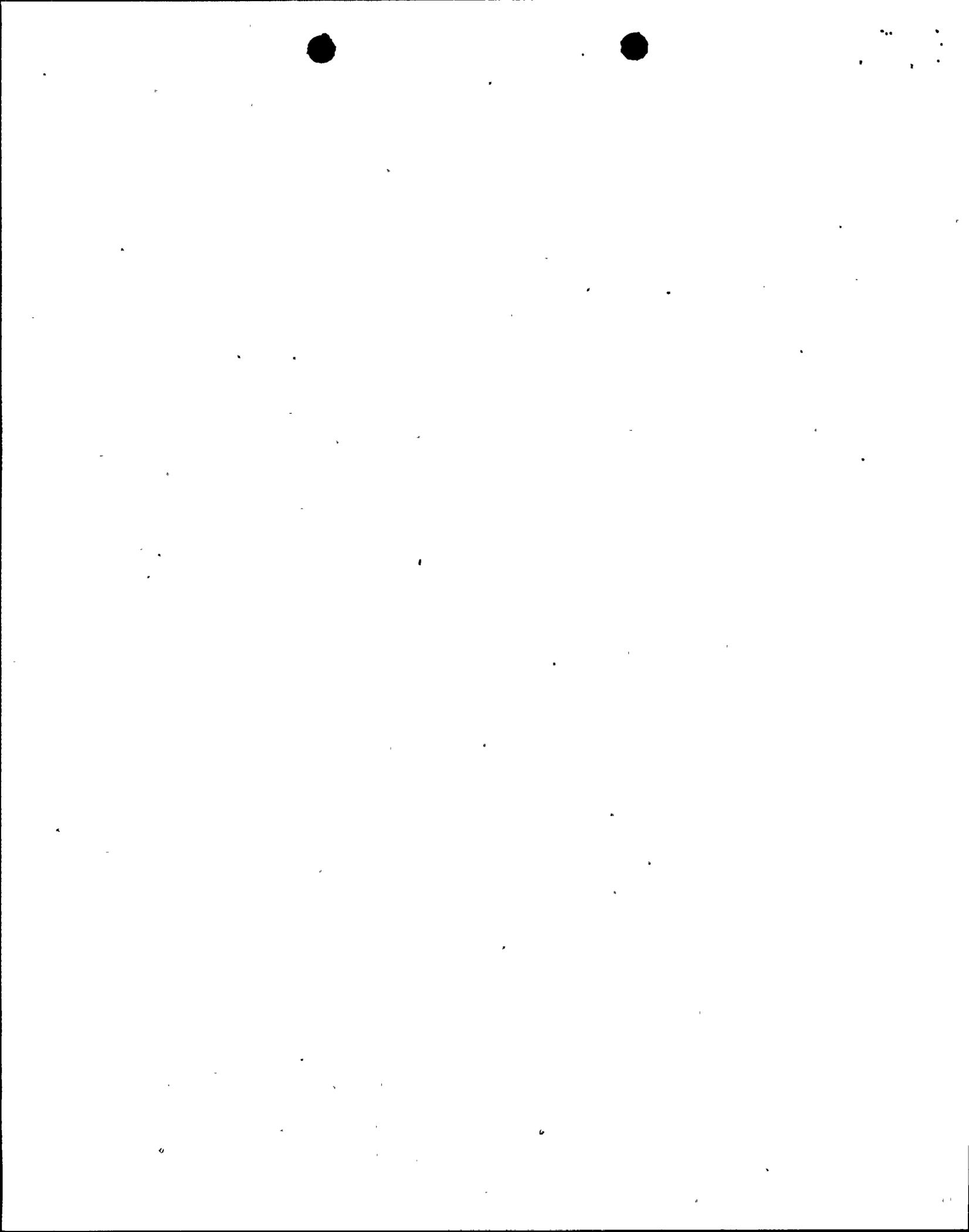
presented in PGandE's Proposed Findings of Fact and need not be repeated here. (PGandE Proposed Findings 46-49) In particular Dr. Brune claimed that Dr. Frazier had selected parameters which necessarily obscured the effects of focusing. (Tr. 628-30) However, the parameters that Dr. Frazier used in the Diablo model were the same as those he used in the San Onofre model (Frazier Tr. 1361, 1365), which Dr. Brune indicates did show the effects of focusing. (Tr. 630) Apparently, Dr. Brune was dissatisfied with Dr. Frazier's selection of only conservative rupture sequences that all included focusing effects and not a defocused (less conservative) rupture sequence. (Tr. 1366-67). In any event PGandE does not place its entire case on the results of the model but offers it merely as one more piece of evidence supporting the conservativeness of the seismic criteria used in the Hosgri reanalysis of Diablo Canyon. (Tr. 1375)

The IV-79 earthquake had absolutely nothing to offer to Intervenor as respects their theory that focusing is a significant factor in the design analysis of Diablo Canyon. To the contrary, the IV-79 data can only be used to show that the theoretical speculation of Dr. Brune remains precisely that.

