Response to Public Comments on Draft Regulatory Guide (DG)-1332
"Nuclear Power Plant Instrumentation for Earthquakes"
Proposed Revision 3 of Regulatory Guide (RG) 1.12

On September 21, 2016, the NRC published a notice in the *Federal Register* (81 FR 64954) that Draft Regulatory Guide, DG-1332 (Proposed Revision 3 of RG 1.12), was available for public comment. The Public Comment period ended November 21, 2016. The NRC received comments from the organizations listed below. The NRC has combined the comments and NRC staff responses in the following table.

Comments were received from the following:

Stephanie Reid
Agencywide Documents Access and Management System
(ADAMS) Accession No. ML16330A495

David Gullott (Exelon Generation Company, LLC)
4300 Winfield Road
Warrenville, IL 60555
ADAMS Accession No. ML16334A277

Scott Burger
612 S. Lauel Street
Richmond, VA 23220
ADAMS Accession No. ML16330A493

Roger M. Kenneally
11160 73rd Avenue
Seminole, FL
ADAMS Accession No. ML16327A010

Erica Gray
VA 23229
ADAMS Accession No. ML16330A496

Justin Wheat (Southern Nuclear Operating Company)
40 Inverness Center Parkway
Post Office Box 1295
Birmingham, AL 35242
ADAMS Accession No. ML16330A492

Anonymous Individual
ADAMS Accession No. ML16330A494 and ML16337A330

Commenter	Section of DG-1332	Specific Comment	NRC's Resolution
Reid-1	General	Comment: "For the nuclear power plants, I believe that everything should be done to keep them safe". Recommendation: No recommendations were provided.	The staff agrees with the comment. No revisions were necessary as a result of this comment.
Anonymous-1	General	Comment: The anonymous individual provided a conference paper entitled "Feasibility study on earthquake early warning and operational earthquake forecasting for risk mitigation at nuclear power plants" and another paper entitled "Seismic alarm system for Ignalina nuclear power plant". Recommendation: No specific recommendations or comments were provided with the submitted papers from the anonymous individual.	Please see response to comment Anonymous-2 below.
Anonymous-2	General	Comment: The anonymous individual submitted the following comment to go with the two papers submitted above (i.e. Anon-1) regarding Early Warning (EEW) information: "the NRC and plant operators should develop protocols to communicate with, receive, and utilize EEW information as it becomes available. This applies both to the West Coast and the Midwest. EEW information may be utilized to recognize impending shaking, avoid critical operations during shaking, adjust plant levels or mitigate any impacts of shaking possibly in advance." The comment also notes that "The USGS is	The staff disagrees with this comment. The USGS ShakeAlert early warning system being developed for the West Coast of the United States is still in the development stage and the system is not yet considered to be reliable enough for public alerts. Limitations of the system are false and missed alerts and underestimation of large magnitude events. Furthermore the area near to an earthquake epicenter may receive little or no warning. The NRC staff is keeping abreast of this work. If the EEW system improves, the staff will re-asses its position. No revisions were made as a result of this comment.

		developing EEW systems and availability of 15-30 seconds of notice of potential shaking could be valuable for a number of reasons as discussed above. Pre-earthquake warning may be more valuable than after the fact analysis of impacts. Recommendation: The NRC and plant operators should develop protocols to communicate with, receive, and utilize EEW information as it becomes available.	
Gray-1	Discussion, page 5	Comment: "Why has the NRC failed to demand implementation of modern day seismic instrumentation at all of our nuclear power plants and one has to wonder why The Channel Check, which is/was a qualitative verification of the functional status of the instrument, sensor and system was ignored, deleted, dismissed or simply forgotten regarding seismic standards and practice?	There were no changes in the RG as a result of this comment. The currently operating reactors were licensed under 10 CFR Part 50 and the seismic instrumentation provides adequate information. New reactor designs have incorporated updated seismic instrumentation and this RG is being updated to address this updated instrumentation. Section D provides guidance on implementation of the guide and it states that "…Applicants and licensees may voluntarily use the guidance in this document to demonstrate compliance with the underlying NRC regulations…The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide..." Other guidance such, as RG 1.166, include steps needed to be taken if there is no instrumentation at the site. As such, demanding the implementation of the latest seismic instrumentation at all of the operating plants is not required. With regard to the comment about use of the Channel Check it is covered by Sections C.4.1, C.9.2.2, and C.9.3.

