John T. Conway, Chairman
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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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January 21, 2003

The Honorable Jessie Hill Roberson
Assistant Secretary for Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Ms. Roberson:

The Defense Nuclear Facilities Safety Board (Board), in its letter of December 16, 2002, requested a report describing how structural design margins will be managed as a function of design uncertainties for the Waste Treatment Plant (WTP). This request was based, in part, on the Board's concerns regarding seismic-related design load uncertainties. The Board has completed its assessment of the WTP ground motion design criteria and, working with the Department of Energy (DOE) and contractor personnel, has resolved most of the technical issues involved. However, one issue remains.

The current site response analysis is based on the premise that the site response characteristics of the soils underlying the Hanford Site 200 areas are similar to those represented in California. However, there is a large uncertainty in the data using this approach, and analysis of the existing data shows that the Hanford Site response in the frequency range of 4 to 10 Hz is about 15 percent greater than that of California sites. The Hanford ground motion criteria do not appear to be appropriately conservative.

The Board understands that the WTP contractor has implemented acceptably conservative compensatory design features to account for uncertainty in the seismic design criteria. The Board believes this conservatism must be maintained for all future design work at Hanford (e.g., future waste treatment capabilities) unless site-specific attenuation relationships are developed.

The enclosed report on this issue is provided for your use should you elect to reassess the Hanford ground motion criteria in order to reduce the design conservatism for future defense

nuclear facilities. Properly executed, this work would justify a lowering of compensatory design conservatism. Please contact me if you have any questions on this matter.

Sincerely,

John T. Conway
Chairman

c: Mr. Roy J. Schepens
Mr. Keith A. Klein
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

January 3, 2003

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: J. Blackman

SUBJECT: Ground Motion Criteria for the Hanford Waste Treatment Plant

This report documents the results of reviews performed by the staff of the Defense Nuclear Facilities Safety Board (Board) of the Waste Treatment Plant (WTP) at the Hanford Site. Staff members J. Blackman and S. Stokes and outside expert P. Rizzo participated in these reviews.

Background. Beginning in March 2002, several meetings and telephone conferences were conducted to discuss the ground motion criteria used in the design of the WTP. These criteria are contained in *Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington,* WHC-SD-W236A-TI-002, Rev. 1A, October 1996. Issues identified by the Board's staff are outlined in the attachment to this report. All issues have been addressed, with the exception of the approach used to develop attenuation relationships for deep geologic formations to characterize the Hanford Site seismic hazard (items 7 and 8).

Discussion. The site response analysis used in the above report is based on the premise that the site response characteristics of the soils underlying the Hanford Site 200 East and 200 West areas are similar to those represented in California time-history strong motion data. Comparative analyses of the response of the Hanford profiles and the generic California profiles to the same input motions (e.g., time histories) were performed using the computer program SHAKE 2000.[1] Log-log plots of median spectral amplification ratios versus period were developed (e.g., Hanford profiles and the generic California profiles). From these plots it was concluded that the Hanford ground motion sites, which are also underlain by deep soil deposits, are similar to ground motions on California deep soil sites with an uncertainty of ±20 percent. However, the Hanford Site exhibits considerably more amplification at certain frequencies (as much as 50 percent) than sites in California used to develop the attenuation relationships.

In an attempt to resolve this issue, a reanalysis was performed using a larger group of time histories and taking into account a broader range of soil properties to better characterize expected behavior. It was anticipated that this approach would result in a more uniform amplification over the entire frequency range of interest. Linear plots of median spectral

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[1]SHAKE 2000 is an updated version of the SHAKE-A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites, Earthquake Engineering Research Center, Report No. UCB/EERC-72/12, University of California, Berkeley, December 1972.

amplification ratios versus period were developed (e.g., Hanford profiles and the generic California profiles) using a range of soil properties based on actual measured data at the WTP. The results, however, indicated that the site response at Hanford is about 15 percent greater than that at California sites in the frequency range of 4 to 10 Hz while frequency ranges below 4 Hz and greater than 10 Hz showed some attenuation. Based on these results, DOE did not incorporate these additional changes in the WTP design ground motion. However, in anticipation of such underestimates, the Board's staff understands that the WTP designers increased the seismic loads by 15 percent. This is an acceptable compensatory measure for the WTP, as discussed in the Board's letter of July 30, 2002.

Conclusions. The Board's staff does not believe that the Hanford ground motion criteria are appropriately conservative. While the staff understands that compensatory measures were implemented for the WTP, all future design work at Hanford, such as future waste treatment capabilities, ought to incorporate similar compensatory measures or develop site- specific attenuation relationships.

DOE Order 420.1A, *Facility Safety* (Section 4.4.4—"Natural Phenomena Hazards Assessment") requires that natural phenomena hazard reassessments be conducted if there are significant changes in the natural phenomena hazard assessment methodology or site-specific information. The Order also suggests that natural phenomena hazard assessments be reviewed and updated, as necessary, at least every 10 years for existing sites. Work on the current Hanford seismic hazard assessment was begun in the early 1990s. Since that time, new approaches and methodologies, such as the technology for using source-to-site attenuation relationships and site-specific amplification studies, have been developed to the point that they are considered standard practice for probabilistic seismic hazard analysis and for the development of design response spectra. In addition, there is an improved understanding of the tectonics at Hanford, including an association of local seismicity with the Yakima Folds and more data pertaining to slip rates. Improved technology and better understanding of tectonics indicate the need for a reassessment of the seismic hazard at Hanford in accordance with the Order.

