Response to Public Comments on Draft SRP Section 3.7.1
(Prepared June 17, 2014)

Comment	Proposed Resolution	NRC Staff Resolution
NEI Comments:		
1. Section 3.7.1 I (Areas of Review, Design Ground Motion), First Paragraph [p. 3.7.1-2] The revised draft states: "Both the GMRS and the FIRS are defined as free-field outcrop spectra (not including any soil layers above that elevation)." This definition is consistent with GMRS definition but it is not consistent with the FIRS definition DC/COL-ISG-017.	Either delete the parenthetical statement or revise it to be consistent with DC/COL-ISG-017.	The staff agrees with the observation; and therefore, SRP Section 3.7.1 I.1.A will be revised as follows: "…Both the GMRS and the FIRS are defined as free-field outcrop* response spectra. The FIRS is the starting point for conducting a soil-structure interaction (SSI) analysis and for making a one-to-one comparison of the seismic design capacity of the standard design and the site-specific seismic demand for a site." *A footnote will be included to define outcrop elevation from DC/COL-ISG-017.

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2. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories), First Paragraph [p. 3.7.1-9] This paragraph says, “When time histories are used, each of the three ground motion time histories must be shown to be statistically independent from the others.” This paragraph should be revised to clarify that the requirement for statistical independence is not needed if in a linear analysis, the maximum response of interest is obtained by taking the square root of the sum of squares (SRSS) of maximum responses from the time history analysis for each of the three earthquake components. See Regulatory Guide 1.92, Rev. 2, Section 2.2(1).	Modify this paragraph to clarify that the requirement for statistical independence is not needed if in a linear analysis, the maximum response of interest is obtained by taking the square root of the sum of squares (SRSS) of maximum responses from the time history analysis for each of the three earthquake components.	The staff disagrees with the comment for the following reasons. For developing design ground motion time histories for use in a linear SSI analysis, statistical independence should be demonstrated regardless whether the algebraic method or the square root of the sum of squares (SRSS) of the maximum responses from the time history analysis for each of the three earthquake components is used. The statistical independence of the three components of ground motion is necessary to ensure that the structural response is insensitive to the orientation of the axes of the structure. If the two horizontal components are correlated then the structural response will depend on the orientation of the axes of the structure with respect to the orientation of the input motions. The use of statistical independence between each pair of ground motions avoids the need to evaluate the critical orientation of the input motions with respect to the structural axes.
3. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories), First Paragraph [p. 3.7.1-9] The proposed addition is not practically feasible. Specifically, the new words state that, “phasing characteristics of the real earthquake records should be preserved.” However, current methods for spectral matching change the phasing characteristics.	Revise the seventh sentence of this paragraph as follows: “When the seed time histories are selected from real earthquake records…phasing characteristics of the real earthquake records should ~~be preserved~~ <u>not change</u> significantly.”	The staff agrees with the observation; and therefore, SRP Section 3.7.1 II.1.B will be revised as follows: “When the seed time histories are selected from real earthquake records…phasing characteristics of the real earthquake records should not change significantly.”

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4. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories), First Paragraph [p. 3.7.1-9] The proposed addition states that, “If the target spectra include multiple characteristic events…the use of multiple time histories may be appropriate…” This premise appears to assume that the effect of characteristic events (i.e., “controlling earthquakes”) is preserved in the target spectra (GMRS or FIRS, as the case may be). However, the methodology for GMRS/FIRS generation is based on a development of a single “broad peak” spectrum whereby the effects of controlling earthquake are embedded in a single spectrum (i.e., low frequency and high frequency content). The suggested approach would require use of multiple time histories all matched to target FIRS that cannot represent the characteristics of the individual events.	Delete the discussion of multiple characteristics events.	The staff does not agree with the proposed resolution. If the design spectra are developed based on multiple characteristic events in a PSHA process, multiple time histories are intended to capture the range of characteristic events included in the design spectra. Therefore, it is appropriate to ensure that earthquake records (binned in terms of magnitude and distance), used to develop the time histories, fairly represent the characteristic events embodied in the target spectra.
5. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories), First Paragraph [p. 3.7.1-9] The proposed addition suggests that seed time histories should be selected based on how close their spectral shapes are to the target spectral shape. For high frequency CEUS target spectra with limited recorded motion available this approach may result in using vertical seed time history to match the horizontal target spectra. This mismatch should be avoided. In addition, the seismic setting, geologic setting and site conditions of the recorded motion should be considered as basis for selecting seed time history for the plant site. Recent studies of multiple time histories (up to 30) with RVT suggest the proposed refinement does not necessarily resolve issues associated with using limited time histories.	Revise this paragraph to avoid suggesting that spectral shape resemblance to target spectra should be a basis for selecting seed time history. Emphasis should be placed on the power spectral density of the time history.	The staff does not agree with the proposed resolution. The seed record should have a similar spectral shape to the target spectra to ensure the seed record is appropriate for the target spectra. To this end, it would avoid the situation where the response characteristics of the seed record misrepresent the target spectra (e.g., use of western US soil site earthquake to match eastern US hard rock high frequency GMRS).