Burger-1	General	Comment: “This is not as stringent as it should be. From how it reads it looks like it's putting in place approval of what North Anna had in place during Virginia's 5.8 earthquake. I am very concerned about this given how close we were to disaster in North Anna and the fact that Dominion is threatening to now build a third reactor. Please take this matter seriously and have extended public hearings.”	The staff does not agree with this comment regarding the guide not being as stringent as it should be. The guide reflects the state of practice of seismic instrumentation. Seismic safety of NPPs is dealt with in the design phase. Instrumentation is for monitoring purposes only. With regard to the comment to hold extended public hearings on specific plants, it is beyond the scope of the guide. New reactors, prior to licensing, go through public hearings at various stages.
Kenneally-1	Section A. Introduction Applicable Regulations	Comment: Add the following regulation: "10 CFR Part 20, "Standards for Protection Against Radiation," licensees are required to make every reasonable effort to maintain radiation exposures as low as is reasonably achievable." Recommendation: Part 20 needs to be cited, it is the basis for Regulatory Positions 1.3 .3 and 1.3 .4 in both RG 1.12, Revision 2, and this draft guide (DG-1332). Also, the second paragraph in Section C (Staff Regulatory Guidance) cites Part 20.	The staff agrees partially with this comment. 10 CFR Part 20 is now cited in the guide in Section B. Discussion rather than in Section A, “Introduction,” under “Applicable Regulations,” as proposed by this comment. Note that 10 CFR 20 is not a regulation directly associated with the purpose of this regulatory guide, which is to provide guidance to establish engineering criteria for seismic events.
Kenneally-2	Section A. Introduction, Related Guidance	Comment: Corrections are need to the last item in the list of related guidance, ANSI/ANS-2.2. The standard was approved July 14, 2016, and the title should be "Earthquake Instrumentation Criteria for Nuclear Power Plants."	The staff agrees with this comment and the suggested revision was made.
Kenneally-3	Section C, Staff Regulatory Guidance, Regulatory Position 1.2,	Comment: Item (7), add the word "not" after foundation (see highlighted text below). (7) Any Seismic Category I structure foundation not included in a certified standard design or facility.	The staff agrees with this comment and the suggested revision was made.

	"Instrument Type and Location,"	Recommendation: Without the "not" this position is the same as Regulatory Position 1.2 (4).	
Kenneally-4	Section C, Staff Regulatory Guidance, Regulatory Position 1.3 .2, "In-Structure Instrumentation,"	Comment: Add two statements (see highlighted text below). The in-structure instrumentation should be placed at optimum locations that have been included in the building dynamic analysis so that the measured motion can be directly compared with the design in-structure response spectra, or other considerations such as risk-informed locations. The instrumentation should not be located on a secondary structural frame member that is not modeled as a mass point in the building dynamic model. Locations should be selected to record highly amplified response rather than slightly amplified response. Thus, it would be inappropriate to locate instruments where amplification would not be expected. Recommendation: The first addition is to include a statement about using risk-insights in the regulatory process consistent with *Federal Register* notices 76 FR 72220, "Incorporation of Risk Management Concepts in Regulatory Programs,"(11/22/2011), and 78 FR 28258, "mPower™ Design-Specific Review Standard,"(05/14/2013). The second addition is to ensure that in-structure instrumentation is not placed in areas with low amplified response. A similar statement is	The staff agrees with the comments and added a footnote explaining that risk informed locations are locations having systems and components identified as important to safety, based on risk importance concepts such as those contained in Regulatory Guide 1.201, "Guidelines for Categorizing Structures, Systems, and Components in Nuclear Power Plants According to their Safety Significance," or a seismic margin assessment.

		specified in ANSI 18.5-1974, "Earthquake Instrumentation Criteria for Nuclear Power Plants," Section 4, "Location and Number of Instruments," third paragraph. This standard is endorsed (with exceptions) in Revision 1 of RG1.12.	
Kenneally-5	Section C, Staff Regulatory Guidance, Regulatory Position 2, "Instrumentation at Multi-Unit Sites,"	Comment: Add two statements (see highlighted text below). All units at the site should have the same instrumentation unless it can be demonstrated that the site conditions across the site are essentially the same and the expected structural responses of each unit are identical. In this case, a reduced set of instrumentation is permitted. Adequate free-field instruments should be provided to capture differences in site response, unless it can be demonstrates that one free-field instrument is adequate. In the case of separate control rooms for the same or different certified designs, annunciation should be provided to all control rooms as specified in Section C. 7 of this guidance. Recommendation: The first addition addresses the situation where the structures of each unit might be identical but oriented differently, resulting in different responses to vibratory ground motion. The second addition clarifies that a free-field instrument may not be necessary for all units at the site.	The staff agrees with the comments and the suggested revisions were made.

