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Subject: AP1000 Response to Request for Additional Information (SRP2.5)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 2.5. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in the response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

A response is provided for RAI-SRP2.5-RGS1-14 through -20 as sent in an email from S. K. Mitra to Sam Adams dated July 8, 2008. This response completes all requests received to date for SRP Section 2.5. A response for RAI-SRP2.5-RGS1-01 through -13 was submitted under letter DCP/NRC2154 dated June 6, 2008.

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

A handwritten signature in cursive script, appearing to read 'Robert Sisk'.

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 2.5

cc: D. Jaffe - U.S. NRC 1E
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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 2.5

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-14
Revision: 0

Question:

In regards to AP1000 Technical Report APP-GW-GLE-004:

Since Regulatory Guide 1.132 provides only guidelines for the site investigation (determination of engineering properties of soil and rocks), but not definition and/or criteria for the site uniformity, you are requested to clarify and provide basis for the evaluation criteria of the site uniformity discussed in this report.

Westinghouse Response:

Evaluation criteria for the site are given in DCD subsection 2.5.4.5, "Subsurface Uniformity" which was revised as described in AP1000 Technical Report APP-GW-GLE-004. The AP1000 is acceptable at uniform sites without additional evaluation. The definition of uniform is based on Regulatory Guide 1.132 which states:

"Subsurface conditions may be considered uniform if the geologic and stratigraphic features to be defined can be correlated from one boring location to the next with relatively smooth variations in thicknesses or properties of the geologic units. An occasional anomaly or a limited number of unexpected lateral variations may occur."

The acceptability of relatively smooth variations is justified by the design analyses of the nuclear island basemat described in DCD subsection 3.8.5. The analyses consider the nuclear island supported on uniform soil springs. The design includes a 20% margin above the results of the analyses on uniform soil springs to accommodate the relatively smooth variations in soil springs that may occur on a uniform site.

Additional evaluation is required for non-uniform sites. The detailed evaluation is dependent on the non-uniformity identified in the site investigations. The evaluation will consider the effect of the non-uniformity on the distribution of bearing reactions or on the basemat member forces as described in DCD subsection 2.5.4.5.3.1.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-15
Revision: 0

Question:

In regards to AP1000 Technical Report APP-GW-GLE-004:

Please address the following issues identified below, which are related to DCD Tier 1 Table 5.0-1, "Site Parameters" (parameters related to soil and SSE):

1. Since the allowable soil bearing capacity (both static and dynamic) is highly site-specific and cannot be determined generically, please provide clarification on your use of the terms "average allowable static soil bearing capacity" and "average allowable dynamic soil bearing capacity."
2. Since the soil bearing demand (static or dynamic) will be uniquely defined once the structural dead weight, site condition, ground motion, etc. are determined, please justify the use of the phrase "greater than or equal to" for the calculated demand values.
3. Regarding the site uniformity, please clarify the following and provide additional information as needed:
 - (1) Criterion 1 states that soils supporting the nuclear island are uniform in accordance with Regulatory Guide 1.132, if the geologic and stratigraphic features at depths less than 120 feet below grade can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units. As discussed in RAI GLE-004-1, there are no definitions of uniformity conditions in RG 1.132 but only subjective references as in Section 4.3.1.1. Clarification is needed. Also, this criterion does not incorporate specific criteria on shear wave (S-wave) and compressional wave (P-wave) velocity profiles that are needed to ensure the adequacy of SSI calculations.
 - (2) Criterion 2 states that site specific assessment of subsurface conditions demonstrates that the bearing pressures below the footprint of the nuclear island do not exceed 120% of those from the generic analyses of the nuclear island at a uniform site. Please clarify how the variability in bearing pressure relates to the corresponding variability of the soil stiffness, shear wave velocity, etc.? Also, describe the basis of this criterion.
 - (3) Since the zone of influence under the foundation level will extend beyond the boundary of the NI foundation mat, please provide basis for using the phrase "within the NI footprint" in the paragraph after Criterion 3.

