NRC Staff Responses to Public Comments on

Draft Regulatory Guide DG-1146
"A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion"

1 Introduction

This document contains NRC staff responses to comments received during the public comment period for Draft Regulatory Guide DG-1146, which ended on December 15, 2006. During this period, the NRC received the following sets of comments (in chronological order):

- Carl J. Constantino Letter dated December 2, 2006 (Internal Comments)
- Nuclear Energy Institute (NEI) Letter dated December 7, 2006, sent by Adrian Heymer (ADAMS Accession No. ML063560072)
- Bechtel Letter dated December 12, 2006, sent by Stephen D. Roth (ADAMS Accession No. ML063520109)
- Jeffrey K Kimball Letter dated December 13 2006 (ADAMS Accession No. ML063520110)
- Comments from the public during December 14, 2006 public meeting (ADAMS Accession No. ML063610506)
- Comments on DG-1146 in Electric Power Research Institute (EPRI) Minutes of December 14, 2006 public meeting (Available from EPRI)
- NEI Letter Dated December 28, 2006, sent by Adrian Heymer. (ADAMS Accession Nos. ML070030382, Supersedes ML063620427 and ML063620430)

Because a significant number of related comments were submitted by the various sources above, this document groups the comments by subject matter and often provides responses that apply to several comments. To assist the reader, all public comments are compiled in a table at the end of this document. This table lists the comments in chronological order, provides a brief description of the topic of the comments, and includes the page number in which the comment is addressed in this document.

The comments were provided in a variety of formats. In some cases one comment addressed several different topics (generally through use of a list). Because this document groups and addresses the comments by topic, individual comments covering multiple topics were split into an appropriate number of sub-comments. Efforts were made to make each sub-comment as clear as the original.

2 Comments on the Regulatory Process

NEI Specific Comment 10 (December 7, 2006)
On page 8, paragraph 5, first sentence, the draft states, "Thus, the performance-based approach combines a conservative characterization of ground motion hazard, with equipment/structure performance (fragility characteristics) to establish risk-consistent SSEs, rather than only hazard-consistent ground shaking, as occurs using the hazard reference probability approach in Appendix B to Regulatory Guide 1.165 (Ref.1)." This sentence provides the basis for having regulatory guide DG-1146 replace Regulatory Guide 1.165 as originally intended in the early meetings of the NEI Seismic Issues Task Force. However, existing applications using RG 1.165 should be allowed based on the date of the applications and the date of the final NRC approval of DG-1146.

NRC Response:
Although Regulatory Guide 1.208 is being developed for use in the nuclear power plant (NPP) application process, the NRC staff will treat Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," issued March 1997, as an acceptable alternative to Regulatory Guide 1.208 in the future.

Resolution:
No changes are required as a result of this comment.

NEI Specific Comment 22 (December 7, 2006)
On page 22, section C.4, "conclusion," first paragraph, sentence 3, the draft states, "Furthermore, the staff sees no adverse effects with retaining Regulatory Guide 1.165, an acceptable alternative to the new regulatory guide for satisfying the requirements of 10 CFR 100.23." We concur with this statement as represented by our specific comment 10.

NRC Response:
The NRC staff and NEI representatives are in agreement on this topic.

Resolution:
No changes to DG-1146 are required.

3 General Topics

3.1 Overall Approach

NEI General Comment 7 (December 7, 2006)
The appendices to the draft are more prescriptive than is appropriate for a Regulatory Guide. Appendix E is an example. This detail should be reserved for Standard Review plans.

NRC Response:
The NRC staff has carefully considered this comment and reviewed the document for consistency with other NRC guidance documents in this context. The staff has made changes to the appendices to bring this document more in line with the level of detail expected in a regulatory guide.

Resolution:
The staff has revised Appendices D and E.

NEI Statement of Interpretation 4 (December 7, 2006)
NEI has interpreted DG 1146 to allow the following: The use of the ASCE/SEI Standard 43-05 Performance-Goal based approach for determining the SSE response spectrum - in Section 5.1, Page 16

NRC Response:
While not all elements of American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) Standard 43-05, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," are being incorporated into Regulatory Guide 1.208, the ASCE/SEI Standard 43-05 performance-based approach in chapters 1 and 2 of that document is being used for development of the site-specific ground motion response spectrum (GMRS).

Resolution: No changes to DG-1146 are required.

Bechtel Comment 27 (December 13, 2006)
Page 19, Figure 3.

a. This figure is not clear. Is the first box about developing a procedure or site specific ground motion?
b. It appears that there should be a box between the first and second boxes that could read, "Develop spectra amplification factors or deconvolution studies," or something similar.

NRC Response:
In light of the comment, it is clear the figure could have been improved.

Resolution:
As part of broader edits to Regulatory Guide 1.208 this figure has been removed.

3.2 Location of SSE Ground Motion

As a result of on-going discussions, it was decided that this regulatory guide will focus on the ground motion response spectrum (GMRS) which leads to the SSE; but will have minimal discussion of the final SSE. Full development of the SSE will be addressed in the Standard Review Plan SRP 3.7. In addressing the below comments, it is understood that the use of the term SSE relates to the GMRS. Because the GMRS leads to the SSE, the location of GMRS is also defined in the free field at free ground surface or at the hypothetical outcrop of the upper most competent soil layer.

NEI Statement of Interpretation 2 (December 7, 2006)
NEI has interpreted DG 1146 to allow the following: Determination of the SSE response spectrum as a free-field spectrum at the ground surface or on the first competent material having shear wave velocity greater than 1000 fps for sites which have thin low shear wave velocity soil layers - in Section 5.3, Page 18

> NRC Response:
> This is a reasonable interpretation. The regulations require that the SSE must be defined on a free ground surface. However, the NRC staff understands that if competent material is lacking at the original ground surface, it may be more appropriate to use an alternate location as long as ground motions are developed as free surface motions. Alternative locations for the site-specific ground motion response spectrum (GMRS) are discussed in Section 5.3 of Regulatory Guide 1.208.
>
> The choice of shear wave velocity measurements of 1000 fps as the definition of competent material comes from existing Design Certification Documentation (DCD).
>
> Resolution:
> For clarity, the wording in Section 5.3 has been edited.

Bechtel Comment 1b (December 13, 2006)
The single most important change between RG 1.165 and DG-1146 is the change from the reference probability approach to the performance-based approach. This change, principally by reference to ASCE 43-05, is well defined and easy to follow. There are, however, a number of fundamental issues within NRC regulations and their CFR antecedents that neither RG 1.165 nor DG-1146 address. Principle among these is:

> b. Definition of a computationally useful horizon at which to define the SSE.
>
> NRC Response:
> The location of the SSE is narrowly defined by the Code of Federal Regulations and cannot be based on what is necessarily computationally simplest for design analyses. Some changes to Section 5.3 will be made for clarification. See the discussions (under NEI Statement of Interpretation 2) above and (under Bechtel Comment 12) below.
>
> Resolution:
> The staff has edited the wording in Section 5.3 to provide additional clarification.

Bechtel Comment 5 (December 13, 2006)
Although subsurface material properties may vary widely at undisturbed sites, it is inconceivable that a nuclear power plant would be founded on materials with inadequate competence to support the foundation mat. The definition of the SSE at the "free ground surface," if by this is meant the undisturbed ground surface could, therefore, imply that the adequacy of earthquake design calculations would be related to completely irrelevant ground motions. Recognizing this, Section C.5.3 of the draft guide states that, "For sites with one or more thin soil layers near the surface that will be excavated, the SSE is specified on an outcrop or a hypothetical outcrop of competent material (Vs ≥ 1000 fps) at a free surface."

a. It is recommended that the SSE be defined on an outcrop of competent material (Vs ≥ 1000 fps) at any site (not only those with "thin soil layers… that will be excavated") at the discretion of the applicant so long as the subsurface between this horizon and the Vs ≥ 9200 fps "hard rock" horizon is adequately characterized.
b. It is recommended that the wording "at a free surface" after "outcrop" be deleted. It is redundant.

NRC Response:
The wording "at a free surface," was intended to note that if a hypothetical outcrop of competent material is used, the SSE is calculated as if it is located at a free surface. The staff has adjusted the wording to clarify the requirement. The location of the SSE (and therefore the GMRS) is defined based on requirements of the Code of Federal Regulations (CFR) and must be consistent for all applicants. See discussion under Bechtel Comment 12, below.

Resolution:
See changes to Section 5.3 in the response to NEI Statement of Interpretation 2, below.

Bechtel Comment 12 (December 13, 2006)
The new standard reactor designs have sizable embedment depth. Unless a shoring system is used, sites are likely to be subjected to a large excavation and backfill. In this context, the meaning of "free-field" should be carefully defined. On the other hand, poor surficial soil layers at some sites will require over-excavation and backfilling. Sampling and testing and site response analysis involving such poor soil layers is not productive for design and may amount to unstable solutions in site responses analysis. In this context also, the meaning of "free-field ground surface" should be clearly stated.

NRC Response:
The GMRS must be based only on site conditions and must be independent of various foundation depths, backfilling, and other design-based issues. In addition, the GMRS and the SSE must be defined such that there is only one SSE per NPP site. The Code of Federal Regulations defines the SSE as being located at the free-field free-ground surface. Working within this constraint, but recognizing that the SSE should not be determined based on soils layers that are not sufficiently competent to act as foundation material and must be removed; the concept of a "hypothetical outcrop" was developed.

As a result of the above constraints, the GMRS (which leads to the SSE) is defined at either the free-field natural ground surface; or in cases in which the surficial soils are too soft to be used as foundation materials, the GMRS is defined at the upper most competent layer that will be exposed. This layer of competent material is called either an outcrop if it is the final excavation level, or a "hypothetical outcrop" if it is not. Backfill soils should not be included in the site response analyses leading to the GMRS. The term free-field is included to differentiate GMRS from in-structure motions.

An acceptable definition of competent material is the definition provided in the design certification documentation (DCD), which currently uses a shear wave velocity (Vs) greater than 1000 ft/s. Section 5.3 of Regulatory Guide 1.208 discusses the location of the GMRS.

Resolution:
The staff has edited the wording in Section 5.3 to provide additional clarification.

Bechtel Comment 25 (December 13, 2006)
Page 18, Section C.5.3, "Location of the Site Safe Shutdown Earthquake Ground Motion." A definition of "thin soil layer" should be added.

NRC Response:
A thin soil layer was meant to imply one that will be completely removed during excavation. For clarity, NRC staff has edited the section.

Resolution:
The staff has edited the wording in Section 5.3 to provide additional clarification.

3.3 Code Required Check on Motions at Foundation Level

Public Comments at NRC Public Meeting Comment 1 (December 14, 2006)
Industry representatives found wording on location of SSE in Section 5.3 acceptable, but would prefer to have 1146 end at the development of the site specific ground motion. The check of 0.1g at the foundation depth would instead be included as a check in the SRP, but not as a fundamental part of the SSE (or the site specific ground motion). They noted that they believe it is a design criterion, not a site criterion.

NRC Response:
See response below NEI Specific Comment 21.

Bechtel Comment 26c (December 13, 2006)
Page 18, Section C.5.4, "Determination of Safe Shutdown Earthquake." It is recommended that the wording on the following issues in this section of the draft guide be revised for clarity.

c. It may be best to apply the requirement of 0.10g motion as a separate deterministic type motion to check the design once the analysis is completed using the SSE motion without the 0.10g. In this case, limiting the amplification of motion in the free-field should be permitted.

NRC Response:
See response below NEI Specific Comment 21.

NEI Specific Comment 21 (December 7, 2006)
Page 18, in order to maintain the nature of the Uniform Hazard and Design Response Spectra for design application, it is suggested that the requirement of 0.10g motion at the foundation level to be separated from development of the design motion. This requirement can be stipulated as a separate seismic analysis to check the design. This would ensure the adequacy of the design and avoid development of multiple SSEs for a plant that may have structures with multiple embedments.

NRC Response:
The NRC staff agrees with the approach of treating the requirement at the foundation level as a separate check during the design phase. Treating this requirement at the foundation level as a design check both separates development of the GMRS from design considerations and maintains

a uniform hazard for all spectral frequencies. The staff will retain Section 5.4 in the document as a summary, but will be edit it to reflect the change in approach. The foundation level check will be discussed in the Standard Review Plan.

Resolution:
The staff has edited Section 5.4 to address this change in approach.

NEI Specific Comment 20 (December 7, 2006)
On page 18, section C.5.4, "Determination of Safe Shutdown Earthquake," first paragraph, "free field motion" at the foundation level should be an "outcrop motion."

NRC Response:
See discussion under Bechtel comment 26a, below.

Dr. Carl Constantino Comment 3 (December 2, 2006)
Line 41 (page 2, paragraph 3, sentence 4) Is the 0.1g criterion defined as an outcrop or in-column PGA?

NRC Response:
See discussion under Bechtel comment 26a, below.

Bechtel Comment 26a (December 13, 2006)
Page 18, Section C.5.4, "Determination of Safe Shutdown Earthquake." It is recommended that the wording on the following issues in this section of the draft guide be revised for clarity.

a. Is the free-field motion at the foundation level discussed an "outcrop" or "within" motion?

NRC Response:
The comparison at the foundation level should be performed using outcrop motions for both the foundation-level site spectrum and the 0.1g check. This is particularly true if the check is made against the spectrum (anchored at 0.1g) of Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Revision 1, issued December 1973, which was designed as a surface spectrum. Use of outcrop motions eliminates two issues related to (potentially large) reductions of in-column motions at the natural frequency of the soil column. The sharp drop in ground motion at the natural period of the soil makes comparisons with a flat spectrum (like the Regulatory Guide 1.60 spectrum) problematic. Related to this issue, if motions must be increased to meet the spectrum chosen for comparison, the final resulting surface spectrum has a spike at the frequency affected.

Resolution:
The new text developed for Section 5.4 will provide clarification.

Bechtel Comment 26f (December 13, 2006)
Page 18, Section C.5.4, "Determination of Safe Shutdown Earthquake." It is recommended that the wording on the following issues in this section of the draft guide be revised for clarity.

f. (Page 18 and also Figure 3 on page 19) Once the foundation motion is determined from free field motion through deconvolution or amplification factors, "the motions at foundation level are compared against appropriate response spectrum with a peak ground acceleration of at least 0.1g." What is the appropriate response spectrum here? How will it be determined?

