



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

MAR 22 1983

MEMORANDUM FOR: Frank Arsenault, Director  
Division of Health, Siting and Waste Management

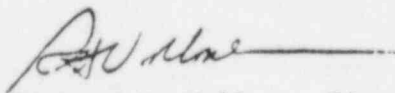
FROM: Richard H. Vollmer, Director  
Division of Engineering, NRR

SUBJECT: DIVISION OF ENGINEERING GEOSCIENCE PLAN TO ADDRESS  
USGS CLARIFICATION RELATING TO SEISMIC DESIGN  
EARTHQUAKES IN THE EASTERN SEABOARD OF THE UNITED  
STATES

Attached for your information is the Division of Engineering (DE) plan to address the U. S. Geological Survey's clarification of position relating to design earthquakes in the Eastern Seaboard of the United States. Some of the elements of the plan are already ongoing and almost all are included in our current user need letter to research or long range research plan for 1983-1984. The Central, Va. part of the plan requires a very limited contribution from NRC and we understand that ORES has already coordinated an effort to undertake this work. If necessary, modified user need requests will be provided to include this new element.

I also recommend that ORES in conjunction with the Geosciences Branch, DE begin scoping a limited modification or clarification of Appendix A as a parallel, but independent effort. I would like to see the results of the attached plan used to help justify clarifying the regulation. Therefore, I do not envision any major manpower commitment of this division until about a year from now, although we will assist in all scoping work.

If you have any questions or comments on the specifics of this plan, please contact Steve Brocoum (24414) on the deterministic assessment portion, Leon Reiter (28443) on the probability assessment portion, or Bob Jackson (28063).

  
Richard H. Vollmer, Director  
Division of Engineering

Attachment:  
As stated

cc: w/attachment  
J. Knight  
R. Jackson  
Z. Rosztoczy  
P. Williams

L. Reiter  
S. Brocoum  
P. Cota  
GSB Staff

T. Speis



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

MAR 02 1983

MEMORANDUM FOR: Harold R. Denton, Director  
Office of Nuclear Reactor Regulation

FROM: Richard H. Vollmer, Director  
Division of Engineering

SUBJECT: DIVISION OF ENGINEERING GEOSCIENCE PLAN TO ADDRESS USGS  
CLARIFICATION RELATING TO SEISMIC DESIGN EARTHQUAKES IN  
THE EASTERN SEABOARD OF THE UNITED STATES

A plan for our proposed program to address the U. S. Geological Survey's clarification of position relating to seismic design earthquakes in the Eastern Seaboard of the United States is attached (enclosure 1). This plan elaborates on the outline provided as an attachment to a memorandum entitled, "Clarification of U. S. Geological Survey Position Relating to Seismic Design Earthquakes in the Eastern Seaboard of the United States", which was sent from the Executive Director of Operations to the Commissioners on November 19, 1982.

The plan is divided into two parts. Part one is a short term probabilistic assessment utilizing an extensive new seismic hazard study currently being developed by Lawrence Livermore National Laboratory. Part two is a longer term deterministic assessment based primarily on long range ORES research with the possible need for utility sponsored investigations at some locations after an assessment of the long term research results. Additionally, we recommend that an industry sponsored seismic hazard study be solicited.

We estimate that the effort to establish the seismic hazard level for the sites and make appropriate comparisons will take approximately three years to complete, utilizing staff resources of about 2.5-3.0 SY per year, and \$300K per year in technical assistance funds. Our preliminary recommendations on which plants, if any, may need further evaluation should be completed in mid-1984. Because of the required research effort, the deterministic element will not be synthesized until 1985.

The proposed program will complement ongoing PRA reviews and the seismic hazard spectra which are developed can also be used for future SEP evaluations. This program, therefore, is basically a continuation, with modification, of our ongoing work. This program does not include resources to complete a reevaluation effort for plants for which design spectra may need to be reevaluated. We recommend that this contingency be considered and included in the operating plan for FY 84. This plan also presupposes that our interim position for licensing reviews (enclosure 2) is found to be acceptable by ACRS and ASLB while we implement this program.