Kenneally-6	References	Comment: When NRC issued Revision 5 to RG 1.29 in July 2016, the title was changed to "Seismic Design Classification for Nuclear Power Plants," revise Ref. 10.	The staff agrees with the comment and the suggested revision was made.
Gullot-1	General	Comment: "One of the benefits, for an existing licensee, of Regulatory Guides (RGs) 1.12, 1.166, and 1.167 is to utilize the cumulative absolute velocity (CAV) in the operating basis earthquake ground motion (OBE) exceedance determination to avoid an unnecessary shutdown. In revision 2 of RG 1.12, it is clear that RG 1.166 and 1.167 also need to be followed. This is no longer mentioned in the "Implementation" section of the proposed Draft Regulatory Guide (DG). The proposed changes from RG 1.12 revision 2 (in particular, free-field locations) may make it difficult for any existing licensee to justify. If the guidance is more achievable, more licensees would voluntarily comply, which would ultimately improve many of the systems across the industry. For example: requiring that a free-field sensor be placed at the surface, but also up to 40 feet below the surface, will be more costly to implement. The below surface location creates problems in terms of addressing accessibility, flooding, ventilation, lighting, confined space, etc."	With regard to the apparent absence of RGs 1.166 and 1.167 in the revised RG, they are cited Section A, "Introduction", under "Related Guidance," and Section B, "Discussion," under "Background." In addition, Appendix A to RG 1.166 is cited as an acceptable method in Section C, "Staff Regulatory Guidance," if the seismic instrumentation is out of service during an earthquake. As such, it is still clear they need to be addressed. With respect to the comment "the proposed changes from RG 1.12 revision 2 (in particular, free-field locations) may make it difficult for any existing licensee to justify," the NRC staff notes that this regulatory guide has been revised to address new reactor plant configurations and the state of practice of seismic instrumentation. Revisions addressing new reactor plant configurations include an additional free-field downhole sensor if the foundation level depth exceeds 40 ft. and that was added to Section C.1.2(1) (b). If downhole instrumentation is needed, the additional cost is not significant. Furthermore, these type of instruments are designed for downhole conditions and therefore it would not be necessary to address flooding and ventilation etc.
Gullot-2		Comment: The criteria for instrumentation, particularly the number of sensors and maintenance, seem excessive. It is likely that there will be some future exception taken to the guidance, and leave licensees with questions on	Disagree with the comment. The specific maintenance tasks described in Section C.9.2 of RG 1.12, Revision 3, are similar to those originally specified in RG 1.12 (Rev. 2). Both documents refer to the supplier of the instrumentation regarding performing testing. However,

		whether the exception will require licensing action(s) over minor maintenance requirements that could have been guided by the manufacturer. Please provide any basis for the expansion of criteria over RG 1.12 revision 2.	RG 1.12, Revision 3 provides guidance regarding the retrieval of downhole instrumentation (Section 9.1 General) and also recommends an increased number of sensors over RG 1.12 (Rev. 2). The increased number of sensors recommended in RG 1.12, Revision 3 is consistent with Section 4.4 of ANSI/ANS 2.2-2016 and is intended to address new reactor plant configurations, which have Seismic Category I structures located on (1) individual foundations, (2) a single foundation (a nuclear island), or (3) a combination or (1) and (2). More than one foundation or basemat instrument may be needed to characterize rocking or torsional behavior for current new designs with a nuclear island that supports the containment and other Seismic Category I structures. In addition, a free-field downhole sensor is needed, if the foundation level depth exceeds 40 ft. The downhole sensor, if needed, would provide a means to validate the site response analyses performed to develop the GMRS and also used to determine the OBE. No revisions were made as a result of this comment.
Gullot-3	Page 2, Related Guidance.	Comment: Suggest addition of: American National Standards Institute/American Nuclear Society (ANSI/ANS)-2.23-2016. "Nuclear Power Plant Response to an Earthquake" which describes actions that the owner of a nuclear power plant shall take to prepare for and respond to a felt earthquake at the plant.	Agree with the comment. The suggestion was adopted since the standard addresses the characteristics of seismic monitoring instrumentation and data acquisition systems in Appendix B of the standard.
Gullot-4	Page 6, Section 1.2(2)	Comment: Additional information on how to meet the guidance in (b) is needed. For example: is the intent that the sensor be placed in the bottom of a manhole? As a result and tradeoff for the additional data point, this location will require a means to	Agree with the comment. The intent is that a downhole sensor be placed at a depth corresponding to the foundation level if this depth exceeds 40 ft. below plant grade (rather than at the bottom of a manhole). As pointed out in the response to Gullot-1, downhole instrumentation is designed for downhole conditions and

