From: Goutam Bagchi
To: "Nilesh Chokshi" <NCC1@nrc.gov>
Date: 10/23/2007 8:07:02 AM
Subject: ACRS Comments on Vogtle SER

I am copying Bill Hinze email here. His Word file is attached. Thanks,
Goutam

Dana,,,here is a brief report on the Vogtle ESP per your request. It is brief but hopefully will provide you with materials for your subcommittee meeting on section 2.5. If you have questions about my comments I will be available through next Monday,,,,,cheers,,,Bill

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To: Dana Powers, ACRS-NRC
From: William J. Hinze, ACNW&M
Subject: Review of Vogtle Early Site Permit Application and NRC's Safety Evaluation Report for the Vogtle Application
Date: October 12, 2007

Introduction

The objective of this brief report is to summarize the salient points of my review of the Vogtle Early Site Permit (ESP) Application (Rev. 2, April 2007) submitted by the Southern Nuclear Operating Company and the Safety Evaluation Report (SER) for this application prepared by the NRC Office of New Reactors (August 30, 2007).

Specifically at your instruction I have focused my review on Section 2.5.1, Basic Geologic and Seismic Information; Section 2.5.2, Vibratory Ground Motion; Section 2.5.3, Surface Faulting; and Appendix 2.5 B, High Resolution Compressional Seismic Survey Field Report. Sections dealing with Geotechnical Engineering as well as other sections of the Application and SER, 2.5. 4-6 were briefly perused. I was aided in the review by my experience as a member of the Rondout Earth Science Team (EST) that participated in the EPRI Probabilistic Seismic Hazard Analysis (PSHA) of eastern North America that was published in 1986. The EPRI-1986 PSHA updated according to current regulations was used as the basis for the seismic analysis presented in the Vogtle ESP Application.

The results of the review of are presented below indexed to the specific sections of the ESP Application and the SER. In the interest of brevity I have not summarized the information presented in the sections, but rather commented on issues of concern.

My overall evaluation of Sections 2.5.1 -3 of the ESP Application is that in general these sections present the information required in the applicable regulations 10 CFR 52.17(a)(1)(vi), 10 CFR 100.23(c), and 10 CFR 100.23(d) and that the SER is a comprehensive and insightful review and analysis of the Application. However, I do have comments, questions, and different views than those specified in the Application and SER that may be useful to you and your subcommittee as the ACRS reviews the Vogtle ESP Application. These are listed below.

Basic Geologic and Seismic Information (Section 2.5.1)

1. The hypotheses dealing with the origin of the potentially seismogenic features of the Vogtle region are relatively mature and notably advanced over the status of geologic and tectonic knowledge of the region at the time of the EPRI-1986 study. These advances have been incorporated in the description of the geology and tectonic structures and their origin in the Application and SER.

2. The principal potentially seismogenic geological features of the region are: (1) the Charleston seismic zone that was the site of the ~7 (6.7-7.3) magnitude

earthquake of 1886, (2) the Eastern Tennessee seismic zone that is the second-most (to the New Madrid seismic zone) seismically active region in the eastern United States, and (3) the early to middle Triassic (~175 Ma) basins which form the basement beneath the coastal plain Cretaceous and Tertiary sediments of much of the States of Georgia and South Carolina. There is no specific evidence that faults of the Triassic basins which were formed from extension of the continental crust during the early stages of the formation of the Atlantic Ocean at the breakup of the supercontinent Pangea are seismogenic, but several authorities have noted that the normal faults of the basins are likely candidates for reactivation in the current stress pattern of the eastern United States. These potentially seismogenic features are adequately described and discussed in the Application and analyzed in the SER. There are numerous other Precambrian (>~615 Ma) faults and others formed during the subsequent Appalachian mountain building periods that are potential sites for reactivation in the current stress regime, but no evidence suggests a correlation of these faults with specific historical earthquakes.