## V

### VERTICAL ACCELERATIONS

Intervenor argue that the IV-79 data shows that the vertical design motion should equal the horizontal design motion for a near field site such as Diablo Canyon. There are four

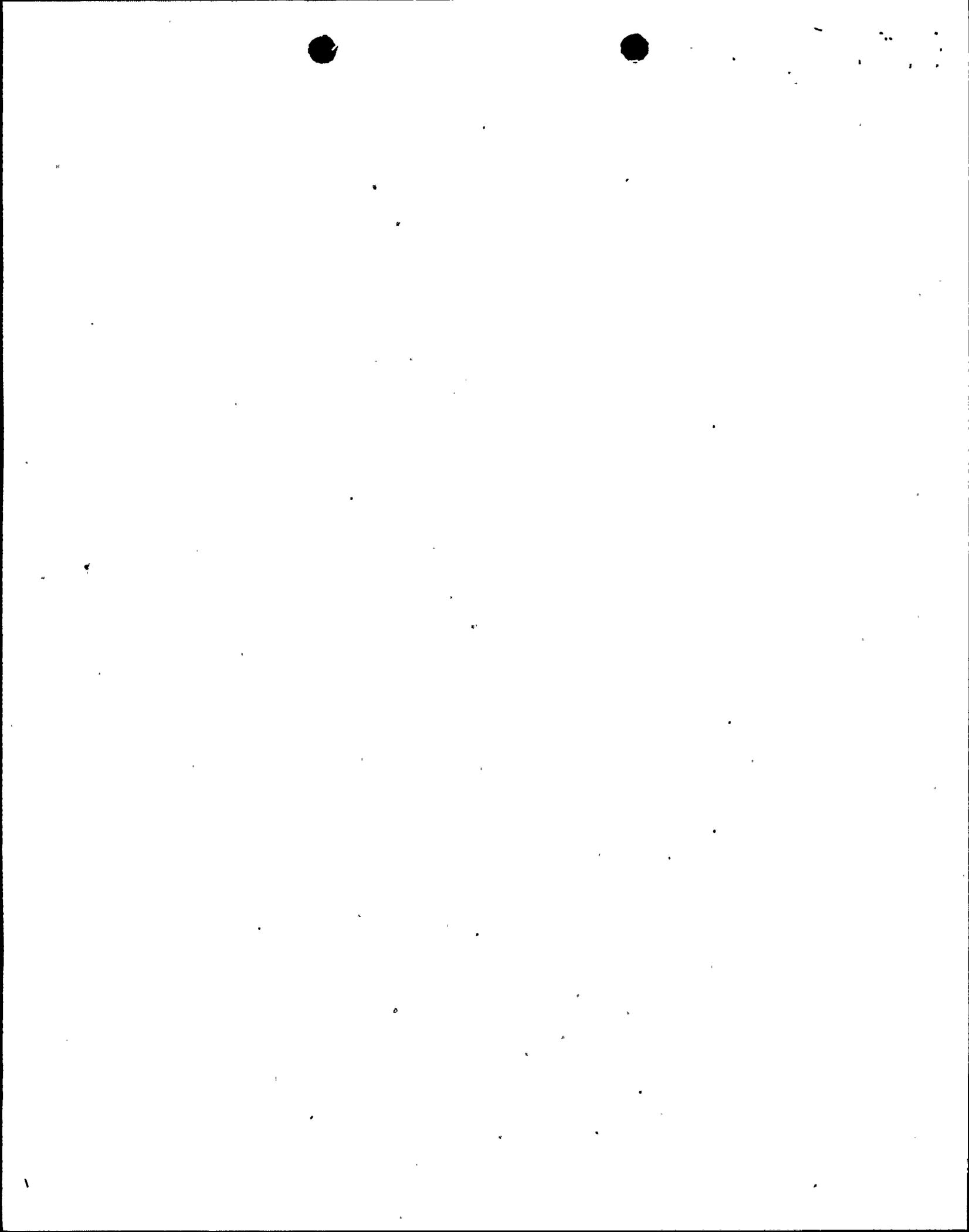


primary reasons why Intervenors' argument fails. First, the Imperial Valley site conditions, which do not exist at Diablo Canyon, were the principal cause of the unusually high vertical acceleration records close to the fault rupture. Second, over-registration of vertical recordings and the anomolous behavior of at least one station (El Centro Station 6) must be considered. Third, the uniqueness of the high vertical recordings at Imperial Valley is further demonstrated by the analyses of other near field earthquake records (USGS 795 and SAN/1011-125) which definitely show vertical peak ground accelerations to be lower than horizontal peak ground accelerations. Fourth, the actual design motions for the significant structures at Diablo Canyon in fact used higher ratios of vertical to horizontal motion than the 2/3 ratio required by NRC Staff.

The IV-79 earthquake also allowed quantification of incoherence in the free field ground motion which now supports a 20 percent reduction in the vertical peak acceleration. Finally, Applicant witnesses Blume and Frazier demonstrated that from a structural design standpoint the vertical peak accelerations at IV-79 had little energy and occurred much earlier than the peak horizontal accelerations even though NRC design practices conservatively required both the vertical and horizontal accelerations to be combined in the Hosgri reanalysis of Diablo Canyon.

#### 1. Imperial Valley Site Conditions

Intervenors basically ignore the undisputed testimony that site conditions at Imperial Valley caused the anomously high



vertical accelerations recorded close to the fault rupture. (Frazier IV-1 to 15) Dr. Frazier's seismological investigations of the IV-79 earthquake shows that the deep sedimentary layering and high velocity gradient combined to cause unusually high vertical peak ground accelerations, a phenomenon not likely to occur at Diablo Canyon. (Frazier IV-10) The deep sedimentary basin acted as an echo chamber concentrating the seismic energy within 20 km. In addition, the high velocity gradient increases P wave amplitudes (the cause of vertical peak ground accelerations). (Frazier IV-3 and 4)

The Intervenor's cite no evidence in opposition to this expert testimony, but cite the concern expressed by Dr. Luco of uncertainty in the attenuation values used by Dr. Frazier. Dr. Frazier addressed Dr. Luco's misunderstanding in the hearing (Tr. 283) and provided additional calculational results to test the sensitivity of his conclusion to the attenuation values chosen. The analysis showed that the Imperial Valley could still be expected to produce substantially higher ratios of vertical to horizontal accelerations than at Diablo Canyon. (Id.) It is also interesting to note that Dr. Brune, while also questioning the attenuation values as used by Dr. Frazier, "borrowed" this portion of Dr. Frazier's work for his own use in his "zone of energy" model for IV-79. (Brune, Tr. 801)

## 2. Instrument Overregistration

Intervenors claim that no relevant analyses support Applicant and NRC Staff witnesses' (Blume, Newmark, Kuo) position



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that vertical instrument records do not reflect true vertical motions that would be experienced by a structure, yet give no reasons to reject the two scientific articles cited.<sup>8/</sup> The only basis given by Intervenors for denying this overregistration is the argument that the USGS and others would surely have corrected their instruments if this were generally true. This reasoning indicates a lack of understanding of the evidence presented.

