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Dwight E. Nunn
Vice President

September 21, 2001

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Subject: **Docket Nos. 50-361 and 50-362**
Seismic Design Basis Assessment
San Onofre Nuclear Generating Station, Units 2 and 3

References: See Enclosure

Gentlemen:

This letter provides the initial response to the information requested in the August 2, 2001 NRC letter [1] concerning the seismic design basis for San Onofre Units 2 and 3. Southern California Edison (SCE) has reviewed the statements by Dr. Mark Legg in item 2 of his comments and is providing the following preliminary assessment. However, at this time, SCE has not seen data that establishes that the Oceanside detachment/thrust system is under San Onofre. There is a great deal of uncertainty as to the fault system's location, extent, and seismogenic potential, and no definitive conclusions can be drawn as to the significance of the postulated fault from the cited references. Therefore, SCE is conducting a study to determine whether the postulated blind thrust fault will have any significant effect on the seismic risk of San Onofre Units 2 and 3 using the seismic risk methodology used for the Individual Plant Examination of External Events (IPEEE). As this study requires significant effort, additional time is required to complete it. The results of the study and our final assessment will be provided to the NRC by December 31, 2001.

Item 2 of Dr. Legg's comments and SCE's preliminary assessment follows:

Comment:

2. *It is now recognized that major detachment fault systems in the region are reactivated as thrust faults, some blind (not reaching the surface). The major Oceanside detachment/thrust system underlies the San Onofre Nuclear Generating Station (SONGS). Consequently, large thrust or oblique-reverse earthquakes on this system may generate shaking levels in excess of the design level of SONGS units 2 and 3. [Bohannon and others, 1990; Legg and others, 1992; Nicholson and others, 1993; Crouch and Suppe, 1993; Bohannon and Geist, 1998; Mueller and others, 1998; Grant and others, 1999; Rivero and others, 2000].*

P. O. Box 128
San Clemente, CA 92674-0128
949-368-1480
Fax 949-368-1490

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Response:

Dr. Legg's statement implies that there is general consensus in the professional and academic communities regarding the activity and seismogenic potential of recently postulated blind thrust faults in the southern California continental borderlands. Whereas there is general agreement that detachment faults are present, there remains a great deal of uncertainty regarding whether or not these faults have been reactivated as blind thrust faults, the degree to which they may have been reactivated along their entire length, and their possible behavior in the contemporary tectonic environment.

Alternative structural models for the interaction of the postulated blind thrust faults and recognized active strike-slip faults (e.g., the Newport-Inglewood-South Coast Offshore Zone of Deformation-Rose Canyon (NI-SCOZD-RC) and San Diego Trough faults) have been postulated by Grant and others (1999) [2], Mueller and others (1998a and b) [3,4], and Rivero and others (2000) [5]. The hazard posed by the postulated blind thrust faults varies considerably depending on the viability of these alternative structural models. Key factors in the assessment of the hazard at the San Onofre Nuclear Generating Station (SONGS) are the activity and seismogenic capability of the Oceanside detachment, and the downdip extent of the NI-SCOZD-RC fault zone, which is dependent on the nature of its intersection with the Oceanside detachment. This intersection is not clearly defined in the offshore seismic data.

The truncation of the NI-SCOZD-RC fault zone by an active SW-vergent blind thrust at a depth of ~6 km is implied by the interpretations of Crouch and Suppe (1993), Mueller and others (1998b), and Rivero and others (2000). The likelihood that the NI-SCOZD-RC fault zone offsets an inactive Oceanside detachment is supported by the focal mechanism and depth of the 1933 Long Beach earthquake along the NI fault, geodetic data that indicate predominantly strike-slip motion at rates of 6 ± 1 mm/yr and low to negligible (< 1 mm/yr) of fault normal convergence across the Southern California borderlands (Walls and others, 1998 [6]); unpublished data presented by Yehuda Bock, IGPP, Scripps Institution of Oceanography, Southern California Earthquake Center (SCEC) Borderlands Workshop, January 30, 2001), and alternative models to explain regional coastal uplift as due to regional isostatic processes. The possibility that both co-exist and are seismogenic, if deemed viable, would have implications for the assessment of the NI-SCOZD-RC fault zone, which is currently characterized as a strike-slip fault extending to seismogenic depth (Risk Engineering, 1995 [7]). The details and viability of these alternative models have been topics of discussion in recent SCEC sponsored workshops (e.g., SCEC Borderlands Workshop, January 2001).

In the following paragraphs are some of the more pertinent data and observations that are available to judge these alternative models and the program SCE has begun to assess the implications of these alternative models to the seismic hazard at SONGS.

