June 22, 1983

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Docket Nos: 50-390
and 50-391

Mr. H. G. Parris
Manager of Power
Tennessee Valley Authority
500A Chestnut Street, Tower II
Chattanooga, Tennessee 37401

Dear Mr. Parris:

Subject: Peak Horizontal Ground Acceleration for Use in Soil Liquefaction Analysis for Watts Bar

Our letter dated March 29, 1983, from T. Novak to H. G. Parris stated that the NRC staff had estimated that, assuming a rock peak acceleration of 0.21g, the range of peak acceleration at the ground surface on shallow soil at Watts Bar would be about 0.35g to 0.42g. As a result of this letter , TVA requested a meeting with the NRC staff on May 20, 1983 (June 6, 1983, meeting summary), at which TVA presented data and additional information regarding the validity of the above range of values. TVA also indicated that a single value for the peak ground acceleration was needed. The NRC staff has reviewed the data and the additional information provided. The NRC staff evaluation is contained in Enclosure 1.

Sincerely,

/S/

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

cc w/encl:
See next page

*NOTE: SEE PREVIOUS WHITE FOR CONCURRENCE

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Docket Nos: 50-390
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Mr. H. G. Parris
Manager of Power
Tennessee Valley Authority
500A Chestnut Street, Tower II
Chattanooga, Tennessee 37401

Dear Mr. Parris:

Subject: Peak Horizontal Ground Acceleration for Use in Soil Liquefaction Analysis for Watts Bar

In a letter dated March 29, 1983, the NRC staff estimated that, assuming a rock peak acceleration of 0.21g, the range of peak acceleration at the ground surface on shallow soil at Watts Bar would be about 0.35g to 0.42g. As a result of this position, the staff had a meeting with the applicant on May 20, 1983, at which they presented arguments which questioned the validity of the above range of values. They also indicated that they need a single value estimate of the peak ground acceleration. The staff has reviewed the problem including the additional information the applicant made available and concludes that 0.4g peak horizontal acceleration be used for the liquefaction analysis. The background and basis for this value are contained in Enclosure 1.

Sincerely,

Thomas M. Novak, Assistant Director
for Licensing
Division of Licensing

Enclosure:
As stated

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DATE	6/8/83	6/8/83	6/8/83	6/ /83	6/ /83		

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Evaluation of Information Provided at May 20, 1983 Meeting

Background

As a basis for the March 29, 1983 estimate, two studies, which reported that the presence of a thin low velocity layer over a high velocity rock can lead to significant amplification of surface ground motion were cited. This memorandum also stated that the site-specific top-of-ground motions study for the ERCW pipeline (Woodward-Clyde Consultants, 1982) which the applicant submitted is lacking, in that the strong motion recordings used in the study do not represent the site specific conditions of the ERCW pipeline. This is because the high shear-wave velocity contrast between the rock and the overlying soil (in the range of 6/1 to 12/1) was not adequately duplicated at the strong motion recording stations.

At the meeting, on Friday May 20, 1983 the applicant presented arguments to counter the staff's position as expressed in the March 29, 1983 letter.

Among these arguments were:

> The references cited by the staff did not use enough data to be statistically significant.
>
> The results of studies performed using small ground motion values are not applicable to large ground motion values that will cause the soil to behave inelastically and attenuate the motion.
>
> Once the shear-wave velocity contrast between the soil and the rock exceeds about 1 to 3 there is no significant increase in peak acceleration amplification and that the critical parameter is the shear-wave velocity of the soil rather than the impedance contrast between the soil and rock.
>
> Theoretical modelling studies performed by the applicant's consultant indicate that the amplification at the Watts Bar ERCW pipeline is not as large as the staff estimated.

In addition the applicant requested that a single peak horizontal ground acceleration value be provided by the staff since they cannot use a range of values in their soil liquefaction analysis.

Evaluation

The staff has reviewed the information provided at the May 20, 1983 meeting, additional information provided by the applicant subsequent to the meeting and several papers on this subject in the seismological literature.