		provide ventilation, lighting, prevent floods, address confined space concerns, etc.	therefore it would not be necessary to address flooding and ventilation etc.
Gullot-5	Page 6, Section 1.2(2).	Comment: Suggest including definition for "three component," or utilizing standard language if meaning is "triaxial" as in other parts of the DG.	Agree with the comment. Changed “three-component” to “instrument” as it is referring to triaxial acceleration sensors in the first paragraph of Section C.1.2. Therefore, it is not necessary to specify in C.1.2 (2).
Gullot-6	Page 6, Section 1.2(2)	Comment: Portion (c) missing "three component" prior to "instrument" as in (a) and (b).	Agree with the comment. Changed “three-component” to “instrument” as it is referring to triaxial acceleration sensors in the first paragraph of Section C.1.2, therefore it is not necessary to specify in C.1.2 (2) (c).
Gullot-7	Page 6, Section 1.2(2).	Comment: ANS-2.23-2016 section 6.4.3 (3rd bullet) allows that when response spectra input motions are defined at the foundation, it can be used in lieu of free-field. It is not clearly stated if the same spectra would apply to all three sensors (if needed) and also not clear how to determine exceedance if only one of three sensors exceed.	There were no changes in the RG as a result of this comment. The comment is related to ANSI/ANS-2.23-2016. NRC staff guidance regarding determination of OBE/SSE exceedance is provided in RG 1.166. Revision 3 of RG 1.12 describes instrumentation location considerations that the staff finds acceptable for nuclear power plants and does not address differences in spectra between sensors. RG 1.166 requires free-field instrumentation for the determination of OBE/SSE exceedance and CAV calculations.
Gullot-8	Page 7, Section 1.2(4)	The intent of this portion of guidance is not clear. For example: if a licensee does not have a Seismic Category I structure where the expected response is different from that of containment, would the licensee select a random Seismic I structure?	Sections C.1.2 (4 and C. 1.2(7) were changed to address the comment. If a NPP does not have a Seismic Category I structure where the expected response is different from that of containment, then an instrument would not be needed at this location. Structural instrumentation is needed for comparison of structural response at key points with the standard design. Changed “Any” to “A” in Section C.1.2 (4) and C.1.2 (7).

Gullot-9	Page 6, Section 1.2(6, 7, and 8).	The basis for additional sensor locations. beyond RG 1.12 revision 2 is not presented. Further, applicability may be clarified (i.e., 1.2(6) is only applicable when 1.2(2)(b) or 1.2(2)(c) selected, and 1.2(7) and 1.2(8) applicable for a design certified under 10 CFR 52).	Agree with the comment. The changes in the number of sensors is to respond to changes in the configuration of new plant designs. The staff deems Section 4.4 of ANSI/ANS 2.2-2016 an acceptable method for the placement of sensors, since the standard addresses new reactor plant configurations. The configurations include placement of Seismic Category I structures on (1) individual foundations, (2) a single foundation (a nuclear island), or (3) a combination or (1) and (2). More than one foundation or basemat instrument may be needed to characterize rocking or torsional behavior for current new designs with a nuclear island that supports the containment and other Seismic Category I structures. In addition, a free-field downhole sensor is needed if the foundation level depth exceeds 40 ft. The downhole sensor, if needed, would provide a means to validate the site response analyses performed to develop the GMRS and also used to determine the OBE. Section B "Discussion" under "Reason for Revision" was revised to present the basis for the additional sensor locations.
Gullot-10	Page 7, Sections 1.2(7) and 1.2(8).	The implementation of this portion of guidance is not clear. The instrument location for (7) and (8) seem to be a duplication of instrument locations for (4) and (5), if there exists at least one-seismic Category I structure where the expected response is different from that of containment.	Refer to comment Kenneally-3. Section C.1.2(7) now states "Any Seismic Category I structure foundation not included in a certified standard design or facility."
Gullot-11	Page 7, Section 1.2(9)	This portion of the guidance adds ambiguity. The intent is not clear (e.g., to require NRC concurrence for any implementation or alteration under this guidance, or to provide for additional location changes that licensee specify and may not apply).	Agree with the comment. This paragraph was modified to clarify that a justification is necessary if alternative sensor locations are proposed: "Alternatives to sensor locations C.1.2(2) through C.1.2(8) may be necessary in order to support other