Drs. Newmark (Tr. 587) and Blume (IV-4 and 5) indicated that the basic problem with the high vertical acceleration overregistration does not lie with the instruments themselves, but with whether and how the instruments are attached to a heavy foundation. USGS does not correct for such effects (e.g., size of the structure) as is shown in USGS-795 where they classify records by building size (USGS-795 at 9) and find lower accelerations for large buildings than small ones.

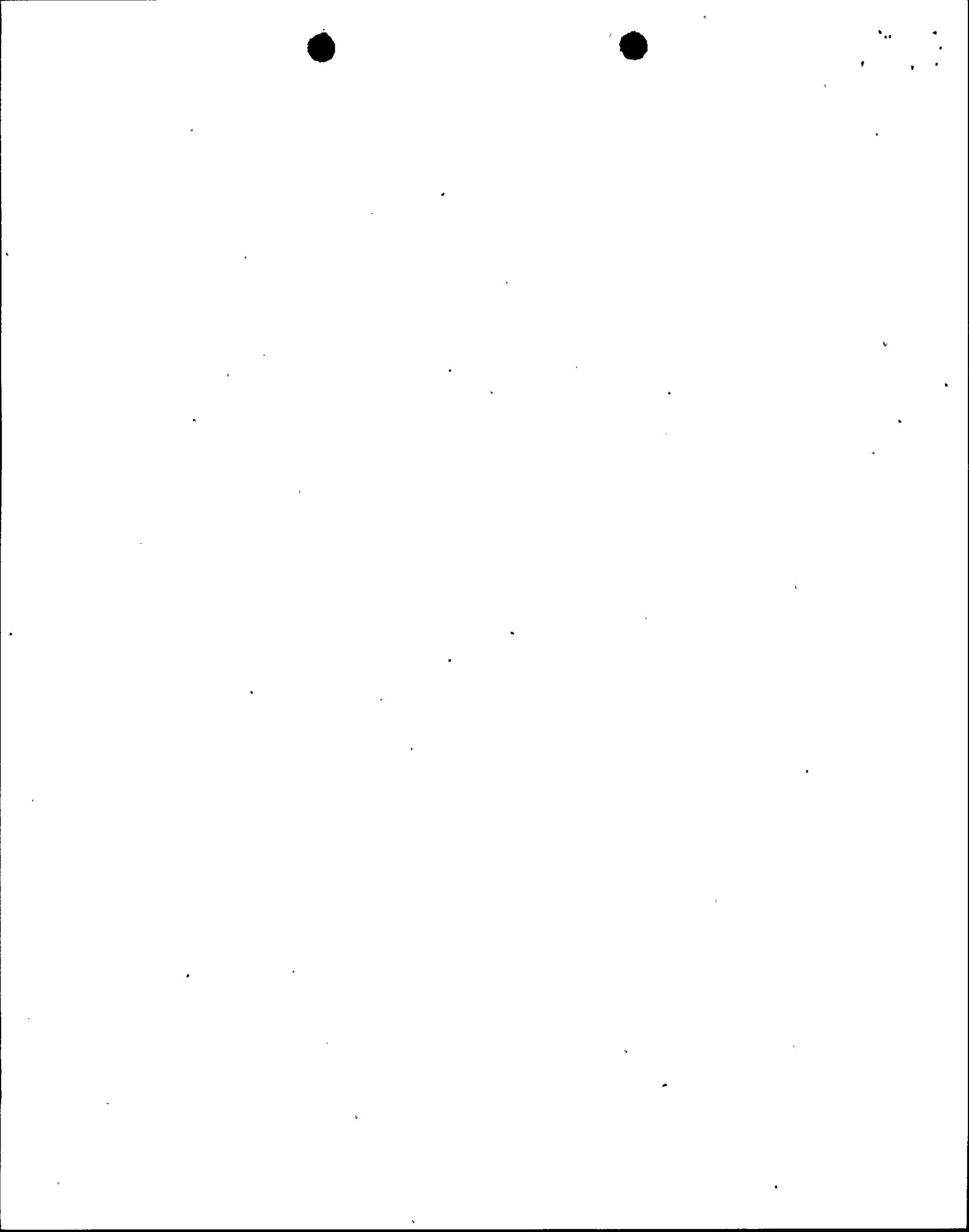
Dr. Frazier testified that Station 6 (1.74 g later corrected to 1.52 g) is located on a wedge-shaped block between the Imperial and Brawley faults and, for this and other geologic reasons, consistently and significantly records higher vertical accelerations than any other stations. (Frazier IV-6 to 8) That testimony was never challenged nor contradicted in any way.