NRC Response:
See response below NEI comment 1.

NEI Specific Comment 1 (December 28, 2006)
On page 2, third paragraph, the draft Regulatory Guide indicates that site specific design spectra should be sufficient to assure that a 0.1g spectrum at the building foundation level in the free field is met. These minimum spectra should have an "appropriate" shape, which the NRC is currently planning to define as the Regulatory Guide 1.60 shape. An "appropriate" shape would include shapes that have adequate energy in the low frequency range, not only the Regulatory Guide 1.60 spectra.

> NRC Response:
> The Regulatory Guide 1.60 spectrum fixed at a peak ground acceleration (PGA) value of 0.1g is one spectrum that the NRC staff would consider acceptable for this purpose. However there may be other spectra that would be considered acceptable for this purpose by the NRC staff if justification for their use is provided. In its review the NRC staff will consider the amount of energy represented in the low frequency range, among other things.
>
> Resolution:
> The new text developed for Section 5.4 will provide clarification.

NEI Specific Comment 2 (December 28, 2006)
On page 18, Paragraph 7, first sentence, the draft Regulatory Guide states, "Once the SSE is developed, it is compared with the seismic design criteria in the design certification documentation." When the site-specific response spectrum is compared to the certified design spectrum, the importance of the spectral exceedances identified, if any, should be evaluated considering the spectral frequency ranges that control soil response to determine liquefaction potential (approximately 1/2 Hz to 2 Hz), structural response (approximately 2 Hz to 10 Hz) and equipment response (greater than 10 Hz). (Note: The frequency ranges shown are approximate.)

> NRC Response:
> As decided at the public meeting on December 14, 2006, Regulatory Guide 1.208 will not discuss this topic. The NRC staff position will be indicated in the Standard Review Plan.
>
> Resolution:
> No changes will be made to DG-1146.

Bechtel Comment 26b (December 13, 2006)
Page 18, Section C.5.4, "Determination of Safe Shutdown Earthquake." It is recommended that the wording on the following issues in this section of the draft guide be revised for clarity.

b. Development of composite spectrum in the free-field at the foundation level and subsequent computation of the SSE at the ground surface level would cause numerous anomalies, several are identified below:

- For plants with structures having multiple embedment depths, this would amount to more than one SSE at the ground surface level.
- There is a penalty for deeper embedment since the 0.10g motion is fixed at the foundation level in the free-field.
- If soil amplification were to be performed for the composite foundation level motion as stated, it is not clear what soil properties from the set of randomized soil properties should be used.
- Is the composite spectra at the foundation motion a UHRS or DRS? If it is a UHRS and it is amplified to the surface, should the same procedure be used to develop the DRS based on the slope of the hazard curve that did not include the 0.10g motion?
- When composite motion is amplified, how is the vertical motion computed?

NRC Response:
The NRC staff considers it acceptable for the foundation level comparison to be treated as a design-level check.

Resolution:
The staff has edited Section 5.4 to remove the concept of a composite ground motion.

Bechtel Comment 26d (December 13, 2006)
Page 18, Section C.5.4, "Determination of Safe Shutdown Earthquake." It is recommended that the wording on the following issues in this section of the draft guide be revised for clarity.

d. There is wording in this section on where the SSE is to be defined, as distinct from the ground motions at the "free field foundation depth." It is noted in this section that it is the motions at the foundation level -- not the SSE [free field surface spectrum]--where the comparison "against appropriate response spectrum with a peak ground acceleration of at least 0.1g." This wording appears to be in conflict with Appendix S to 10 CFR Part 50, which states that the comparison is to be made against the SSE. Consideration should be given to clarifying this wording.

NRC Response:
While the regulations require the SSE to be defined at the free field ground surface, they also require a check of SSE consistent motions at foundation. To address both requirements, the concept of the composite spectrum was developed. Although the concept of the composite spectrum directly addressed the requirements, it led to confusion and unintended issues. By treating the 0.1g check as a separate design check, and not a fundamental part of the definition of the GMRS, this confusion is eliminated. The foundation level check will be discussed in the Standard Review Plan.

Resolution:
The new text developed for Section 5.4 provides clarification.

3.4 SSE versus Design Response Spectrum and Risk Consistent Spectrum

Dr. Carl Constantino Comment 4 (December 2, 2006)
Line 52 (page 2, paragraph 6, sentence 1) I presume that the performance-based SSE is the UHRS scaled by the DF (the risk-consistent spectrum RCS). If so, should you so state? Then the DRS may or may not be the RCS, correct?

> NRC Response:
> The NRC's performance-based GMRS is the UHRS scaled by the Design Factor. The DRS defined in ASCE 43-05 is the same as the NRC's GMRS.
>
> Resolution:
> The NRC staff has edited Regulatory Guide 1.208 for clarity.

Bechtel Comment 1a (December 13, 2006)
The single most important change between RG 1.165 and DG-1146 is the change from the reference probability approach to the performance-based approach. This change, principally by reference to ASCE 43-05, is well defined and easy to follow. There are, however, a number of fundamental issues within NRC regulations and their CFR antecedents that neither RG 1.165 nor DG-1146 address. Principle among these is:

a. Lack of distinction between the SSE and the DRS (design response spectra).

> NRC Response:
> The Design Response Spectrum (DRS) defined in ASCE 43-05 and the NRC's GMRS are the same. They are performance based site-specific ground motion response spectrum and determined by scaling the UHRS (1 E-04) by a design factor. The ASCE DRS is not the same as the SSE, as defined in the Standard Review Plan.
>
> Resolution:
> Section 5.1 has been edited to clarify the differences between the GMRS and the SSE.

Bechtel Comment 26e (December 13, 2006)
Page 18, Section C.5.4, "Determination of Safe Shutdown Earthquake." It is recommended that the wording on the following issues in this section of the draft guide be revised for clarity.

e. It is stated in this section that development of SSE will be more fully described in NUREG-0800. However, an acceptable approach is shown in Figure 3, although sufficient detail is not provided. Would it be better if options for the development of the SSE were more fully described and regulatory positions established in this draft guide?

> NRC Response:
> The additional development of the SSE in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," was intended to deal with the 0.1g PGA check and the composite spectrum. Removal of the composite spectrum concept eliminated many of those issues. As a result, much of the guidance that would have been useful in this section is no longer appropriate.
>
> Resolution:
> The staff has edited Section 5.4 to clarify the concepts of GMRS and SSE. SSE determination will be fully discussed in SRP 3.7

3.5 Other Comments

Dr. Carl Constantino Comment 2 (December 2, 2006).
Page 2, paragraph 3, sentence 3: …spectrum be a smoothed spectrum compatible with the site characteristics,…

NRC Response:
The proposed changes improve the sentence.

Resolution:
The sentence now reads, "In view of limited data available on vibrator ground motions of strong earthquakes, it will usually be appropriate that the design response spectra be a smoothed spectrum compatible with the site characteristics."

4 Performance-Based Design Parameters

NEI Specific Comment 11 (December 7, 2006)
On page 8, footnote 4 needs to be either deleted or corrected. As written, it imposes HCLPF seismic margin requirements that are more stringent than those imposed by SECY-93-087. There is no need for Footnote 4 so we suggest it be deleted. However, if retained, it should be revised to state that the HCLPF margin factor of 1.67 applies to the overall plant damage states leading to Seismic Core Damage (SCD) or LERF. It should not be necessary to demonstrate a HCLPF margin of 1.67 for every SSC in the plant.

NRC Response:
The NRC staff agrees with the comment.

Resolution:
The staff has deleted the HCLPF related statement from Regulatory Guide 1.208.

Bechtel Comment 20 (December 13, 2006)
Page 8, footnote.

a. The footnote at the bottom of the page is more stringent than SECY-93-87 which requires the 1.67 factor above the SSE for plant damage state, not for individual components. The draft guide will add more conservatism to the design of new nuclear power plants. Is this the intent?
b. If a margin study or PRA will be required, as noted in this footnote, specific guidelines are needed to develop the motion and soil properties for the higher level motions.

NRC Response:
The NRC staff agrees with the comment.

Resolution:
The staff has updated wording in the document text and removed the footnote.

Dr. Carl Constantino Comment 6 (December 2, 2006)
Line 110 and Line 290 (page and page 8, paragraph 5, last sentence) Statement is incorrect because as it is always the case that yield is reached before failure.

NRC Response:
This comment relates to fact that in all cases, the inelastic deformation precedes failure and so this in itself does not provide a basis for the new methods.

Resolution:
The staff has modified the wording to address this comment.

Bechtel Comment 3 (December 13, 2006)
The draft guide does not explicitly mention that the new nuclear plants designed in accordance with this draft guide will provide lesser seismic risk. The wording on Page 4 which reads, "Setting the performance goal to be equivalent to the FOSID of SSCs is conservative, since the seismic demand resulting in the onset of significant inelastic deformation is less than that for failure of the SSCs," implies that new nuclear power plants will be, on average, safer. The draft guide should include wording that explicitly recognizes this fact.

NRC Response:

See response to Dr. Carl Constantino Comment 6, above.

Resolution:
The staff has modified the wording in the document.

Bechtel Comment 7 (December 13, 2006)
Finally, the most fundamental problem with RG 1.165 was that it developed criteria based on a reference probability defined in terms of existing nuclear power plant SSE response spectra for frequencies between 1 and 10 Hz, then required that new nuclear power plants be designed for ground motions at frequencies outside this range (and for higher frequencies, in particular) for which the SSE response spectra of existing nuclear power plants would have predicted a much higher reference probability. The SSE response spectra for existing nuclear power plants are not based on UHRS concepts and the 1-10 Hz window used as a benchmark is within a relatively conservative part of the UHRS. Migration to performance-based criteria within the same frequency range does not appear to directly address this issue. If, indeed, it may eventually be shown that high frequency (> 10 Hz) motions are less likely to damage SSCs for a given amplitude than lower frequency motions, this would introduce an additional way to modify the ASCE 43-05 approach in such a way as to reduce the high-frequency component of a performance-based SSE. It is recommended that this eventuality be acknowledged in the draft guide.

NRC Response:
The reference probability approach the NRC used in Regulatory Guide 1.165 was based on the data and the tools available at that time. The frequency range of the ground motions specified was limited by these constraints; Regulatory Guide 1.208 is based on the same set of data. Note that the Regulatory Guide 1.165 reference probability was based on probability exceeding SSE at 5 and 10 Hz, not 1 and 10 Hz. This comment speculates about the consequences of future work and data. It is not appropriate to speculate about future findings within Regulatory Guide 1.208.

Resolution:
No changes are required in Regulatory Guide 1.208.

5 Site Investigation and Site Properties

5.1 Excavations and Construction

NEI Specific Comment 2 (December 7, 2006)
On page 4, last paragraph, the draft states, "Under the combined license procedure, these kinds of features [e.g. faults] should be mapped and assessed as to their rupture and ground motion generating potential while the excavations' walls and bases are exposed, and the NRC staff should be notified when excavations are open for inspection." This requirement needs to be clarified relative to how the new information will be handled under the COL process and in a manner that maintains stability in the regulatory process.

> NRC Response:
> The NRC staff acknowledges the comment. Regulatory Guide 1.70 (DG-1145) is currently being updated and will clarify how this requirement will be implemented.
>
> Resolution:
> No changes are required to DG-1146 except as noted below to achieve consistency with language in the Standard Review Plan (SRP).

NEI Specific Comment 13 (December 7, 2006)
On page 11, fourth paragraph, third sentence, the draft states, "A commitment should be made, in documents (Safety Analysis Reports) supporting the license application, to geologically map all excavations and to notify the NRC staff when excavations are open for inspection." A commitment, as requested for the major excavation is understandable, but "all excavations" is much too broad a term. For example, at what point does grading or ditching become an excavation? This requirement should be consistent with SRP 2.5.1, Section III, which requests a commitment to "geologically map all excavations for Seismic Category I structures, as a minimum...." This is a clearer statement.

> NRC Response:
> See response under Bechtel Comment 21, below

Bechtel Comment 21 (December 13, 2006)
Page 11, 4th paragraph. The draft guide states, "A commitment should be made, in documents (Safety Analysis Reports) supporting the license application, to geologically map all excavations and to notify the NRC staff when excavations are open for inspection." It is recommended that this wording be revised to be consistent with SRP 2.5.1 to "geologically map all excavations for Seismic Category I structures, as a minimum...."

> NRC Response:
> The proposed changes in the above comments would improve Regulatory Guide 1.208 and lead to clarity and consistency with SRP Section 2.5.1.
>
> Resolution:
> The staff edited the line to read as: "A commitment should be made, in documents (Safety Analysis Reports) supporting the license application, to geologically map all excavations of

significant size and to notify the NRC staff when these excavations are open for inspection. This should apply to excavations for construction of all Seismic Category I structures, as a minimum."

NEI Specific Comment 12 (December 7, 2006)
On page 11, section C.1.3, the title of the section should be changed to read "Features Discovered During Excavation" rather than "Features Discovered During Construction." This is suggested because excavation is the activity of concern.

NRC Response:
Although, the section specifically discusses excavations, there may be cases where features are identified that are not tied specifically to excavations. Any potential fault identified on the site must be investigated, regardless of how it is identified.

Resolution:
No change to DG-1146 is required.

Dr. Carl Constantino Comment 7 (December 2, 2006)
Page 4, paragraph, 4: "….faults, potential soft zones or other features of engineering significance"….

NRC Response:
The staff will incorporate the proposed comment.

Resolution:
The line on page 4 now reads: "It should be demonstrated that deformation features discovered during construction (particularly faults, potential soft zones or other features of engineering significance) do not have the potential to compromise the safety of the plant."

Dr. Carl Constantino Comment 10 (December 2, 2006)
Line 383 (page 11, paragraph 4, sentence 1): "….faults, potential soft zones or other features of engineering significance"….

NRC Response:
The staff will incorporate the proposed comment.

Resolution:
The line on page 11 now reads: "It should be demonstrated that deformation features discovered during construction (particularly faults, potential soft zones, or other features of engineering significance) do not have the potential to compromise the safety of the plant."