			instrumentation criteria in this regulatory guide. Alternative locations should be selected and justified by the nuclear plant designer or applicant/licensee to ensure that comparisons can be made with the calculated vibratory responses used in the certified standard design or facility."
Gullot-12	Page 7, Section 1.3.	This paragraph and 1.3.3 contradicts locating a sensor in primary containment, see DG Section 1.2(3), since primary containment is inaccessible during operation and will result in high exposures.	There were no changes in the RG as a result of this comment. As stated in Section C.4.1, "Some instruments may be placed in non-accessible locations; their design should allow for remote in-service testing. In addition, Section C.4.3 states "Instrumentation that has sensors located in inaccessible areas should contain provisions for data recording in an accessible location, and the instrumentation should provide an external remote alarm to indicate actuation."
Gullot-13	Page 7, Section 1.3.1, second sentence.	Clarifying words proposed below: A distance of at least one major structure dimension <u>(height or length. whichever is greater)</u> away from all large structures in the vicinity <u>(those that are likely to cause soil structure interaction effects that could contaminate data), but close enough so that the motion recorded is representative of the structure's input motion,</u> should be maintained where possible as recommended by the "Guidelines for Installation of Advanced National Seismic System Strong-Motion Reference Stations," published by Consortium of Organizations for Strong-Motion Observation Systems (COSMOS) (Ref. 12).	To respond to the comment this paragraph was modified to: A distance of at least one major structural dimension (height or length, whichever is greater) away from all large structures in the vicinity should be maintained where possible as recommended by the "Guidelines for Installation of Advanced National Seismic System Strong-Motion Reference Stations," published by Consortium of Organizations for Strong-Motion Observation Systems (COSMOS) (Ref. 13). The guidelines are an acceptable approach.

Gullot-14	Page 8, Section 1.3.5	This paragraph is inconsistent with the free-field location of requiring a sensor up to 40 feet below the surface, see DG Section 1.2(1).	Disagree with the comment. Downhole sensors are common practice and the maintenance of these sensors is not difficult or costly (see response to Gullot-1). Most seismic instrumentation companies are producing downhole accelerometers and the addition of such sensors would not significantly increase the cost of seismic instrumentation at a NPP. No revisions were made as a result of this comment.
Gullot-15	Page 8, Section 2	The scope of a "reduced set" of instrumentation is not clear, nor a method to determine. No additional seismic instrumentation is needed for identical units.	At multiunit sites, the site response evaluations performed as part of Section C.2.5.2 of an applicant's Final Safety Analysis report, would provide the information necessary to determine whether or not one-free field instrument is adequate, while site-structure interaction calculations may provide input regarding the need for foundation and in-structure instrumentation at each unit. In many cases foundation conditions differ for two identical units at the same site. This section has been modified in response to comment Keneally-5.
Gullot-16	Page 8, Section 4.1	For existing licensees, adding more sensors to a location where there is no existing wiring going back to the central panel will likely make the project infeasible. Having a sensor not connected back to the central panel should be acceptable as long as it is not one used for OBE exceedance determination. The data can still be uploaded for postearthquake analysis using a laptop.	There were no changes in the RG as a result of this comment. Current licensees may choose to add new sensors not connected to the central panel provided that there is adequate justification.

Gullot-17	Page 9, Section 4.6	Bartec Syscom's standard product has up to 60 hours autonomy with an internal battery. Although an external battery can be added to reach the 96 hours guidance, no discussion is provided for the basis of additional autonomous time from RG 1 .12 revision 2.	There were no changes in the RG as a result of this comment. Revisions on battery capacity made in RG 1.12, Revision 3 from RG 1.12, Revision 2 are consistent with ANSI/ANS 2.2-2016.
Gullot-18	Page 10, Section 4.11.	Bartec Syscom's standard certified and tested product is a very stable MEMS sensor at 100dB, providing basically no maintenance and very low cost of ownership. No discussion is provided for the basis of the change from 1000:1 to 300,000:1.	There were no changes in the RG as a result of this comment. The basis for the change of dynamic range from 1000:1 to 300,000:1 in Revision 3 of RG 1.12 from RG 1.12, Revision 2 reflects the need for the instrumentation to have the capability to accurately sense and record a felt earthquake at the plant to determine the need for plant shutdown. This could include potentially large earthquakes in exceedance of the OBE and SSE as well as relatively smaller felt events at the plant. Furthermore, the specified dynamic range is also consistent with present day instrument capabilities such as Bartec Syscom's MS 2005 which provides the specified dynamic range.
Gullot-19	Page 10, Section 4.11	Damping is not applicable to a MEMS sensor.	Agree with the comment. Currently available MEMS sensors do not satisfy dynamic range requirements of 110 db. Their dynamic range is normally about 90 db, much lower than classical force-balance sensors. Hence, they are not recommended for use at NPPs. In the meantime NRC dropped damping requirements in case future MEMS sensors will be able to reach the required dynamic range. Revisions were made to address the comment.