Low-angle reflectors interpreted to be low–angle detachments are evident as relatively continuous features in the 1980s offshore seismic data. These structures are interpreted to be low-angle normal faults that were formed by large-magnitude crustal extension in the latest Oligocene-earliest Miocene time (Crouch and Suppe, 1993 [8]; Bohannon and Geist, 1998 [9]). Crouch and Suppe (1993) show examples of low-angle, east-dipping reflection events on seismic records in the offshore area adjacent to Dana Point just north of SONGS. Bohannon and Geist (1998) analyze U. S. Geological Survey (USGS) records from the Southern California continental borderland and show the "Oceanside detachment fault" in an offshore seismic record adjacent to SONGS. Most recently, Rivero and others (2000), through mapping and structural analysis of seismic data, extend the Oceanside and Thirtymile Banks detachments as far south as the International border.

Recent geological journal articles by Grant and others (1999), and Rivero and others (2000) present evidence suggesting recent activity of blind thrust faults, based on assumptions regarding a structural association to folding and coastal uplift, possible association between observed seismicity (e.g., the 1986 Oceanside earthquake) and the location of a thrust plane, and the apparent association of seafloor scarps and seafloor slope changes associated with post-Miocene folding above the thrust faults. Previous researchers (e.g., Legg and others, 1992 [10]; Crouch and Suppe, 1993) also suggested possible post-Miocene reactivation of the detachments, at least locally. However, except for the San Joaquin Hills thrust, for which there appears to be clear evidence of associated late Pleistocene and Holocene uplift, the evidence for activity of the Oceanside and Thirtymile Banks detachment faults is not conclusive, nor is it well documented along their entire length.

There are a number of critical issues that must be addressed to fully characterize the postulated blind thrust models. Clear documentation of the continuity of features suggesting recent activity along the entire length of the postulated detachment faults is not provided in the published journal articles. There is insufficient information provided in the published articles to provide constraints on the location, geometry, activity, and slip rates of the newly postulated blind thrust faults to adequately characterize the faults for seismic hazard analysis. Recent geodetic analyses (Walls and others, 1998 [6]) suggest that published rates for the postulated thrust faults, if active, are too high.

To better understand the uncertainty in the source characterization parameters for blind thrust faults (e.g., total length, rupture segments, downdip geometry and extent, and slip rate) as well as the structural relationships and interactions of the postulated fault sources and known active strike-slip faults, SCE plans to interface directly with researchers (e.g., C. Rivero, J. Shaw, L. Grant, etc.) to elicit more detailed information needed to evaluate models, parameter values, and associated uncertainty. The information will be used in SCE's study.

Comment:

a. *The SONGS site would not be-5-7 km from the epicentral zone, but instead directly above the potential fault rupture plane. Estimation of strong ground motion should use an epicentral distance of zero (0).*

Response:

Modern strong motion attenuation relationships do not use epicentral distance as a distance measure. They typically use the shortest distance to the rupture surface as the distance measure. Thus, evaluation of any potential ground motion effects from a postulated detachment source beneath the SONGS site would use the distance from the ground surface down to that postulated source.

Comment:

b. *Newer attenuation relations based upon recent large earthquake activity including the 1989 Loma Prieta, California; ... are more accurate in estimating ground motions than the relationships used for the Safety Evaluation conducted in the late 1970s. [Abrahamson and Silva, 1997; Boore and others, 1997; Campbell, 1997; Sadigh and others, 1997].*

Response:

As part of the U.S. Nuclear Regulatory Commission Individual Plant Examination of External Events program, SCE conducted a seismic probabilistic risk assessment for the SONGS plant in 1995. The evaluation used the latest information available at the time to assess earthquake hazards at the plant site (Risk Engineering, 1995 [7]). The ground motion attenuation relationships used included prepublication versions of most of the relations described above.

Comment:

c. *The recent earthquake experience has shown that near source effects are substantial, resulting in strong amplification of ground motions. The SONGS site lies directly above the detachment/thrust system, and therefore is subject to such effects. These effects include focusing of energy due to the rupture propagation and hanging wall effects wherein the seismic energy is trapped and amplified in the wedge of crust above the fault plane.*

Response:

Near-source directivity effects in general and hanging-wall effects for thrust faults could affect ground motions at a site. However, the near-source directivity effects affect the ground motions starting at a frequency of about 2 Hz and become significant only at frequencies significantly lower than 1.5 to 2 Hz (e.g., Somerville et al., 1997 [11]). Since the safety related structures at SONGS have natural frequencies of about 1.5 Hz and higher, it is unlikely that the near-source directivity effects would have significant impacts at the SONGS site. The hanging wall effects are dependent on whether a "detachment/thrust system" actually underlies the site.

Comment:

d. *As stated during my testimony during the NRC hearings in 1981, the reverse fault character of microearthquakes recorded along the Cristianitos fault trend in the mid-1970's and reactivation of minor faulting uncovered during site excavations is consistent with overall reactivation of ancient normal fault structures by a new stress regime involving northeast-directed shortenings or transpression. This assertion has now been confirmed by recent geologic studies in the neighboring offshore region, and in fact, may have been deduced from the proprietary exploration industry data available to the Safety Evaluators in the late 1970s.*

Response:

The two microearthquakes (M=3.3 and 3.8) referenced above occurred on January 3, 1975 near San Juan Capistrano, California. Following a program of detailed investigation undertaken to evaluate the significance of these events, it was concluded that the events were not associated with the north-northwest-trending Christianitos fault, but rather a northeast-trending feature parallel to Trabuco Canyon (SER, Section 2.5.1.7 [*12*]). The events were shown to have a left-lateral oblique thrust sense of motion. Left-reverse oblique slip on northeast-trending fault systems is consistent with the contemporary crustal strain that is characterized by north-south compression and east-west extension in Southern California (Walls and others, 1998 [6]). These earthquakes do not demonstrate reactivation of the Christianitos fault.