3. The Vogtle site is underlain by the north-northeasterly striking Dunbarton Triassic basin which has been identified by drilling through the roughly 300 m of overlying sediments and geophysical studies. The basin is associated with the much more extensive and well-developed South Georgia Triassic basin. The data suggest that the Dunbarton basin is a half-graben with the greatest development of the basin along a normal fault on its northwestern side. This fault has been at least locally reactivated in Tertiary time and is recognized as the Pen Branch fault in the Savannah River Site (SRS) with a southwestern extension into the Vogtle site. There is no evidence that this fault has been active in the last 2 million years and is appropriately analyzed as a non-capable fault in the Application and SER. Its azimuth as recognized in the detailed geological/geophysical investigations of the SRS is incorrectly oriented for reactivation in the current stress field (see item 4.). Several other faults of the SRS which may extend across the Savannah River into Georgia have a similar general azimuth.

   The southeastern edge of the Dunbarton basin may also be fault controlled. The Martin fault (Figure 2.51-16 of the ESP Application) that has been mapped in the SRS may be the surface extension of that fault. This fault which occurs some 30 km southeast of the Vogtle site unfortunately has not been the site of high resolution surface geophysical studies. It should be noted that the Martin fault appears to be identified on Figure 2.5.1-21 of the ESP Application as the Millett fault. Are the Martin and Millett faults the same fault? And if so why is this not made clear in the Application discussion?

4. The information available to the EPRI-1986 ESTs on the stress regime of the eastern United States is essentially equivalent to the currently available data except that regional perturbations in the stress field that were interpreted by some ESTs are not warranted by the current information. Additionally, most of the stress measurements are from the relatively near-surface (<~ 300 m) and thus are

not in the seismogenic region of the crust where earthquakes of the region occur. The maximum horizontal compressive stress is derived from ridge-push forces originating in the Mid-Atlantic Ridge and is generally directed in an N60^{o}E direction. Accordingly, in general faults oriented at roughly 45^o to this direction are subject to strike-slip movement depending on the coefficient of friction, while orthogonally oriented faults are subject to reverse faulting. This information and its implications are well treated in the Application and SER.

5. The relatively short historical seismic record and the low recurrence interval of earthquakes in the Vogtle region inhibit comprehensive characterization of the seismicity of the region. A significant development since the EPRI-1986 study is the mapping of paleoliquefaction features as a useful methodology for identifying the site of past earthquakes, especially in the last 10,000 years. These features occur in friable sediments, commonly in stream valleys, where the groundwater table is close to the surface. Liquefaction of soils occur during the passage of seismic waves originating from earthquakes that generally have a magnitude of greater than 6. Dating of carbonaceous material in these features permit approximate dating of the earthquake. Mapping and studying of paleoliquefaction features in the Charleston seismic zone has been essential to furthering our knowledge of the nature of the 1886 Charleston event.

   The ESP Application and the SER explain that the mapping of paleoliquefaction features has been conducted over an extensive region of the southeastern United States including the Vogtle site vicinity. These studies have failed to identify liquefaction features in the Vogtle site vicinity, however, no information is provided on the specific stream valleys that have been studied and those that have conditions suitable for liquefaction during the passage of strong seismic waves. I consider this to be a significant omission of critical data. There is a need for confidence that the paleoliquefaction studies have been sufficiently detailed and have covered the appropriate regions in the vicinity of the Vogtle site. What are the implications of this omission to our understanding of the seismicity of the Vogtle vicinity?

6. Small long-term ground measurements using location observations from Global Positioning Satellites (GPS) have become a major source of information related to potential seismic events. Ground movements in southeastern United States are likely to be at the margin of resolution of GPS observations during the past decade. Nonetheless, it is important to identify any potentially useful GPS measurements in the region that could bear on seismic activity. Trenkamp and Talwani (2007)[1] have a manuscript on GPS strain measurements that is listed in the publications of Pradeep Talwani in his personal web page at the University of South Carolina site. A search of the literature on strain measurements in southeaster United States should be performed and all pertinent information included in the application and reviewed in the SER.

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[1] Trenkamp, R., and Talwani, P., 2007., GPS strain and strain zonation near Charleston, South Carolina, Journal of Geophysical Research, manuscript in revision.