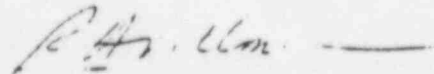
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There is evidence to support this assumption in the recent Appeal Board decision on Summer (ALAB-710).

We have also assessed our ability to implement this plan under the existing regulation, Appendix A to 10 CFR Part 100. We have concluded that, although Appendix A itself does not explicitly recognize the use of probabilistic methods, as a minimum they can be used to assist in reaching deterministic judgements (Seabrook Remand, CLI80-33). It is not clear whether they can be used as the primary tool in setting appropriate ground motion levels. Therefore, we recommend that we implement a limited modification or clarification of Appendix A as previously planned in conjunction with ORES as a parallel, yet independent effort, along with the Charleston plan. This modification has been recommended in SECY-79-300 and endorsed by the Siting Policy Task Force in NUREG-0625 and is necessary to reflect the current state of art. This modification will require an additional 1.0 SY per year for 2 years.

We recommend that you consider placing this effort equally under three resource areas - Operating Reactor Licensing Actions or Safety Technology, Systematic Evaluation Program for older operating plants, and Casework for ongoing OL review plants.

This plan has been developed as a result of extensive discussion within the Geosciences Branch, NRR; and discussions with the Earth Sciences Branch, ORES; and the U. S. Geological Survey.



Richard H. Vollmer, Director  
Division of Engineering

Enclosure:  
As stated

cc: w/enclosure

E. Case	A. Murphy
D. Eisenhut	T. Schmidt
R. Vollmer	W. Russell
R. Mattson	R. Bernero
H. Thompson	GSB Staff
J. Knight	Z. Rosztoczy
R. Jackson	P. Williams
L. Reiter	
S. Brocoum	
T. Sullivan	
L. Beratan	
R. Minogue	
F. Arsenault	
J. Scinto	

Recommended Plan  
Eastern U. S. Earthquakes

Introduction

On November 18, 1982, the U. S. Geological Survey (USGS) forwarded a letter to the Nuclear Regulatory Commission clarifying their past position with respect to the 1886 Charleston earthquake. The USGS letter states that:

"Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient grounds for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

We have evaluated the USGS clarification of position and have concluded that it can be addressed predominantly through existing programs at NRC with the possibility of additional requests for utility - sponsored work. We recommend that a two part program be implemented which will address both the deterministic and probabilistic elements mentioned by the USGS.

Part 1 of the proposed program is a short term probabilistic assessment of plants in the eastern seaboard. This part of the plan is necessary because many of the current tectonic working hypotheses are not amenable to investigation by deterministic methods in the short term.

Part 2 of the proposed program is a longer term deterministic assessment of the causes of large earthquakes, such as the Charleston earthquake, in the eastern seaboard. Specific areas of relatively high seismicity and tectonic structures are identified which we recommend be addressed through the ORES long range research plan.

Based on our evaluation of the research results, some applicants or licensees may be required to investigate tectonic structures which may not have been previously identified during the licensing procedure.

#### Part 1 - Probabilistic Assessment

##### Discussion

The November 18, 1982 letter from the USGS represents not so much a new understanding but rather a more explicit recognition of existing uncertainties with respect to the causative structure and mechanism of the 1886 Charleston earthquake. Many hypotheses have been proposed as to the locale in the eastern seaboard of future Charleston-size earthquakes. Some of these could be very restrictive in location while others would allow this earthquake to recur over very large areas. Presently, none of these hypotheses are definitive and all contain a strong element of speculation.

Traditional deterministic approaches such as that outlined in Section 2.5.2 of the Standard Review Plan are not generally designed to deal

with this situation. Probabilistic methods which allow for the consideration of many hypotheses, their associated credibilities, and the explicit incorporation of uncertainty are much better equipped to provide rational frameworks for decision making. The question that needs to be answered is:

Taking uncertainties into account, have licensing decisions for plants in the eastern seaboard (i.e., in the region affected by the USGS clarified position on the Charleston Earthquake) resulted in acceptable levels of assumed seismic hazard (exposure to earthquake ground motion) at the individual sites?