Gullot-20	Page 11, Section 4.12.1.	The guidance does not state a basis for going from 200 to 250 samples per second. RG 1.12 revision 2 provides a rate of 200 samples per second.	There were no changes in the RG as a result of this comment. The sample rate (recording speed) was revised for consistency with RG 1.208. Specifically, the change in the upper limit of the free-field acceleration sensor frequency range from 50 Hz to a minimum of 100 Hz in Section C.4.11.2 of RG 1.12 ,Revision 3, which is consistent with the upper frequency limit of 100 Hz specified in RG 1.208 in the development of the GMRS (Regulatory Position 3.4). Accordingly, the sampling rate of the recorder is increased to 250 samples per second in order to obtain a 100-Hz bandwidth. The requirement of 250 samples per sec comes from the existing practice of going up to 80% of Nyquist frequency in frequency response.
Gullot-21	Page 11, Section 4.13.1	A 0.01 g seismic trigger (from the previous 0.02g) creates more likelihood of spurious alarms, which contradicts later statements about avoiding spurious actuations. The basis for making this change from RG 1.12 revision 2 is not provided.	There were no changes in the RG as a result of this comment. This change is consistent with ANSI/ANS-2.2-2016. Current practice in the US National Seismic Instrumentation (USGS and CGS) systems is to use 0.005 g as a trigger level, so the requirement of 0.01 g does not introduce any technical problems and is consistent with current practices.
Gullot-22	Page 12, Section 5.1.	Clarifying words proposed below: If a special, light instrument hut is used, the pad should be monolithically cast concrete reinforced with steel rebar or wire mesh, approximately 4 ft. square, with four 6 in. dia. x ~~18~~ 8 in. long (min.), reinforced concrete piers down into soil to ensure effective pad anchoring and coupling with ground (see Ref. 16. Figure 2).	Disagree with the comment. Section C.5.1 is consistent with ANSI/ANS-2.2-2016 (Section 6.1). For supporting information on installation of equipment, Section 5.1 refers to "Guidelines for Installation of Advanced National Seismic System Strong-Motion Reference Stations." No revisions were made as a result of this comment.

Gullot-23	Page 12, Section 5.1.	This is the first mention of "downhole." If the meaning is a buried sensor at the free field, it should be described earlier in the DG.	We agree with the comment and reference to downhole instrumentation was added to Section C.1.2(1)(b).
Gullot-24	Page 13, Section 5.7.	Some sensors may not be able to be connected back to the central panel because of extensive cable costs. Consideration should be made for relaxing the guidance for sensors that are stand-alone in the field. The relative time accuracy can likely be achieved when the sensor is connected back to the central panel, but not when it is stand-alone. RG 1.12 revision 2 does not include provisions for all sensors being connected back to the central panel.	Disagree with the comment. As stated in Section C.4.12.5 of RG 1.12, Revision 3, absolute timing accuracy is important in order to differentiate the main shock from any foreshock and aftershock. As discussed in ANSI/ANS-2.2-2016 Appendix B (Section B.1.8), common timing of the instrumentation is necessary, for example, to determine phasing information between the free-field, basemat, and in-structure responses at each unit and similarities and differences between each unit. No revisions were made as a result of this comment.
Gullot-25	Page 13, Section 5.7	The requirement of Universal Time Coordinated time will require a GPS antenna or some other means (e.g., network connection) to achieve. This will create cyber security concerns. No discussion is provided for why the time precision is important.	Disagree with the comment. The specification of Universal Time Coordinated time is state of the practice and consistent with ANSI/ANS-2.2-2016. GPS may be used to achieve the specified timing accuracy. The following sentence has been added to Section C.4.12.5 of RG 1.12, Revision 3 for clarification (and consistency with ANSI/ANS-2.2-2016): “A GPS, network timing protocols, or another equivalent timing protocol shall be applied to both the timing and sampling of all data channels to provide this minimum accuracy”. In addition, see response to comment Gullot-24 above regarding the importance of timing accuracy. No revisions were made as a result of this comment.

Gullot-26	Page 13, Section 5.7.	Bartec Syscom, a leading seismic instrument vendor, can only achieve 5 milliseconds of relative timing.	Disagree with the comment. Section C.5.7 of RG 1.12, Revision 3 states: "All instruments on the site should maintain a common time scale with relative timing accuracy not less than 1 millisecond and absolute timing accuracy better than 5 milliseconds of absolute Universal Time Coordinated (UTC) time." This is consistent with ANSI/ANS-2.2-2016 (Section 4.6) and reflects present day instrument capabilities. If an instrument does not fit into this criteria, alternative options are available. No revisions were made as a result of this comment.
Gullot-27	Page 13, Section 6.1.	It is understood that the free-field and perhaps the containment sensors should activate all of the recorders. But, if one of the elevation sensors is triggered, it seems that it would only need to trigger itself. Any sensor that gets triggered without the triggering of the free-field or containment foundation is expected to be a spurious trigger.	Disagree with the comment. As stated in Section C.6.1 "since the time history recorders are interconnected, they should be activated by the same trigger. In this case, the trigger should be located with the time history recorder nearest to the free-field ground station." The in-structure sensors would not have triggers. No revisions were made as a result of this comment
Gullot-28	Page 13, Section 6.2.	This statement contradicts the low trigger threshold, see DG Section 4.13.1 and 6.3.	Disagree with the comment. This statement is consistent with Section 6.4.1 of ANSI/ANS-2.2-2016 in that spurious triggering should be avoided. No revisions were made as a result of this comment. See response to comment Gullot-27 for additional clarification.
Gullot-29	Page 14, Section 7.	Ambiguous guidance without additional clarity for intent of "or" and "any." The section can be interpreted to mean that triggering all or just one time-history recorder being triggered needs to annunciate in the control room.	Disagree with the comment. No revisions were made as a result of this comment as the intent of Section 7 is that triggering of any of the recorders should be annunciated in the control room. This remains unchanged from RG 1.12, Revision 2 except for the addition of the downhole sensor (if needed).