5.2 Definition of Rock

NEI Specific Comment 1 (December 7, 2006)
On pages 3, 8, 15, A-2, E-1, and E-3, the draft refers to computing the PSHA for generic *hard* rock conditions, which are defined on page 14, Sec 4, as "… generic hard surficial hard rock conditions [i.e., rocks with a shear wave velocity (VS) about 2.8 km/sec (9200ft/sec)]" and in Appendix E as "… usually with a shear wave velocity (VS) about 2.8 km/sec (9200 ft/sec)." This is the case currently for the CEUS but is not the case for the WUS. It is suggested that the phrase "generic hard rock" be modified to be just "generic rock" and that the discussion on page E-1 of 2.8 km/sec be stated in terms of the current status for CEUS ground motions. It is possible in the future that generic rock ground motion models will be developed for the CEUS for some other commonly found rock condition.

NRC Response:
In terms of the probabilistic seismic hazard assessment (PSHA), the definition of rock conditions is dictated by the data used to develop the attenuation relationships used in the PSHA. The regulatory guidance should have terminology such that cases in both the Western US (WUS) and Central and Eastern US (CEUS) are addressed.

Resolution:
The staff has made edits to address this comment.

Jeffrey K. Kimball Comment 8 (December 13, 2006)
DG-1146 supports the development of rock-based PSHA results, using generic hard rock conditions. Appendix E states that generic hard rock conditions are associated with a shear wave velocity of about 2.8 km/sec (9,200 ft/sec). The basis for defining generic hard rock at a shear wave velocity of 9,200 ft/sec is not provided and is inconsistent with other published definitions of hard rock based on shear wave velocity (see for example FEMA Report 450-1, 2003 Edition of National Earthquake Hazard Reduction Program Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, where hard rock is defined by a shear wave velocity of > 5,000 ft/sec). Additionally it is not clear why an applicant in the Western United States would be required to generate a PSHA for hard rock site conditions when this shear wave velocity may only exist at deep depths.

NRC Response:
The universal use of the hard rock definition in DG-1146 is problematic, as discussed in the response above. In terms of the PSHA, the definition of rock is defined by the attenuation relationships and is dictated by the case history database used in the development of the attenuation relationships chosen for the PSHA. These definitions do not necessarily fit the National Earthquake Hazards Reduction Program (NEHRP) site classification system (as used in Federal Emergency Management Agency Report 450 and other documents).

As noted in the comment, one would not generate a PSHA for hard rock conditions in the WUS because the attenuation relationships were developed using soft rock data. The staff will edit the document to be more inclusive and generic in nature.

Resolution:
The changes noted in the response to NEI Specific Comment 1 above will also address this comment.

5.3 Development of Dynamic Soil Properties

NEI Specific Comment 28 (December 7, 2006)
On page E-3, first paragraph, second sentence states, "When site-specific laboratory data is used, the result should be compared to earthquake recordings on similar soils." It is not clear why this restriction is added on the use of site-specific laboratory data. This restriction could have an important impact on the scope and cost of geotechnical investigations for the next generation nuclear power plants. Clarification is requested.

NRC Response:
During the development of the EPRI strain-dependent shear modulus and damping curves, efforts were made to validate the laboratory results with field data. If new site-specific curves are

developed based on laboratory results, it is expected that these new results will also be checked against field data to ensure their reasonableness.

Resolution:
The NRC Staff has changed the statement to the following: "When new strain-dependent shear modulus and damping curves are developed, these curves should be compared to earthquake recordings on similar soils."

Bechtel Comment 34 (December 13, 2006)
Pages E-2 and E-3, 6th and 7th paragraphs of Section E.3, "Site Response Analysis." The 6th paragraph states, "The strain-dependent shear modulus and damping curves are developed based on site-specific testing results and supplemented as appropriate by published data for similar soils." The second sentence on the 7th paragraph states "When site-specific laboratory data is used." Is there a conflict between these two statements?

NRC Response:
This wording could be interpreted to have a potential conflict. The first statement was intended to indicate that shear modulus and damping curves developed from site-specific testing results can be supplemented as appropriate by published data for similar soils. The second statement asks for a comparison with seismic recording of similar soils.

Resolution:
The staff had updated the wording in Section E.3.

5.4 Other Comments

NEI Specific Comment 16 (December 7, 2006)
On page 15, section C.4.1 "Site and Laboratory Investigations and Testing," first sentence, second line, delete "materials, and their spatial distribution" and replace with "strata."

NRC Response:
The spatial distribution of engineering properties both within individual geologic strata and across the site is an important consideration and should be analyzed. This is in addition to the mean and standard deviation of engineering properties. If properties change across a site, this should be accounted for in analyses.

Resolution:
The staff has clarified this issue in Regulatory Guide 1.208 through the addition of the wording, "Consideration should be paid to spatial distribution both within individual geologic strata and across the site."

Dr. Carl Constantino Comment 9 (December 2, 2006)
Page 10, paragraph 3, last line: What is "ground-truth" recon?

NRC Response:
In this context, ground-truth reconnaissance refers to a visit to the potential source to perform first-hand investigation.

Resolution:

The sentence will be changed to "These investigations should include literature reviews, the study of maps and remote sensing data, and if necessary, on-site ground-truth reconnaissance."

Dr. Carl Constantino Comment 13 (December 2, 2006)
Section C2.5.2 only considers ground failure evaluations associated with site liquefaction effects. However, a number of other "ground failure" issues need to be mentioned such as potential localized soft zones, karst features, etc. whose collapse or consolidation could impact the foundation design.

NRC Response:
The staff has added additional text to address other forms of ground failure.

Resolution:
The staff has added a paragraph that states, "In addition to liquefaction, a number of other forms of ground failure or ground settlement should be investigated. These forms of ground failure and ground settlement include localized soft zones, karst features, seismic settlement of non-saturated soils, all forms of mass wasting, and any other form of ground deformation that has the capacity to impact foundation performance or design."

NEI Specific Comment 23 (December 7, 2006)
On page C-6, section C.2.4, "Surface-Fault Rupture and Associated Deformation at the Site," third paragraph last sentence states, "These structures, such as those found in karst terrain, and growth faulting, which occurs in the Gulf Coastal Plain or in other deep soil regions, cause extensive subsurface fluid withdrawal." This appears to be garbled. It does not appear to flow logically from the preceding sentences. It is assumed that the idea is to provide some examples of non-tectonic faulting and to indicate the origin and/or related surface deformation. The link between extensive subsurface fluid withdrawal and surface displacements should be clarified.

NRC Response:
The NRC staff agrees with the comment.

Resolution:
The NRC staff has edited the document for clarity.

Dr. Carl Constantino Comment 8 (December 2, 2006)
Line 139 (page 5, paragraph 1, sentence 2) I don't understand why the approach used to account for uncertainties depends on the tectonic setting.

NRC Response:
One example of the need to consider tectonic setting in defining epistemic uncertainty relates to the type of faulting anticipated on a fault for which limited data are available. Because some attenuation relationships account for style of faulting, the tectonic setting may help to characterize unknown fault parameters. Uncertainty can also arise in areas where tectonic setting tends to hide evidence of faulting, such as in Southern California, where blind thrust faulting is common.

Resolution:
No change to DG-1146 is required.

Public Comments at NRC Public Meeting: Comment 6 (December 14, 2006)
DG 1146 details specific map scales to be used in reporting. However in the digital age, these scales seem out of date. Please consider revising the text.

NRC Response:
The NRC staff is most interested in the resolution of the underlying map data. While the use of digital data allows for maps that are optimally sized for visualization, it is important that maps provided do not imply or assume a level of resolution higher than the resolution of the underlying mapping. GIS can enlarge a map digitally but do not change the underlying data's resolution. For example, if 1:500,000 geologic maps are imported to a GIS system, the resolution of the product based on these underlying maps is still consistent with a 1:500,000 map, regardless of the ultimate scale of the final product provided.

Resolution: TBD
That staff has edited DG-1146 to clarify the intent of the mapping scales noted.

6 Probabilistic Seismic Hazard Assessment (PSHA) Methods

6.1 Choice of PSHA Techniques and Regulatory Stability

Jeffrey K. Kimball Comment 1 (December 13, 2006)

In October 2006 the United States Nuclear Regulatory Commission (NRC) published Draft Regulatory Guide DG-1146, A Performance Based Approach to Define the Site-Specific Earthquake Ground Motion, for public comment. Section 4 of DG-1146 states "that the proposed action will reduce unnecessary burden on the part of both the NRC and its licensees, while improving the process for siting of nuclear power plants." Because of vague terminology and lack of appropriate guidance on what constitutes an appropriate probabilistic seismic hazard analysis (PSHA), implementation of DG-1146 could well result in an unstable regulatory process, with protracted debate on PSHA related issues.

DG-1146 outlines new methods for defining a site-specific performance based Safe Shutdown Earthquake (SSE), using the approach described in Chapters 1 and 2 of American Society of Civil Engineers (ASCE) Standard 43-05, "A Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities."

One of the most important criterion for evaluating the acceptability of a performance-based approach is the suitability of the seismic hazard assessment to support the determination of an appropriate probabilistic seismic hazard used as part of the ASCE 43-05 process to meet the selected target performance goal (expressed as a target mean performance criterion of < 1x10-5 per year for the frequency of onset of significant inelastic deformation). It is important that any regulatory guidance provide regulatory stability, particularly with respect to potential changes or updates of the input parameters for probabilistic seismic hazard analysis (PSHA).

Use of a site-specific mean 10-4 annual probability level to define the uniform hazard response spectrum (UHRS) as the starting point, based on the precedent set in ASCE 43-05, depends on the stability of PSHA results for a given site. While two divergent mean PSHA curves can be used to meet an intended target performance goal, each may result in widely different design ground motion levels or SSE. Divergent PSHA curves with different slopes could also result in different values for the ASCE 43-05 "design factor".

NRC response:
See response below Jeffrey K. Kimball Comment 11.

Jeffrey K. Kimball Comment 3 (December 13, 2006)

When NRC developed Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion," one of the objectives was to achieve regulatory stability. At that time a decision was made to use the concept of "reference probability," established in part where the EPRI and LLNL PSHA results were found to provide consistent ground motion values. The reference probability was selected as a median 10-5 annual probability. It is important to note that selection of a mean annual probability (for example that needed to support a performance-based approach) for the "reference probability" was not possible, in part, due to wide differences between PSHA results based on EPRI and LLNL.

Completion of a PSHA for a given location should be based on the latest seismic hazard information which depends on the geological and seismological setting of that location. One of the original motivations that NRC had for developing the LLNL results was to provide for an independent check on PSHA results derived by applicants, to ensure that the probabilistically derived ground motion levels were appropriate for seismic design purposes. Such a check and balance should be an explicit part of regulatory oversight to ensure that PSHA results provide an appropriate assessment of seismic hazard.

Because of the divergent EPRI and LLNL PSHA results, NRC, along with the Department of Energy and EPRI, sponsored development of "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," published as NUREG/CR-6372 (commonly referred to as the Senior Seismic Hazard Analysis Committee or SSHAC report). The sponsors of this work saw a need for more stability in the PSHA process. While both the EPRI and LLNL PSHAs were landmark efforts, neither of these studies was completed following the SSHAC guidelines, and thus could be legitimately challenged in terms of providing the necessary regulatory stability for application following the approach found in ASCE 43-05.

Efforts to update either study (such as what has been completed to support Early Site Permit {ESP} applications) needs to be reviewed carefully to ensure that all PSHA input represents the current state of seismologic and geologic practice. It appears as if the trend is to update EPRI PSHA results and ignore past LLNL results. While the technical basis for this trend is not clear (other than the implication that applicants like the lower EPRI PSHA results), it appears to be supported by DG-1146, based on the precedence from Regulatory Guide 1.165 even though that reference was not linked to a performance based approach which requires an accurate absolute estimate of probabilistic seismic hazard.

NRC response:
See response below Jeffrey K. Kimball Comment 11.

Jeffrey K. Kimball Comment 5 (December 13, 2006)
The implication from the above discussion suggests that NRC should be capable of performing confirmatory PSHA assessments as part of their regulatory oversight. It is not clear whether NRC has maintained the capability to execute a "LLNL PSHA" for a given site location as part of their regulatory review and oversight. NRC needs to recognize that different organizations could execute the EPRI, LLNL or USGS PSHA methods for a given location, which could result in widely divergent design ground motions following the approach found in ASCE 43-05. Without addressing these issues it is not clear how regulatory guidance will result in regulatory stability.

NRC response:
See response below Jeffrey K. Kimball Comment 11.

Jeffrey K. Kimball Comment 11 (December 13, 2006)
Any updated regulatory guidance that adopts the ASCE 43-05 approach must address those steps that will result in PSHA stability to ensure overall regulatory stability. Use of pre-existing PSHA results (adjusted or not) and/or recent USGS PSHA results requires more study before such regulatory stability can be defined. Adjusting either the EPRI or LLNL PSHA input may not be feasible given that much of the original work for both of these studies is now about 20 years old. This implies that a comprehensive PSHA update for the CEUS may be needed. The USGS should play a prominent role if this step is taken to ensure appropriate integration of PSHA input parameters with the national seismic hazard map. Finally, NRC should be encouraged to retain the capability to perform independent PSHA confirmatory calculations (as they had with the LLNL PSHA code) as part of their regulatory review.

NRC Response:
In order to serve its mission of protecting public safety, the NRC must work towards a regulatory process that ensures regulatory stability, while maintaining a flexibility that allows adoption of the most recent technical knowledge and tools. It is important that tools and information used for probabilistic seismic hazard assessment (PSHA) in particular are carefully reviewed and applied.

The development of this guide, as well as other work such as development of the SSHAC guidelines in NUREG/CR-6372, has been undertaken to increase stability of PSHA process. The NRC staff acknowledges the above observations about the characteristics of PSHA. The NRC staff also recognizes that PSHA is an evolving technology and is working to incorporate the most recent refinements in techniques and information into regulatory guidance, as appropriate.

As noted, it is essential that the NRC retains the capability to perform independent PSHA calculations. Independent reviews are being performed both in-house and with the assistance of contractors and other federal agencies, including the U.S. Geological Survey (USGS).

Resolution:
The section on PSHA techniques notes the changes that have been made to DG-1146.

