Non-Concurrence Process Record for NCP-2012-009

The U.S. Nuclear Regulatory Commission (NRC) strives to establish and maintain an environment that encourages all employees to promptly raise concerns and differing views without fear of reprisal and to promote methods for raising concerns that will enhance a strong safety culture and support the agency's mission.

Individuals are expected to discuss their views and concerns with their immediate supervisors on a regular, ongoing basis. If informal discussions do not resolve concerns, individuals have various mechanisms for expressing and having their concerns and differing views heard and considered by management.

Management Directive MD 10.158, "NRC Non-Concurrence Process," describes the Non-Concurrence Process (NCP). http://pbadupws.nrc.gov/docs/ML0706/ML070660506.pdf

The NCP allows employees to document their differing views and concerns early in the decision-making process, have them responded to, and attach them to proposed documents moving through the management approval chain.

NRC Form 757, Non-Concurrence Process is used to document the process.

Section A of the form includes the personal opinions, views, and concerns of an NRC employee.

Section B of the form includes the personal opinions and views of the NRC employee's immediate supervisor.

Section C of the form includes the agency's evaluation of the concerns and the agency's final position and outcome.

NOTE: Content in Sections A and B reflects personal opinions and views and does not represent official factual representation of the issues, nor official rationale for the agency decision. Section C includes the agency's official position on the facts, issues, and rationale for the final decision.

The agency's official position (i.e., the document that was the subject of the non-concurrence) is included in ADAMS accession number ML12324A198.

This record has been redacted prior to discretionary release to the public.

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER
NCP-2012-009

SECTION A - TO BE COMPLETED BY NON-CONCURRING INDIVIDUAL

TITLE OF SUBJECT DOCUMENT ENDORSEMENT OF ELECTRIC POWER RESEARCH INSTITUTE FINAL DRAFT REPORT 10252		ADAMS ACCESSION NO. ML12319A074
DOCUMENT SIGNER David Skeen		SIGNER PHONE NO. (301) 415-3091
TITLE Director	ORGANIZATION NRR/JLD	
NAME OF NON-CONCURRING INDIVIDUAL(S) Dogan Seber		PHONE NO. (301) 415-0212
TITLE Senior Geophysicist	ORGANIZATION NRO/DSEA/RGS1	

☐ DOCUMENT AUTHOR ☐ DOCUMENT CONTRIBUTOR ☑ DOCUMENT REVIEWER ☐ ON CONCURRENCE

REASONS FOR NON-CONCURRENCE AND PROPOSED ALTERNATIVES

See attached.

☐ CONTINUED IN SECTION D

SIGNATURE Dogan Seber DATE 12/4/12

SEE SECTION E FOR IMPLEMNATION GUIDANCE

Rationale for Non-Concurrence

This non-concurrence statement pertains to NRC's impending endorsement of the final draft of 'Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID)' document (ML12333A170). The SPID guidance is authored by EPRI in collaboration with NRC staff, NEI, and other industry representatives. It establishes procedures to be followed by the licensees in response to Enclosure 1 of the March 12, 2012, information request issued pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f), the so-called 50.54(f) letter (ML12053A340), regarding the reassessment of seismic hazards at the operating nuclear power plants. The 50.54(f) letter states that the reevaluation and related analysis will serve to meet NRC's obligation under the Consolidated Appropriations Act, for 2012 *(Pub Law* 112-74), Section 402, which states "The Nuclear Regulatory Commission shall require reactor licensees to re-evaluate the seismic, tsunami, flooding, and other external hazards at their sites against current applicable Commission requirements and guidance for such licensees as expeditiously as possible ..."

The NRC management is about to endorse the above mentioned SPID guidance document, with a couple of additional comments, to be used in seismic hazard reassessment of operating nuclear power plants. The NRC's draft endorsement letter (ML12319A074) states:

> The NRC staff has reviewed the SPID report and confirmed that it would provide licensees with the guidance necessary to perform seismic reevaluations, and report the results to the NRC in a manner that will address the Requested Information items (1) through (9) in Enclosure 1 of the 50.54(f) letter.

Contrary to the proposed NRC management's decision, I do not agree with the above quoted assessment and the NRC staff's decision that the aforementioned guidance document is adequate in responding to the requirements of the Consolidated Appropriations Act, 2012, and the 50.54(f) letters which also require the use of "*...updated seismic and flooding hazard information and present-day regulatory guidance and methodologies*, ...". The portions of the SPID guidance related to seismic hazard calculations include procedures that are not within NRC's current regulatory practices and include assumptions that are not scientifically valid. Not only does the SPID document not follow the present-day regulatory guidance and methodologies, it also fails to provide an equivalent, acceptable alternative. If followed, the methodologies and guidance provided in the SPID document for seismic hazard analyses will result in ambiguous and unreliable seismic hazard calculations at the operating nuclear reactor sites.

Background and Summary

The SPID guidance is an extensive document that covers several related topics. My technical disagreement is specifically with those sections dealing with seismic hazard calculations (Section 2) and related site response calculations (Appendix B). In these areas the SPID guidance is inadequate because:

- It places problematic limitations to currently established procedures for seismic hazard calculations
- Lacks requirements for new data collections which are vital in any seismic hazard analyses conducted for nuclear power plants
- Introduces untested and unproven processes for site response calculations
- It contains scientifically unjustifiable assumptions related to geology and layering of rocks near the surface

Collectively, these shortcomings will result in erroneous conclusions in seismic hazard reassessment studies. The impacted plants will primarily be those in the Central and Eastern United States (CEUS), as the western plants will utilize an alternative process and develop their own seismic source models and ground motion prediction equations (GMPEs).

In addition to these technical difficulties, the proposed guidance will also introduce double standards in seismic hazard calculations conducted for nuclear power plants in the USA. Should the NRC go forward with its endorsement, it is clear that the Agency will have to deal with two different procedures to calculate seismic hazards: one for the new licensing applications and the other for operating reactors. Seismic hazard for any nuclear installations should be calculated consistently for a site irrespective of whether it is a future site or the site of a currently operating plant. Unfortunately, the proposed guidance for the operating reactor seismic hazard analyses in the SPID document is significantly less stringent and in cases it is flawed. The logical assumption for safety should be that the existing plant site seismic hazard calculations receive the same rigor and correctness as plant sites planned for future operation. The key technical issue is to get the seismic hazard right, regardless of whether it is a site of a currently operating plant or a site for a future plant. Should the NRC endorse this guidance and industry use it in the reassessments of seismic hazards of the operating nuclear power plants, the conclusions will be ambiguous, not reliable, and most importantly may result in a false sense of safety in the public eye.

Through discussions with the NRC's seismic technical experts along with management in attempts to resolve technical differences, it has become apparent to me that two prior commitments made by the NRC staff played a significant role in developing the direction of this SPID document. The first one is that the NRC management apparently informed the industry that new data collection would not be required to conduct adequate site response calculations. The second commitment seems to be adherence to a previously established timeline and a desire to streamline the process. It is my opinion and the rationale for my non-concurrence of this endorsement letter that the NRC should not endorse a document and/or guidelines streamlining a critical safety process that requires unique and individualized attention for each operating power plant site.

Highlights of Technical Issues and Differences Between the Current Guidance and Those Proposed in the SPID Document

In the following, I provide technical details of some of the problems associated with the SPID guidance and highlight discrepancies observed between the current regulatory practices and guidelines and practices advocated by the SPID guidance. I describe these issues under two separate categories: 1) Issues related to calculation of seismic hazard curves at the operating plant sites and 2) Issues related to site response calculations.

1) Issues Related to Seismic Hazard Calculations

The SPID guidance supports the use of the seismic source models published in NUREG 2115, 'Central and Eastern United States Seismic Source Characterization for Nuclear Facilities' (ML12048A776) to calculate seismic hazard at the operating plants in the CEUS region. With regards to the use of the NUREG 2115 model, in Section 2, the SPID document states:

> For site-specific licensing applications or site-specific safety decisions, these seismic sources would be reviewed on a site-specific basis to determine if they need to be updated. Such evaluations would be appropriate in a licensing application, where focus could be made on sitespecific applications. However, for a screening-level study of multiple plants for the purpose of setting priorities, the use of these seismic sources as published is appropriate.

The seismic source characterization model described in NUREG 2115 has been developed for uses in seismic hazard assessments of nuclear facilities in the CEUS region. NUREG 2115 clearly states it is a regional model and it needs to be updated prior to use in any seismic hazard calculations. Specifically, NUREG 2115 states:

> The CEUS SSC model is a regional model, developed explicitly to calculate seismic hazard at nuclear facilities. For site-specific applications—consistent with the applicable regulatory guidance for the nuclear facility of interest—local data sets will need to be reviewed and possible site-specific refinements made to the model to account for local information. This could include consideration of local geologic structures or local seismic sources that were not considered in this regional SSC model.

This is the current practice in calculating seismic hazard analyses in the CEUS region. However, the SPID guidance states that for operating plant seismic hazard calculations updates to seismic source models are not needed. As I outlined above, seismic hazard calculations should be done for a site regardless of there is an operating plant or a potential future plant. Justification that this is just for a screening study undermines the very nature of the CEUS source models and its requirements. Not every site may require an update, but the current regulatory guidance clearly indicates that the published seismic source models are compared against the local geologic and seismologic information to determine whether updates are needed. Not considering the required updates to seismic source models and their parameters will result in inadequate seismic hazard calculations.

Similarly, the SPID guidance also states:

> For the purposes of responding to the Seismic Enclosure 1 of the March 12, 2012 Request for Information [1], updates to seismic sources to account for historical seismicity since 2008 (the last year of the earthquake catalog in the CEUS Seismic Source Characterization study) are not required. Similarly, updates to seismic sources to account for more recent earthquakes are not necessary.

Although the rationale for this restriction is not clear, it is against the current practices and has the potential of resulting underestimates in seismic hazard calculations. Regulatory Guide, RG 1.208, 'A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion' (ML070310619), which is used in seismic hazard determinations, states that up-to-date information should be used in probabilistic seismic hazard analyses (PSHA) calculations. The following is a sample quote from RG 1.208

> The PSHA is conducted with up-to-date interpretations of earthquake sources, earthquake recurrence, and strong ground motion estimation.

Not requiring updates to seismic source parameters is problematic as this has the potential to underestimate the seismic hazard at the nuclear power plant sites. For example, even in the very short time period since the completion of the work of the CEUS seismic source models, two significant earthquakes occurred in the CEUS region. One is the Mineral Virginia earthquake (**M**5.8) that occurred in August 2011 and the other one is the Oklahoma earthquake (**M**5.6) that occurred in November 2011. Both of these earthquakes are outside the earthquake catalog covered by the CEUS seismic source model described in NUREG 2115, which covers historical and instrumental seismicity until the end of 2008. These earthquakes have the potential to impact the seismic source model parameters in their respective locations and need to be examined for potential impacts on the hazard calculations. In addition, as part of the local updates, NUREG 2115 earthquake rates should be checked. If needed, either seismic source geometries or earthquake rates (or both) may need to be updated. If the local updates are not taken into account, this will have an impact on seismic hazard calculations as well. This restriction of not requiring an update will likely to produce lower seismic hazard for sites in the vicinity of high seismicity zones.

Another potential difference in the calculation of seismic hazard between the current practices and the practices advocated by the SPID document is related to inclusion (or exclusion) of seismic sources in hazard calculations based on their distances. With regards to which seismic sources should be included in the seismic hazard calculations, the SPID guidance states:

> In addition, for applications in a regional study, it is sufficient to include background sources within 320 km (200 miles) of a site, and specifically to include only parts of those background sources that lie within 320 km of the site. This follows the guidance in [18] regarding examination of sources within the "site region" defined as the surrounding 320 km. For RLME sources, it is sufficient to include the New Madrid, Charlevoix, and the Charleston seismic zones if they lie within 1,000 km of a site. Beyond 1,000 km, ground motion equations have not been well-studied, and such distant earthquakes do not generally cause damage to modern engineered facilities. For other RLME sources and sub-regions of background sources with higher rates of activity, it is sufficient to include

> them in the analysis if they lie within 500 km of a site, based on test hazard results published in the CEUS Seismic Source Characterization project.

This is also a departure from the current practices and regulations. 10 CFR 100.23, does not impose any distance limits in seismic hazard calculations, but requires an adequate analysis. 10 CFR 100.23 states:

> The geological, seismological, and engineering characteristics of a site and its environs must be investigated in sufficient scope and detail to permit an adequate evaluation of the proposed site, to provide sufficient information to support evaluations performed to arrive at estimates of the Safe Shutdown Earthquake Ground Motion, and to permit adequate engineering solutions to actual or potential geologic and seismic effects at the proposed site.

In current practice, all seismic sources at least within the 200 mile zone of the site are investigated. RG 1.208 discusses the establishment of the 200 mile zone being essential in seismic hazard analyses to conform with 10 CFR 100.23. However, when seismic sources contribute to the total seismic hazard and they are beyond the 200 mile zone, they also need to be incorporated in seismic hazard studies. The current practice has been to include seismic sources irrespective of their distances if they contribute 1% or more to the total hazard at the site. Imposing rigid distance limits of 200 miles, 500 km, and 1000 km , as indicated by the SPID document is an artificial limit and has the potential to result in lower seismic hazard calculations.

2) Issues Related to Site Response Calculations

The biggest problem with the procedures outlined in the SPID guidance with respect to site response calculations is that the SPID guidance does not require new data collection at the sites of the operating nuclear power plants in order to correctly estimate the local rock geometries and their physical parameters to be used in site response calculations. Because the SPID guidance does not call for collecting new data, and it relies on limited data available in decades old FSAR documents, and available regional data sets, it resorts to unconventional methodologies and proxy estimates for seismic shear wave velocities. The proposed methodologies do not follow current engineering practices, include oversimplifications and in some cases contradict scientific facts. The SPID guidance introduces the concept of using template velocity profiles that are modified to match what is currently known for the sites. The fundamental issue with this proposed approach of using template velocity profiles in sites with limited or no shear wave velocity data is that the SPID guidance treats the problem of lack of data (or limited data) as a problem of uncertainty rather than a problem of unknowns. The following is a short summary on the description of site response and specific examples highlighting inadequacies of the proposed methodologies in site response calculations for the operating nuclear power plant sites.

Site response calculations are an integral part of any seismic hazard analyses for nuclear power plant. In the CEUS region, where the significant majority of the operating nuclear reactors are located, seismic hazard is calculated for generic hard rock site conditions. Generic hard rock is defined by rocks with seismic shear wave velocities of about 9200 ft/s. Other than few exceptional cases, the significant majority of the nuclear power plant sites in the CEUS are not located on hard rock. This necessitates site-specific corrections to the seismic hazard curves calculated for generic hard rock conditions. The process used for this site-specific correction is called site response calculations. This site-specific correction is an extremely critical component of seismic hazard calculations and requires detailed knowledge of the geology, stratigraphy and physical parameters of the rocks underlying any nuclear power plant site. The site response calculations may result in correction factors that can reduce the generic hard rock seismic hazard curves by more than a half or may increase the calculated generic hard rock seismic hazard curves by several times, all depending on the nature of the rocks between the foundation of the nuclear power plant and the location of the rocks with shear wave velocities of at least 9200 ft/s. There are very detailed procedures and practices established on how to conduct such essential site response calculations for nuclear power plants. RG 1.208 provides current procedures and methodologies to be used in site response calculations.

