United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA. 22092

In Reply Refer To:
Mail Stop 905

SEP 5 1979

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

Dear Mr. Denton:

Transmitted herewith, in response to the request of your staff, is our review of the geologic and seismologic data relevant to the General Electric Test Reactor at Vallecitos, California.

This review was prepared by Earl Brabb, Darrel Herd and James F. Devine. Assistance was provided by Robert H. Morris.

Sincerely yours,

Henry W Coulter
for H. William Menard
Director

Enclosure

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General Electric Test Reactor

Vallecitos Nuclear Center

Vallecitos, California

The U.S. Geological Survey (USGS) has reviewed the geologic and seismologic aspects of the material submitted by the General Electric Company concerning the General Electric Test Reactor at Vallecitos, California.

We conclude that the General Electric Company has not investigated adequately the site geology of the GETR to determine to the degree necessary for NRC requirements the potential for surface faulting at the Vallecitos Nuclear Center. Although the February 1979 report of Dr. R. H. Jahns admits (10, p. 2; 11, p. I-1) that the Verona fault may exist, the consultants for GE believe that the shears revealed by trenching at the GETR site are the result of landsliding about 70,000 to 125,000 years ago (12, p. 1). Thus, almost the entire teror of their reports (6 through 13) has been to document this landsliding and to deny faulting. Consequently, critical fault parameters, such as length, width, sense of movement, and timing of movement, have not been determined adequately. Therefore, the potential for surface faulting or vibratory ground motion at the GETR site has not been established reliably or adequately.

ARGUMENTS FOR LANDSLIDING

The original geologic explanation proposed by the licensee's consultants, Earth Science Associates, (7, p. IV-33) to explain the

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thrust faulting seen in trenches T-1 and T-2 was that there are large landslides in the hills above the GETR site which have basal failure surfaces expressed as the faults seen in the trenches. Two amphitheater-like landslide pull-away scarps extending almost to the crest of the hills were envisioned. The probable main and secondary slip surfaces of the landslides were shown on maps accompanying the first report of the consultants on the GETR site (7, figs. 4 and 7). Within the limits of these great landslides, the beds were reported (7, p. IV-32) to have a wide variation in attitude due to rotation of the interior of the landslides. Stratigraphic lineations, presumably bedding, were reported to be discontinuous and disrupted within the landslide boundaries, and to be fairly continuous outside of the landslide area. Shear surfaces were reported (7, p. IV-34) to shallow in a northeasterly direction, presumably curving upward like landslide breaks beyond the eastern limits of the trenches excavated at the foot of the hills northeast of the GETR.

The so-called headwall scarps of the amphitheater-like areas were subsequently trenched. The trenches revealed continuous beds and no features suggestive of large-scale landsliding. The reported variation in bedding can be accounted for in part by faulting and folding, and locally by attitudes that were measured improperly. The changes in dips and strikes of the beds could have been caused by tectonism (the consultant's geologic maps show an anticlinal fold within the landslide area). Greater disruption in bedding outside the boundaries of the purported landslides has not been demonstrated. The geometry of shear surfaces at depth is very important but has not yet been determined adequately. Thus, all of the original evidence for landsliding has either been disproved or cannot be verified.

The only documentable portion of the landslide hypothesis consists of the shears seen in the trenches near the GETR, which the USGS attributes to faulting in the Verona fault zone of Herd (3).

The landslide hypothesis does not explain adequately geologic features in the Vallecitos Nuclear Center area. Specifically, some of these features are:

1. The consultants geologic map (7, fig. 4) shows the middle conglomerate member of the Livermore Gravel as a continuous unit extending around the periphery of the reactor site. Attitudes and fold axes on their map indicate that from trench A for at last 14,000 feet to the southwest, this middle conglomerate has a well-defined northeast-trending structural grain. The unit is essentially truncated by northwest trending gravels within their upper gravel unit. In the vicinity of trench A, the stratigraphic separation is at least 3000 feet and, is probably closer to 4500 feet. The consultants (8, p. 4-5) explain this difference in thickness by progressive eastward thinning of the section, but their data to support this assertion (8, fig. 21) does not show accurately the information on their geologic map. For example, in section DD′, the contact of the stippled gravels in QTlgu is misplaced about 1/4 inch to the left. The map indicates that these beds dip about 35 degrees, but their geologic cross section shows 55 degrees. Livermore Gravel in the Vallecitos Hills is shown as