Dr. Carl Constantino Comment 14 (December 2, 2006). Line C293 The DG mentions only the LLNL/EPRI studies. USGS hazard evaluations are currently in use for many other critical facility designs aside from NPP's.

NRC Response:
The USGS hazard evaluations are currently used in many industries and should be noted as a resource. In addition the USGS hazard database was is used extensively by the NRC staff in the review of every application.

Resolution:
The staff has added a discussion of the USGS as a resource.

6.2 Seismic Source Characterization

NEI General Comment 5 (December 7, 2006)
The draft states that applicants may use accepted seismic source characterizations as the starting basis for developing inputs for a site-specific PSHA. References to such sources and existing databases are at various places throughout the text. But the draft provides inadequate guidance. The Regulatory Guide

should clearly state that seismic source characterizations that have been reviewed either generically (i.e., LLNL, EPRI 1986) or as part of an ESP or COL application and accepted by the NRC are accepted as starting basis for developing inputs for a site-specific PSHA.

NRC Response:
See the response to the below comment.

Public Comments at NRC Public Meeting Comment 9 (December 14, 2006)
Industry representatives noted that in their opinion DG-1146 should clearly state that seismic source characterizations that have been accepted by the NRC generally or as part of an ESP or COL application are acceptable starting bases for subsequent site-specific PSHAs.

NRC Response:
The NRC staff is in general agreement with this approach as long as it is clear that the source characterization is only a starting point and recent work on the sources should be reviewed.

Resolution:
The staff has added the above concept to Section B of Regulatory Guide 1.208.

NEI Specific Comment 4 (December 7, 2006)
On page 5, last paragraph, the last sentence states, "However, if more up to date information is available, it should be incorporated if significant." This position does not define significant or what is expected of the owner/operator if the more up to date information is identified following design and construction.

NRC Response:
Significant information would be that which can have an impact to the site hazard estimate. Sensitivity tests can be used to determine if the new source information is significant or not.

Resolution:
The staff will add wording to provide more clarity.

NEI General Comment 1 (December 28, 2006)
The terms, "Existing Probabilistic Seismic Hazard Assessment (PSHA) database," and "accepted probabilistic seismic hazard studies," appear at various places throughout the text of the draft Regulatory Guide DG – 1146. The draft does not adequately define what is meant by these terms. We recommend that these terms be replaced with the term, Acceptable PSHA model and be defined in the glossary as follows:

Acceptable PSHA model is a method of conducting a Probabilistic Seismic Hazard Analysis (including the seismic sources and ground motion equations) that has been developed using Senior Seismic Hazard Analysis Committee (SSHAC) guidelines and that has been reviewed and accepted by the NRC either for generic application (e.g. the 1989 studies by LLNL and EPRI, with the inherent seismic source description for the CEUS) or as part of an ESP or COL application. Acceptable PSHA models are starting points for developing probabilistic seismic hazard calculations for new ESP or COL applications, yet must be updated with new information on seismicity, geology, geophysics, and ground motion equations, as appropriate for a site that is being reviewed.

NRC Response:
The proposed definition above is in line with NRC staff views.

Resolution:
The staff will add the proposed definition with some modifications to the glossary (Appendix A).

Jeffrey K. Kimball Comment 2 (December 13, 2006)
In three places DG-1146 uses the phrase "accepted probabilistic seismic hazard studies" (see Section B pages 3 and 4, Appendix C page C-1), without defining what these studies are. On page 5 DG-1146 refers to two PSHA studies (Electric Power Research Institute {EPRI} and Lawrence Livermore National Laboratory {LLNL}), and states that "these databases may still represent the latest information available for some seismic sources" (emphasis added). In section C 1.1, page 10, the text discusses situations where new data or interpretations are not adequately incorporated into the existing PSHA database (emphasis added), without defining what these databases are. It is not clear how such language will improve the process for siting of nuclear power plants.

NRC Response:
The term "accepted probabilistic seismic hazard studies" refers to site-specific studies previously accepted by NRC staff. It is expected that over the lifespan of Regulatory Guide 1.208 some of the information used in specific PSHA calculations (e.g. specific source characterizations) will need to be updated. Because seismic hazard analysis and fault studies are areas of active research, it is expected that at any future point in time previously accepted information may still represent the latest information available for some seismic sources and information; but not for others. For this reason, the NRC staff does not explicitly state in Regulatory Guide 1.208 that it will accept source information from any seismic source database (e.g. EPRI, LLNL or the USGS) because some sources detailed in these resources will inevitably become outdated. However, for stability it is noted that the most recent information submitted in support of applications and accepted by the NRC can be used as a starting point.

Resolution:
The staff has edited the language in this section to more directly address the above discussed issues. The phrase, "accepted probabilistic seismic hazard studies" has been adjusted for clarity and has been added to Appendix A.

Jeffrey K. Kimball Comment 4 (December 13, 2006)
Comprehensive PSHA studies have been completed by the United States Geological Survey (USGS) as part of the national seismic hazard mapping project, with results published in 1997 and 2002. The USGS work is being updated for release in 2007. The information and data from the USGS work provides important insight into how the informed scientific community views the assessment of many seismic hazard issues. While some issues are obvious, such as paleoliquefaction findings near Charleston, South Carolina, New Madrid, Missouri, and Wabash Valley, Illinois, other issues are more subtle, such as the preference for smoothed seismicity versus detailed definition of area seismic sources in low seismic hazard environments. The USGS PSHA work is not discussed in DG-1146. The USGS PSHA work can not be ignored given that it represents the most recent comprehensive PSHA work for the United States.

NRC comments:
USGS hazard maps are constantly updated. However, these maps are not targeting critical facility siting studies with long return periods, but civilian structures with shorter return periods. USGS is playing an important role in assisting NRC staff to review each application.

Resolution:
The staff has added a reference to the USGS source database.

6.3 Attenuation Relationships

NEI General Comment 4 (December 7, 2006)
The draft should provide guidance for ground motion modeling for sites located in the WUS, referencing the PEER Next Generation of Attenuation (NGA) models. As the NGA models apply primarily to California, additional guidance is required for modeling ground motion in the plate boundary subduction region of the Pacific Northwest and in the Basin and Range and Rocky Mountain regions. It would be most appropriate to place general guidance in the Regulatory Guide with reference to detailed guidance on modeling ground motion to be provided in the SRP.

> NRC Response:
> The NRC staff recognizes that the NGA relationships represent a significant advancement in the area of WUS seismic hazard assessment and warrants a mention in the document. The NRC staff view is that any methods that find consensus within the scientific community should be considered and reviewed. The updated SRP Section 2.5.2 will also discuss the topic.
>
> Resolution:
> The staff has added a brief discussion of the NGA relationships in Section B of Regulatory Guide 1.208.

Public Comments at NRC Public Meeting Comment 8 (December 14, 2006)
Industry representatives noted that DG-1146 should provide more guidance for ground motion in WUS sites. Some specific topics include the narrow definition of hard rock, which is more appropriate for CEUS that WUS, and the discussion of attenuation relationships that are CEUS based.

> NRC Response:
> Regulatory Guide 1.208 will address both issues raised during the public meeting. Where rock conditions have been mentioned, the terminology has been broadened and generally the term "generic rock" has been use to replace "generic hard rock." This is discussed further in the "Definition of Rock" Section of this document. As noted above, Regulatory Guide 1.208 will include a discussion of the NGA relationships.
>
> Resolution:
> The staff will update the document as noted.

NEI General Comment 2 (December 28, 2006)
The industry comment in the referenced letter relating to the need for guidance for Western U.S. sites should not delay issuance of the Regulatory Guide. This topic could be developed and included as a revision later.

> NRC Response:
> The NRC staff accepts the recent NGA relationships for seismic sources for which they are explicitly designed (shallow crustal faulting in active regions of the WUS) and will note this is in Regulatory Guide 1.208. In addition, the NRC staff will continue to review the acceptability of the NGA relationships for other cases. However, as with all seismic information, these tools may be used as a starting point and any new information available must be reviewed.
>
> Resolution:

The staff has added a brief discussion of the NGA relationships to Section B of Regulatory Guide 1.208.

EPRI Minutes NRC Public Meeting Comment 4 (December 14, 2006)
The industry comment on DG-1146 relating to the need for guidance for Western US sites should not delay issuance of the regulatory guide. This topic could be developed and included as a revision later.

NRC Response:
See response to NEI General Comment 2, above.

6.4 Epsilon and Sigma Values in PSHA

NEI General Comment 3a (December 7, 2006)
The draft does not clearly state the acceptability of using post-EPRI (2004) attenuation relation variability estimates developed in EPRI Task G.3, *("Topical Report 1009684, CEUS Ground Motion Project Final Report")* nor does the draft provide clarity in regards to acceptable approaches for performing dynamic site response analysis to develop site response functions and obtain the uniform hazard response spectra at the surface or appropriate control location of non-hard rock sites. The industry needs generic resolution of these two issues. It is our judgment that the EPRI Task G.3 sigma estimate has strong technical support and is the appropriate current practice.

NRC Response:
This comment discusses two topics. For a discussion of the EPRI Task G.3 sigma value, see comments below. For a discussion of dynamic site response, please see the "Site Response Analysis Methods and Use of Results" section on page 29 of this document.

NEI Specific Comment 7 (December 7, 2006)
On Page 7, topic "Choice of Epsilon in Probabilistic Seismic Hazard Analysis," the aleatory uncertainty, sigma, results from the second part of Task G1.3 have been omitted. This paragraph should be expanded to document the reduced values of sigma documented in the Pacific Earthquake Engineering Research Center (PEER) Next Generation Attenuation study and reported in the results for Task G1.3.

NRC Response:
See response below Bechtel Comment 6c.

Public Comments at NRC Public Meeting Comment 4 (December 14, 2006)
Industry representatives noted that the NRC should clearly accept post-EPRI (2004) sigma estimates as developed in Task G1.3. It was noted that while DG 1146 specifically discussed epsilon that need to be used in the PSHA, it does not discuss the update to sigma proposed in the same document. Industry representatives questioned if this meant that the change in sigma was still in question.

NRC Response:
See response below Bechtel Comment 6c.

EPRI Minutes NRC Public Meeting Comment 2 (December 14, 2006)
DG-1146 specifically accepts the conclusion of Task G1.3 that attenuation variability cannot be bounded/truncated based on currently available data; however, it is silent on the recommended values of Sigma to be used in the analyses.

NRC Response:
See response below Bechtel Comment 6c.

Bechtel Comment 6c (December 13, 2006)
RG 1.165 gave few details concerning computing of site-specific amplification factors. DG-1146, benefiting from experience beginning to be gained from work on recent ESP and COL applications, attempts to do more to help applicants in this regard. However, further changes and clarifications to the wording are needed. A few specific examples of topics needing clarification or correction are:

c. Silence on the matter of adoption of revised "sigma" estimates for EPRI (2004) attenuation relations developed as part of the New Plant Seismic Issues Resolution Program.

NRC Response:
While a discussion of epsilon is warranted in a general discussion of PSHA and applies equally for any attenuation relationship, the sigma value being discussed addresses a specific relationship. As such, it is not appropriate for Regulatory Guide 1.208 to discuss this topic. However, in the public meeting of December 14, 2006 it was noted that the NRC staff has accepted the new sigma values in previous public meetings and continues to do so.

Resolution:
No changes to DG-1146 are required.

NEI Specific Comment 14 (December 7, 2006)
On page 14, section C.3.3, "Conduct a Probabilistic Seismic Hazard Analysis," next to the last sentence, the word "epsilon" is not the appropriate term and should be replaced with "standard deviation of natural log of ground motion." Note that on page 7, section titled "Choice of Epsilon in Probabilistic Seismic Hazard Analyses" epsilon is used correctly and is consistent with Reference 15 of DG-1146, i.e., (Electric Power Research Institute (EPRI) and U.S. Department of Energy (DOE), "Program on Technology Innovation: Truncation of the Lognormal Distribution and Value of the Standard Deviation for Ground Motion Models in the Central and Eastern United States," Report 1013105, February 2006).

NRC Response:
The NRC staff agrees with the comment.

Resolution:
The staff will replace the word "epsilon" with "standard deviation of natural log of ground motion".

Bechtel Comment 15 (December 13, 2006)
Page 7, "Choice of Epsilon in Probabilistic Seismic Hazard Analyses." It is stated that large epsilon values should be used to capture low probability events. It is recommended that the discussion be expanded to include consideration of the limitations of the source and transmissibility of the motion to the site.

NRC Response:
This is an area of ongoing research. A full discussion of this topic is outside the scope of this document and will likely become out of date over the life of the document. As a result, the reader

is instead referred directly to the recent study. As research progresses, the NRC may revisit this issue and provide stronger guidance.

Resolution:
No changes to DG-1146 are required.

6.5 Cumulative Absolute Velocity (CAV) Filtering

NEI Statement of Interpretation 1 (December 7, 2006)
NEI has interpreted DG 1146 to allow the following: The use of a CAV-based lower bound magnitude cutoff when developing the PSHA - on Page 7

NRC Response:
This is correct.

Resolution:
No changes to DG-1146 are required.

Public Comments at NRC Public Meeting Comment 5 (December 14, 2006)
Industry representatives noted general agreement with the guidance related to the use of the CAV-based lower magnitude cut off, the location of SSE as described, using the site response parameters and results to determine the motions at the foundation level, and using the ASCE 43-05 performance goal-based approach.

NRC Response:
See response to NEI Statement of Interpretation, above.

Bechtel Comment 17 (December 13, 2006)
Page 7, "Lower Bound Magnitude Cutoff." This section states that, "An empirical model for estimating CAV in terms of magnitude, peak ground acceleration (PGA), and duration is needed because the PSHA calculation does not use time histories directly." This statement leaves the impression that the industry needs to develop a new model before the CAV method can be used. Is this the intent?