The methodology proposed in the SPID guidance is not what is used in the current practices. In fact, the procedures outlined and recommended in the SPID document should never be acceptable for site response calculations for a critical facility such as a nuclear power plant. The reason is very simple. Site response is a very major component of seismic hazard calculations. Because the impact may have very pronounced effect on the seismic hazard calculations for all sites other than those located directly on hard rock, extreme care must be given to adequately determining the physical properties of the rocks underlying the nuclear power plant. A well-defined site profile must be developed using reliable geophysical measurements before proceeding with site response calculations. Rather than requiring such essential data sets to be collected for site response calculations, the SPID guidance proposes to use any limited data available (or proxies) and estimate the shear wave velocities below the power plants by utilizing the so-called template profiles and incorporate large uncertainties with the hope that by introducing large uncertainties a reasonable site response calculations can be obtained.

With regards to developing site profile to be used in the site response calculations, the SPID guidance states:

> The information available to develop estimates of site properties and characteristics will be primarily based on readily available sources (FSAR and other regional data) for most locations.

The key problem with this statement is that many of the FSARs for the operating plants are decades old. Information contained in them, whatever level it might be, is of varying quality and old. Such information cannot be and should not be used in a current, modern seismic hazard study. The science of geology is ever evolving and the scientific literature is full of specific examples of how old observations can be reinterpreted differently with the use of modern knowledge. Therefore, relying on decades old, limited geologic information in seismic hazard estimates for existing nuclear reactors cannot be justified. The use of geology has the potential of alleviating many of the key issues with regards to site conditions, but the SPID guidance fails to acknowledge the requirement for new, site-specific geologic investigations as part of the site characterization, but states analyses should be conducted with readily available data. Not requiring an essential geologic investigation of the local geology and relying heavily on the limited and incomplete data in the FSARs is a significant problem. Though the above quoted SPID guidance statement also includes readily available 'other regional data', what is essential in site response calculations is the local data. Regional data has a role to play in site response calculations. For example, any deep seismic velocity information from oil wells that are near power plant sites may provide critical information. However, utilization of such regional data requires detailed understanding of local and regional geology.

Another example of inadequacy of the guidelines proposed in this area is related to the use of template shear wave velocities in the absence of detailed local data. Since the SPID guidance does not require collection of new data from the nuclear power plant sites to be used in site response calculations, the SPID guidelines state template velocity profiles should be used instead.

The SPID document states:

> For soil sites where Vs [*shear wave velocity*] is estimated from compression-wave measurements, or was measured only at shallow depths, template profiles will be used based on experience with other, well-documented sites. The template profiles will be adjusted and/or truncated to be consistent with measured or estimated Vs in the upper 30 m of soil, called Vs30, to obtain a reasonable profile to use for analysis that includes the potential effects on ground motion of soils at large depths.
>
> For firm rock sites (typically underlain by sedimentary rocks) that have little measured Vs data, a Vs profile will be adopted that is consistent with shallow estimates or measurements and that increases with depth using a gradient typical of sedimentary rocks. A consistent gradient has been documented for sedimentary rock sites in various locations around the world, and a profile developed in this way will give reasonable results for the potential effects on ground motion of sedimentary rock at large depths.

The methodology described in the above quoted paragraphs, which forms the foundation of the procedures to be employed in site response calculations (expect in co-located COL and ESP sites where significant new information on the site conditions exist) in estimating seismic shear wave velocity profiles for the operating sites is not suitable for the purposes of site response calculations for nuclear power plants, because they do not represent the real conditions beneath the nuclear power plant sites. Some aspects of procedures are also contrary to basic scientific knowledge. For example, limited shallow seismic shear wave velocities, or their proxies as in the case of Vs30, cannot be used as a predictive measure of the deeper velocities. In fact, there is no scientific rationale for estimating deeper geologic layers' shear wave velocities, once an estimate is made for the shallow layers' shear wave velocities.

In addition, the proposed guidelines quoted above imply that shear wave velocities (Vs) can easily and accurately be estimated from compression-wave velocities. The uncertainty in estimating Vs from compression-wave velocities (Vp) varies significantly, especially for soils and rocks near the surface where weathering, local deformation, ground water, etc, play a significant role and reliability of such estimates will not reach the level required to be used in nuclear power plant seismic hazard estimates. Local geology at each site is different. Even if local geology can be accurately determined through extensive mapping and analyses (which is not required by the SPID guidance) estimates of the physical properties of soils and rocks will still vary and require extensive measurements.

The above quotations taken from the SPID document also suggest that not only measured, but also estimated shallow shear wave velocities can be used to select a template profile representing the site conditions; taking the procedures to a level far from an acceptable approach. It is quite concerning that the SPID guidance recommends uses of such unproven, unscientific procedures to be used in estimating shear wave velocities for determining seismic hazards of critical facilities such as nuclear power plants. The concept of Vs30 is introduced in the SPID document as the main criteria in determining which template velocity profile to use. Vs30 is a proxy measure for seismic shear wave velocities in the upper 30m of soils/rocks. This measure has been used in different areas of engineering practices for mostly non-critical facilities. The use of Vs30 in nuclear siting studies has not been justified and it is not a part of the current guidance. The SPID guidance yet suggests for even an estimated Vs30 to be used in determining the shear wave velocities for site response calculations.

The SPID document acknowledges that when there is limited or no measured seismic velocity data for site response calculations, the uncertainties in the results are large and the guidance tries to deal with this by using base case and lower and upper bound shear wave velocity profiles. The lower and upper bound measures are estimated from the base case estimates with varying levels of standard deviations. The SPID guidance falsely assumes if the standard deviations are increased, the results will capture the uncertainties and it is acceptable. However, the SPID guidance fails to acknowledge that the fundamental issue is not with the uncertainties in the case of no data or very limited data, it is simply an issue of determining key unknown parameters (the base seismic wave velocities) accurately in order to conduct reliable site response calculations.

Conclusions

Given the extensive technical issues and non-standard procedures described in the SPID guidance document to calculate seismic hazard at the operating nuclear power plants in the USA, it is imperative that the NRC should not endorse the use of these procedures outlined in the SPID guidance document for seismic hazard and site response calculations. Should the NRC endorse the SPID guidance document, the results obtained from such processes will result in inadequate assessments of seismic hazards at most of the nuclear power plants in the CEUS. While some operating plants' seismic hazard estimates may be unduly high, some others will have seismic hazard estimates significantly below their real hazard levels.

It is my opinion that to remedy the problems outlined above, the NRC endorsement letter should state that in order to obtain an accurate estimate of the seismic hazard, current practices as described in RG 1.208 and NUREG 2115 be followed rather than the simplified processes outlined in the SPID document. In addition, the endorsement letter should indicate that site response calculations are very important part of seismic hazard calculations and they also need to be conducted using the current procedures and practices rather than the methodology outlined in the SPID document. The importance of the usage of real data in site response calculations should be emphasized and licensees must be requested to follow current practices and guidance to obtain fully defendable and reliable site profile data for their sites before conducting site response calculations and determine the GMRS at their sites prior to proceeding to screening processes as outlined in the SPID guidance document.

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

TITLE OF SUBJECT DOCUMENT ENDORSEMENT OF ELECTRIC POWER RESEARCH INSTITUTE FINAL DRAFT REPORT 10252	NCP TRACKING NUMBER NCP-2012-009 ADAMS ACCESSION NO. ML12319A074

SECTION B - TO BE COMPLETED BY NON-CONCURRING INDIVIDUAL'S SUPERVISOR

NAME	
TITLE	PHONE NO.
ORGANIZATION	
COMMENTS FOR THE NCP REVIEWER TO CONSIDER	
	☐ CONTINUED IN SECTION D
SIGNATURE	DATE

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER
NCP-2012-009

TITLE OF SUBJECT DOCUMENT
ENDORSEMENT OF ELECTRIC POWER RESEARCH INSTITUTE FINAL DRAFT REPORT 10252

ADAMS ACCESSION NO.
ML12319A074

SECTION C - TO BE COMPLETED BY DOCUMENT SPONSOR

NAME

TITLE

PHONE NO.

ORGANIZATION

SUMMARY OF ISSUES

ACTIONS TAKEN TO ADDRESS NON-CONCURRENCE

SIGNATURE--DOCUMENT SPONSOR	TITLE
ORGANIZATION	DATE
SIGNATURE--NCP REVIEWER	TITLE
ORGANIZATION	DATE

NCP OUTCOME

Non--Concurring Individual: ☐ CONCURS ☐ NON-CONCURS ☐ WITHDRAWS NON-CONCURRENCE (i.e., discontinues process)

AVAILABILTY OF NCP FORM

Non--Concurring Individual: ☐ WANTS NCP FORM PUBLIC ☐ WANTS NCP FORM NON-PUBLIC

☐ CONTINUED IN SECTION D

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER
NCP-2012-009

TITLE OF SUBJECT DOCUMENT
ENDORSEMENT OF ELECTRIC POWER RESEARCH INSTITUTE FINAL DRAFT REPORT 10252

ADAMS ACCESSION NO.
ML12319A074

SECTION D: CONTINUATION PAGE

CONTINUATION OF SECTION ☐ A ☐ B ☐ C

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

NON-CONCURRENCE PROCESS

SECTION E - Implementation Guidance

Part 1 - Initiation of Non-Concurrence

Individual non-concurs on subject document and completes Section A, including identifying name and ADAMS accession number of document being non-concurred on, name of the subject document signer, and reasons for non-concurrence and proposed alternatives.

If more than one individual non-concurs, Section A should reflect the additional names and signatures.

Individual must request NCP tracking number prior to submitting NCP Form by emailing NCPPM.Resource@nrc.gov or calling (301) 415-2741.

Individual sends NCP Form to immediate supervisor, document signer, NCP PM, and OCWE Champion. (See Contacts on OCWE Web site.)

Part 2 - Staff Review of Non-Concurrence

Document Signer identifies Document Sponsor and forwards NCP Form to Document Sponsor to coordinate staff review. Document Signer may choose to act as Document Sponsor.

Individual's immediate supervisor completes Section B, including views of issues and proposed alternatives and any other information for management consideration and forwards to Document Sponsor.

Document Sponsor documents Summary of Issues (SOI) and emails to individual for comment and consensus. SOI ensures a common understanding of issues and should be agreed upon before NCP Form is evaluated by staff.

Document Sponsor serves to coordinate and document staff's review of the non-concurrence. Non-concurring individual should be included in discussions, when warranted, to maximize understanding and improve decision-making.

Document Sponsor completes Section C to reflect staff's review of issues and actions (if applicable), that were taken to address concerns. Documentation should be complete, on-point, factual, and focused on issues (not individuals).

Document Sponsor puts completed NCP Form in document package and returns package to concurrence.

Document Sponsor updates Section C, as necessary, to reflect any additional changes made during process to address issues.

Part 3 - Management Review of Non-Concurrence

Document Signer reviews NCP Form, may discuss with interested parties (including non-concurring individual), and may return NCP Form and subject document for additional action, prior to signing Section C as the NCP Reviewer and prior to issuance of subject document.

If Document Signer is Document Sponsor, NCP Reviewer is next level manager. Document Signer continues to sign subject document and NCP Reviewer is added to subject document concurrence.

If Document Signer is not SES manager, NCP Reviewer is first SES manager in organizational chain. Document Signer continues to sign subject document and NCP Reviewer is added to subject document concurrence.

Part 4 - NCP Outcome and Record-Keeping

Document Sponsor records outcome of NCP when process is complete (i.e., when subject document is issued) in Section C.

Document Sponsor gets input from non-concurring individual on interest of availability of NCP Form.

If individual wants NCP Form public, Document Sponsor assists in releasability review in accordance with the NRC Policy For Handling, Marking, and Protecting Sensitive Unclassified Non-Safeguards Information (SUNSI) and MD 3.4, "Release of Information to the Public."

NCP Form should be profiled in ADAMS using ADAMS Template NRC-006.

Document Sponsor will email NCP PM and OCWE Champion when process is complete.

NCP PM will post NCP Form and issued subject document on internal Web site and OCWE Champion will highlight to staff, as warranted.

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(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER
NCP-2012-009

TITLE OF SUBJECT DOCUMENT
ENDORSEMENT OF ELECTRIC POWER RESEARCH INSTITUTE FINAL DRAFT REPORT 10252

ADAMS ACCESSION NO.

SECTION B - TO BE COMPLETED BY NON-CONCURRING INDIVIDUAL'S SUPERVISOR

NAME
Nilesh C. Chokshi

TITLE
Deputy Division Director

PHONE NO.
(301) 415-1634

ORGANIZATION
Division of Site Safety and Environmental Analysis, Office of New Reactors

COMMENTS FOR THE NCP REVIEWER TO CONSIDER

See Attached

☐ CONTINUED IN SECTION D

SIGNATURE
Nilesh C. Chokshi

DATE
01/11/2012

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

Form 757 Section B Input

Based on the attached technical evaluation and further explanation below, my conclusion is that to address the issues raised in the non-concurrence process, changes are not required to the SPID guidance, but the endorsement letter should be revised to include the following additional clarification:

> *The staff agrees with the SPID position that for purposes of responding to the request for information, the use of seismic sources as published in SPID Reference 14 is appropriate for the CEUS sites. However, if during the course of hazard reevaluations, a seismic event occurs or information emerges that could have a meaningful impact on the calculated hazard; the licensee should evaluate the new information and modify the source models as necessary.*

In addition to the technical evaluations discussed in the attachment, it is essential to provide a broader perspective on: the overall goal of the 50.54(f) request and subsequent regulatory decisions that may have to be made; overall staff strategies to achieve these goals; purpose and process used in development of the SPID; and bases and factors considered for staff decisions.

The stated purposes in the 50.54(f) letter for the seismic hazard reevaluation are:

- To gather information with respect to Near-Term Task Force (NTTF) Recommendation 2.1, as directed by staff requirements memoranda (SRM) associated with SECY -11-0124, SECY -11-0137, and the Consolidated Appropriations Act, for 2012 *(Pub Law* 112-74), Section 402, and to reevaluate seismic hazards at operating reactor sites

- To collect information to facilitate NRC's determination if there is a need to update the design basis and systems, structures, and components (SSCs) important to safety to protect against the updated hazards at operating reactor sites

- To collect information with respect to the resolution of Generic Issue (GI) 199

The staff has devised a two-stage process for the seismic reevaluations. In the first stage, licensees are to conduct hazard reevaluations and develop ground motion response spectra (GMRS) for their sites and submit to the staff along with any interim actions planned or taken to address new hazard. The second stage consists of performing seismic risk evaluations for those plants whose seismic design basis (i.e., safe shutdown earthquake or SSE) is exceeded by the new GMRS. The process calls for the NRC staff to prioritize plants requiring risk evaluations based primarily on the revaluated hazard information. This process would allow for completion of all hazard reevaluations and risk evaluations for the higher priority plants consistent with the Commission's stated schedule of five years.