At a minimum, a proper reassessment would consist of the following:

- A formal site investigation would be conducted, suitable for site-specific response analysis with new deep borings, shear wave velocity measurements, and laboratory tests (modulus degradation and damping). The borings would be deep enough to adequately characterize in detail the upper 1000 ft of the Columbia River Basalt Group (CRBG); geophysical measurements would be performed to characterize the entire CRBG and correlated with the deep borings (the existing borings and shear wave velocity data are not deep enough for proper characterization of the CRBG).

- A randomized profile would be developed, similar to that developed for the site-wide seismic hazard analysis at the Savannah River Site.

- Earthquake sources and associated source parameters would be defined, with proper consideration of the range of uncertainty.

- Hanford-specific source-to-site attenuation relationships would be developed. If these relationships stem from California data, the Hanford Site response and rock conditions must be adequately considered.

- Given the definition of the postulated sources and associated parameters, source-to-site attenuation relationships and proper amplification studies (including randomized profiles, a new probabilistic seismic hazard analysis, and seismic design response spectra) would be developed.

Attachment

Attachment

Waste Treatment Plant: Ground Motion Criteria Issues and Their Resolution

1. All of the anticlines were formed as part of the same stress field, and all are faulted on the north flank (reverse). There is evidence that one or two (maybe more) are capable. Why would all of the anticlines and the associated faults not be considered capable in a probabilistic analysis? (Closed)

2. It does not appear that the plunging Yakima Ridge anticline has been considered even though it plunges beneath the site, and the adjacent and parallel anticlines are faulted and sources of seismic activity. (Closed)

3. The 200 East area appears to be on a "fault" block bounded on the north by the east-west capable Gable Mountain anticline and fault and on the south by the Rattlesnake-Wallula trend anticline and fault (previously judged as capable). To the west and running north-south across the anticlines is the Hog Ranch feature. In between these two east-west features lies the east-west plunging Yakima Ridge, about which very little is known. Should this setting be treated somewhat differently than the normal approach allowed by a conventional probabilistic analysis? (Closed)

4. Since the faults are classified as reverse faults and there is a strong possibility that there may be many blind faults, should the Waste Treatment Plant (WTP) vertical ground motion be enhanced? (Closed)

5. The Geomatrix report (*Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington,* WHC-SD-W236A-TI-002, Rev. 1A, October 1996) appears to gloss over the effect of a single higher slip rate on one fault, as would be expected with a typical probabilistic study. On the other hand, if the higher slip rates estimated by one of the Geomatrix report panel experts (West) are valid, and if they are indicative of all of the faults associated with the anticlines, the impact would be highly significant for the probabilistic results as well. The validation study (*Validation of the Geomatrix Hanford Seismic Report for Use on the TWRS Privatization Project,* RPT-W375-RU00004, Rev. 0 dated March 17, 1999) makes the statement that "the regional experts stand by the slip rates of the Geomatrix Study . . ."; however, no counterarguments against West's higher slip rates are provided. (Closed)

6. The Washington Public Power Supply System 2 Project deterministic analysis and the Geomatrix Probabilistic Analysis recognize capable faults within 5 to 10 km of the WTP. Discuss the potential for surface rupture at or near the site. (Closed)

7. It appears that documentation of a comprehensive amplification study is not available. In view of the types and location of the events that drive the probabilistic analysis, are other studies available for review? The use of California attenuation data for the Hanford Site is no longer considered accepted practice. At present, a patchwork of analyses has been used

(with no single stand-alone study that applies specifically to the 200 East area). Should a new analysis be considered that would be similar to the approach taken at the Savannah River Site, with source definition and random vibration theory applied to the actual attenuation path and actual soil column? (Open)

8. The spectral amplification ratios (e.g., H1 to S2 Generic) are provided in Appendix A of the Geomatrix report (*Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington,* WHC-SD-W236A-TI-002, Rev. 1A, October 1996) on log-log plots of spectral amplification ratio versus frequency. These plots do not appear to support the conclusion that the site responses for the 200 East area and the generic California site are the same. In fact, they are considerably different at some periods, with the Hanford Site showing more amplification. (Open)

9. Explain how the computer codes used in the analysis were verified and validated. Are public-domain versions of the codes available? (Closed)

10. Provide a list of the experts mentioned in the validation report (*Validation of the Geomatrix Hanford Seismic Report for Use on the TWRS Privatization Project,* RPT-W375-RU00004, Rev. 0, dated March 17, 1999). (Closed)

11. Explain and discuss the weighting factors used for the attenuation relationships for both Appendix A of the Geomatrix report (*Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington,* WHC-SD-W236A-TI-002, Rev. 1A, October 1996) and the validation report (*Validation of the Geomatrix Hanford Seismic Report for Use on the TWRS Privatization Project,* RPT-W375-RU00004, Rev. 0, dated March 17, 1999). (Closed)

12. The DOE standard *Natural Phenomena Hazards Assessment Criteria*, DOE-STD-1023-2002, requires a historical check (using deterministic methods) of the probabilistic analysis. Since historical seismicity is low in the area of the site (numerous small events but with capable faults), it would appear that a deterministic check is appropriate given the number of capable faults that drive the probabilistic analyses. Has a deterministic check been considered? (Closed)