NRC Response:
The purpose of CAV filtering is to remove from the PSHA earthquake scenarios that contribute to hazard (as characterized by the response spectrum) but that do not have the potential to damage. In this case a CAV filter on the foundation motion is replaced by a minimum magnitude truncation threshold. This minimum magnitude is an appropriate engineering parameter derived from the correlation between damage and. NRC has reviewed and accepted the CAV model addressed in task G1.2, "Use of CAV in determining effects of small magnitude earthquakes on seismic hazard analysis." Because of the requirements of NPP design, the approximation made is acceptably accurate. However, because there is some uncertainly associated with a lower bound magnitude cutoff that does not directly account for factors such as site effects, the NRC plans to continue to research CAV filtering and continue the existing dialogue with stakeholders on this topic.

NRC Response:
No changes to DG-1146 are required.

7 Site Response Analysis Methods and Use of Results

7.1 Use of Site Response Transfer Functions

NEI Statement of Interpretation 3 (December 7, 2006)
NEI has interpreted DG 1146 to allow the following: Transferring the SSE response spectrum from the control location to foundation levels using the appropriate site response functions obtained from the dynamic site response analysis - in Section 5.4, Page 18

> NRC Response:
> SSE in this comment is recognized as what the NRC is now defining as the GMRS. There should be consistency between the models and the results of the site response analyses used for development of the SSE and other directly related analyses. As was discussed in the public meeting of December 14, 2006, the site-specific, SSE-consistent response spectrum developed at the foundation level (for purposes of providing a comparison to an appropriate spectrum with a PGA of 0.1g) may be calculated as a free-field surface motion based on the properties used in the site response analyses.
>
> Resolution:
> No changes to DG-1146 are required.

NEI General Comment 1 (December 7, 2006)
On the development of site-specific spectra (Section 4.3), the recommendation for enveloping spectra will give invalid spectra and should be modified. The reason is that the low-frequency earthquake will not have much energy content at high frequencies, so the soil will remain more linear at high frequencies and the amplification factors (soil/rock) will be higher than for the high-frequency earthquake. This means that the low-frequency site amplification applied to the UHRS will control the high-frequency envelope. This is not the intended result. Additionally, it is important to anchor any recommended site spectrum to amplitudes at the frequencies calculated by the PSHA. In recent ESP submittals this has been 7 frequencies (100, 25, 10, 5, 2.5, 1, and 0.5 Hz). A better statement would be:

> To determine the UHRS at the free ground surface, examine the mean surface spectra calculated for the high-frequency and low-frequency input motions, and determine over what frequency range each controls the surface motion. At high frequencies, this will be the high-frequency motion, and at low-frequencies, the low-frequency motion. Apply the appropriate (high- or low-frequency) amplification factors for each frequency range to the mean UHRS to calculate the UHRS at the free ground surface. This should be done at the frequencies where the rock PSHA was calculated, using the rock UHRS values, and at intermediate frequencies using appropriate spectral shapes for the high- and low-frequency ranges.
>
> NRC Response:
> See response below NRC Public Meeting Comment 10.

Public Comments at NRC Public Meeting Comment 10 (December 14, 2006)
Industry representatives noted that the methods used in development the SSE spectrum needs to ensure that the exceedance frequencies of the UHRS are maintained at the surface over all structural frequencies of interest. They further explained their position through examples provided by Dr. McGuire. Through discussion it was clarified that the proposed NEI approach (i.e. multiplying the site amplification factors by the UHRS -- not the individual characteristic earthquakes) was what the NRC had intended to convey. The NRC will review the language in DG 1146 to make this point clearer.

> NRC Response:
> The comments above express, correctly, that the wording in DG-1146 is not sufficiently general and could lead to cases in which using the method described results in surface spectra that do not represent uniform hazard for all spectral periods.
>
> Resolution:
> A revision to Regulatory Guide 1.208 has been made to address the issue.

Bechtel Comment 35 (December 13, 2006)
Page E-3, last paragraph on the page. This paragraph includes the following wording:

> "Once the soil amplification functions are developed, they are applied to the free field rock UHRS to develop two free-field soil spectra. To determine the soil UHRS at the free-field ground surface, for each of the annual exceedance frequencies (1 E-04, 1 E-05, and 1 E-06), multiply the rock-based UHRS at all 25 points and the natural frequency of the site soil column by the site amplification functions, and envelop the results. These two curves are enveloped to determine the final free-field soil UHRS. If the two controlling earthquake response spectral shapes cover a broad range of frequencies such that when scaled and enveloped they approximate the UHRS, then it is also acceptable to multiply the high- and low-frequency controlling earthquake spectra by the appropriate site amplification function and envelope the results."

Two potential problems are identified with this wording. First, the wording states "25 points" when it appears it should state "30 points," despite the problem with having 30- point rock UHRS, discussed previously. More importantly, two approaches are discussed. The first describes that the high- and low-frequency developed amplification factors are applied to the entire rock UHRS spectrum, and the results enveloped to get the corresponding soil UHRS. This approach does not appear to be correct. Even as shown in the example in the draft guide, the high-frequency rock spectrum used as input for site response analysis has higher spectral values at high frequencies than the low frequency rock spectrum at those high frequencies. Due to nonlinear site response, it may be expected that the low-frequency amplification factors at those high frequencies will be higher than the corresponding high-frequency amplification factors at those high frequencies; however, this real possibility is reversed in Figure E.2. Given nonlinear response as expected, the low-frequency amplification factors will give higher soil UHRS values at high frequencies than the application of the high-frequency amp factors at those high frequencies. This conclusion appears counter-intuitive however. The application of the second "acceptable" method appears more reasonable and what the industry has usually followed. Note that this same methodology is again repeated in Section E.4.

NRC Response:
As noted in the response to the comments at the public meeting on December 14, 2006, above, this wording has been changed. The comment notes that the second method discussed is consistent with what applicants have followed in the past. This is true because the method follows from the guidance in Regulatory Guide 1.165. However, it has been removed from Regulatory Guide 1.208 to promote overall consistency with the basis that is the focus of this document. Regulatory Guide 1.165 will continue to be accepted as an alternate to Regulatory Guide 1.208.

Resolution:
The staff has edited this language in this section has been edited for clarity and consistency.

7.2 Alternative Time History Based Site Response Techniques

NEI General Comment 3b (December 7, 2006)
Approaches 2A, 2B, 3, and 4 described in NUREG/CR-6728 and -6769 all are reasonable methods for performing the dynamic site response evaluations that represent the site material variability estimates and should be permitted for use in regulatory practice.

NRC Response:
See the response at the end of this section.

NEI Specific Comment 17 (December 7, 2006)
On page 16, section C.4.3, "Site Amplification Function," second sentence states "To determine the UHRS..., multiply the rock based UHRS by the high frequency and low-frequency site amplification functions separately, and envelop the two results." This appears to be a recommendation for method 2A. Please note that the industry comment in the cover letter provides a recommended rewording of this sentence.

NRC Response:
See the response at the end of this section.

Public Comments at NRC Public Meeting Comment 7 (December 14, 2006)
Industry representatives noted that DG-11146 should address dynamic site response analysis approaches to (1) develop site response function and (2) to obtain UH response spectra at surface/control locations. In particular it should accept approaches 2A, 2B, 3, and 4 from NUREG/CR-6728 and 6729 explicitly. Industry representatives asked the NRC if there is anything that they [industry] could do to make the NRC more comfortable with these approaches.

NRC Response:
See the response at the end of this section.

EPRI Minutes NRC Public Meeting Comment 3 (December 14, 2006)
The descriptions in DG-1146 of dynamic site response analysis appear to relate only to method 2A of NUREG/CR 6728. Methods 2B, 3 and 4 are more accurate and should also be acceptable.

NRC Response:
See the response at the end of this section.

Bechtel Comment 1c (December 13, 2006)
The single most important change between RG 1.165 and DG-1146 is the change from the reference probability approach to the performance-based approach. This change, principally by reference to ASCE 43-05, is well defined and easy to follow. There are, however, a number of fundamental issues within NRC regulations and their CFR antecedents that neither RG 1.165 nor DG-1146 address. Principle among these is:

b. Clear definition of an acceptable method to analyze site-specific amplification.

NRC Response:
See the response at the end of this section.

Dr. Carl Constantino Comment 1 (December 2, 2006)
The current draft implies the use of Method 2A only in the description.

NRC Response:
See the response at the end of this section.

Bechtel Comment 32c (December 13, 2006)
Page E-2, 4th paragraph of Section E.3, "Site Response Analysis."

c. The methodology presented in this Appendix follows Approach 2 given in NUREG/CR-6728. There is no discussion of other approaches (e.g., Approach 3 or 4). Consideration should be given to including Approaches 3 and 4.

NRC Response:
See the response at the end of this section.

Jeffrey K. Kimball Comment 9 (December 13, 2006)
Appendix E provides guidance related to seismic wave transmission analysis including section E.3, Site Response Analysis. The NRC sponsored a comprehensive study of ground motion related issues, published as NUREG/CR-6728, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard and Risk Consistent Ground Motion Spectra Guidelines*. Chapter 6 of NUREG/CR-6728 describes procedures for developing hazard consistent spectra on soil, and provides 4 approaches for developing soil ground motions. While Appendix E of DG-1146 provides useful guidance on site response related issues, the approach for developing soil ground motions represents only 1 of the 4 approaches from NUREG/CR-6728 (approach 2). This would suggest that NRC does not encourage any of the other 3 approaches described in NUREG/CR-6728. Section E.3 of Appendix E should be expanded to provide guidance for completing soil ground motions following approaches 3 and 4 from NUREG/CR-6728.

NRC Response:
See the response at the end of this section.

Similar comments are also included in NEI General Comment 3a (December 7, 2006).

NRC Response:
The NRC staff recognizes that this is an important issue. The NRC staff is in agreement that while one acceptable site response method has been discussed in detail in DG-1146, other approaches can also be accepted, including the alternate methods described in NUREG/CR-6728. The NRC staff also recognizes that the prescriptive nature of the appendices in DG-1146 may have lead to confusion.

Resolution:
Appendices D and E of regulatory guide 1.208 will be edited to make them less prescriptive. A comment on the acceptability of other methods, particularly those in NUREG/CR-6728, will be added.

7.3 Random Vibration Theory (RVT)

NEI Specific Comment 8 (December 7, 2006)
On page 8, topic "Site Response Analysis," second line, the words "may be" should be inserted prior to "used." A frequency-domain procedure (RVT) can be used for site response, which is just as valid as a time-domain procedure.

NRC Response:
The existing language can be expanded to better address random vibration theory (RVT).

Resolution:
The staff will incorporate some discussion in DG-1146.

NEI Specific Comment 9 (December 7, 2006)
Also, the time-domain procedure is assumed on pages 57-58 (Pages E-2 and E-3) in the discussion of time histories and required sets of randomized parameters. This discussion should be changed to at least say, "If a time-domain procedure is used to calculate site response…."

NRC Response:
The existing language can be expanded to better address random vibration theory (RVT).

Resolution:
The staff will incorporate some discussion in DG-1146.

NEI Specific Comment 26 (December 7, 2006)
On page E-1, section E.1 item (2), the words, "If a time-domain procedure is used to calculate site responses," should precede "Performing a suite of site…" This is consistent with our comment 8.

NRC Response:
The existing language can be expanded to better address random vibration theory (RVT).

Resolution:
The staff will incorporate some discussion in DG-1146.

Bechtel Comment 6d (December 13, 2006)
RG 1.165 gave few details concerning computing of site-specific amplification factors. DG-1146, benefiting from experience beginning to be gained from work on recent ESP and COL applications, attempts to do more to help applicants in this regard. However, further changes and clarifications to the wording are needed. A few specific examples of topics needing clarification or correction are:

d. Silence on (or implied exclusion of) RVT rather than SHAKE, and Approach 4 rather than Approach 2 (NUREG/CR-6728), analysis of site-specific amplification factors.

NRC Response:
In general, either time history and RVT-based procedures can be used if the appropriate issues are addressed.

Resolution:
The staff will add general wording on RVT to Regulatory Guide 1.208.

Bechtel Comment 14 (December 13, 2006)
At times, the draft guide is very specific [explicit formulas for Mbar and Dbar; 60 convolution analyses for site response analyses] while, at other times, the wording in the draft guide is somewhat vague about certain issues [site response methods, e.g. Method 2A/3; number of time histories to be used in site response analysis]. As a result, a number of issues are not resolved in the draft guide:

- NRC-acceptable approaches on site response: 2A, 2B, 2A/3
- Use of RVT
- Sigma: not just truncation of epsilon, but what of limiting sigma itself. It is recommended that these issues be addressed in the draft guide.

NRC Response:
For a discussion of sigma, please see the section entitled "Epsilon and Sigma Values in PSHA" on page 26 of this document. For a discussion of RVT, see comments above. For a discussion of alternate time-domain based site response methods, see Section 7.2 of this document.

Bechtel Comment 10 (December 13, 2006).
In a number of locations, the draft guide assumes the soil column analysis is limited only to time history analysis. Currently, soil column analyses are also performed using the random vibration theory (RVT) along with randomized soil profiles and strain-dependent soil properties. For RVT analysis, guidance is needed on the input motion in terms of the acceleration response spectrum and its associated damping and duration.

NRC Response:
In general, the NRC staff currently prefers time history based procedures to RVT based procedures, although both are acceptable. Research on RVT is ongoing and any guidance developed by the NRC staff will be provided in revisions of Regulatory Guide 1.208.

Resolution:
General wording on RVT has been included in Regulatory Guide 1.208.

7.4 Controlling Earthquakes for Site Response Analyses

NEI Specific Comment 6 (December 7, 2006)
Also on page 7, topic "Deaggregation of Mean Hazard," first sentence lists 1E-06 as a mean annual probability. This probability is not needed if the ASCE/SEI Standard 43-05 Performance-Goal based approach is used.

NRC Response:
See response below Bechtel Comment 16.

Bechtel Comment 6b (December 13, 2006)
RG 1.165 gave few details concerning computing of site-specific amplification factors. DG-1146, benefiting from experience beginning to be gained from work on recent ESP and COL applications, attempts to do more to help applicants in this regard. However, further changes and clarifications to the wording are needed. A few specific examples of topics needing clarification or correction are:

c. Confusion over the need for involving 1E-06 motions in guidelines for the SSE that, under ASCE 43-05, requires only 1E-04 and 1E-05 UHRS.

NRC Response:
See response below Bechtel Comment 16.