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moderately dipping, but the strike of the gravel beds there is nearly parallel to the line of section. These beds should have a nearly horizontal apparent dip. Similarly, on section CC' in the vicinity of the stippled gravel unit within QTlgu, the contact is misplaced and the dip used (45°) is more than the observed true dip (35°) and much more than the apparent dip. If these discrepancies are taken into account, the change in thickness is more abrupt. The structural discordance must be explained either as an angular unconformity, which has not been identified in any of the trenches, or by faulting. This fault cannot be the Williams fault, which strikes about N. 25° W. (11, fig. 3). In our judgement it must be a westerly striking fault, and we conclude that it is the Verona thrust fault.

2. The log of trench B-2 (7, fig. E-5) indicates a fault with a length of at least 80 feet extending into the earth at a distance of about 1400 feet from the base of the nearest large hill. The consultant's cross-section (7, fig. 8) speculates that this fault flattens at depth to conform with their hypothesis that the fault forms part of the slip surface of a large landslide. The trench log indicates that the fault is actually steeper (28°) in the bottom part of the trench than in the upper part (18 to 23°). We believe that this fault is tectonic, rather than related to landsliding.

ARGUMENTS FOR FAULTING

The U.S. Geological Survey investigation of the Verona fault has been restricted in scope to studies designed to assess regional fault hazards (3), to a review of the literature, and to a review of information developed by the consultants (ESA) to the General Electric Company. Our analysis correspondingly is fragmentary and incomplete. Nevertheless, considerable evidence has been collected to show that the Verona thrust fault is the most plausible explanation for the shear features observed near the GETR.

1. Trenches T-1 and T-2 were dug by the licensee's consultant to test the existence of the Verona fault as mapped by Herd (3). Faulting (thrust) was observed in both trenches where predicted by Herd (3). The dips of the faults are similar in both trenches; the geologic units offset in both trenches and the direction of movement are also similar. We disagree with the interpretation offered in the ESA report of January 1978 (6, fig. B-2 and B-3) and believe that the uppermost soil horizon of probable late Holocene age is also offset.

2. Trench B-1 and an unnamed and unlogged trench nearby were dug to test the validity of the Verona fault line mapped by Herd (3). Faults were found in both trenches; again, the sense of movement (thrust) and units displaced are similar. We believe that the surficial, Holocene-age soils are offset in these trenches as well as in T-1 and T-2.

3. Trenches B-2 and H were dug, not to test a landslide hypothesis, but in response to an NRC request after USGS and NRC geologists saw lineations in those areas. The direction of movement, general dip and strike, and kinds of geologic units offset are similar to that seen in the earlier trenches. Here too, the uppermost soil (Holocene age) is offset.

4. Trench C requested by the USGS to look for the Verona fault in an area unaffected by landsliding northwest of the GETR, was not dug. Instead, trench E was excavated. Although no evidence for thrust faulting was found, westward-dipping faults with no stratigraphic continuity across them were seen in the east end of trench E.

Trench E has been interpreted by the consultants as both disproving the existence of the Verona fault in that area, as well as limiting its northernmost extent. We believe that this trench was not located properly. Low scarps west of the end of trench E appear to be possibly fault-controlled; the Verona thrust fault may lie at their base. Similarly, a Dinoseis profile (11, fig. C-2) near Sycamore Road has been cited as evidence that the Verona fault does not exist south of trench E. This profile, however, is permissive of an eastward-dipping thrust fault which would emerge in the area between reference points 105 and 130.

