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Gentlemen:

In the Matter of the Application of	)	Docket No. 50-438
Tennessee Valley Authority	)	50-439

BELLEFONTE NUCLEAR PLANT (BLN) - TRANSMITTAL OF TVA POSITION REGARDING SEISMIC DESIGN GROUND MOTION (TAC #79275)

In accordance with TVA's letter to the NRC staff dated December 4, 1990, enclosed for staff review is the TVA position regarding the seismic design ground motion for BLN.

A written staff position on the enclosure is requested by May 15, 1991. As discussed with NRC staff and management, timely resolution of key issues such as noted in the enclosure is important to TVA's consideration of the nuclear option at BLN.

The information and positions discussed in the attached paper are related to two additional position papers to be submitted to the staff on February 15, 1991 (Category I structures), and March 13, 1991 (piping and distributive systems). Should TVA continue construction of BLN after staff resolution of this and other positions, the agreements reached will be used to govern design, construction, and operation of BLN and will be incorporated into the BLN FSAR, as appropriate.

Bruce S. Schofield will contact the BLN Project Manager to schedule working level meetings to assist in the staff's review of these positions. As discussed in our January 17, 1991 meeting with the staff, the first working level meeting will be scheduled approximately 10 days after staff receipt of this document.

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FEB 14 1991

U.S. Nuclear Regulatory Commission

If you have any questions please contact Mr. Schofield at (205) 574-8058.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

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ENCLOSURE

BELLEFONTE POSITION PAPER
REGARDING
SEISMIC DESIGN GROUND MOTION

PURPOSE

This document describes TVA's position on the acceptability of the present licensing basis ground response spectra for the seismic design of Bellefonte Nuclear Plant (BLN). TVA requests NRC staff agreement on the acceptability of the existing seismic ground response spectra for completing and licensing BLN. Also, TVA seeks NRC staff approval of the use of a Seismic Margins Assessment (SMA) to verify the capability of BLN to withstand earthquakes beyond the licensing basis safe shutdown earthquake (SSE).

SUMMARY

It is TVA's position that the Bellefonte licensing basis seismic ground response spectra, as provided in Section 3.7 of the Bellefonte Final Safety Analysis Report (FSAR), are adequate, and no revisions to the spectral shape or peak ground acceleration are warranted. The synthetic time histories which correspond to the ground response spectra will be revised to meet current Standard Review Plan (SRP) guidelines. Furthermore, TVA will perform an SMA to demonstrate BLN's ability to withstand earthquakes above the licensing basis SSE.

BACKGROUND AND REGULATORY STATUS

The licensing basis ground response spectra for the seismic design of BLN are based on a Regulatory Guide 1.60 (1) spectral shape anchored at a peak ground acceleration (PGA) of 0.18g for the SSE and 0.09g for the operating basis earthquake (OBE). Both the horizontal and vertical response spectra are anchored to the same PGA in accordance with Regulatory Guide 1.60. The PGA for the licensing basis SSE was determined using the deterministic, tectonic methods of Appendix A to 10 CFR 100. The results of these analyses are documented in Section 2.5 of the Bellefonte FSAR.

These positions were documented and previously submitted to the NRC in the Bellefonte Preliminary Safety Analysis Report and were accepted in the staff's 1974 Safety Evaluation Report (SER) (2) for a construction permit. In Section 2.5.2 of the SER, the NRC staff reported that "the staff views the SSE acceleration of 0.18g proposed to be used for this facility to be an adequately conservative value." Furthermore, the staff also noted in Section 3.8 that compliance with Regulatory Guides 1.60 and 1.61 (3) was "an acceptable basis for satisfying the provisions of General Design Criterion 2." (Compliance with Regulatory Guide 1.61 is discussed in the Bellefonte Position Paper Regarding Seismic Design of Category I Structures (4).)

Three years later, the NRC staff (in a letter to TVA dated December 27, 1977, (5)) requested additional information concerning the basis on which the PGA was determined for the Sequoyah, Watts Bar, and Bellefonte sites. In particular, the staff letter noted that these three plants lie within the same tectonic province, and that the 1975 version of the SRP (6), which was issued

after Bellefonte received its construction permit, contained more conservative procedures than those used by TVA to convert earthquake intensity to ground acceleration. The letter further stated that a PGA greater than the design basis value would result if these more conservative procedures were used.

In response, TVA performed thirteen major studies in 1978-1979 to provide the additional information requested by the NRC staff. The topic of each study is listed in Table 1. The results of studies 1 through 5, 6 through 8, and 9 through 13 are documented in References (7), (8, 9), and (10), respectively. The results of these studies showed that the seismic design bases for the three plants were conservative and acceptable.