Bechtel Comment 24 (December 13, 2006)
Page 16, Section C.4.3, "Site Amplification Function."
This section of the draft guide states that "1E-04 and 1E-05 UHRS are used to determine the performance-based SSE." On Page 15, Section C.3.5, consideration of 1E-06 annual frequency is also required. If the first two are adequate to define the performance-based seismic design criteria, why is the higher level of ground motion considered? See also the comment for Page 14, Section C.3.4.

NRC Response:
See response below Bechtel Comment 16.

Bechtel Comment 16 (December 13, 2006)
Page 7, "Deaggregation of Mean Hazard," and Appendix E. It is not clear why motion at 1E-06 is needed if the ASCE performance based approach is used. See also the comment for Page 14, Section C.3.4.

NRC Response:
Although the 1 E-06 annual probability is not used as a basis for design, it is requested by the NRC staff for several reasons. This information is used as a check for reasonableness against historic seismicity and against the seismic source database. This information is also used with fragility curves to calculate core damage frequency. The NRC staff also needs the full range of hazard curves for ongoing work to confirm that existing methods ensure adequate performance. Lastly, an important application for the 1 E-06 curves is to verify the performance based results when hazard slope behaves non-linearly on a log-log plot after applying CAV filters.

Resolution:
This staff has added information to Regulatory Guide 1.208.

Bechtel Comment 18 (December 13, 2006)
Page 7, "Deaggregation of Mean Hazard." This section defines the high frequency range as between 5 to 10 Hz. This definition appears to be inconsistent with many studies which define the high frequency motion as greater than 10 Hz. This discrepancy should be addressed.

NRC Response:
This comment applies to a section that discusses site response analyses. The deaggregation of the mean hazard is performed for the purpose of choosing meaningful controlling earthquakes, which are themselves used as a basis for development of time histories necessary for time-domain based site response analyses. The term high frequency in this context relates to the high frequency end of the frequency band that impacts soil response. In the discussions of other topics, particularly incoherency, the term high frequency relates to the range of frequencies that are of particular interest for hard rock sites. Because the frequency range of interest is different for soil and hard rock, the description of what constitutes high frequency also differs.

Resolution:
No changes to DG-1146 are required.

Dr. Carl Constantino Comment 17 (December 2, 2006)
FigE.1: The figure shows the low frequency controlling earthquake spectrum matching the mean UHRS at about 3 Hz rather than at 1.75 Hz and the high frequency controlling earthquake matching at 6.5 Hz rather than 7.5 Hz. The word spectra should be changed to spectrum on the figure.

NRC Response:
The plot has been removed in an effort to bring better cohesion to the overall document.

Resolution:
The plot has been removed in an effort to bring better cohesion to the overall document.

Bechtel Comment 31a (December 13, 2006)
Page D-5, Step 9.

a. The draft guide states that the controlling spectra should be based on the magnitude and distance values taken from the deaggregation and appropriate ground motion models. Later in Section D.3, which gives an example for a CEUS site, the draft guide comments that an appropriate ground motion model would be the EPRI attenuation ground motion models. It is noted that, for current ESP and COL applications, controlling spectra have been/are being developed based on the CEUS spectral shapes given in NUREG/CR-6728 rather than the EPRI ground motion model. This was performed based on the ease of use and also because the CEUS spectral shapes are defined for additional spectral periods over the range of 100 Hz to 0.1 Hz. It is recommended that the draft guide identify this alternate acceptable approach.

NRC Response:
The NRC staff agrees with this comment.

Resolution:
The staff has added language that identifies the use of NUREG/CR-6728 spectral shapes as an acceptable approach.

Bechtel Comment 31b (December 13, 2006)
Page D-5, Step 9.

b. This step describes where the high- and low-frequency spectra are scaled to match the "site rock accelerations at 5 and 10 Hz (high-frequency) and 1 and 2.5 Hz (low-frequency)." Does this mean at 7.5 and 1.75 Hz, respectively? What about the remaining 26 spectral ordinates that were required to be calculated in the PSHA? Also, note the following wording from Section C.4.3:

> "Based on the suite of site response analyses described in Regulatory Position 4.2, site amplification functions are calculated. To determine the UHRS at the free-field ground surface for a specific annual probability of exceedance, multiply the rock-based UHRS by the high-frequency and low-frequency site amplification functions separately, and envelop the two results. If the two controlling earthquake response spectral shapes cover a broad range of frequencies such that when scaled and enveloped they approximate the UHRS, then it is also acceptable to multiply the high- and low-frequency controlling earthquake spectra by the appropriate site amplification function and envelope the results. The surface 1 E-04 and 1 E-05 UHRS are used to determine the performance-based SSE."

The typical scaling to the 7.5 and 1.75 Hz often causes the high frequency spectral shape to sometimes notably exceed the available high frequency PSHA values -- e.g., 25 Hz and PGA PSHA value. Similarly, the low-frequency spectral shape scaled typically to 1.75 Hz under-represents the available low frequency PSHA values -- e.g., 0.5 Hz. It is recommended that

Appendix D provide a discussion about the spectral scaling and the actual PSHA values, as does ASCE 43-05. Also, it is recommended that Appendix D continue with the example to completion, performing the spectral scaling and enveloping.

NRC Response:
The purpose of the controlling earthquakes concept as provided in the appendices is to provide a technical basis for the development of input ground motions to be used in one simplified method of approaching site response analyses. Because soil response is non-linear, it is important that the loads applied are similar to those that contribute most to the hazard at the return period (and frequency range) of interest. Two controlling earthquakes are used in the example. If the frequency ranges represented by these two spectra have a significant gap (such that the amplification factors for that range would not be accurate), then additional controlling earthquakes should be added to address this gap.

If the analyst believes that the controlling earthquakes will not ultimately lead to an accurate estimation of the impact of site response, then a more complex and robust method should be used. This is just one method that is acceptable for many cases; but there are other methods that address time history development in different ways. The important factor is that any method used, be it simplified or complex, must accurately determine the final site specific ground motion.

Resolution:
The staff has added a comment on instances in which there are gaps over significant frequency ranges and included a reference to NUREG/CR-6827 in Regulatory Guide 1.208.

Bechtel Comment 28 (December 13, 2006)
Appendix D, General. Appendix D is specific about the method of determining controlling earthquakes. In a couple of locations, however, the wording could be more explicit in description:

- Step 2(b) says to "calculate the average of the ground motion level . . . ." So as not to cause confusion, this wording could explicitly say "linear average . . ." or even "simple linear average…."
- Appendix D mentions that there may be situations where "alternative binning schemes as well as a study of contributions from various bins will be necessary to identify controlling earthquakes consistent with the distribution of the seismicity." One of the different binning schemes could be a re-defining of the distance bins, the center value being the "centroid of the ring area." It would be most helpful to explicitly define this or give a reference for its calculation. Also, a definition of the "centroid of the ring area" should be included.

NRC Response:
The first change proposed in the comments would add clarity to Regulatory Guide 1.208. The second comment discusses alternative binning schemes. The comment in Regulatory Guide 1.208 was not meant to imply different methods of defining distance. Rather, it was meant to allow for alternative bin allocations based on the locations and seismic potential of sources used in the PSHA.

Resolution:
The staff has edited Regulatory Guide 1.208 to address the first comment. No changes are required based on the second comment.

Bechtel Comment 36 (December 13, 2006)
Page E-3. De-aggregated scaled rock spectra may exceed the rock UHRS as shown in Figure E.1. The soil amplifications are computed using the de-aggregated motion. This may "overdrive" the soil column when compared to the rock UHRS motion and, depending on the site and its degree of soil nonlinearity, may reduce the soil amplification. It may best to "conform" the scaled de-aggregated to the rock UHRS before it is used for soil column analysis. The resultant soil amplifications can be applied to the rock UHRS to obtain soil UHRS.

NRC Response:
The example provided is only one option for performing site response analyses. This method represents one of the more simplified approaches discussed in NUREG/CR-6728. In some cases, issues can occur that lead the analyst to use a different method. It is expected that simplified methods, and indeed all methods, are chosen to best address the issues at hand. If this simplified method is used, it may be expected that the scaled rock spectra will exceed the UHRS at some points.

Resolution:
The staff has edited DG-1146 to discuss alternate site response methods, particularly those in NUREG/CR-6728.

7.5 Additional Comments

Dr. Carl Constantino Comment 15 (December 2, 2006).
Line D377 "..a deaggregation of the <u>mean</u> PSHA."

NRC Response:
The clarification is required.

Resolution:
The staff has incorporated the proposed changes.

NEI Specific Comment 27 (December 7, 2006)
On page E-2, section E.3, "Site Response Analysis," fourth paragraph, fifth line, the word "within" should be replaced with the word "outcrop."

NRC Response:
See response below.

Bechtel Comment 33 (December 13, 2006)
Page E-2, 5th paragraph of Section E.3, "Site Response Analysis." It is suggested that the word "within" be revised to "outcrop."

NRC Response:
The within motion is correct in the context in which it was intended, though the wording in DG-1146 is confusing. Thus, some additional wording is in order. This line was added because, in the experience of NRC staff, some analysts do not realize that many site response programs must first convert the original outcrop motion to a within motion.

Resolution:
The staff will revise the wording.

Dr. Carl Constantino Comment 11 (December 2, 2006)
The issue of the number of convolution analyses needed for the Monte Carlo procedure depends upon the parameters of the soil column and the requirements for output. Typically, we have found that 30 are adequate to achieve the mean iterated profile and the mean estimate of the surface spectrum. Increasing this to 60 is fine and is in fact what we typically do to get a better estimate of the UB and LB site profile. However, to achieve a "reliable" estimate of the standard deviation may require more than 60 realizations.

NRC Response
The NRC staff agrees with the comment.

Resolution
The staff will add appropriate wording to Regulatory Guide 1.208.

Bechtel Comment 32a (December 13, 2006)
Page E-2, 4th paragraph of Section E.3, "Site Response Analysis."

a. The draft guide states that the spectra from the controlling earthquakes (i.e., high and low frequency cases) must be checked against the uniform hazard spectrum at the natural period of the soil column. The controlling earthquake must envelop the UHS at this spectral period. It is noted that, to our knowledge, this additional check has not been/is not being performed for the current ESP and COL applications, although it is not expected to be violated.

NRC Response:
Because the technique detailed in DG-1146 is a simplified method, some checks to ensure that the assumptions inherent in the method are met are warranted. One assumption is that the scenarios used appropriately capture likely soil behavior. Because the soil response is highest at the natural period of the soil, applying a suite of cases that are deficient in this range violates the assumptions of the simplified procedures. The NRC staff has begun to perform this check.

Resolution:
The staff has added text to Regulatory Guide 1.208 explaining the purpose of this check.

Bechtel Comment 32b (December 13, 2006)
Page E-2, 4th paragraph of Section E.3, "Site Response Analysis."

b. The guide states that it is common practice to provide plots of PGA as a function of depth. It is noted that this may not have been done for the past ESP applications.

NRC Response:
In general practice, it is a common check to review the PGA profile with depth because issues with G/G_o curves, damping curves, and other soil properties in the model are often evident in this plot.

Resolution:

No changes will be made to DG-1146

Bechtel Comment 37 (December 13, 2006)
Pages E-4 through E-6. It would be preferable if Figures E.1, E.2, and E.3 were based on the same example to provide a sense of the effects of various variables.

NRC Response:
Some of the figures have been removed to streamline Regulatory Guide 1.208.

Resolution:
Because only one of the figures remains in Regulatory Guide 1.208, no actions are required by the staff.

8 Range and Number of Frequencies Provided for Review

NEI Specific Comment 15 (December 7, 2006)
On page 14, section C.3.4 "Hazard Assessment," a proposed re-write of this section is follows. It reflects the fact that hazard analyses can only be performed at structural frequencies for which equations have been developed for the probabilistic seismic hazard program; and the fact that fractile levels of 0.16, 0.5, 0.84, as well as mean are the most meaningful and adequately represent the seismic hazard for a site.

> Report fractile hazard curves at the following fractile levels (p) for each ground motion parameter: 0.16, 0.50, 0.85, as well as mean. Report the fractile hazard curves in tabular as well as graphical format. Also, determine the mean UHRS for annual exceedance frequencies of 1 E-04, 1 E-05, and 1E-06 at a minimum of 30 structural frequencies approximately equally spaced on a logarithmic frequency axis between 100 and 0.1 Hz.
>
> NRC Response:
> The proposed change in text provides a clear indication of the information desired.
>
> Resolution:
> The proposed change will be included in DG-1146 with the exception that the request for the 0.05 and 0.95 fractile will remain.

NEI Specific Comment 5 (December 7, 2006)
On page 7, topic "Spectral Frequency Range Considered in the Probabilistic Seismic Hazard Analysis," last sentence should be revised as follows with the underlined portion being an addition to the sentence: "…the hazard assessment should be conducted at a sufficient number of frequencies so that the final grouped motion spectrum can be reliably represented at a minimum of 30 frequencies…" This clarification is needed because ground motion equations do not exist for the CEUS at 30 frequencies. Similarly, on page D-1, section D.2 "Procedure To Determine Controlling Earthquakes," Step 1, third bullet, add between "assessment" and "at" the following words, "at a sufficient number of frequencies so that the final ground motion spectrum can be reliably represented." Also, on page E-3, last paragraph, fourth line, the draft states, "…all 25 points…" The basis for 25 is not provided; however, we assume that it is a misstatement of "a minimum of 30 frequencies." If this is the case, then inserting "sufficient number of frequencies so that the final grouped motion spectrum can be reliably represented" is also appropriate.

> NRC Response:
> See response below Bechtel Comment 22.

Jeffrey K. Kimball Comment 7 (December 13, 2006)
Appendix D provides a procedure to determine controlling earthquakes. Step 1 of this procedure states that the site-specific PSHA should be conducted at a minimum of 30 frequencies, approximately equally spaced on a logarithmic frequency axis between 100 and 0.1 Hz. DG-1146 provides no basis that a minimum of 30 frequencies are needed to accurately assess the uniform hazard spectra. This implies that a PSHA will require ground motion attenuation models at each of these frequencies, which is not within the current state of practice. While there may be a need to assess closely spaced frequencies in certain situations, such as higher frequencies (> 10 Hz) for hard rock sites, it will not be necessary for many situations in terms of accurately assessing the uniform hazard spectra.