This is a very complex and difficult problem to resolve. There are no recorded earthquake data available which exactly duplicate the ERCW

pipeline site conditions and theoretical analyses require assumptions about the soil parameters to be used under dynamic loading. There is controversy in the seismological community as to the proper input parameters to be used in the theoretical analyses and the results of the calculations depend significantly on these assumptions. The staff continues to rely on empirical studies and since the May 20th meeting has considered an additional number of these studies with respect to the soil amplification problem. An advantage of the use of empirical studies is that they reflect the actual response to measured earthquake ground motion and do not have to rely on estimates of the properties of the materials under different assumed earthquake loadings.

The applicant claims that the results of studies performed using small ground motion values are not applicable to the situation where large ground motion values would cause the soil to behave inelastically and attenuate the motion. This topic is the subject of considerable controversy in the seismological community. There have been several studies performed which indicate that the same elastic assumptions which hold at low ground motion levels also are valid at higher levels. Joyner and others (1981) compared recordings on soil and nearby rock sites and found no clear evidence of nonlinear soil response. They found that Fourier spectral ratios between bedrock and alluvium show good agreement with ratios predicted from linear models. In the comparison of the peak horizontal acceleration between a rock site and a nearby shallow soil site from the same earthquake they found an amplification of 2 at the soil site over the rock site. Their study indicates that linear models are applicable to the ground shaking at levels of at least 0.25g peak horizontal acceleration and 30 cm/sec peak horizontal velocity. Hays and Algermissen (1982) suggest that these linear models for predicting ground motions can be used at all levels of ground motion except if the site is within a few kilometers of the fault zone of a large-magnitude earthquake. Hays and others (1982) estimate that relative to a rock site, the ground response, as expressed by spectral accelerations, ranges from about 2, for sites underlain by thin, semi-saturated gravel and sand to as much as 10 for sites underlain by thick, saturated clay and silt.

Chen and Bernreuter (1982) addressed the amplification problem by examining amplification of earthquake ground motion at shallow soil sites as compared to nearby rock sites. They examined station pairs which recorded ground motion from the 1975 Oroville, California earthquake and the 1976 Friuli, Italy earthquakes. In the Oroville, California sequence the shallow site, Johnson Ranch, showed an average amplification factor of 2.8 for peak acceleration when compared to two nearby rock stations. At another shallow soil station, however, no significant amplification was observed indicating that radiation patterns, or focusing may also be involved. In the Friuli Italy sequence the shallow site, Forgaria, showed an average amplification factor of 2.2 for the peak acceleration when compared to a nearby rock station (San Rocco).

The staff has reviewed the strong motion data from Forgaria and San Rocco for seven earthquakes in the magnitude range 4.3 to 6.1. The average of the amplification ratio for all the events is 2.02 $\pm$ 0.66. The average of the amplification ratio for the events in the magnitude range 5.5 to 6.1 is 2.20 $\pm$ 0.73. The amplification ratio for each event was compared to the peak ground acceleration at San Rocco to see if there is a systematic decrease in amplification with increased peak ground acceleration which would indicate inelastic effects in the soil. The range of the rock peak horizontal acceleration was from 0.03g to 0.23g. The ratio does not decrease with the amplitude of the rock acceleration.

The question of shallow soil site amplification is a very complex problem and at the present time it is subject to a great deal of uncertainty. Their are no recorded data that represents the exact conditions at Watts Bar. The staff has considered the range of results of numerous studies and reached the conclusion that an amplification factor of about 2 is appropriate, so that a peak horizontal acceleration of 0.4g should be used for all liquefaction analyses under these soil conditions.

References

Chen, J. C. and D. L. Bernreuter, 1982, Assessment of the Need to Correct the Probabilistic Spectra Developed for Big Rock Point Site to Account for the Sites Soil Column, Report to NRC from LLNL.

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Joyner, W. B., R. E. Warrick and T. E. Fumal, 1982, The Effect of Quaternary Alluvium on Strong Ground Motion in the Coyote Lake, California, Earthquake of 1979, B.S.S.A V. 71, pp 1333-1349.

Woodward-Clyde Consultants, 1982, Site-Specific Top-of-Ground Motions for ERCW Pipeline, Tennessee Valley Authority.