One means for answering the above question is a probabilistic assessment of seismic hazard at all nuclear power plant sites east of the Rocky Mountains. Since adequate or acceptable levels of seismic hazard have not been explicitly defined in probabilistic terms, it is assumed that the probability of seismic ground motion exceeding design levels implicitly associated with licensing decisions based upon traditional methods in other regions of the U. S. east of the Rocky Mountains is adequate; these other regions include areas such as the Central Stable Region and the Gulf Coastal Plain. The prime tool for carrying out this assessment is an updated version of the Uniform Hazard Methodology developed for the Systematic Evaluation Program by Lawrence Livermore National Laboratory (LLNL) and its subcontractor TERA Corporation. This methodology relies upon the incorporation of diverse expert opinion with regard to the input parameters needed to make probabilistic estimates. As such, it does not rely upon single hypotheses which do not account for existing uncertainties but rather attempts to incorporate the



hypotheses and their uncertainties into the computations. Identification of plants (if any) in the eastern seaboard at which the probability of exceeding design-level ground motion is significantly greater than has been assumed at other locations may result in an integrated seismic evaluation and/or engineering reanalysis to assure the plant's ability to withstand a more severe earthquake. This study may also identify selected plants outside of the eastern seaboard whose design levels may be inappropriate, relative to other plants, with respect to the seismic hazard.

In addition, we are also initiating, through a technical assistance contract, a study to better estimate ground motion from a large earthquake the size of the 1886 Charleston event to gain a better understanding of how this ground motion should be represented.

#### Major Activities - Probabilistic Assessment

The probabilistic assessment portion of the proposed program is divided into the following elements.

1. January thru April 1983 - Continue development of LLNL study including expert opinion surveys on seismic hazard east of the Rocky Mountains. This study (Seismic Hazard Characterization of the Eastern U.S.) is presently underway as a joint effort of NRR and

ORES. No additional resources above those already allocated are needed.

2. May 1983 thru December 1983 - Calculation of seismic hazard spectra by LLNL for all nuclear power plant sites (approximately 75) east of the Rocky Mountains. An estimation of the probability of seismic ground motion exceeding the design level at each site, taking into account specific site conditions, will be completed and provided as a report. An additional 2.0 SY is needed for LLNL and 0.3 SY for NRC effort during this period.

3. September - December 1983 - Comparison of LLNL study with existing probabilistic studies such as Algermissen and others (1982). An additional 0.2 SY is needed for LLNL effort.

4. March 1983 - December 1983 - Sponsorship by the utilities of a probabilistic estimation of seismic hazard for all nuclear power plants east of the Rocky Mountains. This study, while not a requirement, is strongly recommended so as to complement the LLNL study and provide another independent assessment of seismic hazard. An additional 0.1 SY needed for LLNL and 0.1 SY for NRC effort.

5. December 1983-March 1984 - Using LLNL and other studies, the NRC staff will integrate this information and make comparisons of the probability of seismic ground motion exceeding design levels in the eastern seaboard with probabilities calculated at plants in the rest of the Eastern and Central U. S. Comparisons will be made in several ways including comparison by region alone and by region and plant vintage. Plants in the eastern seaboard (if any) that are associated with significantly greater hazard than those elsewhere



will then be identified. Other comparisons may be needed, but will be decided upon after review of initial results. An additional 0.7 SY is needed for NRC effort.

6. April 1984-September 1984 - Assessment of initial conclusions regarding hazard in light of feedback from expert opinion on original input. A final letter report will be issued with a final recommendation on plants which need reevaluation. An additional 0.2 SY needed for LLNL and 0.2 SY for NRC effort.