NRC Response:
See response below Bechtel Comment 22.

Bechtel Comment 6a (December 13, 2006)
RG 1.165 gave few details concerning computing of site-specific amplification factors. DG-1146, benefiting from experience beginning to be gained from work on recent ESP and COL applications, attempts to do more to help applicants in this regard. However, further changes and clarifications to the wording are needed. A few specific examples of topics needing clarification or correction are:

a. Confusion over the number of frequencies for which UHRS can be computed directly (the 7 for which EPRI attenuation relations are defined) and the number for which UHRS are to be specified (variously 25 or 30 between 0.1 and 100 Hz). The seven-point UHRS can be interpolated/extrapolated for additional points but additional assumptions/choices must be made to allow this. The draft guide would be improved by giving clear detailed examples of acceptable methods by which this could be done.

NRC Response:
See response below Bechtel Comment 22.

Bechtel Comment 19 (December 13, 2006)
Page 8. The ground motion models for CEUS currently are limited to less than 10 frequency points. The required minimum values of 30 frequencies can only be met by interpolation of the motion in between the frequency points. Is this the intent?

NRC Response:
See response below Bechtel Comment 22.

Bechtel Comment 1d (December 13, 2006)
There are, however, a number of fundamental issues within NRC regulations and their CFR antecedents that neither RG 1.165 nor DG-1146 address. Principle among these is:

d. Definition of spectra for frequencies both much higher and lower than the 1-10 Hz frequency range used for the development of the SSE.

NRC Response:
See response below Bechtel Comment 22.

Bechtel Comment 22 (December 13, 2006)
Page 14, Section C.3.4, "Hazard Assessment." The draft guide describes that the PSHA is to be computed at a minimum of 30 frequencies equal spaced in log-space between 100 Hz and 0.1 Hz. In addition, fractile hazard curves should be computed for fractile levels of: 0.05, 0.16, 0.50, 0.84 and 0.95 as well as the mean. Uniform hazard spectra should be developed for annual probability levels of: 1E-04, 1E-05, and 1E-06. The requirement for computing hazard curves at 30 frequencies between 100 Hz and 0.1 Hz is not possible due to the limitation of the number of spectral periods contained in the current attenuation ground motion models. In addition, even ground motion attenuation models for the WUS do not typically go out to 10.0 second spectral period (i.e., 0.1Hz). The computation of the additional fractile levels and three AEP levels is not technically difficult or laborious, however, it is noted that this computation is not being performed for the current ESP and COL applications. No later discussion was found in the draft guide where the 1E-06 level ground motions are used. In fact, at the end of Section C.4.3 on Page 16, the draft guide states, "The surface 1E-04 and 1E-05 UHRS are used to determine the performance-based SSE."

NRC Response:
In DG-1146, ground motion values at 30 frequencies ranging from 100 and 0.1 Hz are requested. While attenuation relationships do not directly calculate values at 30 frequencies within this range, it is common to interpolate between points to create a more robust (and smoother) hazard curve. This interpolation is also required for actions such as performing spectral matching on time histories to be used in time-history based site response and SSI analyses. Typically, interpolation is performed for points equally spaced on a logarithmic frequency axis, though the results sometimes differ between analysts. The NRC staff has requested data at 30 points to ensure that the more robust and smoothed response spectrum being considered in reviews is the same for both the applicant and the NRC reviewers.

The staff also requests that a wide range of frequencies be reported. It is noted that attenuation relationships do not provide values for the full range of frequencies requested and CEUS and WUS relationships provide different ranges of frequencies. In the case of low frequency (long period) motions, one method that can be used to extrapolate the hazard curve is the $1/T$ to $1/T^2$ method. FEMA Report 450 provides a map of the long-period transition period for the United States and a description of the technique.

High frequency ranges beyond those provided by attenuation relationships are in a range where accelerations are assumed to become constant (approaching an infinitely stiff medium and the true PGA). As a result, the hazard levels calculated at the highest frequency provided by the attenuation relationship can be used for higher frequencies.

For the concerns regarding the 1 E-06 hazard curves, please see the response to Bechtel Comment 16.

Resolution:
No changes will be made to DG-1146.

9 Earthquake Recordings (Time Histories)

NEI Specific Comment 31 (December 7, 2006)
We recommend that Appendix F be modified to state that if a suite of time histories are being developed for use in site response analysis, that the criteria for spectral matching should be applied to the average response spectra for the suite of time histories.

NRC Response:
The NRC staff agrees with the comment though Appendix F already notes that the criteria apply to "the average of all accelerograms." However additional wording will be included to improve clarity.

Resolution:
The staff has edited DG-1146.

Bechtel Comment 23 (December 13, 2006)
Page 15, Section C.4.2, "Dynamic Site Response." The draft guide describes that, based on the high and low frequency target spectra from the deaggregation analysis, the site response is performed on a suite of randomized soil profiles and dynamic properties. Generally, at least 60 randomized cases should be performed to define the mean and standard deviation of the site response. Time histories can be selected from the NUREG/CR-6728 database or developed separately for the controlling earthquake and corresponding spectra (i.e., high and low frequency). It is noted in the draft guide that the library of time histories provided in NUREG/CR- 6728 is currently being updated and should be completed in the summer of 2007. The draft guide does not, however, present any information on the changes being made. It could be updating the time history libraries based on the collection of additional strong motion data (e.g., PEER NGA) since the original database was compiled. The discussion presented in the draft guide indicates that only SHAKE analysis would be acceptable for the site response analysis since the draft guide discusses the use of time histories which would not be needed in an RVT site response analysis. Although the draft guide suggests a suite of 60 randomized soil profiles, the draft guide does not discuss the use of multiple time histories matched to the same target spectrum. The draft guide states that 60 cases should be used to develop the mean and standard deviation of the site response; however, the standard deviation is not needed for the approach presented later in the document (i.e., approach 2 not approach 3 or NUREG/CR-6728). It is recommended that the wording on these issues in the draft guide be revised for clarity.

NRC Response:
The project to update NUREG/CR-6728 is ongoing and includes a review of the hazard curves and the time history database in light of current information. At this time, a discussion of the results cannot be provided. The use of multiple time histories is not discussed in DG-1146, but should be included in Regulatory Guide 1.208. Although the standard deviation of the site response is not further discussed in this document, it is required for later use in SSI and other analyses. The comment on RVT is addressed in Section 6.3 of this document. A discussion of RVT can be added to Regulatory Guide 1.208.

Resolution:
The staff has added information in Regulatory Guide 1.208 as noted.

Bechtel Comment 38 (December 13, 2006)
Pages F-1 and F-2. Appendix F provides the necessary criteria when developing spectrum compatible time histories. These criteria are very similar to the spectral matching criteria given in both NUREG/CR-6728 and ASCE 43-05. One additional check that is contained in these criteria is that the mean ratio (match to target spectrum) be greater than 1.0 over the frequency range of 0.2 - 25.0 Hz. It is noted that, although this specific criterion may not have been explicitly checked for some of the spectral matches for the previous ESP applications, it is not expected to be violated based on meeting the other matching criteria (e.g., no more than 9 consecutive points below the target).

NRC Response:
The NRC staff agrees with the comment.

Resolution:
The staff will include this check in Regulatory Guide 1.208.

Dr. Carl Constantino Comment 12 (December 2, 2006)
Line 556 (Section 4.2, last paragraph), "….the response spectrum and have characteristics appropriate for the controlling earthquake."

NRC Response:
The NRC staff agrees with the comment.

Resolution:
The staff will update wording in DG-1146 as recommended.

Dr. Carl Constantino Comment 5 (December 2, 2006)
Some of the records in the CEUS bins appear to have some issues. I presume that this is not the place to discuss the problems, but the DG should indicate that care needs to be employed when using these records for site response calculations.

NRC Response:
The NRC staff has looked into this question with the document authors, who noted that the records provided in the CEUS bins are expected to be used as seed motions that can be adjusted using a spectral matching program such as RASCAL or RSPmatch, if necessary.

Resolution:
The staff has addressed this issue in Regulatory Guide 1.208.

10 Incoherency Transfer Function

Note that NRC staff review of the Incoherency Transfer Function is ongoing. This subject will be more fully addressed in SRP 3.7.

NEI General Comment 2 (December 7, 2006)
Acceptance of the use of the incoherency function as presented in the Task S2.1 reports is very important for utilities to file their COLs. The timeline for making plant siting decisions is critically short, and a common and satisfactory understanding must be reached shortly in order to support already established COL schedules.

> NRC Response:
> See discussion below EPRI Minutes of NRC Public Meeting Comment 1.

Public Comments at NRC Public Meeting Comment 3 (December 14, 2006)
Industry representatives noted that they would like incoherency explicitly mentioned in the appropriate NRC document(s). It was noted that they believe that incoherence effects should be incorporated into the SSI analyses. The function would be those proposed by EPRI and could be implemented in CLASSI and SASSI (perhaps in addition to other codes). It was also noted that the timeline for applicants to incorporate incoherency into their analyses is critically short.

> NRC Response:
> See discussion below EPRI Minutes of NRC Public Meeting Comment 1.

EPRI Minutes NRC Public Meeting Comment 1 (December 14, 2006)
It is critical to reach a common understanding with the NRC staff on the following topics: 1) that incoherency corrections to the site-specific ground response spectrum can be made, and 2) on the specific coherency function and methodology to be applied.

> NRC Response:
> The NRC staff understands the importance of timely review of an incoherency function in light of high spectral accelerations in the high-frequency range predicted by the PSHA for some CEUS locations. Ongoing discussions between the NRC staff and industry representatives on the topic of the incoherency function have been fruitful and a possible way forward was identified and detailed in the public meeting held on December 20-21, 2006.
>
> Because the method currently being proposed by industry representatives would be implemented as part of the SSI analyses, discussion of the incoherency function is outside the scope of Regulatory Guide 1.208. If an incoherency function is accepted, it would be more appropriate in the Standard Review Plan (NUREG-0800).
>
> Resolution:
> No action is required for DG-1146. However, ongoing work on the incoherency function will continue.

Bechtel Comment 2 (December 13, 2006)
The draft guide does not identify the issue that current ground motion estimates at rock sites in the CEUS result in high spectral accelerations in the high frequency range. This is an important issue for the analysis of new nuclear power plants in the CEUS region, although it is recognized that high frequency

content is not generally damaging to typical plant structures, systems and components except for certain high frequency sensitive devices. It is recommended that the draft guide and/or NUREG-0800 explicitly address this issue, provide some discussion, and describe acceptable methods of resolution.

NRC Response:
It is not appropriate to discuss the issue of high ground motions in the high-frequency range in Regulatory Guide 1.208. However, the NRC staff is aware of the problems related to this issue and there in an ongoing dialogue between the NRC staff and stakeholders in relation to this topic. One key issue under discussion is the use of an incoherency function in SSI analyses (see comments above). The SSI itself will also reduce high-frequency ground motions due to the behavior of the NPP overall system behavior. The details of SSI are outside the scope of the regulatory guide, but will be addressed in Section 3.7.2 of the Standard Review Plan (NUREG-0800).

NRC staff is reviewing how an exceedance of the predicted motion above the standard plant design spectra will be addressed in the Standard Review Plan. Of particular interest are how different frequency ranges affect the individual structures, systems, and components (SSCs) and how exceedance in these frequency ranges should be evaluated. There is an ongoing discussion between the NRC staff and stakeholders that was advanced at the public meeting on December 14, 2006.

Resolution:
No action is required for DG-1146. However, ongoing work on the incoherency function and Standard Review Plan, Section 3.7.2 will continue.

Bechtel Comment 11 (December 13, 2006)
The report just completed by EPRI on Task S2.1 has shown that incoherency of ground motion significantly affects the responses of structures on large foundations, reducing the structural response to the high frequency ground motions. It is also known that ground motion estimates for the CEUS at rock sites contain significant high frequency content as mentioned earlier. It is recommended that the draft guide include a discussion on the incoherency of ground motion and how it might affect the seismic design basis for the site. In fact, one option would be to apply the incoherency reduction during the process of determining the SSE. Options that are acceptable to the NRC in determining the incoherency effects should be discussed in the draft guide to help the industry focus on approaches that may be instrumental in resolving the high frequency content issues.

NRC Response:
As noted above, incoherency transfer functions as currently proposed by EPRI are applied in SSI analyses. Recent SSI analyses performed by ARES Corporation indicated that applying the incoherency function to reduce the SSE-based input ground motions does not produce the same results as when the incoherency function is applied as part of the SSI analyses directly. As a result, the NRC staff will not accept a reduction in the SSE ground motion based on incoherency. The EPRI report referenced in the comment has been superseded by more recent work.

Resolution:
No action is required for DG-1146.

11 Soil-Structure Interaction (SSI)

SSI related issues will be fully addressed in relevant SRP sections.

NEI General Comment 6 (December 7, 2006)
Additional guidance is needed for Soil Structure Interaction (SSI) analyses using the SSE established in accordance with DG-1146. Industry technical committees are developing guidance for inclusion in a future revision of the ASCE Standards. We recognize NRC plan to include guidance in the update of the Standard Review Plan. The timeline for making these analyses is critically short, and a common and satisfactory understanding must be reached shortly in order to support already established COL schedules. NEI would like to have the opportunity to discuss the recommendations to be included in the Standard Review Plan before the Standard Review Plan is finalized. This subject could be included in the ongoing discussions on incorporation of incoherence in the SSI analyses.

> NRC Response:
> The NRC recognizes the importance of SSI analyses and the need for guidance development in this area. However, it was decided that Regulatory Guide 1.208 would not include this topic. Discussions related to SSI will be developed for the SRP. Changes to the SRP related to SSI will be developed in consultation with stakeholders and public comments will be incorporated.
>
> Resolution:
> No changes to DG-1146 are required.

Public Comments at NRC Public Meeting Comment 2 (December 14, 2006)
Industry representatives noted that they prefer to use the foundation excitation motion as that developed at the foundation level from the site response analyses. They further noted that they believe that the soil properties used for the SSI analyses should be the same as those used for the site response analyses.

> NRC Response:
> The NRC agrees that the soil properties should be consistent between the site response analyses and the SSI analyses, provided that changes in properties related to the change in confining stress are not required.
>
> Resolution:
> No changes to DG-1146 are required.