7. In response to RAI 2.5.1-7 the applicant rejected the Grenville front as a potential seismic feature because it is of Precambrian age. However, there are numerous Precambrian faults throughout the eastern and central United States that are potentially seismogenic as a result of reactivation in the current stress field. Furthermore, one of the identified seismogenic regions of the eastern United States, the Anna, Ohio seismic zone (Figure 2.1-15 of the Application), has been identified as the location of the intersection of a Precambrian rift with the Grenville front (tectonic zone). See for example Hinze and Hildenbrand (1988)[2].The treatment of this topic in the Application is inadequate on this point.

8. The applicant has correctly recognized the potential for distant large earthquakes in the central and eastern United States to contribute to ground motion hazards at the Vogtle site. The applicant and the SER identify the New Madrid seismic zone as the most significant to the seismic hazard characteristics of the site and the only distant seismic zone that needed updating since the EPRI-1986 study. The updating indicates the need to lower the generally accepted recurrence interval in this zone to roughly 500 years. The treatment of this topic is handled well both in the Application and the SER. However, there is no mention of the concern with "far-field triggering" of earthquakes. Recent studies and publications take note that large earthquakes may trigger earthquakes at distances of several hundreds of kilometers distance. This topic was also raised with respect to the ESP of the Clinton site. The possibility of far-field triggering of earthquakes should be noted in the Application and its implications with regard to seismic hazards considered.

9. *To summarize, in general the Application and the SER fully describe the current state of information regarding geology and seismicity of the Vogtle site region and I concur with the conclusions (2.5.1.4) of the SER with the exceptions noted above. The Pen Branch fault should not be considered a capable fault based on the current evidence. The seismic characteristics of the Charleston seismic zone control the seismic design basis ground motion.*

Vibratory Ground Motion (Section 2.5.2)

1. In the PSHA it is clear that the primary sources of ground motion in the region are the Eastern Tennessee and Charleston seismic zones. The Eastern Tennessee zone, which is included even though it occurs immediately outside the 300 km distance, is associated with unknown faults that likely strike northeasterly in the Precambrian and Cambrian rocks which underlie the folds of the Valley and Ridge geomorphic province. The Eastern Tennessee seismic zone lies between the geophysically identified New York-Alabama lineament, which has been related to a Precambrian or early Paleozoic strike slip zone, and the Appalachian Clingman-

[2] Hinze, W.J., and Hildenbrand, T.G., 1988, The utility of geopotential field data in seismotectonic studies in the eastern United States, Seismological Research Letters, 59, 289-297.

Ocee geologic lineament. This is a zone of major release of earthquake energy but historic earthquakes do not exceed a magnitude of ~4.6 and no earthquake epicenter has been identified with a specific fault. This information has not changed significantly since EPRI-1986 study. It is appropriately identified in the Application and SER as of only minor significance to ground motion at the Vogtle site.

2. Significant new information has been obtained about the Charleston seismic zone since the EPRI-1986 study which has been incorporated into the Application and appropriately reviewed and analyzed in the SER. The new information has come about as a result of geophysical studies, liquefaction investigations, microseismicity monitoring, and continued analysis of the integrated data. It is significant to note that the 1886 Charleston event has not been identified with a particular fault in the area, but the best evidence is that it occurred near the intersection of the NNE extending Woodstock fault and the Summerville cross fault. The Woodstock fault has been related to the East Coast fault zone which is interpreted to extend NNE from the Charleston area.

   The Charleston seismic zone is particularly important to the ground motion studies of the Vogtle site because of its proximity and the large magnitude of the 1886 Charleston earthquake. The recent interpretations of the Charleston seismic zone suggest a decreased recurrence interval. Based on dating of paleoliquefaction features over the past few thousand years the recurrence interval is of the order of 500 years with an uncertainty of perhaps no more that 50 years. Furthermore, there is much clearer information on the configuration of the seismic zone. In the EPRI-1986 study information on faulting in the Charleston area was only becoming available. As a result the ESTs differed considerably in their specification of the zonal boundaries. These boundaries are now much more constrained and have been used appropriately by the applicant.