As part of the follow-up work documented in Reference (10), TVA developed a single set of site-specific response spectra (SSRS) for the Sequoyah, Watts Bar, and Bellefonte sites. A comparison of the Bellefonte licensing basis ground response spectrum and the 84th percentile lognormally-distributed site-specific response spectrum at 4 percent damping is shown in Figure 1. The site-specific response spectrum is anchored at a PGA of 0.215g and is slightly higher than the licensing basis spectrum at frequencies between approximately 4 Hertz (period = 0.25 sec) and 8 Hertz (period = 0.125 sec) and at frequencies above approximately 20 Hertz (periods below 0.05 sec). Given the uncertainties in such spectra, these exceedances are not considered significant. For all other frequencies, the site-specific spectrum is lower than the licensing basis spectrum.

The SSRS were used by TVA at both Sequoyah and Watts Bar in studies and evaluations to further confirm the adequacy of their seismic design bases. The NRC SER for Sequoyah (11), issued in March 1979, accepted the original seismic design basis for the Sequoyah plant. For Watts Bar, the NRC SER (12), issued in January 1991, accepted the original seismic design basis for existing structures, but required that new designs and modifications of Category I structures be designed to the envelope of the seismic responses obtained using the original seismic design response spectra and the SSRS.

A comparison of the Bellefonte horizontal SSE licensing basis ground response spectrum at 5 percent damping with the corresponding spectra for Sequoyah and Watts Bar is shown in Figure 2. The Bellefonte spectrum is a Regulatory Guide 1.60 spectral shape. The spectral shapes for Sequoyah and Watts Bar are modified Housner and modified Newmark, respectively. All three spectra are anchored to the same PGA (0.18g). As shown in Figure 2, the Bellefonte licensing basis ground response spectrum is equal to or exceeds the Sequoyah and Watts Bar spectra over the entire range of frequencies (periods).

After submittal to the NRC staff of the results of the thirteen studies relating to Watts Bar, Sequoyah, and Bellefonte, noted above, the NRC staff provided no response regarding Bellefonte that would alter or call into question the staff's position set forth in its 1974 SER. The design of the Bellefonte plant has continued in accordance with the approved licensing basis and is now essentially 100 percent complete for both units. In addition, the construction of structures and the installation of major equipment items and distribution systems is essentially complete for Unit 1.

TECHNICAL POSITION AND APPROACH

1. The existing licensing basis ground response spectra (i.e., the Regulatory Guide 1.60 spectral shape anchored to 0.18g for the SSE) are conservative and acceptable for the seismic design of BLN.

2. The synthetic ground motion time histories which correspond to the licensing basis response spectra will be revised to meet the Power Spectral Density (PSD) targets and the spectra enveloping requirements of the SRP (13).

3. An SMA will be performed utilizing the final guidelines of the NRC's Individual Plant Examination of External Events (IPEEE) Program. This review will be performed using ground response spectra anchored at a PGA of 0.30g (which exceeds the PGAs for both the licensing basis spectra and the SSRS). The purpose of the SMA is to demonstrate that BLN is seismically adequate for earthquake levels well above the 0.18g licensing basis SSE.

TECHNICAL JUSTIFICATION

The technical justification for the TVA position on the seismic design ground motion for BLN is summarized below.

1. The Bellefonte licensing basis ground response spectra were developed using accepted procedures at the time and the criteria in 10 CFR 100, Appendix A.

   a. The spectral shape and the relationship between the horizontal and vertical spectra are in accordance with Regulatory Guide 1.60. (In particular, the horizontal and vertical spectra are equal for frequencies at or above 3.5 Hz.)

   b. The PGA of 0.18g for the SSE was determined using the "Tectonic Province" approach defined in 10 CFR 100, Appendix A. This is the most conservative approach specified in Appendix A. The results of TVA's follow-up studies (previously discussed in this paper) confirmed the adequacy of the 0.18g PGA for the Bellefonte site.

2. The revised ground motion time histories will be in accordance with the single time history option discussed in Section 3.7.1 (August 1989) of the SRP. The ground motion time histories will meet the PSD and spectra enveloping requirements.

3. The Bellefonte seismic ground response spectra approximately envelope the SSRS developed in 1979 at frequencies below 20 Hz. Furthermore, at the frequencies where the SSRS exceed the Bellefonte seismic ground response spectra, the differences are not significant. (See Figure 1.) The main reason for this is that experience with actual earthquakes, as well as analyses, has shown that spectral frequency content in excess of 10 Hz has limited damage potential.

4. The acceptability of the Bellefonte licensing basis seismic response spectra is further supported by the results of independent studies.

In particular, studies have been performed by Lawrence Livermore National Laboratory (LLNL) and the Electric Power Research Institute (EPRI) to address issues raised by the "Charleston Earthquake." These studies focused on the hypothesis that a large earthquake, such as the Charleston Earthquake of 1886, may occur in the central and eastern United States in regions where geologic and tectonic features are similar to those in the Charleston region (14). The studies used state-of-the art methods to develop probabilistic uniform hazard curves for various sites in the eastern and central United States.