Consistent with the Commission guidance and the process outlined in the 50.54(f) letter, the NRC staff (through a multi-disciplinary, multi-office team) has engaged with an industry task force and other stakeholders in publicly open forums during the development of the 50.54(f) letter and the associated implementation guidance. The primary purposes for the development of the implementation guidance are to: (1) establish requirements and approaches that can be applied consistently and uniformly across the operating reactor fleet; and (2) identify technical issues that require specific implementation of mutually agreed upon approaches. The implementation guidance is published both in the industry developed guidance documents and NRC developed interim staff guidance. For the purposes of seismic hazard reevaluation the industry guidance is contained in the document titled: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic. The process calls for the staff endorsement of the SPID, with or without comments. The SPID deals with seven technical areas: seismic hazard development, GMRS comparisons and screening of plants, seismic hazard and screening report, prioritization, seismic risk evaluation, and spent fuel pool integrity evaluation. The issues raised in this non-concurrence are with respect to the seismic hazard development.

Industry and the NRC staff at the very outset recognized that in order to meet the intent of the Commission request with respect to scope and schedule, some of the approaches and practices used for new reactor siting reviews would need to be adjusted recognizing the differences between already licensed and operating reactors and new reactor siting, which starts from scratch. This approach is consistent with past regulatory practices. The need for adequate alternative technical approaches stem from various factors: (1) available resources to simultaneously conduct studies for all of the operating reactors (hazard reevaluations for all of the CEUS sites will be completed and reported by September 2013); (2) consideration of timely regulatory actions and safety enhancements; and (3) most importantly, whether the information gathered by licensees during the initial siting reviews is sufficient for the 50.54(f) hazard revaluations, or not.

The positions in the SPID were developed based on many technical supporting studies and interactions with the staff. The initially proposed positions were modified and additional investigations were undertaken as a result of staff interactions. The seismic hazard evaluation guidance that is in Section 2 and Appendix B of SPID, and which is in contention here, was developed through this interactive process. The SPID, consistent with the 50.54(f) letter, specifies that a probabilistic seismic hazard analysis be performed for each operating reactor site in order to develop a GMRS. Rather than requiring licensees to acquire new site specific geological and geotechnical information, the SPID outlines a conservative approach to estimating the local site response.

The use of available information to conduct necessary studies is also part of other SPID positions related to seismic risk evaluation. For example, the SPID outlines conditions under which the existing structural models for the operating reactors can be used for evaluation for the current purposes. The SPID also includes situations where there is a need for data or collection of new information. For example, the SPID outlines a test program that the industry has undertaken to address issues related to the high frequency sensitive components. The SPID further outlines how the test results will be incorporated in a risk evaluation. This issue alone would have taken a long time, if an industry wide test program, which will be completed within a timeframe of one year, was not undertaken. Thus, the development of SPID (and the NRC ISG) and its endorsement is an extremely important element in timely implementation of the NTTF Recommendation 2.1.

Another important element to consider is the role of the guidance documents in the staff review of the submitted information in response to the 50.54(f) requests. It is important to recognize that this is not a review for a new reactor license; that type of review is neither needed nor desirable for timely completion of the program. A detailed review of existing geological information was conducted at the time of licensing. The guidance documents identify the focus area of the reviews where significant judgments are exercised. It also identifies areas where positions are very clear and implementation of guidance is straight forward, requiring minimal reviews.

Finally, it is important to address an assertion contained in the non-concurrence document. The document implies that a management decision was made to not require new data for the site response calculations, thus requiring technical staff to develop an unsound technical approach. As discussed above, a very open and interactive process was used in developing all of the guidance contained in the SPID document, including Section 2.0 and Appendix B. Industry proposed and staff evaluated the site response approach in the SPID. Based on the staff's evaluation of the technical merits, the staff concluded the approach was acceptable to generate reasonable estimates of the site responses. The attached technical document explains basis for the staff's technical conclusions. If such conclusions could not have been reached and the staff concluded that additional, detailed site investigations are the only approach to estimate the site response, staff would have required site investigations. The assertion is baseless.

In summary, considering the technical evaluation presented in the attachment and overall goal of understanding plant responses to the newly reevaluated hazard, and to identify any enhancements or further regulatory actions, the approach outlined in the SPID is considered adequate.

Attachment to Form 757 Section B Input

Non-Concurrence on Endorsement of SPID

INTRODUCTION

On December 12, 2012, Dr. Dogan Seber submitted a non-concurrence on the NRC staff's endorsement letter of the Seismic Evaluation Guidance: Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic (ML12333A170). The SPID, which was developed by EPRI in collaboration with the NRC staff, provides guidance to addressees of the 10 CFR 50.54(f) request for information letter (ML12053A340) on how to reevaluate the seismic hazards for their respective nuclear power plant sites. The SPID also provides extensive guidance on performing seismic risk evaluations for those operating plants where the reevaluated seismic hazard exceeds the current plant's seismic design basis.

<u>10 CFR 50.54(f) Letter</u>

Enclosure 1 to the 50.54(f) letter, issued as part of the lessons learned from the accident at the Fukushima Dai-ichi nuclear facility, requests that all power reactor licensees and holders of construction permits in active or deferred status reevaluate the seismic hazards for their respective sites. Specifically, the 50.54(f) letter requests that licensees reevaluate the seismic hazards at their sites against present-day NRC requirements and guidance and based upon this information, the NRC staff will determine whether additional regulatory actions are necessary to protect against the updated hazards.

The 50.54(f) letter outlines a five- to seven-year process for the seismic reevaluations depending on whether the nuclear power plant is located in the central and eastern United States (CEUS) or the western United States (WUS). The seismic hazard reevaluation is scheduled to take 1.5 years for licensees in the CEUS and 3 years for licensees in the WUS. This difference in the schedule for the hazard reevaluations for CEUS and WUS sites is due to the availability of recently developed and NRC-approved seismic source models for the CEUS (NUREG-2115), which can be directly implemented by CEUS licensees. The remaining time (3 to 4 years) is for licensees to perform a seismic risk evaluation if necessary.

<u>SPID Seismic Guidance</u>

For the development of the SPID guidance, the Electric Power Research Institute (EPRI) worked with the NRC staff to develop a process that provides the information requested by the 50.54(f) letter. Consistent with the 50.54(f) letter and current NRC regulatory guidance, the SPID specifies that a Probabilistic Seismic Hazard Analysis (PSHA) be performed to determine the Ground Motion Response Spectrum (GMRS) for each operating reactor site. The major elements of a seismic hazard evaluation to develop design level ground motions for a prospective nuclear power plant site are (1) an evaluation of seismic sources surrounding the site, (2) development of regional ground motion prediction equations, and (3) an evaluation of the local site amplification or response to incoming seismic waves. Current regulatory requirements in 10 CFR 100.23 explicitly recognizes PSHA as an appropriate method, and guidance in RG 1.208 specifies that a probabilistic approach be used to arrive at the design ground motion levels, referred to as the GMRS. The 50.54(f) letter requests that, in accordance with RG 1.208, addressees develop the GMRS for their sites for comparison with the existing plant's seismic design basis, referred to as the Safe Shutdown Earthquake ground motion (SSE). If the GMRS exceeds the SSE, then a seismic risk evaluation of the nuclear plant is needed to determine whether additional regulatory actions are necessary to protect against the updated hazards.

Applicants for new reactor siting also follow RG 1.208 to develop GMRS for their sites. Prior to submitting their Early Site Permit (ESP) or Combined License Applications (COLA), applicants spend a considerable amount of effort and time to characterize the site subsurface geology and engineering properties. This effort involves a considerable number of borings to assess the site stability and soil or rock properties in order to develop a site subsurface profile. These subsurface properties, such as soil or rock shear wave velocity, density, and layer thickness, are key parameters to determine the response of the site to incoming vertically propagating seismic waves.

Non-Concurrence Issues

Each of issues that follow explain why Dr. Seber believes that the SPID guidance for reevaluating the seismic hazard and developing the GMRS for currently operating nuclear power plants is inconsistent with the current regulatory guidance and practices for hazard evaluations for new reactor siting. Dr Seber states,

> The proposed guidance [SPID] will also introduce double standards in seismic hazard calculations conducted for nuclear power plants in the USA. Should the NRC go forward with its endorsement, it is clear that the Agency [NRC] will have to deal with two different procedures to calculate seismic hazards; one for the new licensing applications and the other for operating reactors. Seismic hazard for any nuclear installation site should be calculated consistently irrespective of whether it is a future site or the site of a currently operating plant. Unfortunately, the proposed guidance for the operating reactor seismic hazard analysis in the SPID is significantly less stringent and in cases it is flawed. The logical assumption for safety should be that the existing plant site seismic hazard calculations receive the same rigor and correctness as plant sites planned for future operations. The key technical issue is to get the seismic hazard right, regardless of whether it is a site of a currently operating plant or a site for a future plant. Should the NRC endorse this guidance and industry use it in the reassessments of seismic hazards of the operating nuclear power plants, the conclusions will be ambiguous, not reliable, and most importantly may result in a false sense of safety in the public eye.

The specific issues addressed in Dr. Seber's non-concurrence are:

1. The SPID guidance does not correctly implement the use of the recently developed seismic source models for the CEUS.

2. The SPID guidance incorrectly constrains the distances out to which seismic sources are to be evaluated for the Probabilistic Seismic Hazard Analysis (PSHA).

3. The SPID does not require that geologic field investigations or geophysical measurements be performed at the operating reactor sites in order to develop correct estimates of the local site ground motion amplification functions. Instead the SPID specifies a site response approach that (1) includes assumptions that are not scientifically valid and (2) does not address the issue that the site subsurface geology is unknown.

As a result of the issues described above, Dr. Seber does not believe that the staff's endorsement of the SPID guidance is consistent with Near Term Task Force (NTTF) Recommendation 2.1 (R2.1) that present-day regulation and guidance be used to reevaluate the seismic hazard for operating reactor sites. Dr. Seber states,

> If followed, the methodologies and guidance provided in the SPID document for seismic hazard analysis will result in ambiguous and unreliable seismic hazard calculations at the operating nuclear sites.

<u>Summary of NTTF R2.1 Seismic Team Evaluation</u>

The NRC Seismic Team for the implementation of NTTF Recommendation 2.1 reviewed each of the issues identified in Dr. Seber's non-concurrence. Based on these reviews, the Seismic Team finds that the NRC's endorsement of the SPID guidance is technically sound and the SPID guidance, if followed, will provide the information requested in the staff's 50.54(f) letter.

In reaching this conclusion, the Seismic Team reviewed and considered Dr. Seber's non-concurrence report, the SPID guidance, and the 50.54(f) letter. The focus of the team's review was to assess whether (1) the staff's endorsement of the SPID guidance is based on sound technical judgment, (2) implementation of the SPID guidance will provide a seismic hazard reevaluation that is consistent with 50.54(f) letter, and (3) implementation of the SPID guidance will provide the NRC staff with sufficient information to identify the nuclear power plants that may need to update their design basis and systems, structures and components important to safety to protect against the updated hazards.

Dr. Seber's non-concurrence argues that NRC regulatory guidance and current practices for review of potential new reactors be completely implemented for seismic hazard reevaluations of operating plants under NTTF Recommendation 2.1. While the NTTF Seismic Team understands this position, the team believes that the correct implementation of the SPID guidance by licensees will provide the staff with adequate information to identify those plants that may need to be upgraded as well as providing this information commensurate with the schedule outlined in the 50.54(f) letter. Both the 50.54(f)letter and the SPID guidance present a somewhat abbreviated approach for reevaluating the seismic hazard compared to the analysis performed for new reactor siting. However, the Seismic Team believes that these simplifications will not impact the seismic hazard results in a significant manner and will ensure that operating plants that need to perform additional risk analyses will be identified.

As a result of the issues raised by Dr. Seber, the staff will add additional information to their endorsement letter for the SPID to clarify when it would be necessary to evaluate whether the CEUS seismic source models need to be updated. Experience gained from this process will also be used to develop staff guidance on writing the Safety Evaluation Reports (SERs) for the licensee's seismic hazard and screening submittals to ensure that the technical bases for the staff's decisions are adequately described.

NON-CONCURRENCE EVALUATION

Summary of Issues

Issue 1

The SPID guidance does not fully implement the guidance for use of the recently developed Central and Eastern US (CEUS) seismic source model for use in reevaluating the hazard at operating nuclear power plant sites in the CEUS. The use of the CEUS Seismic Source Characterization (CEUS-SSC) models is described in NUREG-2115, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities."

- The SPID states that site-specific adjustments to seismic sources are not necessary. However, NUREG 2115 states that the CEUS-SSC is a regional model and further states that local geology should be reviewed to determine if site- specific refinements to the regional model are necessary. This would include consideration of local geologic structures or local seismic sources. If local earthquake rates and seismic zone configurations are not assessed, then the overall hazard calculation may be under estimated.

- The SPID states that updates to seismic sources to account for historical seismicity since 2008 (the last year of the earthquake catalog in the CEUS-SSC study) are not required. However, RG 1.208 states that the Probabilistic Seismic Hazard Analysis (PSHA) is to be conducted with up-to-date interpretations of earthquake sources, earthquake recurrence, and strong ground motion estimation. The 2011 M5.8 Mineral Virginia and M5.6 Oklahoma earthquakes are examples of earthquakes whose impact on the CEUS-SSC models should be assessed.

Issue 2

The SPID guidance incorrectly constrains the distances out to which seismic sources are to be evaluated for the Probabilistic Seismic Hazard Analysis (PSHA). The SPID states that it is sufficient to include diffuse areas of seismicity or "background" seismic sources within 320 km of the site and in situations where the entire background source is not within 320 km of the site, only include those parts that lie within 320 km of the site. In addition, the SPID states that it is sufficient to include the largest repeating fault sources (specifically New Madrid, Charlevoix, and Charleston) only if they lie within 1000 km of the site. The SPID specifies that other seismic sources with higher rates of activity and/or larger magnitudes (repeating large magnitude earthquakes or RLMEs) be included only if they lie within 500 km of the site.

These constraints imposed by the SPID guidance are contrary to RG 1.208, which does not place any constraints on the distance from the site for which seismic sources should be evaluated. In addition, these constraints in the SPID guidance are inconsistent with the current practice for new reactor siting reviews, which calls for the inclusion of all seismic sources that contribute 1% or more to the total hazard in the PSHA.

Issue 3

The SPID does not require that geologic field investigations or geophysical measurements be performed at the operating reactor sites in order to develop reliable estimates of the local site subsurface shear wave velocity profile and material properties. The geologic data in the FSARs are decades old, generally sparse, and of limited use in determining the local site response. Because new geologic and geophysical data are not being collected at each of the operating reactor sites, the geology of the subsurface and in particular the soil and rock properties cannot be established in sufficient detail to perform a correct site response evaluation. Extensive measurements at each of the operating reactor sites should be required to arrive at estimates of the soil and rock properties.

The SPID attempts to overcome the deficiencies, described above, by using unconventional methodologies that are overly simplistic and may not characterize the nature of the soil and rock subsurface geology. The site response methodology, described in the SPID, attempts to cover a wide range of uncertainty to compensate for the lack of subsurface data at the sites. However, if the subsurface soil and rock properties are unknown, simply increasing the uncertainty for the site response methodology will not result in the correct site amplification function. In addition, the site response methodology makes use of a proxy measure for the soil or rock shear wave velocity in the uppermost 30 m below the surface (V_{s30}) to determine an appropriate shear wave velocity template to use for the site response evaluation. The use of V_{s30} is not part of current practices for new reactor siting reviews. In addition, the site response method in the SPID uses shear wave velocity templates based on V_{s30} value and geologic information in the FSARs rather than actual direct measurements of the shear wave velocity beneath the site. The use of these shear wave velocity templates is not scientifically valid because the templates do not match the actual shear wave velocities of the rock and soil beneath the site.