7. January 1983-December 1983 - Ground motion estimates at different distances and site conditions from a large Charleston type earthquake. Both theoretical and empirical estimates using data from recent earthquakes will be made. This study is presently being initiated through a technical assistance contract with LLNL. No additional resources are required.

Status summary reports of research into probabilistic estimates of seismic hazard funded by ORES will be needed by December 1983 so as to incorporate them into task number 5.

#### Implementation of Probabilistic Assessment Results

The implementation of results is outlined above in elements 5 and 6.

#### NRR Staff and Cost Requirements - Probabilistic Assessment

The additional effort required for this portion of the program will be 2.5 SY for LLNL (1.9 in FY 83, 0.6 in FY 84) and 1.3 SY for NRC (0.3 in FY 83, 1.0 in FY 84). This staff effort can be accommodated with the currently available resources in the Geosciences Branch because this

program complements ongoing staff activities and may replace other staff activities for individual sites. This program does not include resources to complete the seismic evaluation and/or engineering reanalysis which some plants may require as a result of the probabilistic elements.

#### Utility-Sponsored Study in Conjunction with the Probabilistic Assessment

A recommended utility-sponsored study is outlined above in element 4.

#### Schedule - Probabilistic Assessment

The proposed schedule for implementing this plan appears in Table 1.

### Part 2 - Deterministic Assessment

#### Discussion

The deterministic portion of the proposed program is designed to better understand the causes of large earthquakes, such as the Charleston earthquake, in the eastern seaboard. This effort may require some expansion of immediate and long term ORES programs. Increased understanding of the cause of seismicity in the eastern seaboard will allow a reduction in the uncertainty in estimating the seismic hazard for nuclear power plants. The primary problem with seismic hazard characterization in the eastern seaboard is that no causative mechanism for seismicity has been identified to date and no surface offsets due to earthquakes are known. Although there are literally thousands of crustal structures known in the eastern seaboard, which, if they were active, could produce strong earthquakes, none have been demonstrated to have been active during the Quaternary (the last two million years) or

proved to be capable. The result is that, to date, there has been no generally accepted association between eastern seismicity and crustal structure.

The overall approach of the deterministic assessment is to study areas of relatively higher seismicity in the eastern seaboard to determine if tectonic features and processes responsible for the seismicity can be identified and correlated. This will be pursued by crustal studies at hypocentral depths to determine if there is any correlation between crustal structures at hypocentral depths and the earthquake hypocenters. The primary tool for determining crustal structure at hypocentral depths will be the use of multi-channel seismic reflection profiles. The primary tools for locating the hypocenters will be the continued monitoring and analysis of earthquakes from the existing microearthquake nets. These nets will have to be maintained and upgraded in order to improve depth locations of hypocenters if there is to be an improved ability to correlate between hypocenters and tectonic structures at depths of up to 25 kilometers.

This research will be contracted and monitored by ORES, and does not represent a radical departure from past programs. Increased coordination between NRR and ORES will be required, however, to better define the problems that are to be resolved in order to improve our understanding of eastern seismicity in the licensing context. This portion of the program is designed to improve our ability to assess the adequacy of the design of nuclear facilities on the eastern seaboard. The result, in part, will be summary reports which will represent the current status of research including a review and synthesis of available

data. These results will be used to modify, if necessary, conclusions drawn from the probabilistic studies and identify individual features, if appropriate, for assessment by utilities.

#### Major Activities - Deterministic Assessment

The deterministic assessment portion of the proposed program is divided into the following elements appropriate to each region listed.

##### A. Charleston Region

Since the causative mechanism of the Charleston earthquake of 1886 continues to be one of the primary unresolved problems in evaluating seismicity in the eastern seaboard, research in the Charleston area should continue with the goal of testing the various hypotheses as to the cause of the earthquake. In particular, emphasis should be placed on determining if suggested features such as the Ashley River and Woodstock Fault zones constitute the source zones of the Charleston earthquakes.