The LLNL and EPRI results for the Bellefonte site are summarized in References (15) and (16), respectively. A comparison of the Bellefonte licensing basis ground response spectrum with the LLNL and EPRI uniform hazard spectra (at 5 percent damping) for probabilities of exceedance of $2x10^{-4}$ and $1x10^{-4}$ are presented in Figures 3 and 4, respectively. As shown in Figure 3, at a probability of exceedance of $2x10^{-4}$, the Bellefonte licensing basis ground response spectrum envelopes the EPRI 50th fractile (median) uniform hazard spectrum at all frequencies and also envelopes the EPRI 85th fractile spectrum at frequencies below approximately 20 Hz (periods above 0.05 seconds). As shown in Figure 4, at a probability of exceedance of $1x10^{-4}$, the Bellefonte licensing basis ground response spectrum virtually envelopes the EPRI 50th fractile uniform hazard spectrum and envelopes the EPRI 85th fractile spectrum at frequencies below approximately 14 Hz (periods above 0.07 seconds). In both Figures, the LLNL spectra are higher than the corresponding EPRI spectra. (Note: As identified in NUREG-1407, Section A.2, the LLNL estimates of seismic hazards "were dominated by the input of one ground motion expert." As a result, the NRC staff requested LLNL to perform a sensitivity study of sites east of the Rocky Mountains, leaving out the input of this expert. (17).)

To date, no criteria are available for defining an SSE in terms of probability of exceedance, and the published LLNL and EPRI probabilistic seismic hazard curves are not intended to be used as the bases for selecting a plant's seismic design basis. However, the EPRI studies do show that Bellefonte's licensing basis ground response spectra envelope the $1x10^{-4}$ uniform hazard spectra for those frequencies at which damage to nuclear plants is likely to occur. Recent studies (18) on the performance of structures and equipment during actual earthquakes have shown that earthquakes with high frequency energy content have limited damage potential for nuclear plant structures and equipment.

5. The probability of exceeding the SSE at the Bellefonte site is lower than a majority of the nuclear plants in the central and eastern United States. As indicated above, the results of the EPRI and LLNL seismic hazard studies are not intended to be used in an absolute sense; instead, they provide a means of evaluating the relative seismic hazard, and its consequences, among plant sites. The Nuclear Management and Resources Council (NUMARC) has calculated the median composite probability of exceeding the licensing basis SSE for 59

nuclear plants in the central and eastern United States using EPRI seismic hazard curves (19). The composite probability is a weighted value of the overall probability of exceeding the SSE using the unit weights specified in Reference (17) and the likelihoods of exceeding spectral response ordinates at 2.5 Hz, 5 Hz, 10 Hz, and the PGA. The results are presented in Figure 5. The probabilities range from a low of about 7×10^{-7} to a high of about 4×10^{-4}. The composite median probability of exceeding the Bellefonte SSE is about 1.1×10^{-5} which places it in the lower third of the plants evaluated. Furthermore, when other measures of seismic hazard are used (e.g., mean, 85th percentile, and LLNL results without the input of the one expert discussed earlier), Bellefonte's composite probability of exceeding its licensing basis SSE is consistently lower than the composite probability for at least half of all central and eastern U.S. nuclear plants.

6. The SMA will provide additional verification of the seismic adequacy of the Bellefonte plant. The NRC staff is currently preparing guidelines for implementing the IPEEE Program as part of its policy statement on severe accidents in nuclear plants. Reference (17) is the draft report which summarizes these guidelines. To fulfill the request for the seismic portion of the IPEEE, either a seismic Probabilistic Risk Assessment (PRA) or an SMA can be performed by the nuclear plant licensee.

   TVA will perform an SMA using a 0.30g Review Level Earthquake. By performing the SMA, TVA intends to show that the Bellefonte plant is seismically rugged and adequate for earthquake levels well above the 0.18g licensing basis SSE. Thus, the adequacy of the licensing basis PGA at Bellefonte in light of the SSRS results will be addressed and evaluated in the SMA. TVA considers the performance of an SMA to be an efficient and technically justified approach to address possible questions from the NRC staff in connection with the licensing basis seismic ground response spectra. Follow-up evaluations using site-specific response spectra, such as those performed in the past at Watts Bar and Sequoyah, are not considered technically justified. This is especially true considering the fact that the Bellefonte licensing basis spectra are very close to or above the SSRS over the frequency range of interest.

In conclusion, it is TVA's position that the licensing basis seismic ground response spectra documented in the Bellefonte FSAR are adequate, and no revisions to the spectral shape or PGA value are warranted. Nonetheless, a Seismic Margins Assessment will be performed to demonstrate the capability of the Bellefonte plant to safely withstand earthquake levels well beyond the licensing basis SSE.

REFERENCES

1. Regulatory Guide 1.60, Design Response Spectra for Seismic Design of Nuclear Power Plants, Revision 1, U.S. Atomic Energy Commission, December 1973.

2. Safety Evaluation of the Bellefonte Nuclear Plant Units 1 and 2, U.S. Atomic Energy Commission, May 24, 1974.

3. Regulatory Guide 1.61, Damping Values for Seismic Design of Nuclear Power Plants, U.S. Atomic Energy Commission, October 1973.