### 3. Near Field Vertical Records

Intervenors argue that the IV-79 vertical records should be used in lieu of any other data since other studies have relied

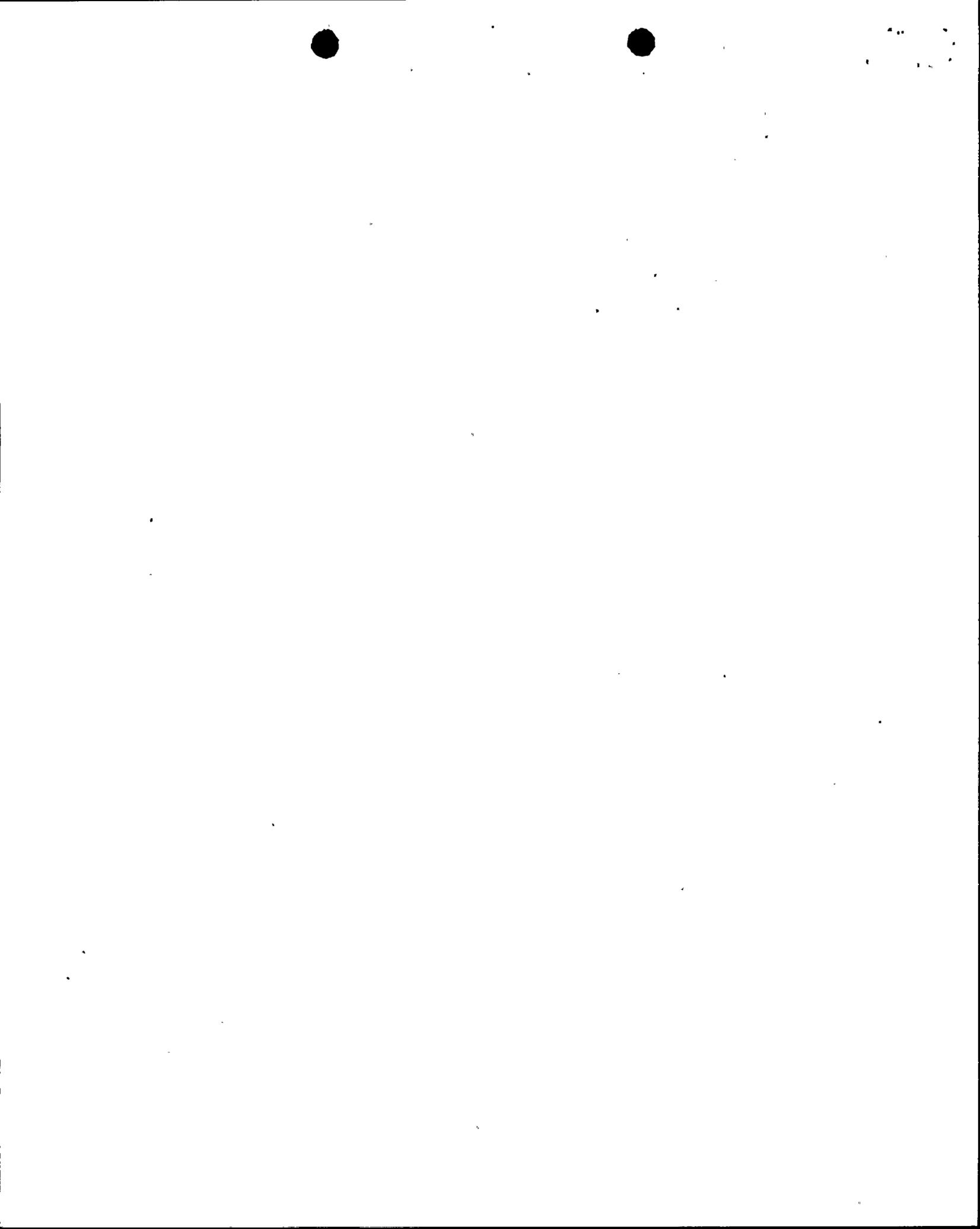
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<sup>8/</sup>Newmark (1973) and Bolt and Hansen (1977).



upon far field data. Additionally, Intervenors refer to Governor Brown's Ex. R-15 which presents a mean plus sigma unscaled vertical response spectra from 12 IV-79 records as "startling" since it exceeds the Diablo Canyon reanalysis spectra.

Again Intervenors seem to ignore much of the record developed in these hearings. Specifically, evidence they introduced or their witnesses referenced (USGS-795 and SAN/1011-125) address near field vertical acceleration data. Examination of USGS-795 (J.I. Exhibit R-1) shows that the trend of vertical peak ground acceleration data in the near field is less than horizontal peak ground acceleration. This is observed by overlaying Figure 1 with 14, Figure 2 with 15 and Figure 3 with 16 representing horizontal PGA and vertical PGA from M 5-5.7, M 6.0-6.4 and M 7.1-7.6 records, respectively. In each case the horizontal PGA curves are above the vertical PGA curves. Additionally, Governor Brown's witness Dr. Young, cites SAN/1011-125 as indicating "design criteria providing vertical response equal to two-thirds of the horizontal response would be adequate." (Tr. 28) Dr. Young also notes that SAN/1011-125 also contains near field data (Id.). In fact, the title of the document is "Correlation of Peak Earthquake Ground Acceleration in the Very Near Field". Examination of Equation 1-1 on page 1-2 of the exhibit does indeed support the finding that vertical PGA is less than horizontal PGA in the near field of earthquakes. Therefore, what Intervenors have failed to note is that, except for IV-79, the other available near field analyses support the 2/3 ratio of vertical to horizontal ground



motion. For the geological and seismological reasons discussed above however, one would expect IV-79 to generate higher vertical PGA.

Intervenors present Governor Brown Exhibit R-15 as "startling" evidence since they use the same 12 stations as Dr. Blume used for horizontal and yet compute a mean plus one sigma instrumental response spectra above the Hosgri reanalysis spectra for verticals. This result is dominated by one record, that of Station 6 which recorded a vertical of 1.74 g. Dr. Frazier discussed the behavior of this anomolous station (Frazier, IV-6) including the findings of other scientists from the USGS (Boore and Fletcher (1980) and Porchella (1978)) that indicate a specific geologic site condition responsible for historically high vertical recordings at Station 6. No other evidence was offered in opposition to these analyses. It, therefore, is inappropriate to sponsor an analysis as "startling" whose results are dominated by this one anomolous record. They are only startling to those who do not understand the statistical effect of including one of twelve points whose value is over four times the mean value. In fact, the mean plus one sigma is reduced from 0.87 g to 0.67 g when Station 6 is omitted in the standard log normal analysis.