5. Trench A was dug at the suggestion of the USGS and NRC to examine the anomalous thinning of the Livermore Gravel stratigraphic section in the hills northeast of the GETR and the abrupt structural termination of the beds mentioned previously. USGS geologists predicted that the Verona thrust fault would be encountered in that trench, and that it is the cause of the apparent stratigraphic thinning of the Livermore Gravels between trench A and the GETR. A fault was indeed found in trench A, juxtaposing unlike Livermore Gravel sections. The consultant, however, has interpreted this fault to be a high-angle feature associated with the northerly-trending Williams fault. USGS

geologists believe the orientation, sense of movement, and age of the faults in trench A are comparable to those of the Verona fault. The orientation of the Williams fault (which strikes N.25° W.) cannot explain the structural dislocation and thinning observed. The faults seen in trench A strike generally N.65° W. to N.80° W. We believe that significant evidence for thrust faulting at this locality, has been overlooked and we also believe that the uppermost Holocene-age soil has been offset by this fault.

6. East-west-striking beds in the hills east of Sycamore Road are truncated at the southwest-facing escarpment of the Verona fault. This area is not shown as landslide by the consultant (7, fig. 4).

7. Nearly vertical beds of the Livermore Gravel crop out along a creek east of Sycamore Road. This area is not mapped as a landslide by the consultant. We believe these vertical beds are associated with thrust movement along the Verona fault.

8. Similar steeply dipping beds are present in a valley marked "canyon excavation" by the consultant (7, fig. 4). We believe these steep beds are related to fault movement.

9. Other geologists who have independently found evidence for a prolongation of the Verona fault in a northerly direction are:

(A) Hallenbech-McKay and Associates (5, fig. 3) who mapped a fault with the same orientation and location as the Verona fault in the vicinity of Alisal Road. The fault was mapped on the basis of photo lineations.

(B) Judd Hull and Associates (4) who mapped a fault in the vicinity of the sewage disposal plant in Pleasanton based on air photo lineations, offset geologic materials, offset drainage channel, offset water table, and seismic anomalies. This fault is along the projection of the Verona fault of Herd (3). Their work indicates that the Verona fault is not limited by trench E, as stated by Jahns (10, p. 12).

(C) The California Department of Water Resources map (16, fig. 4) shows a fault similar in orientation and location to the fault mapped by Judd Hull and Associates. This fault appears to have been mapped by CDWR on the basis of offset gravel layers and a displaced water table. This information, plus information from other sources was used by the California Division of Mines and Geology to establish a zone of potentially active faulting under provisions of the Alquist-Priolo act. This zone is directly along the northerly projection of the Verona fault.

(D) Griscom, et al, (15) interpret a gravity survey to indicate anomalies in the vicinity of the Pleasanton sewage plant that can be interpreted as a fault. This independent survey corroborates the work of Judd Hull and Associates, CDWR, and CDM.

10. The presence of a possible fault at the foot of the hills behind the GETR, in the same location as mapped by Herd (3), was noted previously by two consultants (1, 2) who prepared geologic reports for the General Electric Company.

In summary, the existence of the Verona fault has been determined independently by a number of investigators using different methods, including two consultants for the licensee, General Electric, in 1958 and 1973. The existence of the fault was tested by the current GE consultants, ESA, in 8 places and in our judgement confirmed in 7 of those places. The sense of movement in all places is consistent. The landslide hypothesis, in contrast, was tested in 3 places without success in our judgement. In our view, the information provided by the licensee establishes firmly the existence of the Verona fault and does not support the landslide hypothesis.

REGIONAL FAULT TECTONICS

Earth Sciences Associates (11) presents a tectonic model for the Livermore Valley region which would preclude both the Verona and Las Positas faults. They believe that the most striking characteristics of the structure of the Livermore Valley region is a consistent north-northwest- to northwest- trend of all major folds and faults and of most geologic contacts.

Survey mapping (Fig. 1 is a generalized sketch of Survey mapping) shows the Livermore Valley to be an anomalous east-west-trending valley bounded on the east, south, and west by late Quaternary-age faults. An unusual northeast-trending fault, the Las Positas fault, extends from the southeast corner of Livermore Valley southwest to La Costa Valley, just east of the GETR. The Las Positas fault is evidenced by offset stream terraces, a groundwater barrier, and geologic field relationships. The Las Positas fault is exposed in outcrop along Arroyo Seco south of Lawrence Livermore Laboratory, and has been trenched at the Sandia Laboratories (examined by USGS and CMG geologic personnel). It is interesting to note that in the one area where ESA has conducted