4. Bellefonte Position Paper Regarding Seismic Design of Category I Structures, Enclosure to TVA letter from E. G. Wallace to NRC dated February 14, 1991.

5. NRC Letter from R. S. Boyd to Tennessee Valley Authority (G. Williams, Jr.), Seismic Design Basis for the Sequoyah, Watts Bar, and Bellefonte Nuclear Plants, December 27, 1977.

6. NUREG-75/087, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, U.S. Nuclear Regulatory Commission, September 1975.

7. Justification of the Seismic Design Criteria Used for the Sequoyah, Watts Bar and Bellefonte Nuclear Power Plants, Phase I, Tennessee Valley Authority, August 1978.

8. Justification of the Seismic Design Criteria Used for the Sequoyah, Watts Bar, and Bellefonte Nuclear Power Plants, Phase II, Tennessee Valley Authority, August 1978.

9. Prediction of Strong Motions for Eastern North America on the Basis of Magnitude, Weston Geophysical Corporation [Supplemental Report to Reference 8], August 1978.

10. Justification of the Seismic Design Criteria Used for the Sequoyah, Watts Bar, and Bellefonte Nuclear Power Plants, Phase II, Responses to NRC Questions 1 through 6, Tennessee Valley Authority, June 1979.

11. NUREG-0011, Safety Evaluation Report Related to the Operation of Sequoyah Nuclear Plant, Units 1 and 2, U.S. Nuclear Regulatory Commission, March 1979, pp. 2-21 through 2-33.

12. Safety Evaluation Report Related to Amendment Nos. 54 through 64 for Sections 3.7.1 and 3.7.2 of Final Safety Analysis Report of Watts Bar Nuclear Plant, Units 1 and 2, Tennessee Valley Authority, U.S. Nuclear Regulatory Commission, January 1991, pp. 1 through 4.

13. NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, U.S. Nuclear Regulatory Commission, Section 3.7.1, Revision 2, August 1989, Appendix A to Section 3.7.1, Revision 0, August 1989.

14. Draft Report, Probabilistic Seismic Hazard Evaluation in the Central and Eastern United States, Project RP 101-53, Prepared for the Electric Power Research Institute - Seismicity Owners Group, March 1989.

15. NUREG/CR-5250, Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains, Volume 3, Lawrence Livermore National Laboratory, January 1989, pp. 12 through 27.

16. Probabilistic Seismic Hazard Evaluation for Bellefonte Nuclear Power Plant, Project RP 101-53, Prepared for the Electric Power Research Institute-Seismicity Owners Group, April 1989.

17. NUREG-1407 (Draft), Procedural and Submittal Guidance for the Individual Plant Examination of External Events for Severe Accident Vulnerabilities, U.S. Nuclear Regulatory Commission, July 1990.

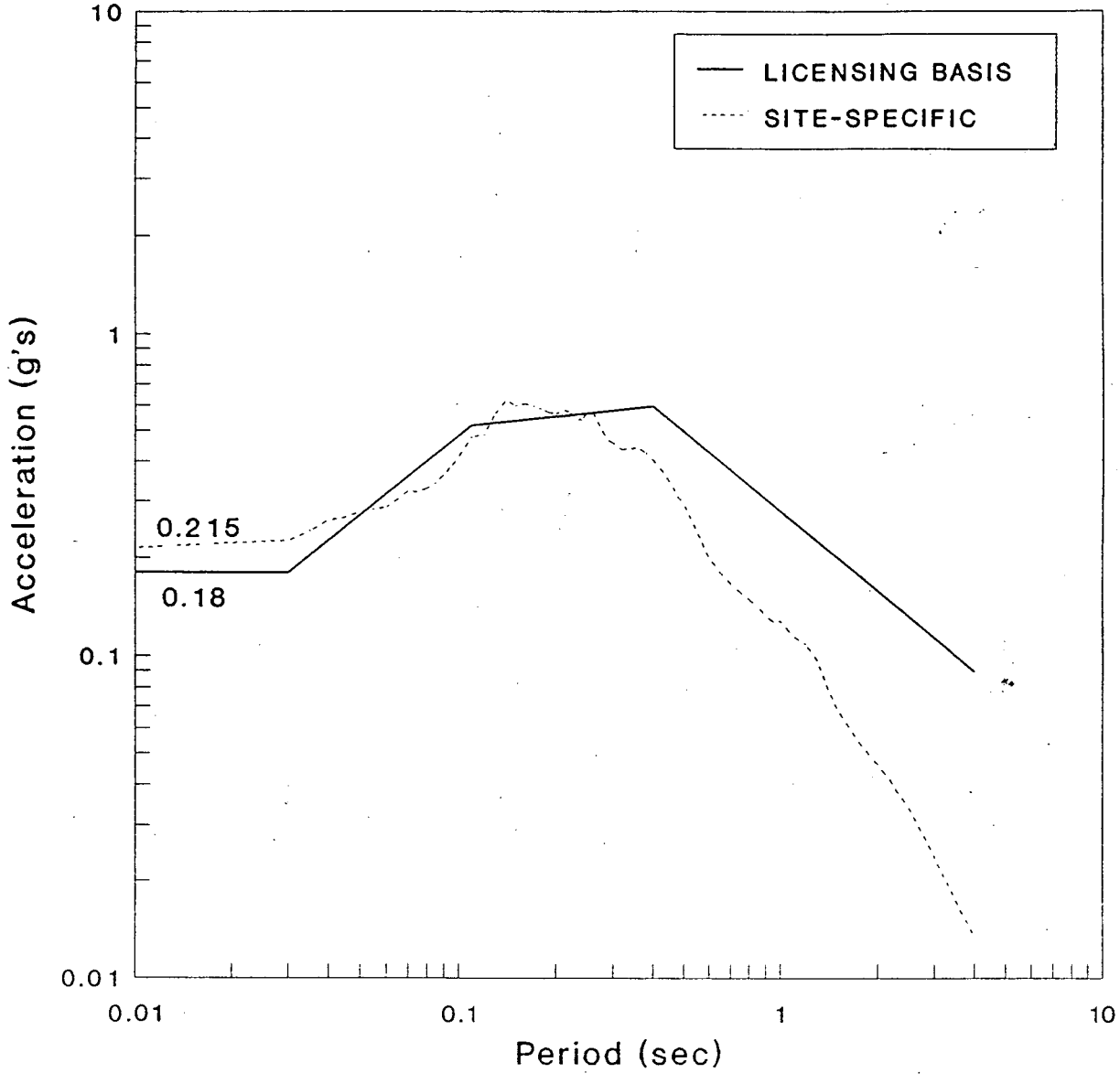
18. Analysis of High-Frequency Seismic Effects, J. Reed, R. Kennedy, B. Lashkari, and R. Kassawara, presented at the Third Symposium on Current Issues Related to Nuclear Power Plant Structures, Equipment and Piping, sponsored by North Carolina State University and EPRI, December 5-7, 1990, Orlando, Florida.