Evaluation

Issue 1 – Incorrect Implementation of Seismic Source Models for CEUS

10 CFR 50.54(f) Letter and SPID Guidance. The 50.54(f) letter states with regard to the seismic hazard reevaluation for CEUS licensees:

> Addressees of plants located in the CEUS are expected to use the Central and Eastern United States Seismic Source Characterization (CEUS-SSC) model and

> the appropriate Electric Power Research Institute (2004, 2006) ground motion prediction equations. Regional and local refinements of the CEUS-SSC **are not necessary** [emphasis added] for this evaluation.

The SPID guidance reaffirms that the CEUS-SSC model can be used as is:

> For the purposes of responding to the Seismic Enclosure 1 of the March 12, 2012 Request for Information, updates to seismic sources to account for historical seismicity since 2008 (the last year of the earthquake catalog in the CEUS Seismic Source Characterization study) are not required. Similarly, updates to seismic sources to account for more recent earthquakes are not necessary.

Previous Seismic Source Models and Development of CEUS-SSC. As RG 1.208 was written before the development of the CEUS-SSC, the guidance specifies that either the EPRI or LLNL seismic source models should be used as the starting point for characterizing the regional and local seismic hazards for a prospective new reactor site. While both of these seismic source models are considered first-of-a-kind and important milestones, they were developed in the 1980s and reflected the scientific knowledge of the time. Prior to using these older seismic models for ESP and COL applications, EPRI developed new ground motion models in 2004 and individual ESP and COL applicants updated the seismic source characterizations for New Madrid, Charleston, and other significant seismic sources. As these updates became more frequent and as not all of the updates were uniformly applied by each of the COL and ESP applicants, the NRC together with DOE and EPRI decided that a completely new model for seismic sources should be developed. This model is the recently completed CEUS-SSC, which is documented in NUREG-2115.

The CEUS-SSC project was conducted over a three year period (2008 to 2011) to provide a regional seismic source model for use in probabilistic seismic hazard analyses (PSHAs) for nuclear facilities. As such the CEUS-SSC model replaces the EPRI and LLNL regional seismic source models. Unlike the EPRI and LLNL projects, which were conducted independently, the CEUS-SSC project had multiple stakeholders, including EPRI, DOE, and NRC.

Need for Updating CEUS-SSC. The CEUS-SSC models are regional models and the NRC requires that the use of the CEUS-SSC for a site-specific new reactor siting application be accompanied by appropriate site-specific assessments of local geology. This entails the identification by ESP or COL applicants of all known faults in the area around the site and a determination as to whether these faults are capable. ESP and COL applicants are also expected to address any recent earthquakes to determine their impact, if any, on the seismic source models. These investigations are to determine if more recent data since the completion of the CEUS-SSC in 2011 impacts the models.

Although these local geologic and seismic investigations are required, it is not expected that local refinements to the CEUS-SSC will be necessary over the next 5 years or so given that the CEUS-SSC models have been recently developed. In addition, the CEUS-SSC is a fairly refined model with calculations of earthquake recurrence rates within one-quarter degree or half-degree latitude and longitude cells. Different smoothing of the local seismicity over these cells reflects the varying reliance of smaller magnitude events for the prediction of larger earthquakes. In addition, within each seismic source zone there is a unique maximum magnitude distribution that reflects both the seismic activity within the region and worldwide seismic activity within similar stable continental geologic regions.

Another significant factor for why the NRC seismic team has concluded that the local geologic investigations are not necessary for this application is that licensees have already performed extensive geologic investigations of the area around their sites and this information is well-documented in the Final Safety Analysis Report for each of the operating plants. Examples of these detailed geologic investigations for operating reactors are discussed in a document prepared by a retired NRC staff geologist, Dr. Richard McMullen. The title of the report is "Selected Case Histories of the Application of The Nuclear Regulatory Commission's Geologic and Seismic Siting Criteria" (ML09307014440). This report provides insights on how the staff assessed the geologic investigations and interpretations performed by licensees.

Further justification for the NRC seismic team for NTTF R2.1 concluding that evaluations to determine if potential refinements are needed to the CEUS-SSC are not necessary for this application are (1) the completeness of the CEUS-SSC models, (2) recency of the CEUS-SSC models, (3), the focus on earthquake ground motions of engineering interest, and (4) the level of precision in mean hazard estimates for CEUS sites.

Appendices C and D of the CEUS-SSC report (NUREG-2115) present over 250 pages of data evaluation and summary tables used to develop the CEUS-SSC. Several hundred publications and data sets related to CEUS geology and seismology were evaluated by the CEUS-SSC team members. Publications related to major fault systems as well as smaller individual faults were examined by the team to characterize each of the seismic source models in the CEUS-SSC.

Due to the low rate of seismic activity in the CEUS and its general diffuseness, the NTTF R2.1 seismic team believes that modifications to the CEUS-SSC that would result in significant changes to the models are unlikely to occur over the 1.5-year time frame in which licensees are reevaluating the seismic hazards for their sites. While not explicitly stated in the SPID, in the event a large earthquake occurs during the review, the NRC staff would expect CEUS licensees to evaluate its impact on the hazard reevaluations. As such, the NRC will indicate this in its endorsement letter for the SPID guidance.

The purpose of NTTF R2.1 is to assess the impact of the reevaluated seismic hazard on currently licensed operating nuclear power plants. For this reassessment of the hazard, the NRC is interested in determining ground motions of engineering interest that may impact currently operating nuclear facilities. It is the NTTF seismic team's judgment that local refinements to the CEUS-SSC models will not result in significant changes in the reevaluated seismic hazard and ultimately the GMRS.

Finally, there are many uncertainties associated with CEUS seismic source modeling (magnitudes, locations, rates) that have been incorporated in the CEUS-SSC. In addition to the uncertainties associated with the source characterization, there are also uncertainties with the development of the ground motion prediction equations and the local site response analysis. In composite, the model developers for the CEUS-SSC have estimated that the level of precision is about 25% for seismic hazard estimates for CEUS sites. Or in other words, if an alternative assumption or parameter is used and it changes the mean hazard less than 25%, then the potential change is less than the highest level of precision with which we can calculate the mean hazard. For this reason, the NTTF R2.1 Seismic Team believes that a geologic investigation to assess the potential activity of local faults is unlikely to impact the hazard reassessments that are currently underway by operating plant CEUS licensees.

2011 Mineral, VA and Oklahoma Earthquakes. Dr. Seber in his non-concurrence stated that the 2011 Mineral, Virginia and Oklahoma earthquakes are examples of events that should be evaluated to determine if any updates to the CEUS-SSC are necessary. Specifically, these two earthquakes are the August 23, 2011 Magnitude (M) 5.8 Mineral, Virginia earthquake and the November 5, 2011 M 5.6 Oklahoma earthquake.

Prior to the publication of the final CEUS-SSC model earlier this year, the model developers evaluated the impact of the 2011 Mineral, Virginia earthquake and found that there would be little or no impact on any aspects of the model. The NTTF R2.1 seismic team has performed a confirmatory analysis of the Mineral, VA earthquake and determined that inclusion of this event in the CEUS-SSC earthquake catalog will not result in significant changes to the seismic hazard model. Figure 1 shows that the recurrence rates for the Central Virginia Seismic Zone both with (red line) and without (blue line) the Mineral, Virginia earthquake differ only slightly. In addition, Table 7.4.2-1 of the CEUS-SSC report (NUREG-2115) indicates that the lower bound of the maximum magnitude distribution for the ECC-AM (Extended Continental Crust – Atlantic Margin) source zone, which covers the Mineral, VA earthquake, starts at M6 and ends at M8, which exceed the magnitude of the Mineral earthquake. Hence, the occurrence of the Mineral earthquake does not challenge the existing maximum magnitude distribution for this source zone.

Similarly, Table 7.4.2-1 and Figure 7.4.2-8 from NUREG-2115 (included below), illustrate that the magnitude of the November 11, 2011 M5.6 Oklahoma event is equal to the lower bound of the maximum magnitude distribution (M5.6 to M8.0) for the Mid C-B (Mid-Continent-Geometry B) seismic source zone that is implemented in the hazard calculations. Table 7.4.2-1 illustrates two additional points. First, any change to the underlying distributions to incorporate the occurrence of the M 5.6 event will impact only the lower bound portion of the final distribution. Second, in the current implementation of the model, this lower bin is given the same weight as a M8 on the upper bound. Hence the maximum magnitude range for the Mid C-B seismic zone covers the M5.6 Oklahoma earthquake.

Although these two recent earthquakes do not impact the CEUS-SSC model, any significant future earthquakes would be assessed to determine their influence on the seismic source models as part of future reevaluations of the seismic hazard for nuclear power plants in the CEUS.

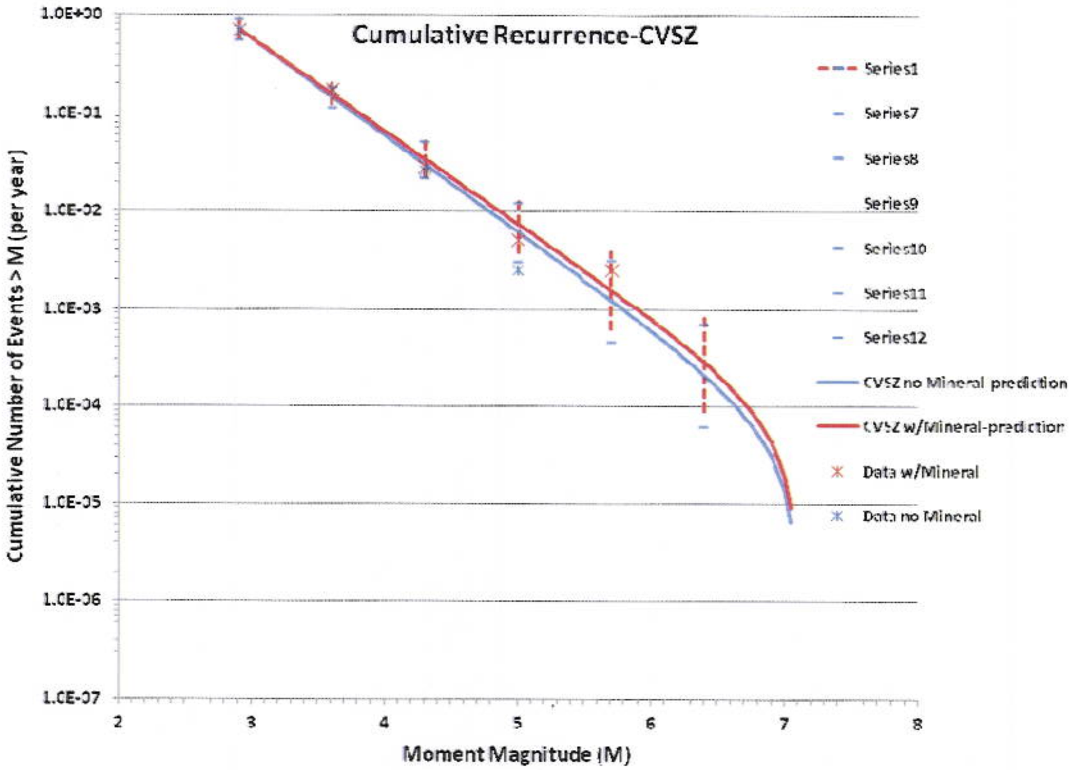

Figure 1. Comparison of recurrence statistics for the region of the central Virginia seismic zone (CVSZ) developed including the 8/23/11 Mineral, VA earthquake (red lines and symbols) and excluding the Mineral event (blue lines and symbols). The vertical lines and symbols represent 95% confidence bounds on the recurrence prediction.

Table 7.4.2-1
Maximum Magnitude Distributions for Seismotectonic Distributed Seismicity Sources

	Maximum Magnitude for:												
Weight	AHEX	ECC_AM	ECC_GC	GHEX	GMH	IBEB	MidC-A, MidC-B, MidC-C, and MidC-D	NAP	OKA	PEZ_N and PEZ_W	RR	RR_RCG	SLR
0.101	6.0	6.0	6.0	6.0	6.0	6.5	5.6	6.1	5.8	5.9	6.2	6.1	6.2
0.244	6.7	6.7	6.7	6.7	6.7	6.9	6.1	6.7	6.4	6.4	6.7	6.6	6.8
0.310	7.2	7.2	7.2	7.2	7.2	7.4	6.6	7.2	6.9	6.8	7.2	7.1	7.3
0.244	7.7	7.7	7.7	7.7	7.7	7.8	7.2	7.7	7.4	7.2	7.7	7.6	7.7
0.101	8.1	8.1	8.1	8.1	8.1	8.1	8.0	8.1	8.0	7.9	8.1	8.1	8.1

Table 7.4.2-1 (NUREG-2115). Maximum magnitude distributions for the CEUS-SSC seismotectonic source zones. The 2011 M5.8 Mineral, VA earthquake occurred within the

ECC_AM seismic source zone and the 2011 M5.6 Oklahoma earthquake occurred within the Mid-B source zone.

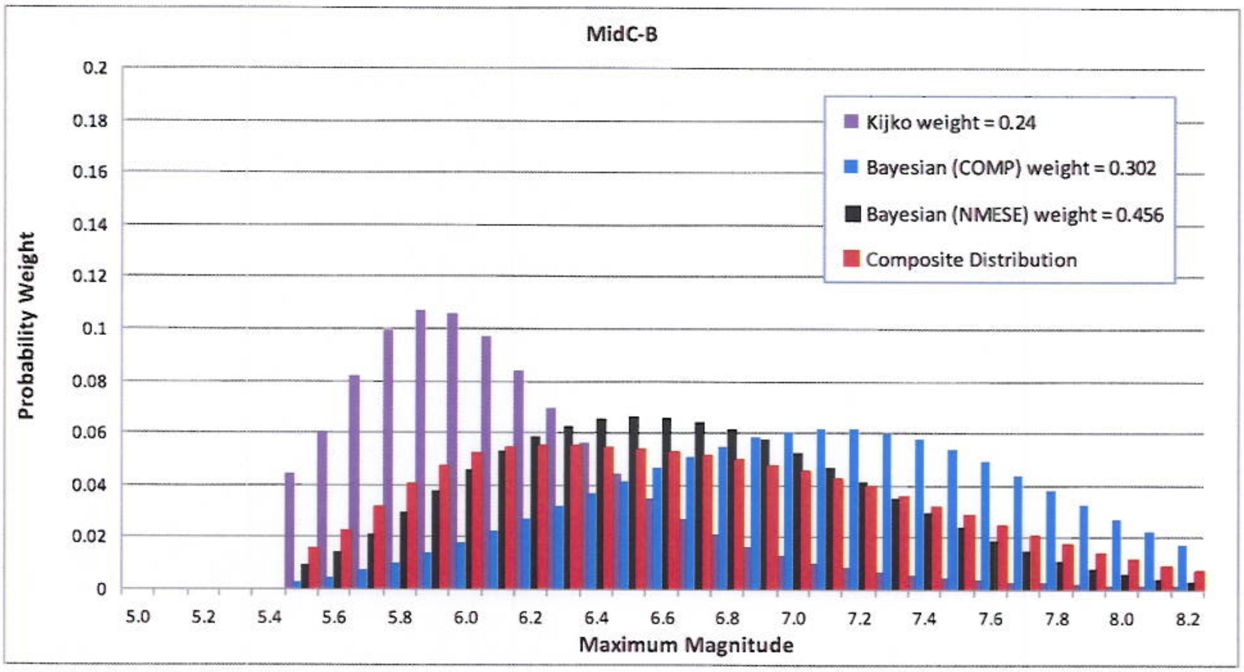

Figure 7.4.2-8
Mmax distributions for the MidC-B seismotectonic zone

Figure 7.4.2-8 (NUREG-2115). Maximum magnitude distribution for the CEUS-SSC MidC-B seismic source zone. The 2011 M5.6 Oklahoma earthquake occurred within the Mid-B source zone. M5.6 is at the lower end of the composite distribution.