Applicant witness Dr. Blume indicates the additional margin in the design of many Diablo Canyon structures to accept greater vertical to horizontal response than  $2/3$  since the "tau" reduction was only applied to horizontal motion. (Blume IV-2 and 3) Intervenors argue that if the "tau" reduction were disallowed,

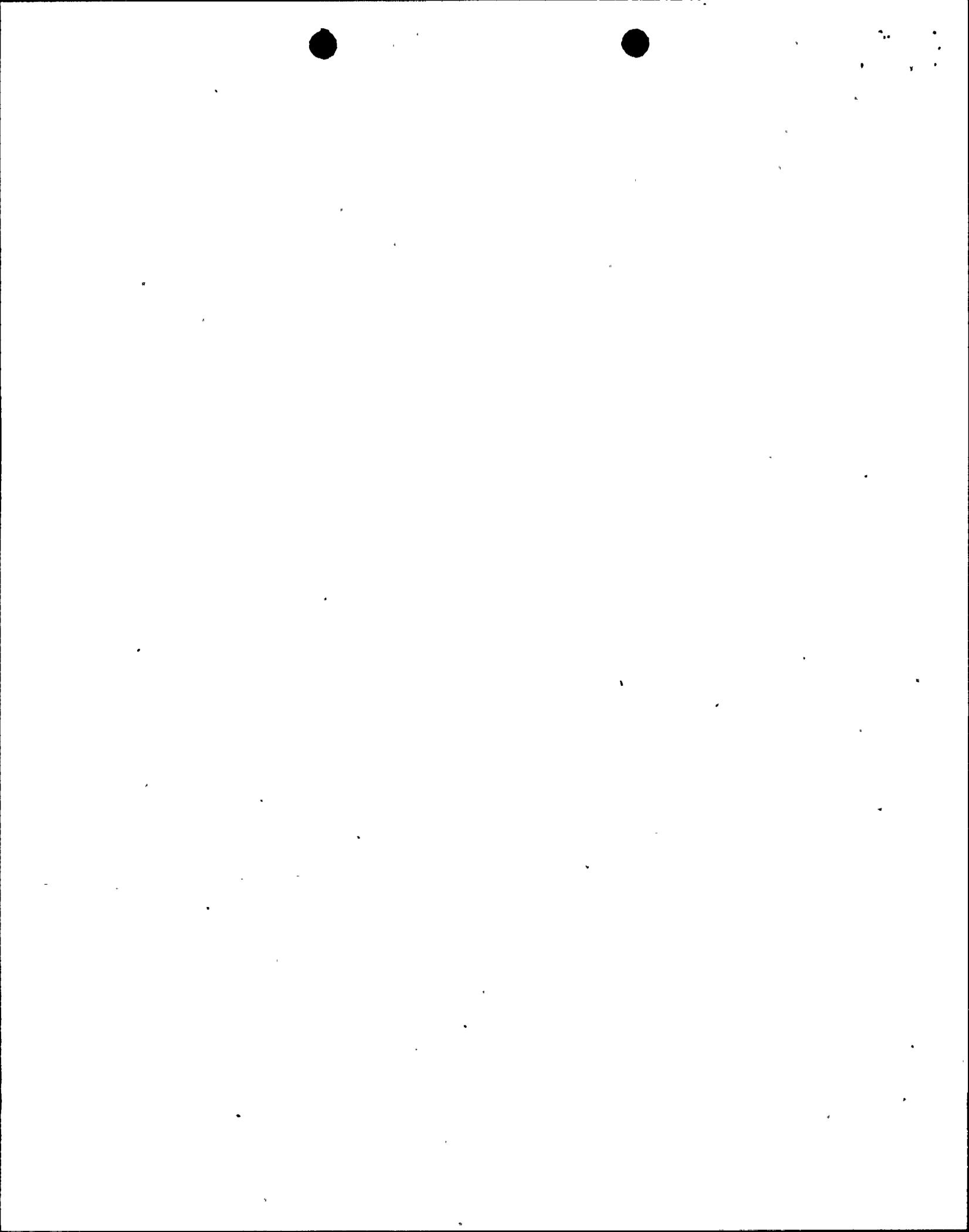


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then all structures at Diablo Canyon would be designed to a 2/3 ratio. This is obviously correct, but inconsistent with the evidence supporting horizontal ground motion reduction from free field instrumental ground motion. More significant as respects verticals however, is the IV-79 data and analyses performed by Dr. Smith (Smith V-3 to 6; Tr. 1386-95) which Intervenor ignore even though it demonstrates that vertical high frequency motion would be reduced by a structure's foundation by about 20 percent based upon the observed incoherence in ground motion recordings.

Furthermore, Dr. Blume and Dr. Frazier testified as to the effect that the high vertical accelerations which occurred at IV-79 might have on structures, noting the lack of damage even though several very high peak ground accelerations occurred (Blume IV-5, Frazier IV-10). This was explained by the fact that the few large vertical pulses were isolated and contained little energy (Blume IV-6, Frazier IV-10), and by the fact that the high vertical accelerations arrived well before the onset of strong horizontal ground motion (Frazier IV-9, Blume IV-6). Dr. Frazier quantified the margin that exists in the Diablo Canyon Hosgri reanalysis due to just one factor -- the separation in time of the vertical and horizontal ground motion. Comparing the procedures used in the Hosgri reanalysis which assume simultaneous vertical and horizontal motion with the actual motion at several stations having very high vertical PGA, Dr. Frazier found an average margin of 24% in the assumed motion (Frazier IV-10).