1. May 1983 - "Workshop on the 1886 Charleston Earthquake and Its Implications for Today" - the U. S. Geological Survey and the scientific community will present a summary and evaluation of the tectonics and seismicity at Charleston.
2. September 1983 - ORES in consultation with the U. S. Geological Survey and the scientific community should have a program in place to test the most likely tectonic hypothesis for seismicity. *RFP - (April 1984)*
3. June 1984 - ORES presents the results of the program

*June 1985 - preliminary results*

of testing the highest-weighted hypothesis.

4. January 1985 - ORES presents summary report describing the results of the Charleston work testing the highest-weighted tectonic hypothesis.

#### B. Ramapo Fault Zone

The Ramapo Fault Zone, a Precambrian fault zone that was intermittently active until the Mesozoic, is the northwestern boundary of the Newark Triassic Basin. Low level seismicity occurs in the area and may be associated with the fault zone, however, the seismicity in the region forms a band 40 kilometers wide. Detailed field work and limited trenching and core drilling suggest that the Ramapo Fault has not been recently reactivated. The purpose of studying the fault is to establish whether there is a causal relationship between Mesozoic or older faults such as the Ramapo Fault and current seismicity in this area by determining the location and geometry of these faults at hypocentral depths.

1. April 1983 - ORES initiates a new evaluation of the Ramapo Fault. The study should include multi-channel seismic reflection profiling and other geophysical techniques such as in-situ stress measurements and geodetic measurements to determine the current state of stress at hypocentral depths.
2. <sup>Feb</sup> January 1984 - ORES presents preliminary results of the program to date, and plans for the coming year.
3. <sup>March</sup> January 1985 - ORES presents summary report on this aspect of the Ramapo Fault Study including the identification and analysis of any seismic source zones.

### C. Central Virginia Seismic Zone

Recent work by earth scientists at Virginia Polytechnic Institute have suggested that there may be a relationship between the seismicity in Central Virginia and the northeast trending thrust faults and decollement of the Piedmont crust of the Appalachian Orogenic Belt. The purpose of this part of the program is to continue evaluation of the relationship between the faults and the earthquakes.

1. April 1983 - ORES presents a plan for undertaking the seismic reflection profiling, and applying other geophysical techniques such as geodetic measurements and in-situ stress measurements.
2. January 1984 - ORES presents the preliminary results or progress to date, and plans for the coming year.
3. January 1985 - ORES presents a summary report on the the Central Virginia Study including the potential identification and analysis of any seismic source zones.

### D. Giles County, Virginia

The Giles County Seismic Zone is a northeast trending linear zone of seismicity which apparently is located beneath the decollement and thrust faults associated with the Valley & Ridge Province of the Appalachian Orogenic Belt. It has been suggested that the seismic zone has occurred as a reactivated northeast trending normal fault associated with the opening of the Proto-Atlantic (called the Iapetus) in the late Proterozoic and early Paleozoic (800-500 million years ago).

1. April 1983 - ORES initiates planning for the proposed research.



2. August 1983 - ORES initiates study of the Giles County structure using seismic reflection profiling.
3. <sup>March 1984</sup> ~~April~~ 1984 - ORES presents preliminary results and plans for the coming year.
4. April 1985 - ORES presents summary results of this phase of the research including the potential identification and analysis of any seismic source zones.

#### E. New England

The research in New England has been underway for several years and will be continued. Increased emphasis should be placed on evaluation of the source mechanism for the New Brunswick and Gaza, N.H. earthquakes, the neotectonics of seismically active areas, and the orientation and magnitude of the stress field in the seismically active areas of the region. An in-situ stress measurement at hypocentral depths will be conducted at Moodus. Depending on the results of the seismic reflection studies described above, additional seismic reflection surveys may be conducted in seismically active areas of New England such as Moodus, Connecticut; New Hampshire; Massena, New York and New Brunswick, Canada.