Issue 2 – Constraint on Distances for Inclusion of Seismic Sources in PSHAs for CEUS

At very large distances, earthquake ground motions for even very large magnitude events are very low. Figure 2 shows the peak ground acceleration (PGA) versus distance for earthquake magnitudes ranging from 6 to 8. Accelerations for each of the magnitudes are very low (about 0.1g) beyond 200 km. The black dashed line at 0.1g in Figure 2 represents the minimum PGA for which all plants have to be designed even if the estimated PGA for the site is lower. Therefore, as shown in Figure 2, the minimum required PGA of 0.1g is significantly greater than the estimated peak accelerations from distant seismic sources beyond 400 km. Going beyond to a distance of 1000 km, the estimated peak accelerations even from M8 earthquakes approach zero. Even at the low probabilities used to determine the GMRS (10^{-4}/yr to 10^{-5}/yr) ground motions at such large distances are negligible.

Aside from the low ground motions from earthquakes at large distances, the ground motion models developed for the CEUS only extend out to 1,000 km. In addition, modelers only use data out to 600 km to develop the ground motion models. Therefore, going beyond 1,000 km to predict ground motions is an extrapolation not supported by data.

Regulatory Guide 1.208 states that new reactor applicants should investigate and characterize the seismic sources within a radius of 320 km (200 mi) of the site. In addition, RG 1.208 states that this radius may need to be expanded to include capable tectonic sources, relatively high seismicity, regions with complex geology, or regions that have experienced a large geologically recent earthquake identified in historical records or by paleoseismic data.

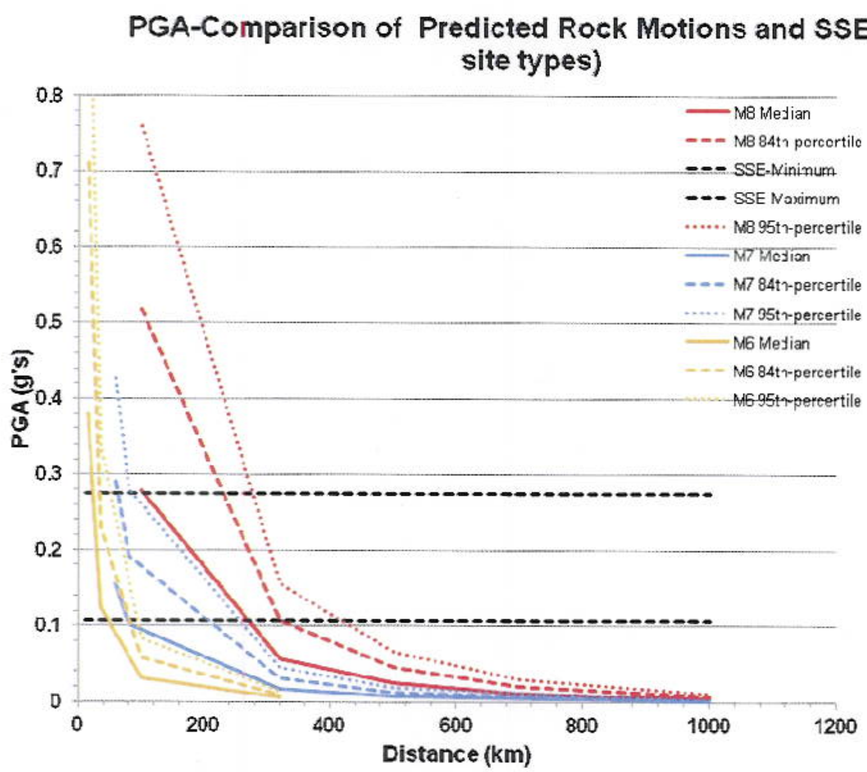

Figure 2. Illustration of predicted peak ground acceleration (PGA) versus distance for magnitude 6, 7, and 8 earthquakes. Results calculated using the 2004, 2006 EPRI ground motion prediction model for rock site conditions. The 50th (median), 84th and 95th percentile estimates are shown for each magnitude. The black dashed horizontal lines indicate the range of values for the SSE for the 96 NPPs operating in the CEUS.

The SPID guidance elaborates on the RG 1.208 recommendations by limiting the expansion of the radius out to which seismic sources should be included in the PSHA. Specifically the SPID states

In addition, for applications in a regional study, it is sufficient to include background sources within 320 km (200 miles) of a site, and specifically to include only parts of those background sources that lie within 320 km of the site. This follows the guidance in RG 1.208 regarding examination of sources within the site region defined as the surrounding 320 km. For RLME [Repeating Large Magnitude Earthquake] sources, it is sufficient to include New Madrid, Charlevoix, and the Charleston seismic zones if the lie within 1000 km of a site. Beyond 1000 km, ground motion equations have not been well-studied, and such distant earthquakes do not generally cause damage to modern engineered facilities. For other RLME sources and sub-regions of background sources with higher rates of activity, it is sufficient to include them in the analysis if they lie within 500 km of a site, based on test hazard results published in the CEUS Seismic Source Characterization project [NUREG-2115].

The purpose of these further qualifications in the SPID is to focus the seismic hazard reevaluations on potentially damaging ground motions by excluding non-damaging motions that are not of engineering or safety significance to nuclear power plants.

Although RG 1.208 does not constrain the distance out to which seismic sources should be included in the seismic hazard evaluation, the NTTF Seismic Team believes that the limitations recommended by the SPID guidance are very conservative and will result in a reasonable estimate of the seismic ground motions for each of the operating reactor sites.

Issue 3a – Absence of New Site Specific Geologic and Geotechnical Investigations

Although the NRC would welcome any field investigations performed by licensees, the 50.54(f) letter does not request that licensees perform new site-specific geologic field investigations or geophysical and geotechnical investigations to reconfirm or verify the previous site investigations performed during the original licensing process. The NTTF R2.1 Seismic Team has determined that consistent with the 50.54(f) letter this re-verification is not necessary.

The Final Safety Analysis Reports (FSARs) for the operating reactors provide a significant amount of geologic and geotechnical information from their original siting investigations. The requirements for geologic, seismic, and geotechnical engineering investigations have existed in Appendix A to 10 CFR 100 since its promulgation. Most of the current operating plants are licensed under the provisions of Appendix A. While the available investigation tools and methods have evolved, the fundamental requirements, such as identification and evaluation of local and regional tectonic structures and the investigation of local site geology have always existed. As such, a basic level of geological and seismological information exists for all operating plants. This information is sufficient for the reevaluation of the seismic hazards for these plant sites. Therefore, using the available site geology and geotechnical properties, a subsurface profile can be developed that is adequate for the purposes of the 50.54(f) seismic hazard reevaluations.

To exercise and evaluate the site response approach in the SPID, NRC staff performed a case study at an operating plant located next to an ESP site. The NTTF R2.1 Seismic Team developed a geologic profile for the operating site based on the information and data in the FSAR using the approach in the SPID. This result was then compared with the modern data acquired by the ESP applicant for the adjacent site. Figure 3 shows that this ESP profile reasonably matches and falls within the three base estimates of the profile developed using the FSAR data and the SPID approach. Figure 4 shows that the application of the site response approach described in the SPID using the geologic information from the operating plant FSAR closely matches the results from the co-located ESP, which is based on direct geophysical measurements of the subsurface. What is important to note in Figure 4 is the comparison between 1 to 10 Hz. Determination of whether a plant SSE has been exceeded and additional plant risk evaluations are needed or not is based on comparing the SSE and GMRS in this frequency range. This is the important frequency range for many of the nuclear power plant structures, systems, and components. This comparison further shows that in a probabilistic analysis, due to randomization and multiple analyses, seemingly large variations in profiles and properties are much less important in the aggregated results, such as the mean amplification factors shown in Figure 4.

Universally requiring new site geologic and geophysical investigations is unnecessary and is counter to the objective of improving the safety of the operating reactors in a timely way. Requiring licensees to perform new site-specific geologic and geophysical investigations to reconfirm their earlier investigations would push the schedule for the 50.54(f) seismic hazard reevaluation out a significant amount of time (on the order of years). Because licensees need the seismic hazard reevaluation results to determine if they need to perform a seismic risk evaluation or take any interim actions, requiring site investigations will unnecessarily delay our understanding of seismic risk at the plants. This in turn would also delay any actual plant upgrades.

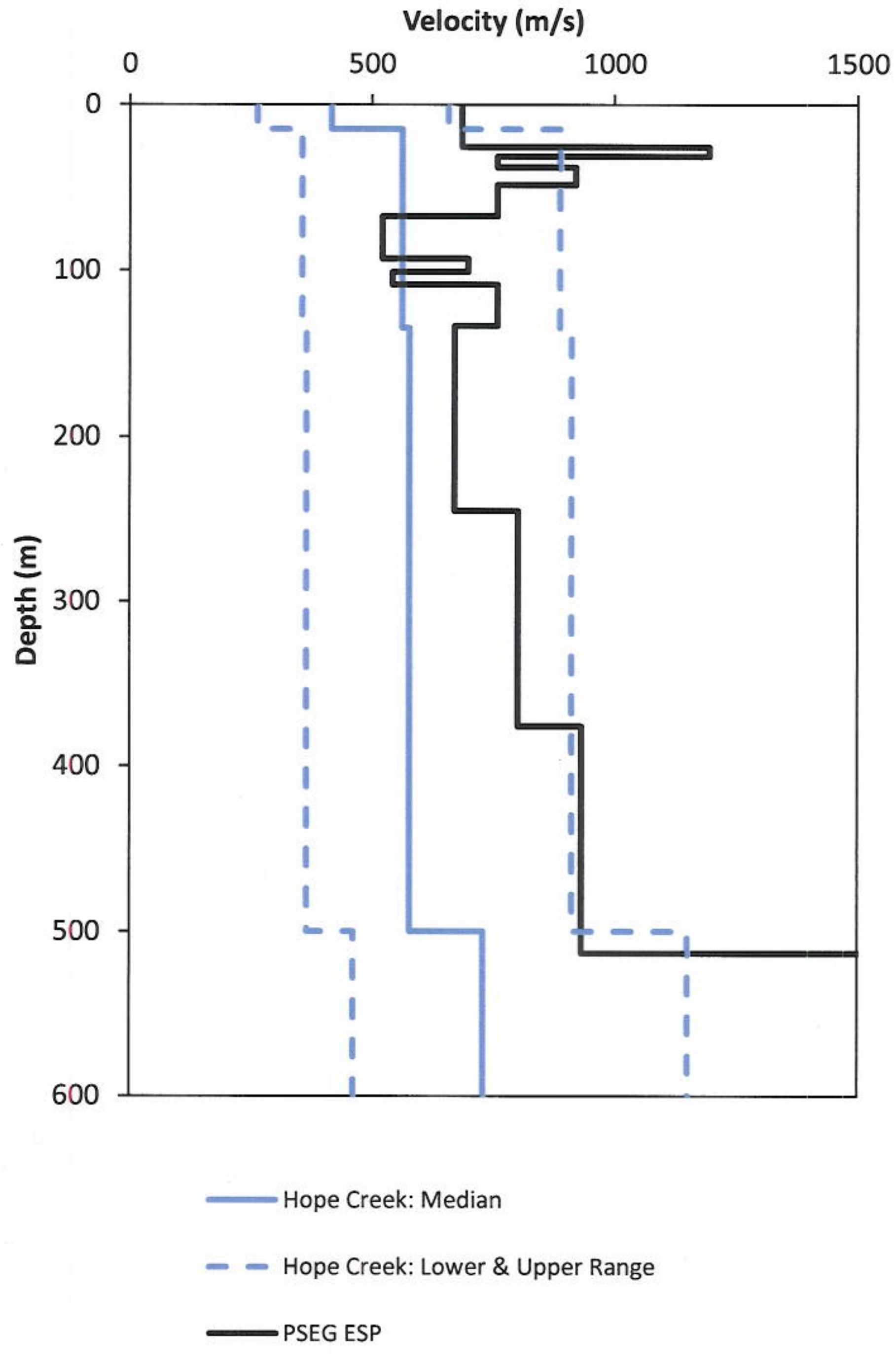

Figure 3. Comparison of shear-wave velocity profiles developed independently utilizing only the information in the Hope Creek FSAR (blue curves representing lower range, median, and upper range) with the single velocity profile used in the PSEG ESP site response analyses.

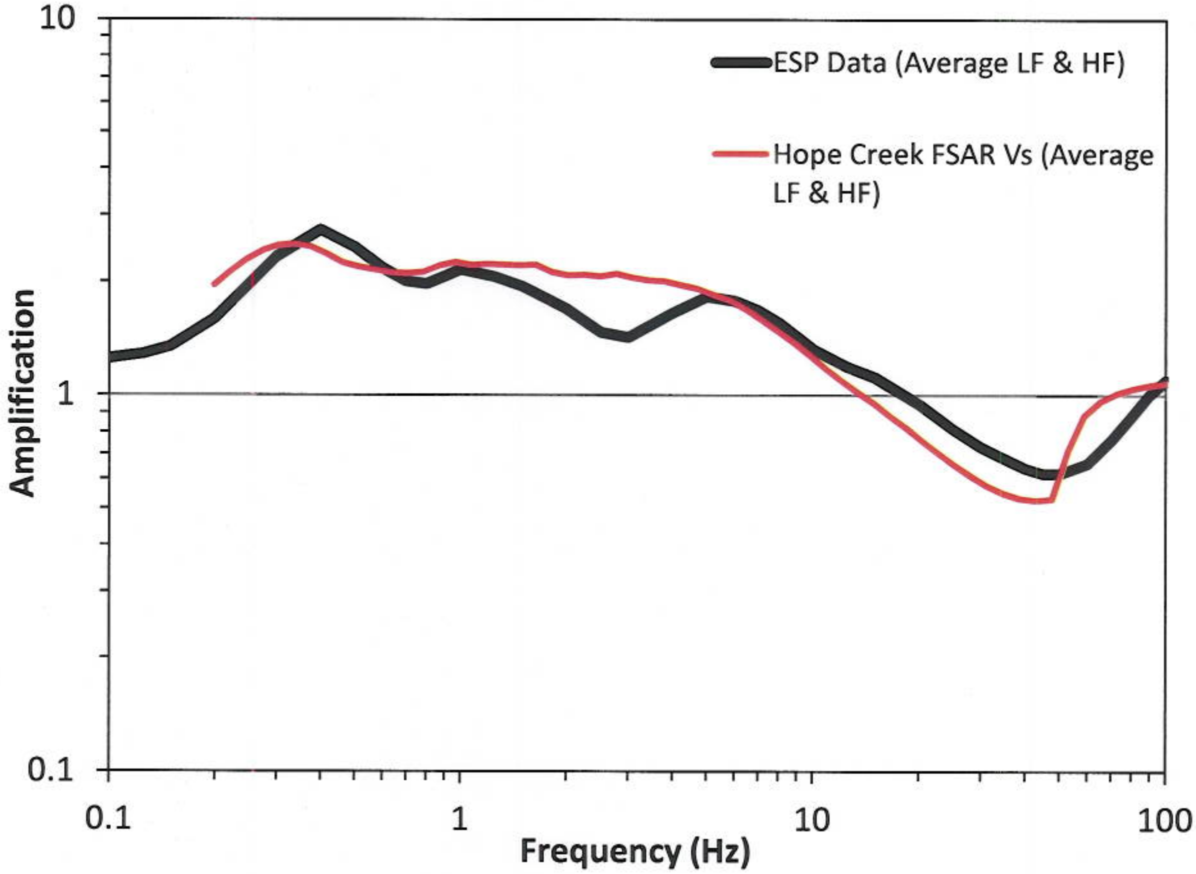

Figure 4. Comparison of amplification functions from ESP and co-located operating plant. The amplification function for the operating plant was developed using the geologic information from the FSAR and the site response method developed in the SPID. The ESP amplification function was developed from direct geophysical measurements of the subsurface.