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6. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories, Option 1, Approach 1), Fourth Paragraph [p. 3.7.1-12] This section of the SRP suggests using tabulated values in Appendix B as one approach for developing target power spectral density (PSD). Since most soil column analyses start with hard rock high frequency and low frequency spectra (and associated magnitude and distance) as input, it is suggested that the associated hard rock high frequency and low frequency PSD be used and amplified similar to the amplification of the hard rock spectra to GMRS and used as a companion target PSD for the GMRS and time history development for GMRS.	This paragraph should be revised to acknowledge that alternate methods for developing target spectra for GMRS/FIRS are also acceptable and will be reviewed on a case by case basis.	The staff agrees with the comment; and therefore, SRP Section 3.7.1.II.B, Design Time Histories, Option 1, Approach 1, will be revised as follows: “For design response spectra other than RG 1.60 response spectra, a compatible target PSD should be generated. For generation of target PSD in such cases (i.e., spectra based on NUREG/CR-6728 or other spectra), the guidelines and procedures provided in Appendix B to this SRP section can be used. These guidelines and procedures are consistent with the approach described in NUREG/CR-5347, “Recommendations for Resolution of Public Comments, Seismic Design Criteria,” dated June 1989. Alternative methods for developing target spectra PSD can be used and are reviewed on a case-by-case basis.”
7. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories, Option 2), First Paragraph [p. 3.7.1-13] The basis for selecting four time histories for linear analysis is not clear. Recent studies show that obtaining stable mean responses may require either a RVT approach or use of a larger set of time histories.	Add a reference to provide the basis for the selection of four time histories for linear analysis.	The staff agrees with the comment in part, basis will be added, however, staff must correct some points made in the comment. The existing criterion indicates that a <u>minimum</u> of four time histories should be used (not simply four). The basis for the use of a minimum of four time histories is contained in NUREG/CR-5347, "Recommendations for Resolution of Public Comments, Seismic Design Criteria,” June 1989. This reference will be included in the update to the SRP. It is also noted that the American Society of Civil Engineers (ASCE) 7 Standard, Section 16.1,3 of ASCE/SEI 7-05, indicates that when performing a linear response time history analysis, a suite of not less than three appropriate ground motions shall be used in the analysis.

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8. Section 3.7.1 II (SRP Acceptance Criteria, Design Ground Motion, Design Time Histories, Option 2), Fourth Paragraph [p. 3.7.1-14] This paragraph says, “In addition, if the extent of the nonlinear response is found to be significant or if the nonlinear response due to one or several time histories is found to be substantially different from the others results, then additional time histories should be considered.” It would be helpful to provide some additional guidance on what would be “substantially different.” Otherwise, it becomes difficult to use this part of the SRP since it does not explain what would be acceptable.	Provide additional guidance on what “substantially different” means.	The phrase “substantially different” is intended to ensure that the responses from the multiple time history analyses fall within a reasonable range which will be reviewed on a case-by-case basis. Therefore, no changes will be made to this revision of the SRP.
9. Section 3.7.1 II (SRP Acceptance Criteria, Review Considerations for DC and COL Applications, COL Referencing an ESP and CD), Item vi. [p. 3.7.1-15] Item vi. states that FIRS are derived as free-field outcrop spectra and that only the effects of materials that are below the base elevation of the seismic category I structure are included in the analysis. This statement is not accurate and inconsistent with DC/COL-ISG-017.	Define FIRS by appropriate reference, (e.g., DC/COL-ISG-017).	This comment has been addressed in the NRC staff resolution to NEI Comment No. 2.