- ✓ 1. April 1983 - ORES completes plans for stress measurement at Moodus.
2. <sup>Apr 1983</sup> August 1983 - Conduct stress measurements at Moodus.
3. <sup>July 1984</sup> ~~April~~ 1984 - ORES presents preliminary results of stress measurements and their relationship to the local seismicity and tectonics. *inadequate resolution*
4. January 1985 - ORES presents summary results of stress measurements and other studies described above.

5. Jan. 1986 - Status Report

#### Implementation of Deterministic Assessment Results

As the results from the deterministic studies become available, they will be evaluated, and, the effect, if any, on operating plants and plants in the Operating License stage of review will be determined. The need for additional evaluations of particular structures by utilities will be assessed as the information becomes available. Two problems will be addressed by the deterministic portion of the program; (1) whether or not the deterministic findings warrant any reassessment of the conclusions drawn from the probabilistic study; and (2) whether there are any particular tectonic structures which are associated with or similar to tectonic structures associated with seismicity which, because of their proximity to individual sites, should be analyzed by the utilities. The above effort will take about two to three years (early 1985) to complete. The impact of this research on nuclear power plants will be determined by the NRC staff with technical assistance contracts, if necessary.

#### NRR Staff and Cost Requirements - Deterministic Assessment

This effort will require continuous communication among NRR, ORES and the contractors. As research funds are limited and the amount of time is short, careful interaction will be necessary to obtain the information required to allow a resolution of eastern seismicity. It is estimated that one staff year per year for three years will be necessary for NRR to implement this deterministic part of the overall plan. The research effort will be funded by ORES and technical assistance contracts will be funded by NRR. It is estimated that for the

deterministic assessment, \$200,000 may be required to implement the NRR technical assistance program to determine the impacts of the findings on the nuclear facilities in the eastern U. S.

Utility-Sponsored Studies as Result of the Deterministic Assessment

During FY 1983 no deterministic work by the utilities is currently recommended, beyond that necessary to pursue their normal efforts to continue to assess any hazards identified by them for their sites.

After the results of the research are available and if any source zones are identified which have particular importance to specific sites or have impact on the probabilistic program, some utilities may be required to investigate structures in the vicinity of their plants.

Schedule - Deterministic Assessment

The proposed schedule for implementing this plan follows as Table 1. Our ability to meet this proposed schedule may be somewhat optimistic and is contingent on implementing the appropriate contracts. We will be better able to assess this schedule when the work has been initiated.

#### REFERENCE

Algermissen, S. F., D. M. Perkins, P. C. Thenhaus,  
S. L. Hanson, and B. L. Bender, 1982, Probabilistic  
Estimates of Maximum Acceleration and Velocity in  
Rock in the Contiguous United States, United States  
Department of Interior, Geological Survey, Open-File  
Report 82-1033, 99 p.

# Calendar Year Schedule for Probabilistic and Deterministic Seismic Hazard Program

	1983	1984	1985
<u>Part 1 Short Term</u>	Meet with ACRS to discuss Program	Meet with ACRS to discuss Preliminary Recommendations	
1. Update LLNL Seismic Hazard Methodology	+Complete Methodology		
2. Calculate Seismic Hazard Spectra for Eastern Sites	+_____	+Report with Spectra	
3. Compare with other available probability studies	+_____	+Report with Comparisons	
4. Initiation of Industry-Sponsored Seismic Hazard Study	+_____	+Production of Study Results	
5. Comparison of Seismic Hazard at Sites		Letter Report with Preliminary Recommendations +_____+_____	+Final Recommendations
6. Assessment of Impact of Expert Feedback		Initiate Feedback +_____	Assess Impact on +Previous Results
7. Charleston Ground Motion Study	Initiate Tac with LLNL +_____	+Issue Report	

Table 1

Calendar Year Schedule for Probabilistic and Deterministic Seismic Hazard Program