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Response to Request For Additional Information (RAI)

- (4) In Case 1, you provide the criterion for a soil layer with a low strain shear wave velocity greater than or equal to 2,500 ft/sec. Please describe and provide the criterion for the case of a soil layer with a low strain shear wave velocity of less than 2,500 ft/sec.
- (5) The criterion for the minimum shear wave velocity, "greater than or equal to 1000 ft/sec based on low-strain, best estimate soil properties over the footprint of the nuclear island at its excavation depth," should be corrected to state "greater than or equal to 1000 ft/sec based on low-strain, **minimum soil** properties at its excavation depth."
- (6) Safe Shutdown Earthquake SSE)

Please clarify the following issues related to the description of the SSE:

- (i) The free field ground motions (modified RG 1.60 ground response spectra anchored to 0.3g) was used for the nuclear island (NI) seismic analyses and standard design. According to the ISG definition, these ground motion response spectra should be termed as the certified seismic design response spectra (CSDRS) instead of the SSE.
- (ii) In the second sentence of the first paragraph, you stated that "if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific ..." The term "outside the range evaluated" needs to be clearly clarified, because the possible "inversions" indicated in the site-specific shear wave velocity profiles were not discussed in the description. These "inversions" may significantly affect the results of site response analyses and SSI analyses.
- (iii) In the second paragraph, you stated that the HRHF GMRS are defined at the foundation level. It is our understanding from the DCD review that the SSI analyses performed with both the CSDRS and the HRHF GMRS ground motions for soil sites define the input motion at ground surface in the free field. This inconsistency needs to be clarified.
- (iv) The last sentence of the second paragraph states that a site is acceptable if its site specific GMRS fall within the AP1000 HRHF GMRS. A phrase, "over the entire frequency range," should be added to the end of this sentence.
- (v) In addition to the issues identified in items (i) through (iv) above, Tier 1 Table 5.0-1 and Tier 2 Table 2-1 need to be updated to agree with changes in subsections within Section 2.5.

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Westinghouse Response:

1. The proposed text in Tier 1 Table 5.0-1 and in Tier 2 Table 2-1 on allowable bearing and demand was revised in the response to RAI-SRP 2.5-RGS1-09 as shown below.

| Table 2-1 (Sheet 1 of 3) | |
|--|---|
| SITE PARAMETERS | |
| Soil | |
| Average Allowable Static Bearing Capacity | The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the average bearing demand of 8,900 lb/ft ² over the footprint of the nuclear island at its excavation depth |
| Maximum Allowable Dynamic Bearing Capacity for Normal Plus SSE | The allowable bearing capacity, including a factor of safety appropriate for the design load combination, shall be greater than or equal to the maximum bearing demand of 35,000 lb/ft ² at the edge of the nuclear island at its excavation depth |

The "Average Allowable Static Bearing Capacity" and the "Maximum Allowable Dynamic Bearing Capacity for Normal Plus SSE" are site specific parameters that must exceed the AP1000 demand.

2. The site specific allowable bearing capacity (including a factor of safety appropriate for the design load combination) must be "greater than or equal to" the AP1000 calculated demand values.
3. Regarding the site uniformity, please clarify the following and provide additional information as needed:
 - (1) It is recognized that the uniformity conditions in RG 1.132 are subjective, and are therefore applicable only to clearly uniform sites. Where uniformity is not clearly present, the site will be considered as a non-uniform site and will be evaluated as described in DCD subsection 2.5.4.5.3.1. Criteria for shear wave (S-wave) velocity profiles are covered by the requirements of DCD subsection 2.5.2.
 - (2) The Site-specific assessment of subsurface conditions in Criterion 2 is described in DCD subsection 2.5.4.5.3.1 "Rigid Basemat Evaluation". The design includes a 20% margin above the results of the analyses on uniform soil springs to accommodate the relatively smooth variations in soil springs that may occur on a uniform site. The member forces and required reinforcement in the nuclear island basemat are conservatively assumed to increase in the same percentage as the bearing pressure.