19. NUMARC Letter (with attachments) to NRC (W. Minners) Forwarding Final Industry Comments on Draft Supplement 4 to Generic Letter 88-20 and Draft NUREG-1407, October 10, 1990.

Table 1

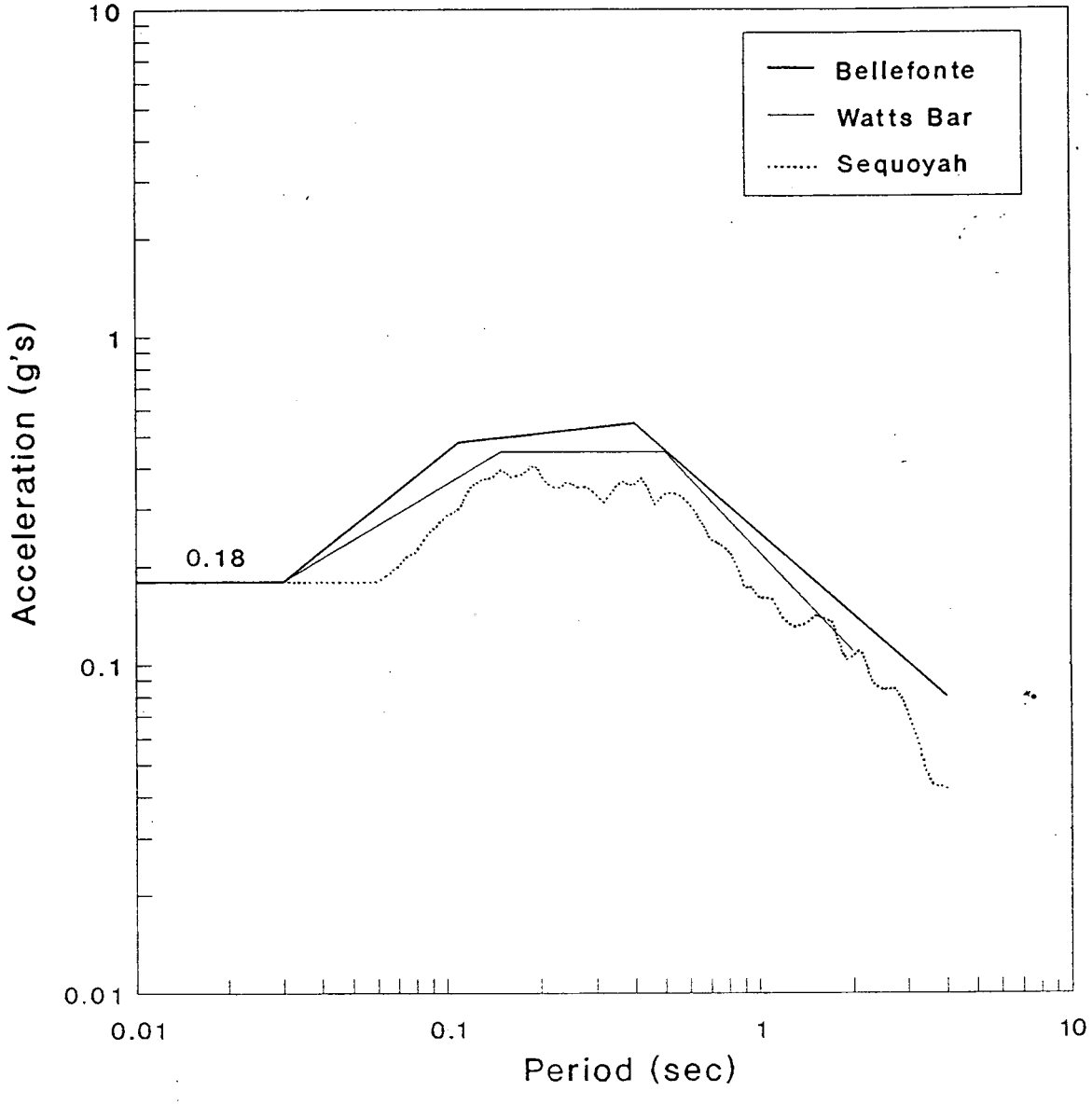
STUDIES PERFORMED BY TVA

1. Evaluation of Giles County Earthquake
2. Evaluation of Site Conditions on Earthquake Intensity
3. Evaluation of Acceleration Variation With Depth
4. Comparison of Accelerations Recorded on Rock and Soil During a Given Earthquake at a Given Site
5. Evaluation of Intensity - Acceleration Relationships