	1983	1984	1985
<u>Part 2 Long Term</u>	Meet with ACRS to discuss Program	Meet with ACRS to to discuss Preliminary Recommendations	
1. Charleston Research	Workshop- Interim Synthesis + x	Progress Report on Hypothesis Testing x	Results of Testing xx-----
2. Ramapo Fault Research	Initiate Study + x	Preliminary Report x	Summary Report xx-----
3. Central Va. Research	Initiate Study + x	Preliminary Results Report x	Summary Report xx-----
4. Giles County, Va. Research	RFP + x	Initiation of Study x	Preliminary Results x Summary Report xx-----
5. New England Seismotectonic Research	Stress Measurements Plan + x	Conduct Measurements x	Preliminary Results x Summary Report -----xx
6. Assessment of Impact of Deterministic Studies on Sites	Preliminary Evaluation of Results of RES + x	Summary of Source Zones x	Summarize Review of Deterministic Work +

Table 1 (cont'd)



Interim Position on Charleston Earthquake  
for Licensing Proceeding

The NRR Staff position with respect to the Intensity X 1886 Charleston earthquake has been that, in the context of the tectonic province approach used for licensing nuclear power plants, this earthquake should be restricted to the Charleston vicinity. This position was based, in part, on information provided by the United States Geological Survey (USGS) in a letter dated December 30, 1980 from J. E. Devine to R. E. Jackson (see Summer Safety Evaluation Report). The USGS has been reassessing its position and issued a clarification on November 18, 1982 in a letter from J. E. Devine to R. E. Jackson. As a result of this letter, a preliminary evaluation and outline for NRC action was forwarded to the Commission in a memorandum from W. J. Dircks on November 19, 1982.

The USGS letter states that:

"Because the geologic and tectonic features of the Charleston region are similar to those in other regions of the eastern seaboard, we conclude that although there is no recent or historical evidence that other regions have experienced strong earthquakes, the historical record is not, of itself, sufficient grounds for ruling out the occurrence in these other regions of strong seismic ground motions similar to those experienced near Charleston in 1886. Although the probability of strong ground motion due to an earthquake in any given year at a particular location in the eastern seaboard may be very low, deterministic and probabilistic evaluations of the seismic hazard should be made for individual sites in the eastern seaboard to establish the seismic engineering parameters for critical facilities."

The USGS clarification represents not so much a new understanding but rather a more explicit recognition of existing uncertainties with respect to the causative structure and mechanism of the 1886 Charleston earthquake. Many hypotheses have been proposed as to the locale in the eastern seaboard of future Charleston-size earthquakes. Some of these

could be very restrictive in location while others would allow this earthquake to recur over very large areas. Presently, none of these hypotheses are definitive and all contain a strong element of speculation.

We are addressing this uncertainty in both longer-term deterministic and shorter-term probabilistic programs. The deterministic studies, funded primarily by the Office of Research of the NRC should reduce the uncertainty by better identifying (1) the causal mechanism of the Charleston earthquake and (2) the potential for the occurrence of large earthquakes throughout the eastern seaboard. The probabilistic studies, primarily that being conducted for NRC by Lawrence Livermore National Laboratory (LLNL) will take into account existing uncertainties. They will have as their aim to determine differences, if any, between the probabilities of seismic ground motion exceeding design levels in the eastern seaboard (i.e. as affected by the USGS clarified position on the Charleston earthquake) and the probabilities of seismic ground motion exceeding design levels elsewhere in the central and eastern U. S. Any plants where the probabilities of exceeding design level ground motions are significantly higher than those calculated for other plants in the Central and Eastern U. S. will be identified and evaluated for possible further engineering analysis.

Given the speculative nature of the hypotheses with respect to the recurrence of large Charleston-type earthquakes as a result of our limited scientific knowledge and the generalized low probability associated with such events, we do not see a need for any action for

specific sites at this time. It is our position, as it has been in the past, that facilities should be designed to withstand the recurrence of an earthquake the size of the 1886 earthquake in the vicinity of Charleston. At the conclusion of the shorter-term probabilistic program and during the longer-term deterministic studies, we will be assessing the need for a modified position with respect to specific sites.