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Response to Request For Additional Information (RAI)

- (3) In Tier 1 Table 5.0-1 and Tier 2 Table 2-1, add “and 40 feet beyond the boundaries of the nuclear island footprint” as already stated in paragraph 3 of DCD subsection 2.5.4.5.3.
- (4) The criterion for the case of a soil layer with a low strain shear wave velocity of less than 2,500 ft/sec was included in DCD Rev 16 but removed in the changes proposed by APP-GW-GLE-004. The tight limits of +/- 10% were found to be unrealistic based on variability in measurement of shear wave velocity at soil sites. Hence soil sites require evaluation on a site specific basis.
- (5) The criterion for the minimum shear wave velocity is being revised in Tier 1 Table 5.0-1 and Tier 2 Table 2-1.
- (6) Safe Shutdown Earthquake SSE)
 - (i) The ground motion response spectra have been revised to the certified seismic design response spectra (CSDRS) instead of the SSE as shown in the response to RAI-SRP2.5-002.
 - (ii) The paragraph referred to in this RAI was edited and moved to section 2.5.2.3 in response to RAI-SRP2.5-RGS1-04. “Inversions” are addressed in a proposed revision to item 6 of DCD subsection 2.5.2.1 shown below in the DCD revisions.
 - (iii) The second paragraph of DCD subsection 2.5.2 was revised in the response to RAI-SRP-RGS1-002 as follows:

The AP1000 is evaluated at a hard rock site for high frequency input using the response spectra specified in Appendix 3I, Figures 3I.1-1 and 3I.1-2. The seismic response spectra given in Figures 3I.1-1 and 3I.1-2 are bounding GMRS with high frequency content representative of sites where the nuclear island is founded on hard rock; that is, HRHF GMRS.

Item 4 of DCD subsection 2.5.2.1 was revised in the response to RAI-SRP-RGS1-003 as follows:

4. In lieu of (1) and (2) above, for a site where the nuclear island is founded on competent rock with shear wave velocity greater than 8000 feet per second, the site-specific peak ground acceleration and spectra may be developed at the top of the competent rock and shown at the foundation level to be less than or equal to those given in Figures 3I.1-1 and 3I.1-2.

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As stated in DCD Appendix 3I subsection 3I.2, the HRHF GMRS is calculated at foundation level (39.5' below grade), at the upper most competent material and treated as an outcrop for calculation purposes. Hence the second paragraph of DCD section 2.5.2 and item 4 in subsection 2.5.2.1 are correct. Item 4 is further modified in the following paragraph.

- (iv) Item 4 of DCD subsection 2.5.2.1 has been revised to include “over the entire frequency range”.
- (v) Tier 1 Table 5.0-1 and Tier 2 Table 2-1 have been revised to agree with changes in subsections within Section 2.5. The revised tables will be included in DCD Rev 17.

Design Control Document (DCD) Revision:

The revisions shown below are those associated with this RAI response. The base text shown is from a draft of DCD Rev 17 that includes changes to DCD Rev 16 previously transmitted to NRC in the form of Technical Reports and RAI responses. The changes in this RAI response will also be incorporated in DCD Rev 17.

Revise items 4 and 6 in second paragraph of subsection 2.5.2.1 as follows:

- 4 In lieu of (1) and (2) above, for a site where the nuclear island is founded on ~~competent hard~~ rock with shear wave velocity greater than 8000 feet per second, the site-specific peak ground acceleration and spectra may be developed at the top of the competent rock and shown at the foundation level to be less than or equal to those given in Figures 3I.1-1 and 3I.1-2 over the entire frequency range.
- 6 For sites where the nuclear island is founded on soil, the minimum estimate of the strain-compatible soil shear modulus and hysteretic damping is compared to the values used in the AP1000 generic analyses shown in Table 3.7.1-4 and Figure 3.7.1-17. Properties of soil layers within a depth of 120 feet below finished grade are compared to those in the generic soil site analyses (soft soil, soft-to-medium soil, and upper bound soft-to-medium soil). The shear wave velocity should generally increase with depth. The average low strain shear wave velocity in any layer should not be less than 80 percent of the average shear wave velocity in any layer at higher elevation.