Issue 3b – <u>Site Response Approach in SPID is Invalid</u>

The framework for developing site amplification estimates at operating reactor sites outlined in the SPID is conceptually the same as is currently being followed in the COL/ESPs. The major difference is in the greater specificity in the SPID approach that attempts to explicitly capture uncertainty in certain parameters. The process to determine site amplification functions (the output of the site response analyses) outlined in the SPID attempts to compensate for the absence of, or limitations in, certain types of data at some sites by developing broader ranges of uncertainty in the site characterization parameters. The full distribution of uncertainty in the site amplifications is then propagated through the calculations to determine the site-specific soil hazard estimates. Using this approach, the staff concludes that the major site response behavior will be captured.

Shear wave velocity templates, which are based on previous field measurements of sites in different geologic settings, are used as a starting point to approximate the site subsurface velocities. However, these initial templates are then modified to account for the site specific geological information. A similar approach is used for new reactor siting to extend the shear wave velocities for depths beyond which measurements have been made. In addition, the parameter V_{s30}, the shear wave velocity in the uppermost 30 m, is not used directly in assigning velocities for the site response analysis. It is only used to identify the different shear wave velocity templates.

Site Response Background. The ground shaking at the surface observed during an earthquake is dependent on the source characteristics of the earthquake, the travel path from source to the site, and the local soil conditions. The effect of the local site conditions can be very significant, with the site response changing the amplitude, frequency content, and duration of the shaking. This response of soils and soft rocks to earthquake shaking is determined by two major factors. The first is the geologic structure itself (the material type, thickness and stiffness of each stratum). The second is the potential non-linear behavior of the materials when subjected to strong ground shaking.

As seismic waves travel upward through the geologic profile towards the surface, if the materials become less stiff the amplitudes of the waves may increase. This elastic amplification effect can be tempered or offset by the non-linear damping that occurs in geologic materials as the amplitude of the waves (and hence strain) increases. The properties of the site that need to be characterized to enable site response analyses to be performed are the following:

(1) Variation of shear-wave velocity with depth (including thickness of layers)
(2) Types of materials in each layer
(3) Non-linear properties of each layer
(4) Depth to very hard bedrock.

Each of these factors is discussed briefly below and the approach proposed in the SPID for each is summarized. A short discussion of the impact of uncertainty in site amplification on derived hazard results is then presented.

Variation of Shear-Wave Velocity with Depth. The stiffness of the materials in the subsurface is characterized by the seismic shear-wave velocity. Ideally, the shear-wave profiles at a given site are measured directly. However, for many locations (even well-characterized sites) the velocity measurements do not extend to sufficient depths to allow the unambiguous definition of deep velocity structure and some inferences based on regional data will be required. The use of inferred values has been previously utilized (and accepted by NRC staff) in some of the COL and ESP submittals.

The figure below illustrates the level of uncertainty that often arises in the characterization of a particular site. It shows the measured shear-wave velocity profiles measured at a DOE site. These data were acquired recently using modern techniques. Based on the number of detailed investigations performed, this would be described as a "well-characterized" site. It is clear that the predicted velocity profiles are subject to considerable uncertainty associated with the method used to measure in-situ shear-wave velocity. This uncertainty will vary with the characteristics of the site and the type of measurement technique being used. It is not accurate or appropriate to infer that even well-characterized sites have no uncertainty associated with the site profiles. This uncertainty in the estimates of shear-wave velocity results in uncertainty in the site response.

The variation of physical properties with depth is usually represented as a sequence of horizontal layers. The definition of the thickness of "layers" is based on an integration of velocity measurements with geologic and geotechnical data.

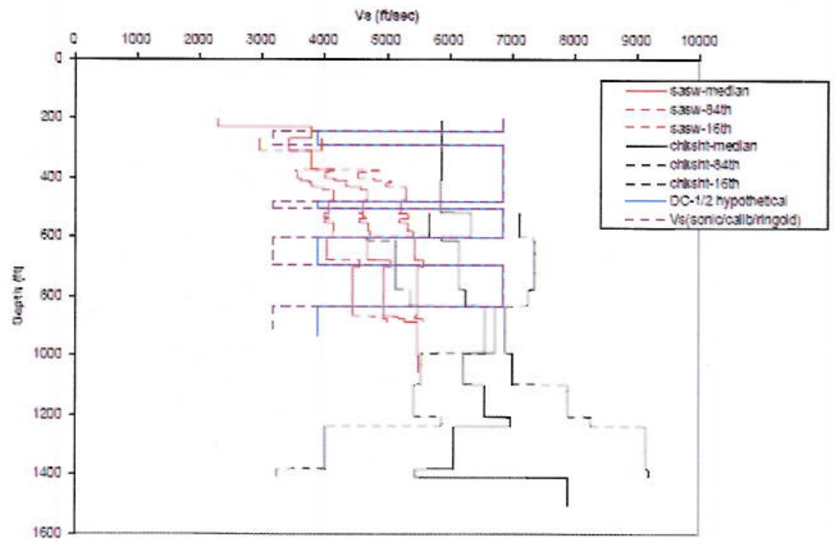

Figure 2.5.10. Combined Plot of Fractile S-Wave Models for SASW and Checkshot Surveys the Saddle Mountains Basalt. Also shown is the DC-1 inferred model for two hypothetical values of Vp/Vs.

The approach outlined in the SPID attempts to develop estimates of the potential uncertainties in characterizing the shear-wave velocities at a given site that is based on the amount and quality of information available at that site. Those sites with less data must incorporate enhanced levels of uncertainty through the use of multiple base-case velocity profiles. The impact of this uncertainty is then propagated through the analysis process and directly incorporated into the estimate of site-specific hazards. The use of multiple base-case models to represent uncertainty in portions of the velocity profile has been used in ESP/COL submittals and accepted by NRC staff. The approach outlined in the SPID will integrate the extensive existing geologic investigations that have been performed at all operating reactor sites to characterize the near-surface geologic and geotechnical properties. This information is utilized in conjunction with available velocity information to develop both profiles and constrain depth to hard rock. The NTTF Seismic Team concludes this process will result in profiles that will produce soil hazard estimates that are reasonable and appropriate to determine if additional regulatory actions (including additional site investigations) are necessary.

Defining Material Types. It is also necessary to define the material types within each layer. This would be the type of sedimentary material such as clay, sands and silts, or glacial till.

The information acquired in the initial licensing of the operating reactors consisted of detailed site investigations and characterization consistent with the standards for nuclear facilities at the time. The NTTF Seismic Team believes this extensive, existing geological characterization is appropriate for performing this evaluation and is proposed in the SPID.

Non-linear Properties. To represent the behavior of the near-surface materials with increasing input ground motion amplitude it is necessary to characterize the non-linear dynamic properties of these strata. These properties are generally represented by using standardized curves. For well-characterized sites (such as the COL and ESPs) laboratory measurements are conducted to develop estimates of dynamic material properties; however these data are used only to verify the use of standardized curves.

The SPID suggests the use of multiple standardized curves for responding to the 50.54f letter to capture the uncertainty in this characterization. The use of a single set of non-linear dynamic property curves is currently accepted for ESP and COL submittals. The NTTF Seismic Team believes that utilizing multiple sets of curves as proposed in the SPID will appropriately capture the uncertainty in characterizing non-linear material behavior.

Depth to Bedrock. The depth to a very hard rock interface can be estimated from direct velocity measurements if those measurements extend to sufficient depths or from geological information. This assessment can be made with relatively high confidence based on either shear-wave or compressional wave data if it exists. Geological and geotechnical data are also important for this assessment for some sites.

While the estimation of depth to very hard rock can be made using a variety of geophysical and geological data, the approach outlined in the SPID recognizes this depth parameter as a very important source of uncertainty in the site response calculations. It is specifically identified as an aspect of the assessment that must be treated with care and appropriate levels of uncertainty incorporated in the final model. It is the judgment of the NTTF Seismic Team that the importance of this assessment is appropriately treated in the SPID.

Incorporation of Uncertainty in Hazard Results

The approach currently utilized in the development of the GMRS for COL/ESPs utilizes a mean estimate of the site-specific amplification function for those sites not located on hard rock. The approach described in the SPID explicitly incorporates the full uncertainty distribution in the calculation of the soil hazard. This approach is conservative relative to the approach utilized in the COL/ESPs. An example of this effect is shown in the Figures 5 and 6 below.

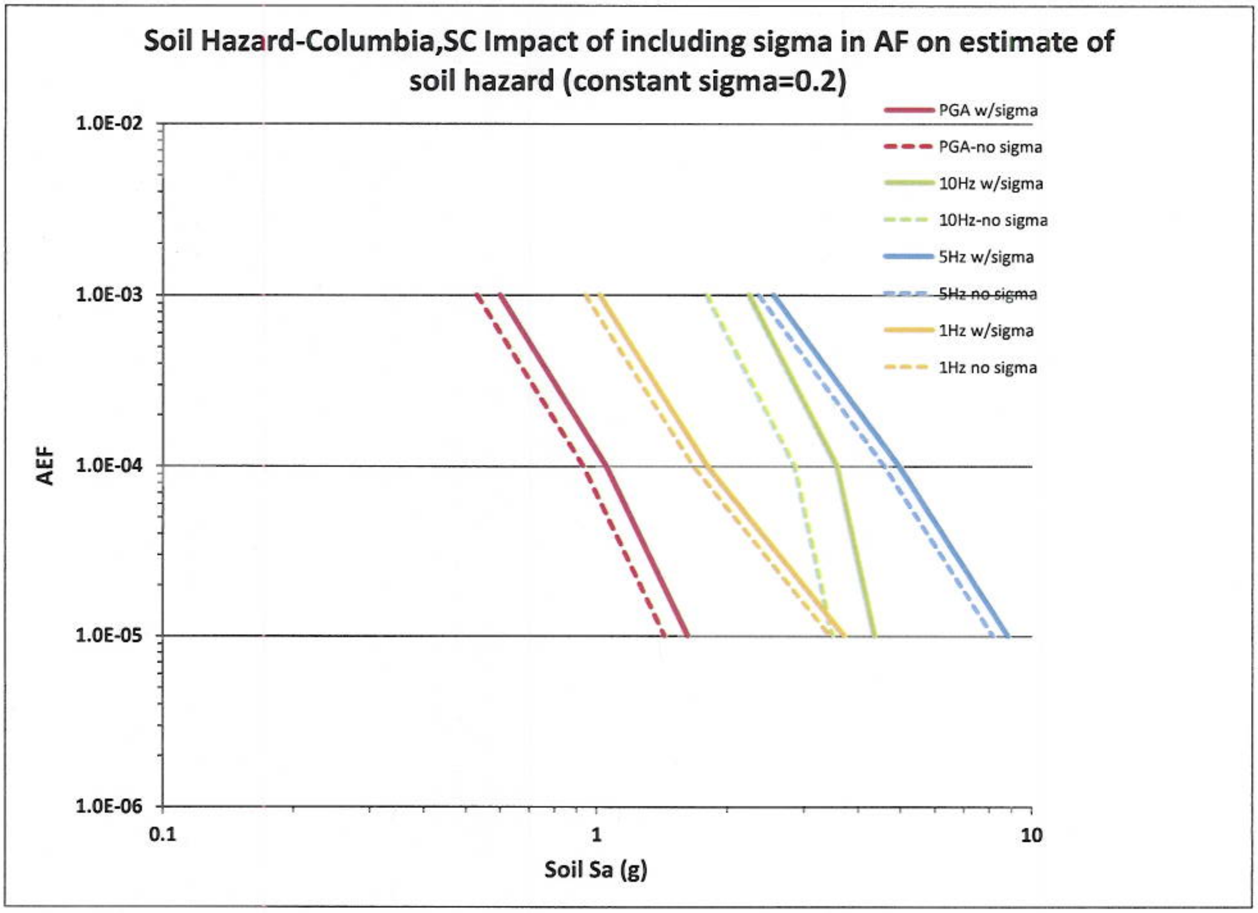

Figure 5. Comparison of soil hazard curves derived incorporating the full distribution of uncertainty in the amplification functions (solid curves labeled "with sigma") to the approach that only utilizes mean amplification function (dashed curves). For all cases incorporating the full distribution approach produces higher ground motions for a specified annual exceedance frequency (AEF).

The NRC NTTF Seismic staff concludes that the approach outlined in the SPID realistically evaluates the impact of uncertainty in site and material properties on estimates of the site-specific seismic hazard. Increased uncertainty in the site amplification function results in conservative estimates of the seismic hazards relative to approaches that do not explicitly incorporate this uncertainty. The effect of increased uncertainty in the site amplification functions on the computed soil hazard is illustrated in the figure below. Using this approach, the NTTF R2.1 Seismic Team believes that a reasonable estimate of the site-specific hazard for most sites can be determined. The estimate of the GMRS derived from the site-specific seismic hazard is used to determine if further risk evaluations of the nuclear power plant in the form of a seismic PRA or seismic margins analysis is warranted.