In summary, it is clear that the IV-79 earthquake produced atypical vertical motions for reasons of unique site



conditions. The available near field analyses of other earthquakes support a vertical PGA less than horizontal PGA. Should a nuclear power plant such as Diablo Canyon be subjected to even these anomalously high vertical accelerations, the design response spectra would be adequate since incoherence would reduce the peak vertical acceleration by 20 percent and the conservative simultaneous combination of vertical and horizontal motion would have resulted in an additional design margin of 24%.

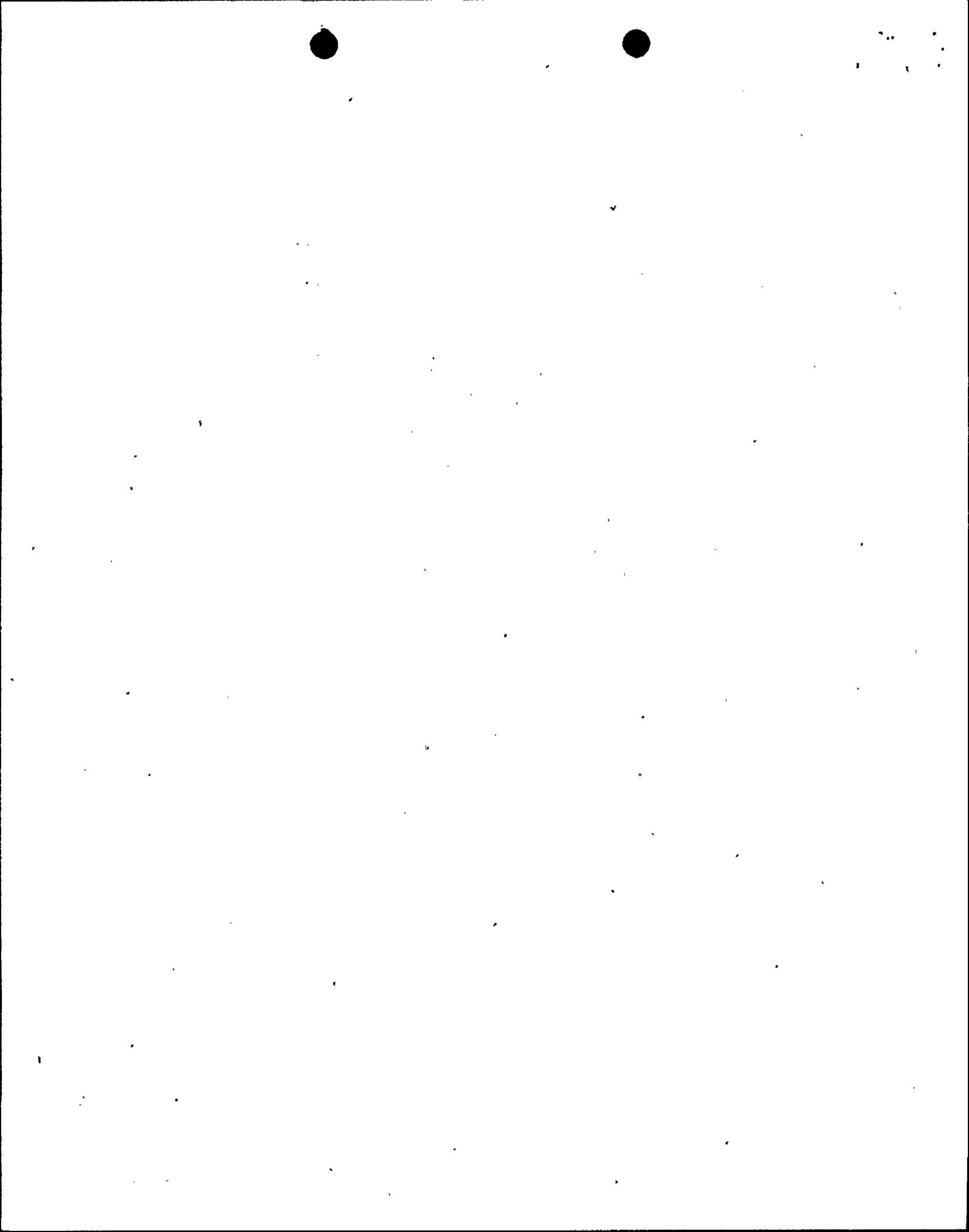
## VI

### EL CENTRO STEAM PLANT

Intervenor Governor Brown argues that the data on the El Centro Steam Plant and testimony adduced therefrom is of no value to this Board in its deliberations regarding Diablo Canyon. Such a posture is not surprising as Intervenors had no testimony to offer at the hearing<sup>9/</sup> and all of the testimony that was received is contrary to their ultimate goal in this matter. The attempt in Governor Brown's proposed findings to play down the effect of the El Centro Steam Plant information is a thorough distortion of the record. Neither this Board nor any witnesses ever claimed that the Steam Plant and Diablo Canyon were not different (as implied by Governor Brown at 74) and it was never claimed that the Steam Plant had been severely overstressed. (Brown at 77) For Governor Brown

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<sup>9/</sup>While not offering testimony at the hearing through qualified witnesses, Governor Brown attempts to now testify on this subject in his proposed findings (See, e.g., Brown at 78).



to claim that such was the case is to have sadly misread the record or to have an abysmal lack of understanding of fundamental seismic design (or both).<sup>10/</sup>