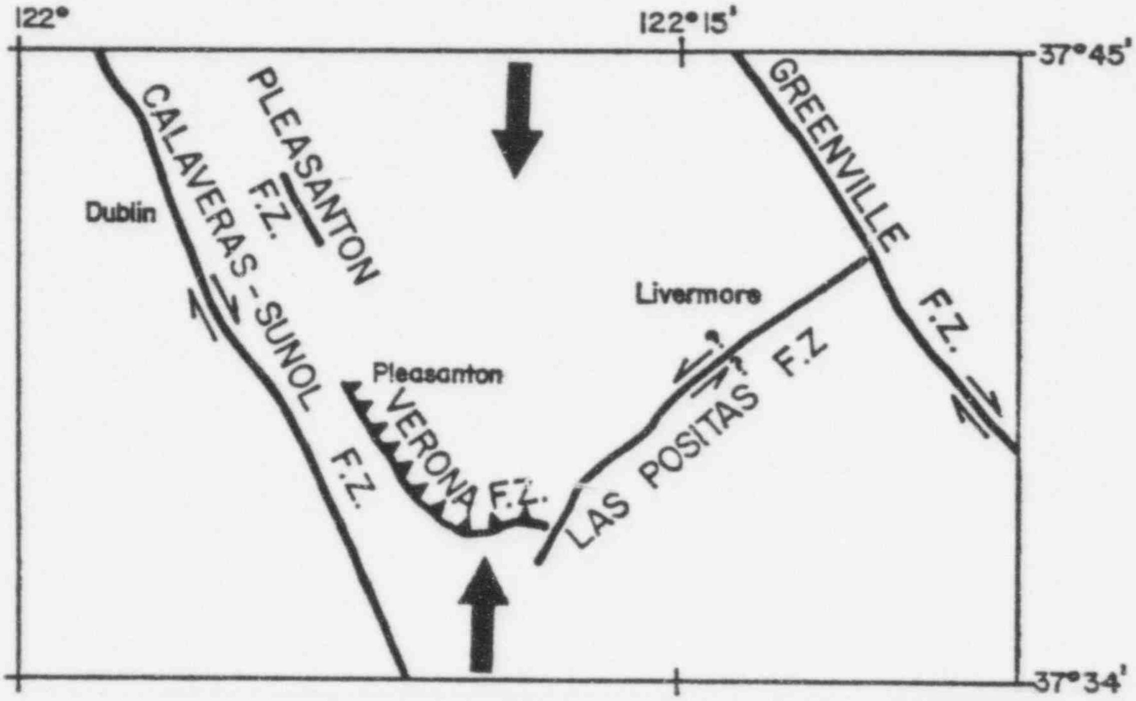

Fig. 1.--Tectonic framework of Livermore Valley. Principal active faults are shown. The maximum compressive stress axis is represented by the dark bold arrows.

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field work near the Las Positas fault (at its southwest end), the geologic map (11) is practically identical to that of Herd (3).

The Las Positas fault ends to the northeast against the Greenville fault, a northwest-trending fault with evidence for right-slip movement. The Calaveras-Sunol fault, a northwest-trending right-slip fault, bounds the west side of Livermore Valley.

The tectonics of Livermore Valley are controlled by a right-lateral stress couple in the California Coast Ranges caused by the northwestward movement of the Pacific plate past North America. The maximum stress axis of this right-lateral couple in the Livermore Valley area lies at an angle of about 30° to the strike of both the Calaveras-Sunol and Greenville faults (the maximum stress axis of a stress ellipsoid bisects the 60° angle between intersecting strike-slip failure planes of the stress ellipsoid). This right-lateral stress couple causes right-slip movement along the Calaveras-Sunol fault, and could produce left-lateral strike-slip movement along the Las Positas fault, which lies at a 60° angle to the Calaveras-Sunol fault. Although there is no geologically well-documented strike-slip component of movement along the Las Positas fault, the groundwater barrier along the fault near Lawrence Livermore Laboratory (3), possible horizontal slickensides seen in the fault zone in trenches at the Sandia Laboratories, and change in direction in face of scarps along the fault are consistent with left-lateral strike-slip movement.