3. Although microseismicity, paleoliquefaction, geologic, and geophysical investigations have identified a complex pattern of 9 faults in the Charleston seismic zone, there is no generally acceptable hypothesis to explain why this combination of geologic structures has been repeatedly active with large earthquakes in the past. Without this explanation restricting seismicity to the Charleston seismic zone, it is questionable that this is the only such set of geologic structures in the region that could cause large earthquakes. Could there be other similar structural regions that have not been identified because of the lower intensity of investigations and the lack of microseismicity and paleoliquefaction features? A positive answer to this remains a possibility but the lack of other areas in the Vogtle site region that have experienced similar large earthquakes, particularly in view of the 500 year recurrence interval of the Charleston seismic zone, suggest that the probability of this possibility must be very low.

4. In view of the paucity of information on earthquakes in the region of the Vogtle site, the relatively long recurrence interval, and short historical record, it appears likely that an earthquake may occur anywhere in the region, the so-called controlling earthquake. If indeed this is the case what is the maximum magnitude earthquake that could occur anywhere in the area and how is this "floating" earthquake magnitude established in the region?

5. The Application is based on ground motion as determined from PSHA using updated EPRI information. The applicant did not choose to use the LLNL methodology as permitted in the regulations. Why did the applicant choose the EPRI methodology over the LLNL approach? This is not discussed in the application. What are the implications to the results of the seismic hazard from the use of the EPRI methodology?

6. As noted in the SER there is inconsistent data regarding the shear wave velocity of the sediments underlying the Vogtle site. This inconsistency needs to be explained and the shear wave velocities should be verified.

7. The staff's conclusion that the site is located within the Mesozoic passive margin which includes Triassic rift basins leading to Open Item 2.5-1 is thoroughly justified. The source of the difference between the applicant and the SER needs to be explained.

8. SER's Open Item 2.5-3 regarding the possible contribution of the larger magnitude earthquakes in the Eastern Tennessee seismic zone is significant and needs to be answered by the applicant.

9. Open Item 2.5-5 of the SER dealing with limitations in the regional paleoliquefaction studies is consistent with the concerns of 2.5.1, item 5 above. This is a particularly significant open item.

10. *To summarize, the Application and the SER do a credible job of evaluating 2.5.2. The conclusions of the SER on this topic given in 2.5.2.4 are germane. However, I have some concerns as indicated above. I concur with all of the Open Items identified in the SER.*

Surface Faulting (Section 2.5.3)

No specific comments are required for this section, but, in summary, the SER appropriately treats the Application in dealing with the potential for surface faulting and Open-Item 2.5-10 is justified.

Stability of Subsurface Material and Foundation (Section 2.5.4)

This section was only briefly reviewed, but the conclusions of the SER (Section 2.5.4.4) are appropriate and the concern with insufficient supporting information is warranted.

Stability of Slopes (Section 2.5.5)

This section was only briefly reviewed, but the SER's evaluation of this section of the Application is appropriate.

Embankments and Dams (Section 2.5.6)

This section was only briefly reviewed, but the evaluation of this section of the Application is appropriate.

High Resolution Compressional Seismic Survey Field Report (Section Appendix 2.5 B)

1. There is ambiguity in the interpretation of the results of the reflection seismic survey because the survey is 2-dimensional in nature requiring interpolation of the strike and nature of the Pen Branch fault between the individual survey lines. This is inevitable in a 2-dimensional survey such as conducted at the Vogtle site especially where *en echelon* faults may be present.. This problem could have been minimized by conducting a 3-dimensional survey. The resources needed for acquiring and processing a 3-dimensional survey are considerably greater than for a 2-dimensional survey. However, the importance of achieving the higher resolution in the study of this strategically located fault suggests that the state of the technology methodologies should have been considered for this important study.

2. The seismic reflection survey was limited to the Vogtle site. Consideration should have been given to extending the survey to the southeast where the basement equivalent of the Martin fault may bound the southeastern margin of the Dunbarton Triassic basin. Reactivation of the Pen Branch fault suggests that the Martin fault which is only 30 km from the site may too have been reactivated in more recent time. A seismic reflection study of this fault could have been useful in determining if this fault was active in more recent time. This is important because of the proximity of the southeastern border fault to the Vogtle site.