The testimony of witnesses Blume and Gangloff was not that the Steam Plant equipment was severely overstressed during IV-79, but rather that it was not severely overstressed while calculations, using the same methods and assumptions that were used in the Hosgri reanalysis, predicted overstresses several times more severe than what was actually observed. (Blume VIII-3, 10; Gangloff VIII-8, 9) The differences between calculational results and observed effects arises not from differences between the Steam Plant and Diablo Canyon, but from conservatisms in the calculational methods and assumptions. (Id.) The equipment which was considered included pumps, tanks, heat exchangers, transformers, electrical cabinets, etc., all of which is quite similar to equipment found in any nuclear generating facility, including Diablo Canyon. (Gangloff VIII-1)

The unchallenged evidence submitted by both the Applicant and Staff makes the record clear that the methods and assumptions

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<sup>10/</sup>In a similar vein, Governor Brown fails to understand the import of the testimony as well as fundamental seismic design when, at p. 78, he argues that the maximum pipe stress at node point 3810 could not have been 131.7 ksi as there was a restraint which allowed only 2.8 inches of displacement and not 21 inches necessary to arrive at 131.7 ksi. The point is that the testimony states that using the calculational methods and assumptions used in the Hosgri reanalysis a movement of 21 inches would be predicted and that observation of deformations in the piping insulation at node point 3810 showed that physical displacement did not even approach the predicted movement. (Gangloff VIII-7)



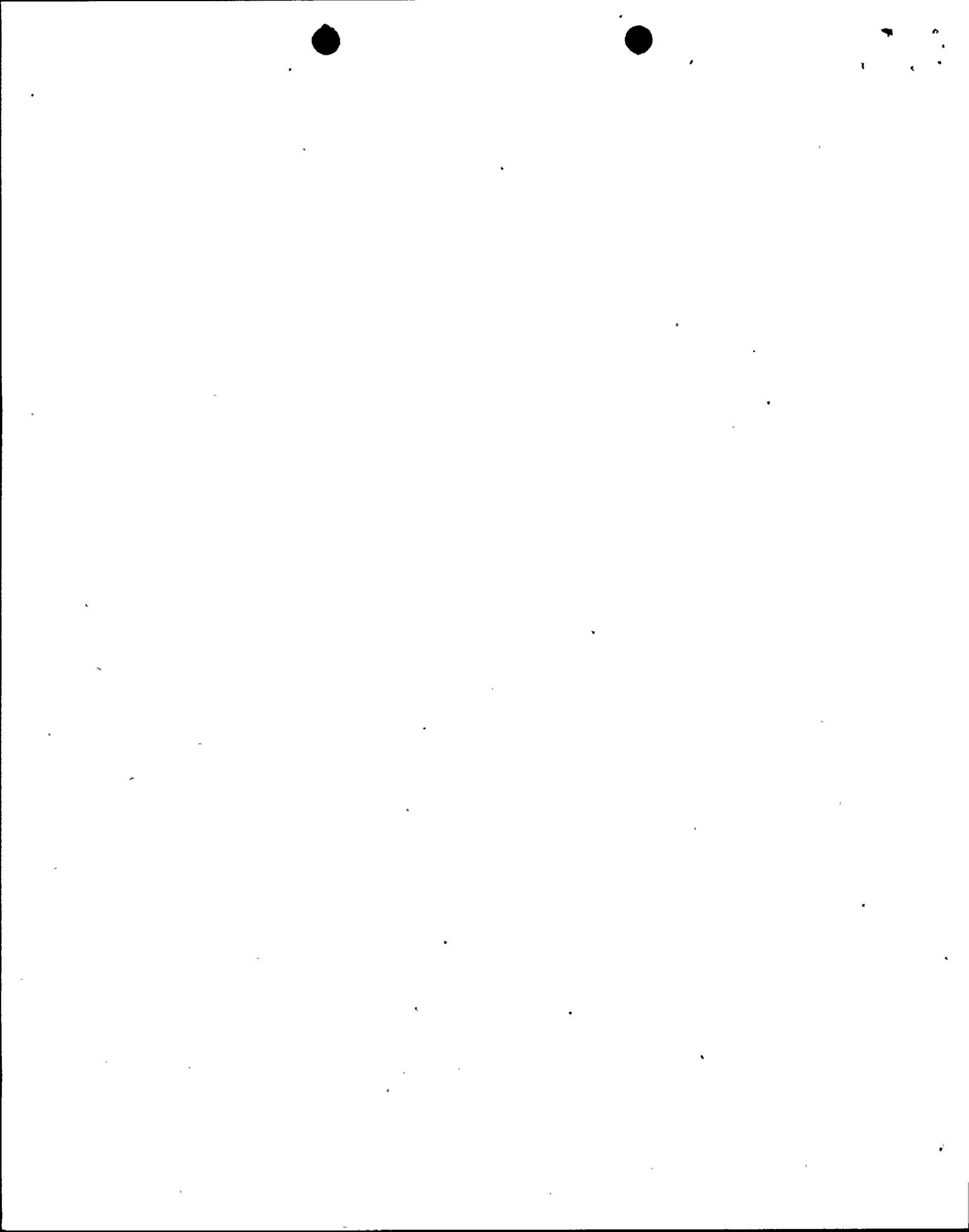
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required by the NRC in the Hosgri reanalysis and the codes and standards which were applied during the construction of Diablo Canyon have resulted in very significant factors of safety and design margins. These factors provide an inherent capability of the facility and the equipment therein to withstand vibratory motion well beyond any design basis spectrum used in such design calculations. The same analyses were done on components of the El Centro Steam Plant which was located 5 kilometers normal to the Imperial Valley fault (Blume VIII-1) and those calculations significantly overpredicted the actual results. The comparison is an actual demonstration that the analytical methods and assumptions used in the Hosgri reanalysis contain significant conservatism. (Blume VIII-10; Gangloff VIII-9)

## VII

### PROPOSED CONCLUSION

Based on the consideration of the foregoing analyses of the evidence submitted on the eight questions appended to our prior decision to reopen these proceedings (ALAB-598, 11 NRC 876) relating to the significance of the October 15, 1979 Imperial Valley earthquake data to the seismic findings of the Licensing Board (LBP-79-26, 10 NRC 453, pp. 465-507), as well as the evidence submitted on the ninth question relating to the 1927 Lompoc earthquake, we conclude that there is nothing in the Imperial Valley earthquake data or in the USGS review of the 1927 Lompoc



earthquake which contradicts or is inconsistent with the Licensing Board's findings.