Bechtel Comment 8 (December 13, 2006)
For consistency of analysis and meeting the ASCE target performance goal, the draft guide should provide a discussion of the application of the SSE motion and its associated strain-compatible soil properties for soil-structure interaction (SSI) analysis. Specifically, when randomized soil profiles are used, guidance for selection of limited soil columns and associated input motion for SSI analysis should be provided.

> NRC Response:
> As noted in the response to NEI General Comment 6 above, a discussion of SSI will not be included in Regulatory Guide 1.208 and is more appropriate for NUREG-0800.
>
> Resolution:
> No changes to DG-1146 are required.

Bechtel Comment 4 (December 13, 2006)
Paragraph IV(a)(1)(i), of Appendix S to 10 CFR Part 50, requires that "the SSE must be characterized by free-field ground motion response spectra at the free ground surface." And that "…it will usually be appropriate that the design response spectra be smoothed spectra." This language seems to imply that the motion is to be defined in the absence of any modification by the presence of the nuclear island ("free-field ground motion"), is unclear as to whether the "free ground surface" is in-situ at the undisturbed site or should include consideration of as-constructed modification of shallow soils between some at-depth competent material horizon and finished grade, and obscures the possibly important distinction between a point estimate of ground motion and an estimate of ground motion integrated over the area or the depth of a mat foundation, which motion will act on the structures, systems, and components (SSCs) of the nuclear island.

a. It is recommended that the draft guide, NUREG-0800, and DG-1145 address these issues by more carefully defining the SSE and the DRS as potentially separate motions to be defined, respectively, in FSAR/SSAR Sections 2.5.2 and 3.7.1. Issues of modification of point ground motions by the foundation mat, such as may be addressed in soil-structure interaction or incoherency analyses, are better left to the engineering design sections of the FSAR. FSAR Section 2.5.2 may introduce these topics in general terms, then refer to FSAR Section 3.7.1… as appropriate.
b. It is recommended that "free-field" and "free-ground surface" be defined to remove the above-noted ambiguities.

NRC Response:
The SSE is defined in the free field, without the presence of the nuclear island as required by the regulations. The single SSE defined for a site is necessarily defined based on site conditions and is independent of foundation depth, backfilling, and other design-based issues that impact the design response spectra. As noted, these issues, as well of those related to the motions integrated over the mat are more relevant to SSI analyses as discussed in NUREG-0800. The staff has added some discussion of the difference between SSE and DRS to Section 5.1. A discussion of the meaning of free-ground surface has been added to Section 5.3. The suggestion that the terms "free field" and "free ground surface" be removed from regulations to remove ambiguities is not within the scope of Regulatory Guide 1.208.

Resolution:
As noted, the staff has added some addition language to Sections 5.1 and 5.3

Bechtel Comment 13 (December 13, 2006)
The SSE is required to be developed at the ground surface level. This implies a deconvolution analysis of the motion for embedded structures. Since the SSE is the result of a soil amplification for a wide range of soil columns developed by a randomization process, deconvolution in limited soil columns, particularly with the lower bound properties, would result in unrealistically high ground motions at the foundation level in the free-field. A similar problem exists if the SSE motion is defined in the free field as "outcrop" at any specific depth, e.g., foundation depth. The soil column analysis using limited soil columns, e.g., upper, mean, and lower bounds, is likely to develop motions at the ground surface level that would exceed the SSE if the SSE were to be developed at the ground surface using the mean results of all randomized profiles. This observation suggests that for application of the SSE to SSI, a consistent pair of high frequency and low frequency motions with their soil columns should be identified. It is recommended that the draft guide address this issue.

NRC Response:
The SSE must be defined as a free surface motion according to regulation and cannot be relocated based on design issues. However, a way to provide for materials that are sufficiently competent

to be left in place has been included in Regulatory Guide 1.208. Section 5.3 provides a discussion of the location of the site-specific ground motion response spectrum GMRS, which leads to the SSE. The specific issues raised in this comment are related to design response spectra and to analyses used in the design phase. Regulatory Guide 1.208 will not address these topics in detail, but they are addressed in NUREG-0800.

Resolution:
No changes to Regulatory Guide 1.208 are required for this comment beyond the edits to Sections 5.1 and 5.3 discussed elsewhere.

12 Proposed Technical and Typographical Editing

NEI Specific Comment 3 (December 7, 2006)
On page 5, last paragraph, second line, a period is missing between "(Refs. 9, 10)" and "A PSHA."

NRC Response:
The NRC staff agrees with this comment.

Resolution:
The staff will incorporate the proposed changes.

NEI Specific Comment 18 (December 7, 2006)
On page 16, section C.5.1 "Horizontal Spectrum," paragraph 3, sentence 1, the draft states, "The performance-based site-specific earthquake ground motion is developed using a method analogous the development of the design response spectrum (DRS)…" Add the word, "to," after the word, "analogous."

NRC Response:
The NRC staff agrees with this comment.

Resolution:
The staff will incorporate the proposed changes.

NEI Specific Comment 19 (December 7, 2006)
On page 16, section C.5.1 "Horizontal Spectrum" in the explanation of equation 1, there is a reference to Regulatory Position 4.4. It is assumed that this reference should be to Regulatory Position 4.3 since there is no Regulatory Position 4.4.

NRC Response:
Regulatory Position 4.3 was intended.

Resolution:
The staff will incorporate the necessary changes.

NEI Specific Comment 30 (December 7, 2006)
On page E-6, section E.4, "Free-Field Ground Surface Uniform Hazard Response Spectra," our comment 19 applies to this paragraph.

NRC Response:
See NEI Specific Comment 19.

Resolution:
The staff will incorporate the necessary changes.

NEI Specific Comment 24 (December 7, 2006)
On page C-8, second paragraph, first sentence, second line, add a space between the word "with" and the word "previous," and add a space between the word "the" and "following."

NRC Response:
The NRC staff agrees with this comment.

Resolution:
The staff will incorporate the proposed changes.

Bechtel Comment 29 (December 13, 2006)
Page D-3, Table D.1. The entries to the cells of the table should be stated.

NRC Response:
See response to NEI Comment 25, below.

Resolution:
No changes to DG-1146 are required.

NEI Specific Comment 25 (December 7, 2006)
On page D-3, Table D.1, the entries to the cells of the table need to be provided.

NRC Response:
The table was provided as an example for the reader's convenience

Resolution:
No changes to DG-1146 are required.

NEI Specific Comment 29 (December 7, 2006)
On page E-5, Figure E.2, the ordinate label should be "Response Spectral Ratio" instead of "Response Spectral Rati."

NRC Response:
The NRC staff agrees with this comment.

Resolution:
The staff will incorporate the proposed changes.

Dr. Carl Constantino Comment 16 (December 2, 2006). Line E750 These strain-dependent models are typically referred to as the EPRI-93 curves. Should also include the reference for these.

NRC Response:
While the EPRI-93 curves are not the only ones available, the staff will include a reference to them.

Resolution:
The staff has added the reference to the text and to the list of references in Appendix E.

Bechtel Comment 30 (December 13, 2006)
Pages D-4 and D-5, Step 7.

a. There is explanation of the calculation required if the contribution to the hazard calculated in Step 5 [1 - 2.5 Hz] for distances of 100 km or greater is less than 5%. (sb. greater than)
b. Revise the last subscript in Equation 7 from "1" to "2."

NRC Response:

The wording as shown is not in DG-1146.

Resolution:
No changes to DG-1146 are required.

13 Comments on Specific Plant Applications

Jeffrey K. Kimball Comment 6 (December 13, 2006)
To compound these issues, the recent submission of the Vogtle ESP application, Site Safety Analysis Report, further demonstrates that PSHA stability does not exist. Consistent with other ESP applications (North Anna, Grand Gulf, Clinton), the Vogtle applicant has chosen to use an update to the EPRI PSHA to assess seismic hazard and establish appropriate ground motion for seismic design. The update to the EPRI PSHA for Vogtle, however, is significantly different than the EPRI PSHA work used by the preceding three ESP applicants, and inconsistent with material provided by EPRI as part of the ongoing dialog regarding resolution of seismic hazard issues (Program on Technology Innovation: Assessment of a Performance-Based Approach for Determining Seismic Ground Motions for New Plant Sites, V1 Performance-Based Seismic Design Spectra, V2 Seismic Hazard Result at 28 Sites; EPRI Technical Reports (1012044 and 1012045). Specific issues related to the EPRI PSHA update used for Vogtle are provided following the remaining comments.

Jeffrey K. Kimball Comment 10 (December 13, 2006)
Specific issues related to the EPRI PSHA update used for Vogtle ESP application, Site Safety Analysis Report

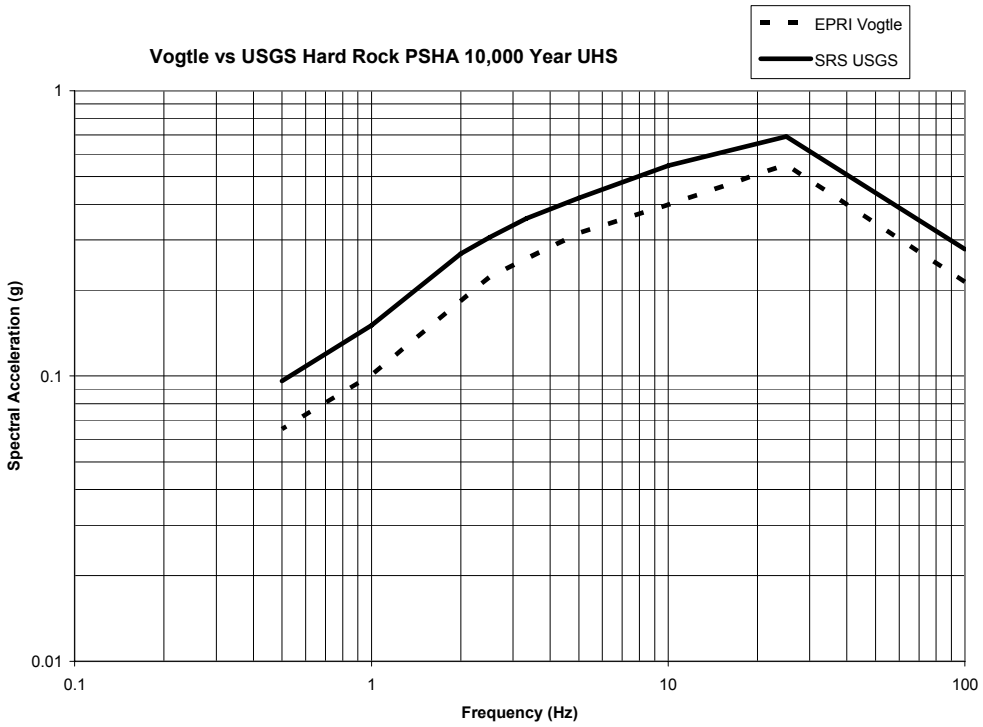
- The Charleston seismic source is modeled using four possible source delineations applied to each of the EPRI seismic source teams. Modification of the EPRI team(s) Charleston sources, by necessity, requires modification of other sources (given that the revised Charleston source areas no longer match the aerial extent from the EPRI expert teams). This implies that the seismic sources beyond Charleston also need revision, not just to fill the aerial gap, but because Charleston is more restricted, with more frequent large earthquakes, judgments regarding nearby seismic sources would likely also change. The aerial gap was addressed by allowing portions of "old" EPRI source zones that lie outside the new replacement Charleston source zone to default to the existing EPRI background zones for each team. Why such an approach is assumed to represent the informed technical community, based on seismic source definitions that are about 20 years old, is subject to debate. To maintain the PSHA process the expert teams should be the ones to agree to these adjustments. This change by itself implies that the updated EPRI PSHA results are inconsistent with the SSHAC process and objective of representing the informed scientific community (versus the views of the applicant's contractor).

- A key argument for not revising much of the EPRI team seismic sources relates to lack of paleoseismic evidence and stability of seismic activity rates outside of Charleston. Such a conclusion strongly suggests that there would be little technical basis for modifying the LLNL expert seismic sources in those locations. The basis for ignoring the LLNL seismic sources in terms of representing views of the informed scientific community has not been provided.

- Review of the USGS PSHA input suggests that there is much less scientific community support for aerial seismic sources beyond those locations which have paleoseismic evidence for large prehistoric earthquakes in the central and eastern United States (CEUS). It is not clear why applicants would not be required to incorporate this information into their PSHA work, especially given that this seismic source input is much more recent compared to those portions of the EPRI or LLNL PSHA based on seismic source input from the 1980's. Additionally, differences between EPRI and USGS for the Charleston seismic source should be evaluated.

- Review of EPRI PSHA input for the southeast US indicates that at least one team has areas where there is no host seismic source zone for a large percentage of the time (Dames and Moore team, seismic source 53, Southern Appalachian Mobile Belt). When this zone does not exist (probability of activity = 0.26) there does not appear to be a replacement seismic source zone. It is not clear that such a view represents the informed scientific community today, especially given the information contained in the USGS national seismic hazard map. Review of the USGS PSHA input to the national map indicates that no location in the CEUS should be judged as having no local seismic hazard. The recent moment magnitude 6.0 earthquake in the intraplate region of the Gulf of Mexico provides additional evidence that moderate sized earthquake can occur anywhere. A complete technical review of the EPRI PSHA input is needed before it should be supported as providing adequate input for a mean PSHA assessment.

- Application of the USGS PSHA code for hard rock site conditions for the Vogtle site location would likely show different mean PSHA results for all annual probability levels. Any differences between EPRI and USGS should be evaluated in detail, to determine if both results can be supported and should be used to represent mean PSHA derived ground motions. The figure provided below compares uniform hazard spectra for a return period of 10,000 years between the Savannah River Site (USGS results) and the Vogtle site (modified EPRI results) both for hard rock site conditions, suggesting the PSHA stability does not exist.



NRC Response:
Regulatory Guide 1.208 will not discuss individual facilities. The NRC staff is currently reviewing the Vogtle application and will document its findings in the final SER. USGS is actively assisting staff in this review process.

Resolution:
No changes to Regulatory Guide 1.208 are required.

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