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10. Section 3.7.1, Appendix B, Table 1 [p. 3.7.1-27] The PSD values for CEUS rock sites for Magnitude 6-7 are the same as those for Magnitude 7+. It is not clear if the values are listed accurately.	The PSD values should be checked for accuracy.	The staff agrees with the comment and determined that the PSD values contain errors. In view of the observation noted in the comment and in order to provide more meaningful guidance for developing minimum target PSDs for response spectra based on NUREG/CR-6728 or other spectral shapes, SRP 3.7.1 Appendix B is revised. The existing tables and figure in Appendix B are deleted, and instead, new guidelines and procedures, along with new tables and figures, are added for developing minimum target PSDs for time history records for response spectrum with spectrum shapes consistent with the Magnitude and Distance bins in NUREG/CR-6728, as well as guidance for other spectral shapes.
11. Section 3.7.1, Appendix C [p. 3.7.1-31] Recent PEER report 2012/201 dated July 2012 provides a strong correlation between magnitude and distance and spectra damping amplification. The values listed in Appendix C do not appear to be consistent with the PEER report.	The values in Appendix C should be reviewed and alternative amplification functions considered.	The staff agrees with comment and because earthquake data and methods to develop free-field response spectra for different damping values have evolved over time, Appendix C is deleted and SRP Subsection 3.7.1 II.1.A.ii is revised to state: “For the case of the free-field design response spectra that are different from RG 1.60 response spectra, procedures to calculate response spectra for different damping values other than 5% can utilize the latest available data/methods such as those in PEER Report 2012/01 or NUREG/CR-6728. The procedures used are reviewed by the staff on a case-by-case basis.”

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ARES Comments:		
1. General question regarding to the specification for minimum power spectral density requirement for non RG 1.60 horizontal spectrum, SRP 3.7.1-10: If the design time history is developed from the required matching CSDRS which has been modified from the RG 1.60 spectra to include some more EUS high frequency content, the target PSD functions provided in the Appendix A is no longer valid and a compatible target PSD should be generated based on the guideline and procedures provided in the Appendix B. For the case of the spectra is non-consistent with the Magnitude and Distance bin shape in NUREG/CR-6728 (such as the one described above that consists of major portion of RG 1.6), is any additional guideline for generate the target PSD?	*	Revision 4 to SRP 3.7.1, Appendix B was revised to provide guidance on developing target PSD for response spectra that are not consistent with NUREG/CR-6728.

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GEH Comments:		
Yonggang Fang - Nuclear and Radiation Safety Center; Comments:		
1. Equation (1) in SRP 3.7.1 App A and B should be circular frequency ω, namely 2πf. If using the frequency f to substitute for 2πf directly, then the 2π should be cancelled in denominator, otherwise the difference 2π exists in the equation. In addition, the formula in NUREG/CR-5347 cited by SRP 3.7.1 also use the circular frequency ω, and it isn't so simple for SRP to change it for f. Is our description right, you know, someone found the problem when deducting the equation. However, I think it should be checked.		We agree with the comment that the use of frequency designation should be concsistent throughout the development of the target PSDs. Equation (1) in SRP 3.7.1, Appendices A and B, can be written in either form, i.e., in terms of frequency f or ω for the purpose of performing the PSD check. The calculated Fourier amplitude would have the same value regardless of whether it is determined based on f or ω. This occurs because in the case of Equation (1), the equation only indicates that F is a function of f. However, to be consistent with NUREG/CR-5347 (which is referenced in Appendices A and B) and other references such as ASCE-4, the SRP is revised. Equations (1) and (2) in Appendix A and Equation (1) in Appendix B are revised to use the circular frequency ω.