6. Evaluation of Response Spectra Based on Intensity
7. Development of Response Spectra Based on Site-Specific Records
8. Development of Response Spectra Based on Magnitude
9. Calculation of the Probability of Exceedance for Various Response Spectra
10. Evaluation of the OBE
11. Additional Probability Studies
12. Determination of Site-Specific Response Characteristics
13. Southern Appalachian Tectonic Study



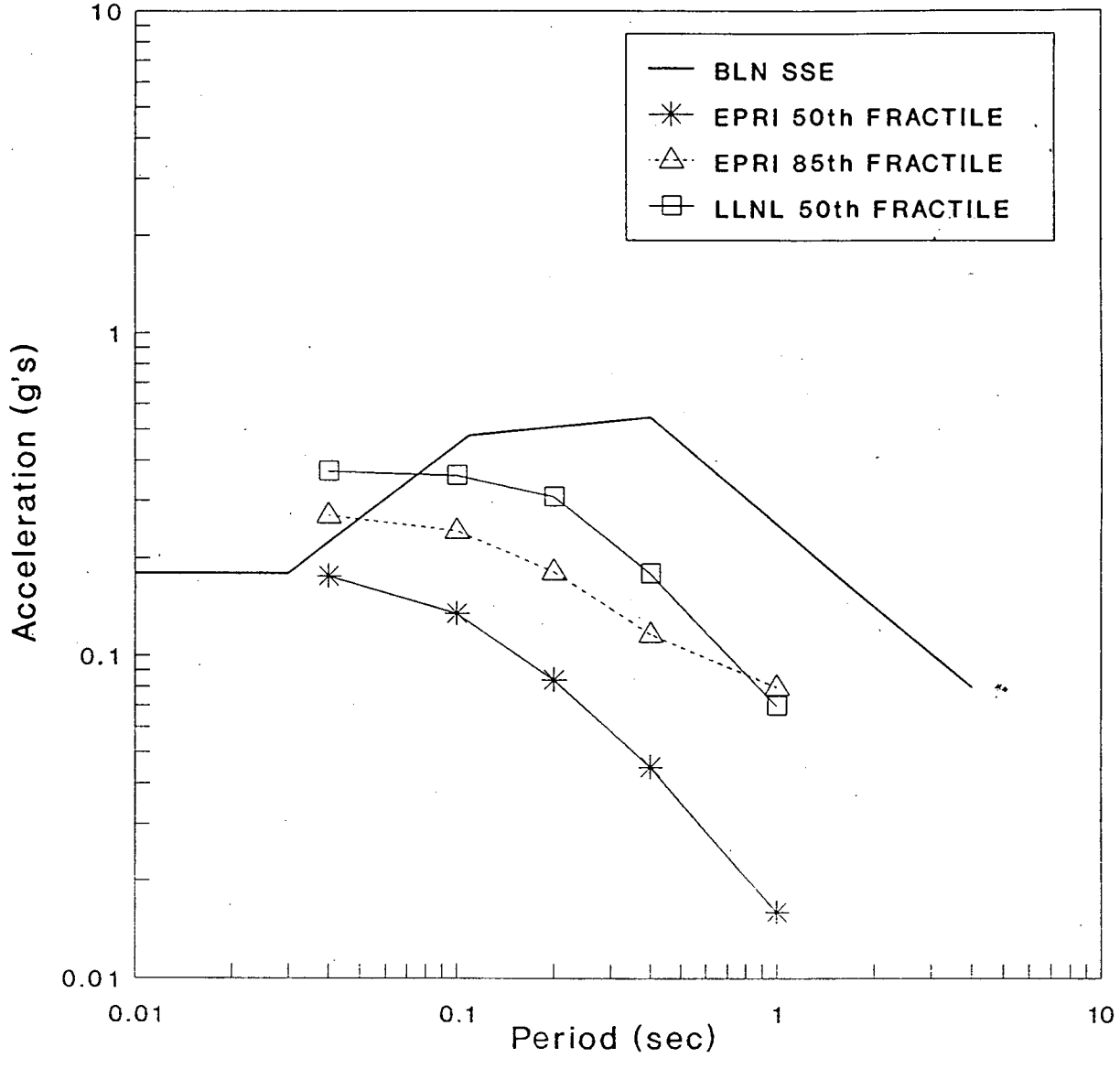
COMPARISON OF BELLEFONTE LICENSING BASIS RESPONSE SPECTRUM (SSE) AND SITE-SPECIFIC RESPONSE SPECTRUM (DAMPING = 4%)