Revise fourth paragraph of subsection 2.5.4.5.3 as follows:

As an example of sites that are considered uniform, the variation of soil properties in the material below the foundation to a depth of 120 feet below finished grade within the nuclear island footprint and 40 feet beyond the boundaries of the nuclear island footprint meets the criteria outlined below:

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Response to Request For Additional Information (RAI)

Revise Tier 1 Tables 5.0-1 and Tier 2 Table 2-1 as follows:

| | |
|---------------------|--|
| Shear Wave Velocity | Greater than or equal to 1,000 ft/sec based on the <u>minimum best estimate</u> low-strain soil properties over the footprint of the nuclear island at its excavation depth |
| Lateral Variability | <p>Soils supporting the nuclear island should not have extreme variations in subgrade stiffness. This may be demonstrated by one of the following:</p> <ol style="list-style-type: none"> 1. Soils supporting the nuclear island are uniform in accordance with Regulatory Guide 1.132 if the geologic and stratigraphic features at depths less than 120 feet below grade can be correlated from one boring or sounding location to the next with relatively smooth variations in thicknesses or properties of the geologic units, or 2. Site-specific assessment of subsurface conditions demonstrates that the bearing pressures below the nuclear island do not exceed 120% of those from the generic analyses of the nuclear island at a uniform site, or 3. Site-specific analysis of the nuclear island basemat demonstrates that the site-specific demand is within the capacity of the basemat. <p>As an example of sites that are considered uniform, the variation of shear wave velocity in the material below the foundation to a depth of 120 feet below finished grade within the nuclear island footprint <u>and 40 feet beyond the boundaries of the nuclear island footprint</u> meets the criteria in the case outlined below:</p> <p>Case 1: For a layer with a low strain shear wave velocity greater than or equal to 2500 feet per second, the layer should have approximately uniform thickness, should have a dip not greater than 20 degrees, and should have less than 20 percent variation in the shear wave velocity from the average velocity in any layer.</p> |

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-16
Revision: 0

Question:

In regards to AP1000 Technical Report APP-GW-GLE-004:

For the description in Section 2.5.2.3, "Sites with Geoscience Parameters Outside the Certified Design," please address the following:

1. Definition of the term "Geoscience Parameters."
2. The first sentence of this section states that if the site-specific spectra at foundation level exceed the response spectra in Figures 3.7.1-1 and 3.7.1-2 at any frequency, or if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed. However, the last paragraph of DCD Section 3.7.1.1 states that the design response spectra are applied at the foundation level in the free field at hard rock sites and at the finished grade in the free field at firm rock and soil sites. Clarification is needed for this inconsistency.
3. You also stated in this paragraph that the site design response spectra at the foundation level in the free-field given in Figures 3.7.1-1 and 3.7.1-2 were used to develop the floor response spectra. This statement is not consistent with that of DCD Section 3.7.1.1 for soil sites. Clarification is needed.

Westinghouse Response:

DCD subsection 2.5.2.3 was rewritten in response to RAI-SRP2.5-RGS1-04. The revised section is shown below in the DCD Revision section with additional editing to subsection 2.5.2.3.2 to address the comments in this RAI. Also, further clarification is given in subsection 2.5.2.3.1 related to acceptability of 2D analyses.