Respectfully submitted,

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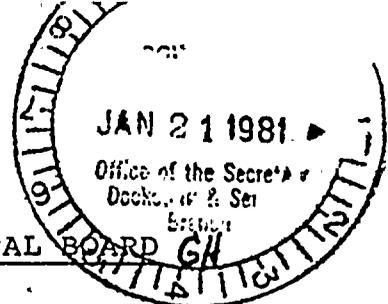
By   
Bruce Norton

DATED: January 16, 1981.



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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION



BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of )  
 ) Docket Nos. 50-275 O.L.  
PACIFIC GAS AND ELECTRIC COMPANY ) 50-323 O.L.  
 )  
(Diablo Canyon Nuclear Power ) (Seismic Issues)  
Plant, Units No. 1 and 2 )

CERTIFICATE OF SERVICE

I hereby certify that copies of "APPLICANT PACIFIC GAS AND ELECTRIC COMPANY'S RESPONSE TO INTERVENORS' PROPOSED FINDINGS ON IV-79", dated January 16, 1981, have been served on the following by deposit in the United States mail, express\* and regular, this 16th day of January, 1981:

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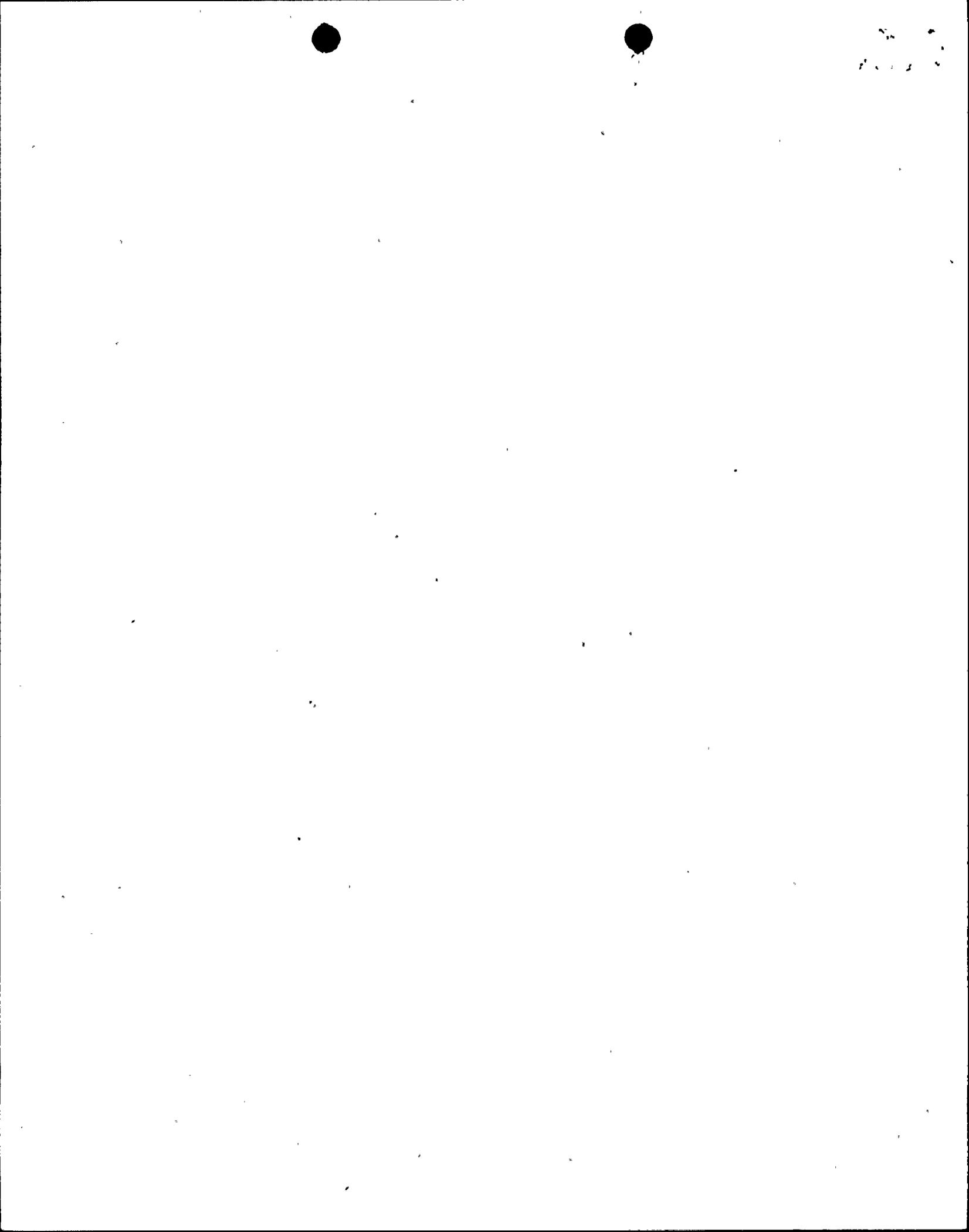
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ELD File Room 27709

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Subject: NRC-STAFF'S Brief