FIGURE 1



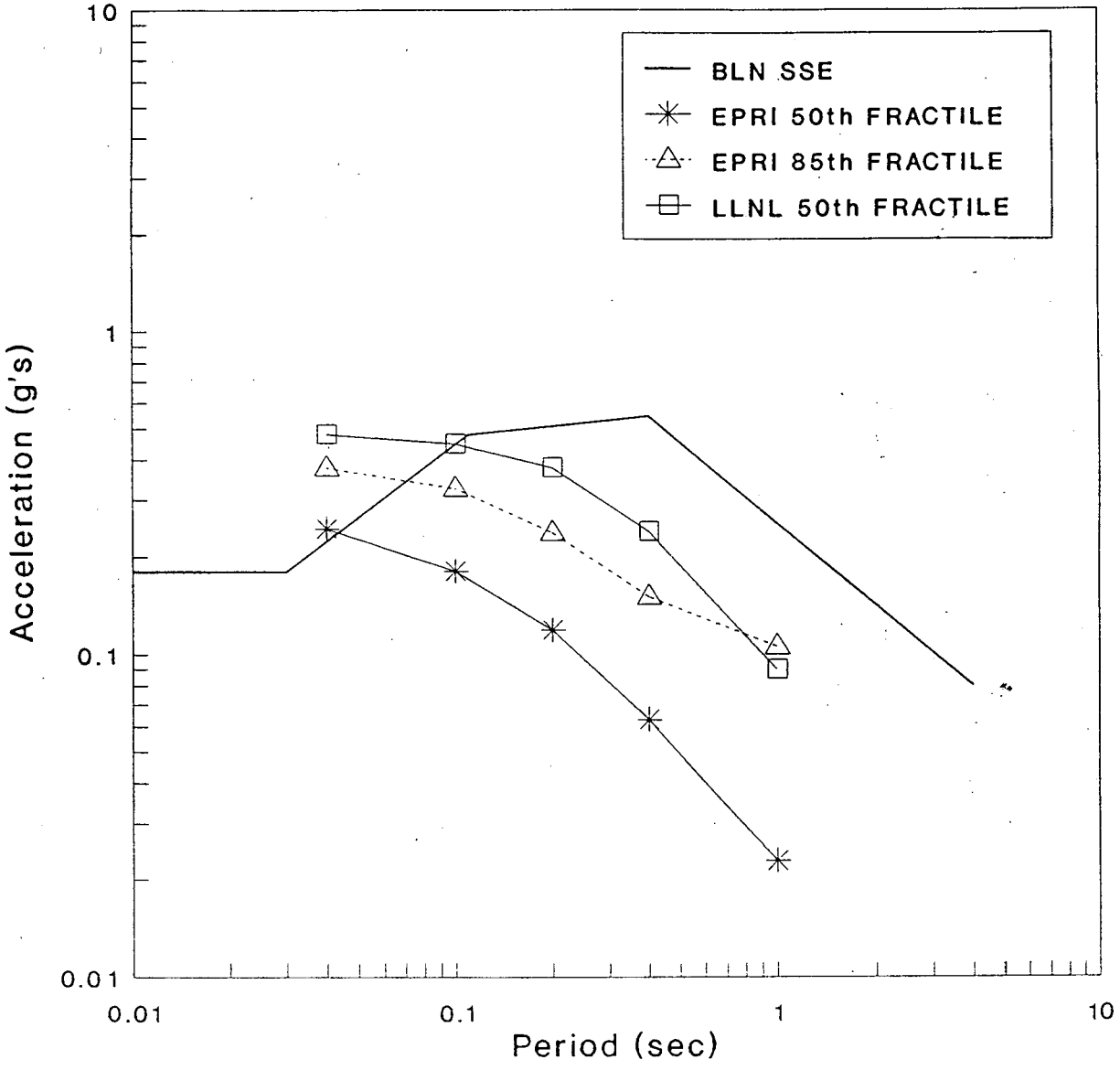
COMPARISON OF BELLEFONTE, WATTS BAR, AND SEQUOYAH SSE DESIGN GROUND RESPONSE SPECTRA FOR 5% DAMPING