Gullot-30	Page 14, Section 9.1.	Additional clarity for intent of guidance needed. The MEMS sensors are usually only functionally checked by putting on a tilt table. Testing should be based on the manufacturer's recommendations since they will differ from one system to the next.	Disagree with the comment. This is captured in Section 9.3: "the supplier of seismic instrumentation should include in the documentation of each product a specific explanation of how to accomplish channel check, channel functional test, and channel calibration." No revisions were made as a result of this comment.
Gullot-31	Page 15, Section 9.2.	Guidance does not address a station whose refuel cycle is every 2 years when it says "whichever comes first." It should state "24 months or during each refueling outage, whichever comes first" to include a 2 year refuel cycle.	This recommendation was adopted.
Gullot-32	Page 16.	In the RG 1.12 revision 2, there was discussion of the need to comply with the other two associated RGs 1.166 and 1.167. In this revision, there is no mention of this requirement.	No revisions were made as a result of this comment See response to Gullot-1. Since RG 1.12, Revision 2 was developed, NRC regulatory guides have undergone some reformatting (including Section D. Implementation). In Revision 3 of RG 1.12, RG 1.166 and RG 1.167 are cited in Section B, "Discussion," under "Background." In addition, Appendix A to RG 1.166 is cited as an acceptable method in Section C, "Staff Regulatory Guidance," if the seismic instrumentation was out of service during an earthquake.
Gullot-33	Page 19, Glossary.	Clarifying words proposed below: Free field The free-field is defined as those locations on the ground surface or in the site soil column that are sufficiently distant from <u>(not influenced by)</u> the nuclear power plant structures to be essentially unaffected by the vibration of these structures.	Disagree with the recommendation. The addition of "not influenced by" was not added. The sentence already implies this by stating "…to be essentially unaffected by the vibration of these structures" No revisions were made as a result of this comment.

		Therefore, a time-history recorder located at the free-field records essentially the free-field ground motion.	
Gullot-34	Page 20, Glossary.	Additional term proposed below: Soil-Structure Interaction The phenomena in which a large structure rocks and translates in the surrounding soil thereby modifying the earthquake motion in its immediate vicinity and also changes the response of the structure. Such phenomena, which are more typical in relatively rigid structures such as nuclear power plant containments, can both decrease and increase the response of the structure at different frequency ranges.	Disagree with the comment. This definition was not added because soil structure interaction is not explicitly discussed in the guide. No revisions were made as a result of this comment.
Gullot-35	Page 22, References.	Tied to comment 21 above. Additional reference: 16. EPRI TR-104239 "Seismic Instrumentation in Nuclear Power Plants for Response to OBE Exceedance: Guideline for Implementation," Electric Power Research Institute, Palo Alto, California, June 1994.	Disagree with this suggestion. Comment 21 does not refer to this reference. EPRI TR-104239 is not referenced in the guide since it is surpassed by more recent guidance. No revisions were necessary as a result of this comment.
Wheat-1	Section B. Discussion	Comment: The 2nd paragraph, 1st sentence refers to "foundation level." It is not clear if this is intended to mean outside the structure at the foundation level, i.e.: embedded. Recommendation: Provide clarification of "foundation level."	Agree with this comment. Some clarification of foundation level is already provided in Section C, Staff Regulatory Guidance, Section 1.2. In response to this comment, additional clarification is provided at the end of this section by adding a reference to Table 1 and Figures 1 through 4 in ANSI/ANS-2.2-2016, which illustrate sensor locations and numbers for various nuclear power plant design configurations. The figures show that one instrument is necessary at the foundation level (outside the structure i.e. free field instrument) if this depth exceeds 40 ft. below the plant grade.