The 'minor faulting' mentioned by Dr. Legg was described in detail in reports submitted to the NRC in 1974 and 1976 (SER, Section 2.5.1.3 [12]). These features (designated A, B, C, & D type features) comprise a set of shears having limited lateral extent that are observed solely within the Pliocene to Mio-Pliocene San Mateo formation. The shears are overlain by undeformed marine terrace deposits. The age of the overlying terrace deposits indicates that the features have not been active in the past 70,000 to 130,000 years. As stated in the SER, Section 2.5.1.3 [12], these features are not capable faults as defined in Appendix A to 10 CFR Part 100.

The two lines of evidence cited by Dr. Legg do not demonstrate that faults in the vicinity of SONGS have been reactivated and are capable faults that would pose a significant hazard to SONGS. Reactivation of minor faults in the coastal region does not require or demonstrate that the older normal faults, such as the Christianitos and the Oceanside detachment, are being reactivated as reverse faults in the current transpressive tectonic setting.

As stated above, this information is a preliminary assessment of item 2 of comments made by Dr. Legg. SCE has not seen data that establishes that the Oceanside detachment/thrust system underlies San Onofre, and there are many uncertainties associated with the fault system. Thus, further study is underway to determine, using the IPEEE seismic risk methodology, whether the postulated blind thrust fault would have any significant effect on the seismic risk of San Onofre Units 2 and 3. The results of the study and our final assessment will be provided to the NRC by December 31, 2001.

If you have any questions or would like additional information, please contact me or Mr. Jack L. Rainsberry (949/368-7420).

Sincerely,

Enclosure

cc: E. W. Merschoff, Regional Administrator, NRC Region IV
M. L. Scott, NRC Project Manager, San Onofre Units 2, and 3
C. C. Osterholtz, NRC Senior Resident Inspector, San Onofre Units 2 and 3

ENCLOSURE

REFERENCES

1. NRC (S. Dembeck) to SCE (H. B. Ray) letter dated August 2, 2001, Subject: San Onofre Nuclear Generating Station Seismic Design Basis.

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3. Mueller, K. J., Grant, L. B., and Gath, E., 1998a, Late Quaternary Growth of the San Joaquin Hills Anticline—A New Source of Blind Thrust Earthquakes in the Los Angeles Basin: Seismological Research Letters, v. 69, no. 2, p. 161.

4. Mueller, K., Shaw, J., and Rivero, C., 1998b, Determining the Geometry of the San Joaquin Hills Blind Thrust: Implications for Earthquake Source Characteristics; Progress Report Submitted to Southern California Earthquake Center, February 23, 1998.

5. Rivero, C., Shaw, J. H., and Mueller, K., 2000, Oceanside and Thirtymile Bank Blind Thrusts: Implications for Earthquake Hazards in Coastal Southern California: Geology, v. 28, p. 891-894.

6. Walls, C., Rockwell, T. Mueller, K., Bock, Y., Williams, S., Pfanner, J., Dolan, J., and Peng, F., 1998, Escape Tectonics in the Los Angeles Metropolitan Region and Implications for Seismic Risk: Nature, v. 394, p. 356-360.

7. Risk Engineering, August 25, 1995, Seismic Hazard at San Onofre Nuclear Generating Station.

8. Crouch, J. K., and Suppe, J., 1993, Late Cenozoic Tectonic Evolution of the Los Angeles Basin and Inner California Borderland: A Model for Core Complex-Like Extension: Geological Society of America Bulletin, v. 105, p. 1415-1434.

9. Bohannon, R., and Geist, E., 1998, Upper Crustal Structure and Neogene Tectonic Development of the California Continental Borderland: Geological Society of America Bulletin, v. 110, p. 779-800.

10. Legg, M. R., Nicholson, C., and Sorlien, C., 1992, Active Faulting and Tectonics of the Inner California Continental Borderlands, (abs.): EOS Transactions American Geophysical Union, v. 73, p. 588.

11. Somerville, P. G., Smith, N. F., Graves, R. W., and Abrahamson, N. A., 1997, Modification of Empirical Strong Ground Motion Attenuation Relations to Include the Amplitude and Duration Effects of Rupture Directivity: Seismological Research Letters, v. 68, No. 1, p.199-222.

12. NRC Safety Evaluation Report for San Onofre Nuclear Generating Station, Units 2 & 3, dated February 1981, NUREG-0712.