FIGURE 2



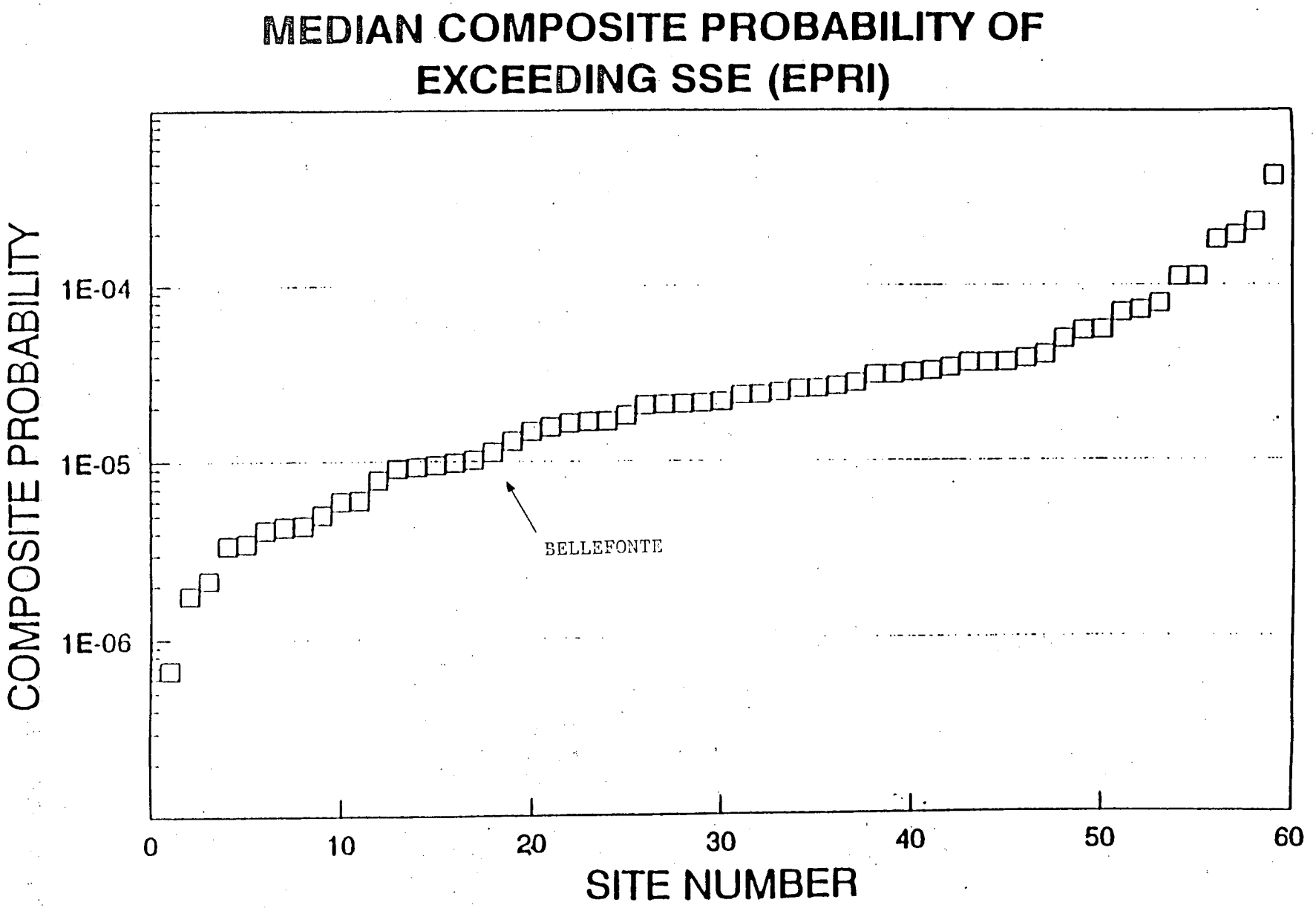
COMPARISON OF BELLEFONTE SSE RESPONSE SPECTRUM WITH EPRI AND LLNL UNIFORM HAZARD SPECTRA FOR 2 X 10^{-4} PROBABILITY OF EXCEEDANCE (DAMPING = 5%)

FIGURE 3



COMPARISON OF BELLEFONTE SSE RESPONSE SPECTRUM WITH EPRI AND LLNL UNIFORM HAZARD SPECTRA FOR 1 X 10^{-4} PROBABILITY OF EXCEEDANCE (DAMPING = 5%)

FIGURE 4



Annual Probability of Exceeding Seismic Design Basis for CEUS Plants in the NRC's 0.3g and 0.5g Bins.

FIGURE 5