Wheat-2	Section B. Discussion and Section C. Staff Regulatory Guidance, Section 1.2(1)	Comment: Section B provides the purpose for seismic instrumentation at different locations. Free-field instruments are used to compare to design input motion for structures and determination of OBE exceedance. Instrumentation at the foundation level and at elevations in the structure is used for seisrnic structural response and input to equipment and piping and long-term evaluations. Section/bullet C 1.2 (1) Free-field lists two locations where sensors should be installed. One is to be at the free ground surface and a second at depth. The second sensor, according to the Draft Guide as it is currently proposed, would be downhole seismic instrumentation. The purpose of the downhole instrumentation is not clearly described in Section B. Recommendation: Provide.further explanation of the purpose of the downhole instrument in Section B, Discussion.	Agree with this comment. To address it a short description of the purpose of the downhole instrumentation was added to the Discussion Section. It notes that the primary goal of the downhole instrument is to obtain quality recordings of in situ strong motion at depth. Downhole instrumentation, which is needed if the foundation level depth is greater than 40 ft., is used to validate site response calculations used to develop the GMRS and FIRS, as well influencing the selection of the OBE.
Wheat-3	Section C. Staff Regulatory Guidance, Section 1.2(1)(a)	Comment: The GMRS is characterized by horizontal and vertical response spectra determined as free-field motions on the ground surface or, as provided in RG 1.208, as free- field outcrop motions on the uppermost in-situ competent material using performance-based procedures following RG 1.208. Suggest adding "or". Recommendation: To provide clarity to this sentence, suggest rewording as follows: "At the	The specific recommendation was not adopted as the intent of this sensor location is to be consistent with the site conditions and properties used to determine GMRS. To address the situation where it may be necessary to have the free-field instrument site condition different from the GMRS or FIRS site condition, a reference to ANSI/ANS-2.2-2016 has been added to Section C.1.2 and C.1.2(a) was modified as follows: “At the free ground surface, the location should be consistent with the site conditions and properties used to determine the site-specific GMRS. If the site condition

		free ground surface, or the location consistent with the site conditions .... "	at the free-field instrument location is different from the site condition at the plant site, transfer functions should be developed in advance to transfer the free-field motion at the instrument location to the plant site and should be included in the assessment of the free-field recorded motion at the plant site."
Wheat-4	Section C. Staff Regulatory Guidance, Section 1.2(1)(b)	Comment: This section/bullet is confusing. It would be more clear to define conditions for Category I structures founded on rock vs. soil sites. Recommendation: Reword the section/bullet to define conditions for Category I structures founded on rock vs. soil sites.	This comment is no longer be applicable as Section C.1.2(1)(b) has been revised as a result of previous comments. No revisions were made as a result of this comment
Wheat-5	Section C. Staff Regulatory Guidance, Section 1.2(1)(b)	Comment: Section/bullet C 1.2 (1) *Free-field* currently states the sensor should be installed "at a depth corresponding to the top of competent rock, or at foundation level if that is where the certified seismic design response spectra (CSDRS) and GMRS are defined if this depth exceeds 40 ft. below plant grade." At some sites, "rock" can be at a significant depth below the free ground surface. No definition of "top of competent rock" is provided. The "top of competent rock" could be defined as "the top of the first in-situ layer of competent material." The DG does not indicate what the measured motion at this location be compared to. Recommendation: Provide clarification or definition of "top of competent rock." Provide clarification as to the purpose of the sensor and its use.	This comment is no longer applicable as Section C.1.2(1)(b) has been revised as a result of previous comments. Specifically, Section 1.2(1)(b) has been revised to "Downhole instrumentation at a depth corresponding to the foundation level, if this depth exceeds 40 ft. below plant grade." The reference to competent rock has been removed and therefore this definition is no longer necessary. Regarding the clarification as to the purpose of the downhole sensor, refer to the response to comment Wheat-2, which states that a short description of the purpose of the downhole instrumentation was added to the Discussion Section. No revisions were made as a result of this comment

Wheat-6	Section C. Staff Regulatory Guidance, Section 1.2(1)(b)	Comment: This section/bullet is describing a "downhole instrument'. The installation and particularly the maintenance of a seismic downhole instrument is problematic. Keeping the instrument dry, and removing and reinstalling the instrument for maintenance are some of the main challenges. These real challenges have to be weighed against the potential benefits of Installing this second free-field instrument. Recommendation: Provide a basis demonstrating that the costs of installing and maintaining a seismic downhole instrument have been shown to be outweighed by the benefit of the information that would be provided, including lower cost alternatives such as a surface array of broad-band sensors. A surface array would be less expensive and easier to install and maintain than a downhole instrument.	Disagree with the recommendation. As stated in response to comment Wheat-2, the primary goal of the downhole instrument is to obtain quality recordings of in situ strong motion at depth. Downhole instrumentation is used to validate site response calculations used to develop the GMRS and FIRS, as well influencing the selection of the OBE. Existing downhole instrumentation including cabling is water proof. Downhole accelerometers are used all across the state of California near many bridges. They have been working there for many years. Broadband arrays are not required for engineering purposes. No revisions were made as a result of this comment.