Thrust movement along a west- to west-northwest-trending Verona fault would be expected because the fault lies nearly perpendicular to the maximum stress axis. The Verona fault apparently joins the Las Positas fault east of the GETR (the southeastward prolongation of the Verona fault is exposed in both trench A and in the La Costa Water Tunnel), and left-lateral strike-slip movement along the Las Positas fault would cause westward thrusting of Livermore Gravels along the Verona fault.

North-south extension of Livermore Valley, which was originally proposed by the licensee's consultant (6) to explain the tectonics of the valley and to negate the possibility of thrust faulting along the Verona fault, mechanically cannot exist. The valley is compressed in a north-south direction by the maximum compressive stress which causes right-lateral strike-slip movement along the northwest-trending faults in the California Coast Ranges.

CONCLUSION

Since the existence of the Verona fault has not been accepted by the licensee, the parameters necessary to determine the potential for fault displacement and vibratory ground motion have not been determined adequately. Specifically,

1. The northern extension and location of the Verona fault have not been established adequately. The information already available (5, 6, 15) has not been evaluated properly.

2. Likewise, the eastern extent of the Verona fault has not been determined. We believe the Verona fault probably extends into and becomes a part of the Las Positas fault.

3. A conservative position based on information available is that

the Verona - Las Positas fault system extends from the Calaveras to the Greenville fault, a distance of at least 29 km. The hypothetical fault proposed by the licensee is restricted to a distance of 8.2 km (7, p. 1-12).

4. The width of the fault system has not been determined adequately. More critical examination of the area beyond trenches B and H may show additional faulting relatd to the Verona thrust system. Trenches B and H do establish that the system is at least 2000 feet wide in the vicinity of GETR.

5. The geometry of the fault system at depth has not been established. The dip of the faults in all the trenches is critical in determining whether faulting or landsliding is involved but bore holes that could help resolve this problem were used only in trench T-1. We believe that the consultant's interpretation (7, p. IV-34) of a northward shallowing of shear surfaces between trench T-3 and bore holes BH-1 and BH-3 is incorrect, and that the same evidence can be used to establish a thrust fault dipping northward.

6. The age of the fault system has not been well established. Roy Shlemon, soil consultant for the licensee has argued that the last movement on faults in the GETR area predates the development of the uppermost Holocene-age soil. However, we believe that faulting at the GETR site displaces this most recent soil, and that this recency of faulting demonstrated repeatedly in the 7 trenches which exposed the Verona fault.

7. The potential for surface faulting beneath the GETR vessel

cannot be evaluated properly with the information currently available. The one trench (trench B) that has been excavated immediately next to the reactor is insufficient to preclude faulting. In that trench, no faults were seen striking toward the reactor vessel. However, late Quaternary alluvium, which could obscure faults in older, underlying Livermore Gravel, was exposed in the trench immediately opposite the reactor vessel. The assertion that there has been no faulting in the GETR site area in the last million years because Livermore Gravel was not exposed in that trench is not conclusive. There could well be other unknown faults which directly pass beneath the reactor vessel which would have not been seen in trench B, or which have an older age of last displacement.

Even if there were no known faults directly beneath the GETR, the possibility of new surface faulting beneath the reactor vessel cannot be discounted. The GETR lies within the center of the wide Verona thrust fault zone, and could well exprience surface faulting along a new break which could form in the zone. All faults are new at some time.

8. Inasmuch as the length, width, geometry, and age of the Verona fault have not been determined, the Survey believes that any geologic and seismologic parameters proposed for this site must reflect an awareness of this information deficiency. Consequently, the Survey reviewers believe that the next slip that could occur on the Verona greatly exceeds the proposed one meter. Also, the estimate of a magnitude 7.3 earthquake occurring along the portion of the Calaveras fault nearest the site (2 km) is credible. (18, p.A11) With the above

mentioned data void it is not possible to arrive at reasonable estimates of the earthquake size and resulting ground motion from the maximum credible earthquake that could originate on the Verona and Las Positas faults. However, it should be remembered that the San Fernando earthquake of 1971 occurred on, as then, a poorly known fault which may be similar in many ways to the Verona-Las Positas fault system. That earthquake had a magnitude of 6.6 and produced ground motion in excess of 1 g acceleration very near the fault break.

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