Design Control Document (DCD) Revision:

The revisions shown below are those associated with this RAI response. The base text shown is from a draft of DCD Rev 17 that includes changes to DCD Rev 16 previously transmitted to NRC in the form of Technical Reports and RAI responses. The changes in this RAI response will also be incorporated in DCD Rev 17.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

2.5.2.3 Site Specific Seismic Evaluation

The Combined License applicant may identify site specific features and parameters that are not clearly within the guidance provided in Subsection 2.5.2.1. These features and parameters may be demonstrated to be acceptable by performing site specific seismic analyses. These analyses may be either 2D or 3D. Results will be compared to the corresponding 2D or 3D generic analyses.

2.5.2.3.1 2D analyses

Where features of the site are not within the parameters specified for the AP1000, site-specific soil structure interaction analyses may be performed using the 2D SASSI models described in Appendix 3G for variations in site conditions that can be represented in these models. Results should be compared to the results of the 2D SASSI analyses described in Appendix 3G. Such analyses may be used to demonstrate that local features, such as soil degradation properties or backfill, are well within the bounds established by the design cases. If the results are not clearly enveloped at the six significant frequencies of response at the six key locations compared with the floor response spectra of the certified design at 5-percent damping then a 3D SASSI analysis may be required. These evaluations and comparisons will be provided and reviewed as part of the Combined License application.

2.5.2.3.2 3D Analyses

If the site-specific spectra at foundation level at a hard rock site or at grade for other sites exceed the certified seismic design response spectra in Figures 3.7.1-1 and 3.7.1-2 at any frequency, or if soil conditions are outside the range evaluated for AP1000 design certification, a site-specific evaluation can be performed. This evaluation will consist of a site-specific dynamic analysis and generation of in-structure response spectra at six key locations to be compared with the floor response spectra of the certified design at 5-percent damping. The certified seismic site design response spectra at the foundation level in the free-field given in Figures 3.7.1-1 and 3.7.1-2 were used to develop the floor response spectra. They were applied at foundation level for the hard rock site and at finished grade level for the soil sites. The site is acceptable if the floor response spectra from the site-specific evaluation do not exceed the AP1000 spectra for each of the locations identified below or the exceedances are justified:

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-17
Revision: 0

Question:

In the second paragraph of Section 2.5.4.5, you summarized your survey of nuclear plant site conditions in the United States, and stated that the review of the 22 commercial nuclear power plant sites in the United States suggests that the majority of AP1000 sites exhibit "uniform" soil properties within the nuclear island footprint. Since the AP1000 is designed to be located at sites where site conditions may be different from those associated with the 22 existing plants, please explain the applicability of the survey and how the survey results can be used to justify the site uniformity of a prospective site?

Westinghouse Response:

The second paragraph of DCD subsection 2.5.4.5 was deleted in response to RAI-SRP2.5-RGS1-12.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-18
Revision: 0

Question:

In the second paragraph of Subsection 2.5.4.5.1, you only incorporated standard static loading conditions into the criteria for site investigations. Please also incorporate the potential effects of no uniformity outside the NI footprint on SSI responses.

Westinghouse Response:

DCD subsection 2.5.4.5.1 was deleted in the response to RAI-SRP 2.5-RGS1-13.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-19
Revision: 0

Question:

There are no faulting criteria discussed in this report. Clarification is needed.

Westinghouse Response:

Faulting is not discussed as a separate criterion. Faulting may result in different soil properties each side of the fault. The difference in properties would be evaluated against the criteria for lateral variability specified in DCD subsection 2.5.4.5.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP2.5-RGS1-20
Revision: 0

Question:

In Subsection 2.5.4.5.3, you provided site uniformity evaluation criteria for the case of a soil layer with a low strain shear wave velocity greater than or equal to 2,500 ft/sec. Please justify why you did not provide site uniformity evaluation criteria for the case of a soil layer with a low strain shear wave velocity less than 2,500 ft/sec.

Westinghouse Response:

See response to RAI-SRP2.5-RGS1-15 item 3 (4).

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None