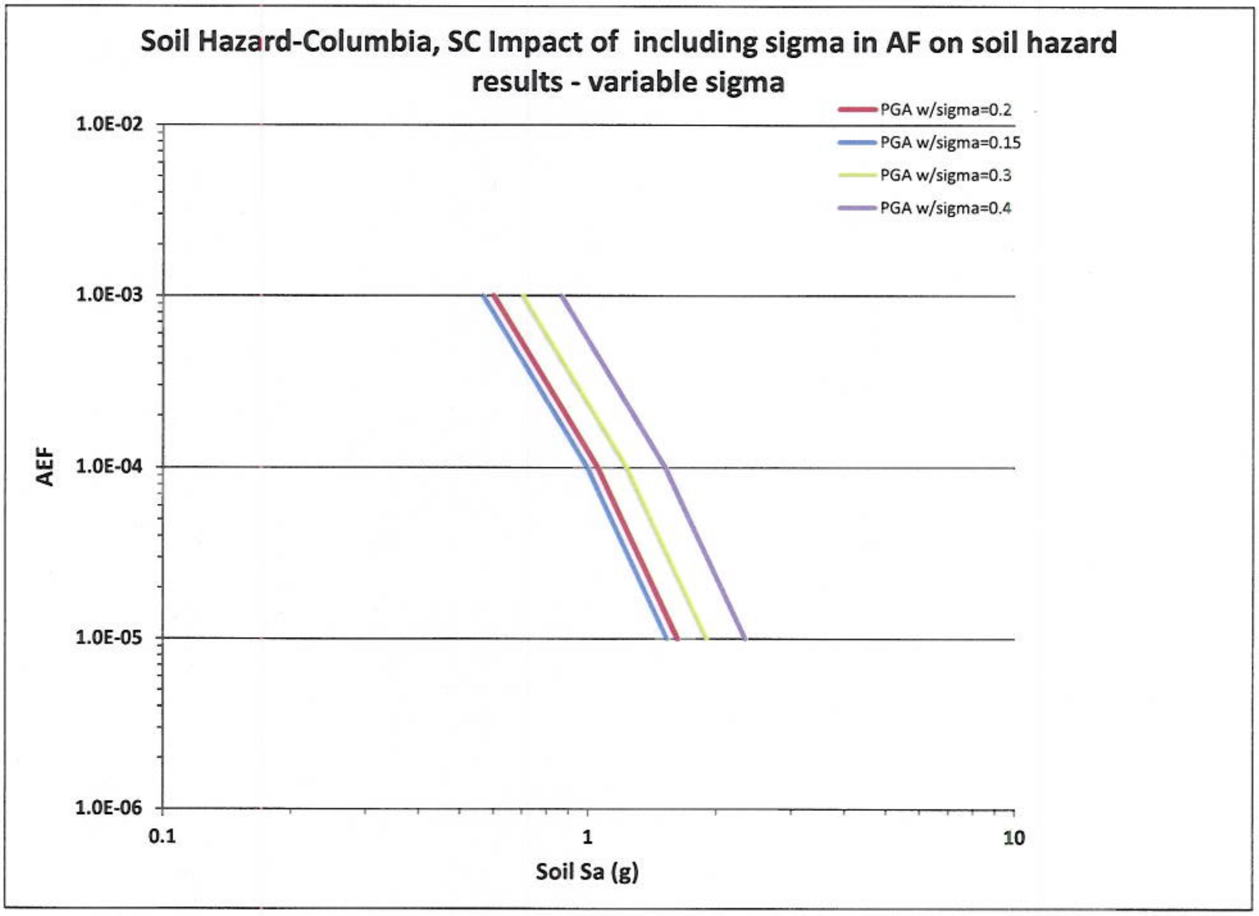

Figure 6. Example of the effect of increased uncertainty in amplification function (sigma) on computed soil hazard curves. Well characterized sites with low uncertainty typically have sigma values near 0.2 (natural log units). Preliminary estimates for sites evaluated using the methodology in the SPID suggest sigma values > 0.4.

In summary, within the NRC regulatory framework the objective of the process to estimate site-specific ground motions is to develop seismic loads that can be used in the design process or an evaluation process to provide reasonable assurance of plant safety for operating reactors. Given what the engineering seismology community recognizes about the between-earthquake variability in site response at a single station and the inherent ambiguity in characterizing sub-surface properties, to claim that we can produce the "right" answer is neither realistic nor consistent with the NRC's regulatory objective. The goal is to produce ground motion estimates that capture the currently recognized uncertainty in the various parameters in the predictive models and can be used with reasonable assurance for a specific regulatory purpose.

NRC FORM 757
NRC MD 10.158
(7-2011)

U.S. NUCLEAR REGULATORY COMMISSION

NON-CONCURRENCE PROCESS

NCP TRACKING NUMBER

TITLE OF SUBJECT DOCUMENT
Endorsement of Electric Power Research Institute Draft Report 10252

ADAMS ACCESSION NO.

SECTION C - TO BE COMPLETED BY DOCUMENT SPONSOR

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ORGANIZATION
Division of Site Safety and Environmental Analysis

SUMMARY OF ISSUES
See attached

ACTIONS TAKEN TO ADDRESS NON-CONCURRENCE
See attached

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DATE 2/5/2012

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DATE 2/7/2013

NCP OUTCOME

Non--Concurring Individual: ☐ CONCURS ☑ NON-CONCURS ☐ WITHDRAWS NON-CONCURRENCE (i.e., discontinues process)

AVAILABILTY OF NCP FORM

Non--Concurring Individual: ☑ WANTS NCP FORM PUBLIC ☐ WANTS NCP FORM NON-PUBLIC

☐ CONTINUED IN SECTION D

SEE SECTION E FOR IMPLEMENTATION GUIDANCE

Non-Concurrence Form 757 Section C
(Input from Sponsor to the Signatory or Attachment to Section C)

INTRODUCTION

As the document sponsor, I have prepared the following response for your consideration as signatory of the endorsement letter and Section C of Form 757. This response attempts to address the issues raised in sufficient detail to explain the basis for my recommendations on how to proceed. To obtain a full understanding of the issues raised and the positions of the staff members involved, see Sections A and B (including attachments). If you desire additional information or would like to discuss this issue further, please contact me.

BACKGROUND

On December 4, 2012, Dr. Dogan Seber submitted a non-concurrence related to the U.S. Nuclear Regulatory Commission's (NRC's) endorsement of the industry's Screening, Prioritization, and Implementation Details (SPID) document. The purpose of the SPID document is to provide guidance on the preparation of plant seismic evaluations for response to the NRC's request for information regarding the Near-Term Task Force (NTTF) recommendation 2.1. The SPID document provides guidance on several topics necessary to fully respond to the NRC's request for information, including the seismic hazard development and the seismic risk evaluation. Dr. Seber's concerns are associated with the seismic hazard development. The details of his concerns are described in Section A, and the highlights are presented in the summary of issues section below.

On January 11, 2013, Dr. Nilesh Chokshi submitted the supervisor response to the non-concurrence (Section B of Form 757). His response also included supplemental information prepared by Drs. Cliff Munson and Jon Ake. Drs. Munson and Ake led the NRC's technical interactions with industry during the preparation of the SPID document. Their response addresses each of the concerns raised by Dr. Seber and explains why Drs. Chokshi, Munson, and Ake concluded that the SPID document was acceptable to endorse. After reviewing the non-concurrence, Dr. Chokshi maintains the position that the SPID document should be endorsed, but he proposes one modification to the endorsement letter.

To complete the evaluation of this non-concurrence, I evaluated the information submitted by Drs. Seber and Chokshi. Additionally, I reviewed the SPID and a number of other documents, such as regulatory guides, NUREGS, industry documents, and the final safety analysis report (FSAR) for several nuclear power plants located in the central and eastern United States (CEUS) (issues raised by Dr. Seber do not relate to the Western US sites). A complete list of documents reviewed is attached. Additionally, I met individually and collectively with Drs. Seber, Chokshi, Munson, and Ake. I also met with the other agency seismologists and geotechnical engineers not directly associated with the development or review of the SPID document. The discussion with the other seismologist focused on current review practices, clarification of scientific facts, and accepted practices in the seismology community.

After consideration of all the information referenced above, I recommend endorsement of the SPID. However, I propose additional revisions to the endorsement letter to assure that the letter explicitly states certain NRC positions and expectations. The basis for this conclusion and a discussion of the proposed changes to the endorsement letter are discussed in the evaluation section below.

SUMMARY OF ISSUES

Issue 1

The SPID guidance does not fully implement the guidance for use of the recently developed CEUS seismic source model for use in reevaluating the hazard at operating nuclear power plant sites in the CEUS. The use of the CEUS Seismic Source Characterization (CEUS-SSC) models is described in NUREG-2115, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities."

- The SPID states that site-specific adjustments to seismic sources are not necessary. However, NUREG-2115 states that the CEUS-SSC is a regional model, and it further states that local geology should be reviewed to determine if site-specific refinements to the regional model are necessary. This would include consideration of local geologic structures or local seismic sources. If local earthquake rates and seismic zone configurations are not assessed, then the overall hazard calculation may be underestimated.

- The SPID states that updates to seismic sources to account for historical seismicity since 2008 (the last year of the earthquake catalog in the CEUS-SSC study) are not required. However, regulatory guide (RG) 1.208, "A Performance-Based Approach To Define the Site-Specific Earthquake Ground Motion," states that the Probabilistic Seismic Hazard Analysis (PSHA) is to be conducted with up-to-date interpretations of earthquake sources, earthquake recurrence, and strong ground-motion estimation. The 2011 magnitude (M) 5.8 Mineral Virginia and M 5.6 Oklahoma earthquakes are examples of earthquakes whose impact on the CEUS-SSC models should be assessed.

Issue 2

The SPID guidance incorrectly constrains the distances out to which seismic sources are to be evaluated for the PSHA. The SPID states that it is sufficient to include diffuse areas of seismicity or "background" seismic sources within 320 kilometers (km) of the site. In situations where the entire background source is not within 320 km of the site, it states to only include those parts that lie within 320 km of the site. In addition, the SPID states that it is sufficient to include the largest repeating fault sources (specifically New Madrid, Charlevoix, and Charleston) only if they lie within 1,000 km of the site. The SPID specifies that other seismic sources with higher rates of activity or larger magnitudes (repeating large magnitude earthquakes (RLMEs)) be included only if they lie within 500 km of the site.

These constraints imposed by the SPID guidance are contrary to RG 1.208, which does not place any constraints on the distance from the site for which seismic sources should be evaluated. In addition, these constraints in the SPID guidance are inconsistent with the current practice for new reactor siting reviews, which calls for the inclusion of all seismic sources that contribute 1 percent or more to the total hazard in the PSHA.

Issue 3

The SPID does not require that geologic field investigations or geophysical measurements be performed at the operating reactor sites to develop reliable estimates of the local site subsurface shear wave velocity profile and material properties. The geologic data in the FSARs are decades old, generally sparse, and of limited use in determining the local site response.

Because new geologic and geophysical data are not being collected at each of the operating reactor sites, the geology of the subsurface and, in particular, the soil and rock properties cannot be established in sufficient detail to perform a correct site response evaluation. Extensive measurements at each of the operating reactor sites should be required to arrive at estimates of the soil and rock properties.

The SPID attempts to overcome the deficiencies, described above, by using unconventional methodologies that are overly simplistic and may not characterize the nature of the soil and rock subsurface geology. The site response methodology, described in the SPID, attempts to cover a wide range of uncertainty to compensate for the lack of subsurface data at the sites. However, if the subsurface soil and rock properties are unknown, simply increasing the uncertainty for the site response methodology will not result in the correct site amplification function. In addition, the site response methodology makes use of a proxy measure for the soil or rock shear wave velocity in the uppermost 30 meters below the surface (V_{s30} is the average shear-velocity down to 30 meters) to determine an appropriate shear wave velocity template to use for the site response evaluation. The use of V_{s30} is not part of current practices for new reactor siting reviews. In addition, the site response method in the SPID uses shear wave velocity templates based on V_{s30} value and geologic information in the FSARs rather than actual direct measurements of the shear wave velocity beneath the site. The use of these shear wave velocity templates is not scientifically valid because the templates do not match the actual shear wave velocities of the rock and soil beneath the site.

EVALUATION

This evaluation responds to the issues raised in sufficient detail to explain the basis for the recommendations proposed. To obtain a full understanding of the issues raised and the positions of Dr. Seber, as well as Drs. Chokshi, Munson, and Ake, see Sections A and B (including attachments).

Issue 1

Dr. Seber takes the position that the SPID does not properly use the CEUS-SSC model because it does not require licensees to update their seismic sources. Specifically, he notes that NUREG-2115 states that the CEUS-SSC model is a regional study and needs to be updated with local geologic structures and seismic sources, including recurrence rates and seismic zone configurations. Dr. Seber also points out that RG 1.208 also requires earthquake sources, recurrence rates, and strong ground motion estimations be updated to ensure the PSHA is conducted with up-to-date interpretations of these important parameters.

Drs. Chokshi, Munson, and Ake take the view that updates to the CEUS-SSC model are not necessary for the purposes of conducting the NTTF recommendation 2.1 seismic reevaluations. They provide an extensive discussion to support their position. Specifically, they point out that the model was just published, uses current data, and has the capability to accurately develop a site-specific source model. They also suggest that information previously collected regarding seismic activity in the vicinity of each site is sufficient to inform the site-specific source models and obviates the need for new site geologic investigations.

In examining the issue raised by Dr. Seber, it is necessary to review RG 1.208 to understand staff guidance on updating seismic source models. It is without question that RG 1.208 expects a PSHA to be conducted using up-to-date information. Section B of RG 1.208 states the following:

> The PSHA is conducted with up-to-date interpretations of earthquake sources, earthquake recurrence, and strong motion estimation. ... The hazard curves are developed in part by identifying and characterizing each seismic source in terms of maximum magnitude, magnitude recurrence relationship, and source geometry.

R.G 1.208 also provides guidance on why and how seismic source information should be updated. RG 1.208 states that:

> In the CEUS, it is most likely that the determination of the properties of the seismogenic source, whether it is a tectonic structure or a broad areal source zone, will be inferred rather than demonstrated by strong correlations with seismicity or geologic data. Moreover, it is not generally known what relationships exist between observed tectonic structures in a seismic source within the CEUS and the current earthquake activity that may be associated with that source. The historical seismicity record, the results of regional and site studies, and expert judgment play key roles in characterizing a source zone.
>
> ...The primary objective of geological, seismological, and geophysical investigations[1] is to develop an up-to-date, site-specific earth science database that supports site characterization and a site-specific PSHA. The results of these investigations will also be used to assess whether new data and their interpretation are consistent with the most recent information used in probabilistic seismic hazard studies accepted by NRC staff. If new data, such as new seismic sources and new ground motion attenuation relationships, are consistent with the existing earth science database, updating or modification of the information used in the site-specific hazard analysis is not required. It will be necessary to update seismic sources and ground motion attenuation relationships for sites where there is significant new information provided by the site investigation.

Drs. Chokshi, Munson, and Ake do not dispute that RG 1.208 requires a PSHA to use up-to-date information. In their view, use of the CEUS-SSC model provides sufficient, up-to-date regional and site-specific information to complete seismic reevaluations required by NTTF recommendation 2.1. In his non-concurrence writeup and subsequent discussions, Dr. Seber acknowledges that the CEUS-SSC model is a relatively recent model and could possibly be sufficient for certain sites. However, he holds the view that licensees should be required to check relevant information to determine if the characterization of the seismic source (e.g., earthquake recurrence rates, source geometries) needs to be updated. In my view, the issue in question is whether the CEUS-SSC model provides sufficiently up-to-date source characterizations to conduct a site-specific PSHA without updating site-specific information.

I see three aspects to this issue that need to be considered:

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[1] It should be noted that the term investigation includes non-field work such as literature reviews.

(1) Does the CEUS-SSC model provide sufficient information to develop a site-specific source model?

(2) What is the likelihood that additional site investigations would identify new seismic sources or new interpretations of the seismic geometries in the vicinity of a site that could meaningfully affect the PSHA?

(3) What is the likelihood that additional investigations would identify an earthquake event or any other new information of significance such that the recurrence rate and other source characteristics used in the CEUS-SSC model would need to be updated?

As discussed by Drs. Chokshi, Munson, and Ake, the CEUS-SSC model is a refined model that could be used to effectively characterize seismic sources for a site-specific model. The model calculates the earthquake recurrence rates and local seismicity of quarter degree longitude and latitude cells. We would expect that this approach would allow for most sites to use the CEUS-SSC model without modification. Additionally, from discussions with the Division of Site Safety and Environmental Analysis staff, at least one combined license (COL) applicant has used the new CEUS-SSC model, and although the applicant was required to check, it did not have to update the seismic sources.

In an effort to assess the likelihood that additional site investigation would result in identifying a new seismic source in the vicinity of the site, I reviewed the report referenced in the writeup submitted by Drs. Chokshi, Munson, and Ake—entitled "Selected Case Histories of the Application of the Nuclear Regulatory Commission's Geologic and Seismic Siting Criteria"—and the FSAR Geology and Seismology section of 20 sites located in the Central and Eastern United States. The majority of FSARs indicate that extensive regional and site geologic investigations were conducted for currently operating reactors, such that it is reasonable to conclude that the understanding of seismic sources in the vicinity of operating reactor sites is well known. Additionally, the database that was used to develop the CEUS-SSC model was extensive and, as discussed above, the model is fairly refined. As a result, it is likely that the CEUS-SSC study considered significant sources near operating reactor sites. Therefore, in my view, it is unlikely that additional site investigations will identify any new significant seismic sources in the vicinity of an operating reactor site.

A key reason to update a seismic characterization database is to assure the appropriate earthquake recurrence rate is identified for a given site. Dr. Seber points out in his non-concurrence that significant earthquakes have occurred in the central and eastern United States since 2008, when the CEUS-SSC database was developed. If a licensee fails to consider these earthquakes, the recurrence rates could be underestimated. Drs. Munson and Ake pointed out that the earthquake in Mineral, VA, was considered before the issuance of the CEUS-SSC study. It was concluded that the earthquake had no impact on the model and that the model accounts for such an earthquake. Drs. Munson and Ake also discussed the Oklahoma earthquake and concluded that it would not affect the seismic source characterization, including recurrence rates. Although Drs. Chokshi, Munson, and Ake concluded that the earthquakes referenced by Dr. Seber do not affect the CEUS-SSC, they do agree that licensees should consider any large earthquakes that may occur or new significant information that emerges during the reevaluation to determine if the source model needs to be updated. They maintain the view that this position is understood by licensees, even though it is not explicitly stated in the SPID.

Considering the information submitted by Drs. Seber, Chokshi, Munson, and Ake, as well as the additional information considered, I conclude that it is reasonable that the SPID guidance does not require licensees to update the CEUS-SSC model for the purposes of the NTTF recommendation 2.1 seismic reevaluations. The principal reason for this conclusion is that the CEUS-SSC model reflects the most up-to-date characterization of the central and eastern United States, and it is a refined model that allows for appropriate characterizations of site-specific sources. Further, the earthquake activity in the CEUS is generally low so that it is reasonable to expect the recurrence rates in the model to remain valid for a while. This is not inconsistent with RG 1.208, which requires updating the source characterization model when data from regional and site investigations are inconsistent with previously accepted NRC interpretations. This is most likely to occur when significant time has passed since the model or study being considered was prepared or a new site that has not previously been investigated is considered. I do agree that a significant earthquake could produce data that are inconsistent with previous interpretations or significant new information could emerge that revise interpretations. In these cases, the new information should be considered to determine its impact on the PSHA.

It should be noted that language in Section 2.2 of the SPID could be read to provide an entirely different basis than that provided by Drs. Chokshi, Munson, and Ake as to why the CEUS-SSC model does not need to be updated for the 2.1 reevaluations. Specifically, it states:

> For site-specific licensing applications or site-specific safety decisions, these seismic sources would be reviewed on a site-specific basis to determine if they need to be updated. Such evaluations would be appropriate in a licensing application, where focus could be made on site-specific applications. However, for a screening-level study of multiple plants for the purpose of setting priorities, the use of these seismic sources as published is appropriate.

The plain reading of the above text is inconsistent with the NTTF recommendation 2.1 seismic reevaluation. A key aspect of the reevaluation is to develop a site-specific ground motion response spectrum (GMRS). The GMRS is then compared to the plants' existing design basis safe shutdown earthquake to determine which plants need to complete a seismic risk analysis. The term screen is only appropriate in the context of screening in or out of the risk analysis. The GMRS computed is expected to be a reasonably accurate site-specific estimate. In subsequent discussions with Dr. Chokshi, he noted that staff emphasized that the GMRS is to be an appropriate site-specific GMRS. Industry indicated that the guidance in the SPID is likely to result in a conservative GMRS for some sites, given the approaches proposed to account for the uncertainty in the site response. As a result, industry suggested that some opportunity be given to later refine the GMRS. The staff indicated that any refinements, including any necessary investigations, should be conducted before submittal of the hazard reevaluation.

I recommend that the endorsement letter be revised to clarify that the CEUS-SSC model does not need to be updated because it is considered sufficiently update and not because recommendation 2.1 is a screening-level study of multiple plants for the purpose of setting priorities. The letter should explicitly state the staff's expectation that any significant earthquakes that occur or new information that emerges during the reevaluations be considered to determine if the seismic source characterization models need to be updated. I also recommend that the endorsement letter explain that responses should be based on a site-specific GMRS calculated using appropriate site-specific source characterization models.

Issue 2

Dr. Seber is of the view that the SPID document incorrectly constrains the distance out to which seismic sources should be considered in the PSHA. He contends that such constraints are inconsistent with RG 1.208.

Drs. Chokshi, Munson, and Ake take the position that the SPID document limits consideration of distant seismic sources in an effort to focus the seismic reevaluations on potentially damaging ground motions. They note that the ground motion models are based on data that extend out about 600 km and consideration of earthquakes greater than 1,000 km are unsupported by data. They also demonstrate that the peak ground acceleration for earthquakes beyond 1,000 km, even large magnitude earthquakes, approaches small values for the probability of exceedence levels (1in 10,000/yr [10-4/yr]) of interest. In a subsequent discussion, Dr. Munson pointed out that small earthquakes close to sites are also excluded from the PSHA because they do not produce damaging ground motions.
First, I assessed whether the SPID was inconsistent with staff guidance in RG 1.208. In my view, it is not. RG 1.208 states that applicants should consider sources out to 320 km from the site. While it does not limit the distance beyond 320 km, it does state that in the CEUS it may be necessary to extend the investigations out tens or hundreds of km. Certainly consideration of sources out to 1,000 km would not be inconsistent with extending the investigation tens or hundreds of km.

In subsequent discussions with Drs. Seber and Munson, Dr. Seber explained that, for some sites with low seismicity, the most significant contributor to the GMRS could be from distant earthquakes. He also notes that for several COL reviews all seismic sources within 500 km of the site are considered, which is contrary to the SPID guidance that would only consider sources with high activity or RLMEs within 500 km. Dr. Seber's view is that not considering all sources within 500 km and limiting consideration of large sources to no more than 1,000 km would lead to an underestimated GMRS for certain. Dr. Munson acknowledged that for some sites, distant seismic sources may contribute significantly to the GMRS; however for these sites the overall hazard is very low and the contributions from distant seismic sources do not impact the safety of the plant. Furthermore, Dr. Munson points out that the impact from these distant seismic sources is in the lower ground motion frequency range, which generally do not cause earthquake damage to well-engineered structures such as a nuclear power plant. Dr. Chokshi is of the view that one cannot conclude that the GMRS will be underestimated based solely on whether certain distant sources are included in the analysis. He notes that to assess whether a GMRS is underestimated requires an examination of the entire process used to generate the GMRS and how uncertainty is handled for the various components of the GMRS.

In developing a recommendation for this issue, I looked to RG 1.208 for some perspective. RG 1.208 states "every site is unique; therefore, requirements for analyses and investigations vary. It is not possible to provide procedures for addressing all situations. In cases that are not specifically addressed in this regulatory guide, prudent and sound engineering judgment should be exercised." The points made by Drs. Chokshi, Munson, and Ake are compelling, and the guidance contained in the SPID seems reasonable. Therefore, I do not recommend modifying the SPID. However, I do think it is important to include language in the endorsement letter similar to that in RG 1.208 regarding the inability to predict all situations and the importance of prudent engineering judgment. I am of the view that such an addition is worthwhile to ensure licensees are aware that if staff determines seismic sources beyond the distances specified in the SPID have safety significance to the GMRS, we will request that they be considered.

Issue 3

Dr. Seber contends that the lack of site-specific geologic field investigations or geophysical measurements to develop reliable estimates of the local site subsurface shear wave velocity profile and material properties will prevent appropriate estimates of the local site response. He takes the position that geologic data in the FSARs are decades old, generally sparse, and of limited use in determining the local site response. Without new geologic and geophysical data being collected at each of the operating reactor sites, the geology of the subsurface and, in particular, the soil and rock properties cannot be established in sufficient detail to perform a correct site response evaluation. Dr. Seber concludes that extensive measurements at each of the operating reactor sites should be required to arrive at estimates of the soil and rock properties.

Dr. Seber also expresses concern with the approaches proposed in Appendix B of the SPID to overcome, in his view, deficient data. Specifically, he takes issue with the proposed method to increase the uncertainty in the site response amplification function to account for the lack of data, and with the method to use estimates of the shear wave velocity in the upper 30 meters to select shear wave velocity templates for site response analysis.

Drs. Chokshi, Munson, and Ake again provide an extensive response to the issue. Key to their position is that plant FSARs do include extensive information obtained from site geologic and geotechnical field investigations. They note that the SPID states that licensees should use all geological information in performing their site response analysis. Drs. Munson and Ake also provide a comparison of a site response amplification function, using the method proposed in the SPID developed with data from the FSAR to an amplification function computed for an early site permit (ESP) application co-located at the same site. The ESP amplification function was computed using data from new measurements. Drs. Munson and Ake also contend that the methods included in the SPID are conceptually consistent with the methods used in COL\ESP reviews and differ primarily in how explicitly the approach attempts to capture the uncertainty in certain site response parameters.

To examine the issues raised regarding the SPID's approach to the site response analysis, I reviewed the FSARs of 20 sites located in the central and eastern United States, as well as current and previous versions of RG 1.132, "Site Investigations for Foundations of Nuclear Power Plants," and RG 1.138, "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants." Additionally, I met with Dr. Seber and separately with other members of my staff. In discussions with staff members, I sought input on accepted scientific approaches to conduct a site response analyses. Most of these discussions focused on whether a reasonable site shear wave velocity profile could be developed without direct measurements of the subsurface soil and rock shear wave velocities. The staff members all agreed that, if done properly a reasonable shear wave velocity profile could be developed with site-specific soil profiles, such as that collected from core borings. Core borings of sufficient depth that included details of the soil types, depths, and thicknesses of each soil layer could be used to estimate a shear wave velocity profile. The shear wave velocity profile could be estimated based on correlations accepted within the scientific community. In discussions with Dr. Seber, he agreed that using core borings and assigning representative shear wave velocities is a better strategy than the use of Vs30 and template velocity profiles. His view is that such an approach will clearly produce a better profile; however, the velocity profiles determined using such procedures may be significantly off and will contain large uncertainties. To properly account for the uncertainty will take significant effort and still may result in an unreasonable estimate of the shear wave velocity.

The FSARs reviewed contained varying amounts of geologic, geotechnical, and geophysical information that would be useful for a site response analysis. However, all but one site clearly had specific soil profiles based on core borings. For that one particular site, it was unclear if the soil profile presented was based on site-specific borings or a correlation from regional data. In that case, the FSRA referenced a separate site-specific report that likely would have provided additional details, but I was unable to review that report. Although there have been advances in geologic, geophysical, and geotechnical field investigations, core borings remain a primary means of characterizing the subsurface. Information obtained from core borings is durable in that soil types and soil depths measured in the 1960s, 1970s, and later still accurately characterized the subsurface.

Although I did not review the FSAR for every plant, it is likely that all sites have sufficient geological information particularly when considering the age of some of the sites in the sample I selected to review, as well as the long established practice of characterizing the subsurface for geotechnical reasons. Additionally, another 11 COL/ESP applications are co-located with operating reactor plants not included in the 20 sites reviewed. For those sites, I am reasonably certain significant geologic and geotechnical information is available.

The methods presented in the SPID to estimate the site response seem similar to the approaches used in COL/ESP applications as stated by Drs. Munson and Ake. However, in one section of Appendix B, it seems to allow the selection of a velocity profile template without consideration of site geology. In discussions with Drs. Munson and Seber, Dr. Munson agrees that section of Appendix B could be interpreted not to require consideration of site geologic information. However, he notes that other portions of Appendix B clearly emphasize the need to consider site geology.

For this issue I recommend the staff endorse the SPID; however, the endorsement letter should emphasize the staff's expectation that the licensees use site geologic information to complete their site response analysis rather than relying on generic templates. The staff would also expect that site geologic information would be a key component in forming the site response basis that licensees are required to submit.

SUMMARY OF RECOMMENDATIONS

To address the non-concurrence, I recommend the staff endorse the SPID, but revise the endorsement letter to assure certain NRC positions and expectations are clearly stated. I propose the following revision to the endorsement letter.

1. Clarify that the CEUS-SSC model does not need to be updated because it is considered sufficiently up to date and not because recommendation 2.1 is a screening-level study of multiple plants for the purpose of setting priorities.
2. Explicitly state the staff's expectation that any significant earthquakes that occur or new information that emerges during the reevaluations be considered to determine if the source characterization models need to be updated.
3. Explain that responses are considered site-specific GMRS.
4. Include language similar to that in RG 1.208 regarding the inability to predict all situations and the importance of prudent engineering judgment. The language should also inform licensees that if staff determines sources beyond the distances specified in the SPID have safety significance to the GMRS, we will request that they be considered.

5. Emphasize the staff's expectation that the licensees use site geologic information to complete their site response analysis. The staff also expects site geologic information to be a key component of the site response basis licensees are required to submit.

CONCLUSION

While I recommend that the SPID should be endorsed, consideration of the issues raised in the non-concurrence has led me to recommend additional comments be included in the endorsement letter. I believe those changes to the endorsement letter will clarify the staff's positions and expectations for the licensees' seismic reevaluations. I recommend that I work with Dr. Chokshi and you to develop the specific wording for the proposed changes to the endorsement letter. I also would like to note the professional manner in which Drs. Seber, Chokshi, Munson, and Ake interacted. All discussions were conducted in a collegial and professional manner with an effort to seek understanding of the others' views. While there are clear differences of opinion among the seismic experts, everyone's focus was squarely on the safety mission of agency.

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Abbreviations: *U.S. Nuclear Regulatory Commission (USNRC), U.S. Dept. of Energy (USDOE), Electric Power Research Institute (EPRI), Senior Seismic Hazard Analysis Committee (SSHAC)*