[redacted]

STAFF EVALUATION OF WESTINGHOUSE COLUMBIA FUEL FABRICATION FACILITY RESPONSE TO GENERIC LETTER 2015-01: TREATMENT OF NATURAL PHENOMENA HAZARDS IN FUEL CYCLE FACILITIES

I. Background

On June 22, 2015, the U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2015-01, “Treatment of Natural Phenomena Hazards in Fuel Cycle Facilities” (Agencywide Documents Access and Management System (ADAMS) Accession No.: ML14328A029). The GL requests information from licensees of fuel cycle facilities to verify the assumptions in the facilities' integrated safety analyses (ISAs) regarding how each facility addressed the potential consequences of natural phenomena hazards (NPH) events in the ISA. By letter dated August 26, 2015, the Westinghouse Columbia Fuel Fabrication Facility (Westinghouse) responded to GL 2015-01 (ADAMS Accession No.: ML15238B643). The NRC staff (staff) issued a request for supplemental information on February 22, 2016 (ADAMS Accession No.: ML16005A112) and by letter dated June 21, 2016, Westinghouse provided its response (ADAMS Accession No.: ML16173A375). In addition, the staff visited the site on December 8-9, 2015, to review onsite calculations and perform structural walkdowns. A summary of the site visit is available at ADAMS Accession No.: ML16013A366.

The purpose of this evaluation report is to document the staff’s review of Westinghouse’s response to GL 2015-01, including its response to the request for supplemental information and onsite calculations, to determine if Westinghouse adequately addressed the potential effects of NPH events in the ISA. The staff selected a subset of NPH using a risk-informed approach to verify that Westinghouse used appropriate methods to evaluate the impacts of NPH in conducting the facility's ISA. The staff did not perform a complete assessment of the ISA for all NPH events nor did it conduct a design certification review for NPH. This method is consistent with NRC guidance in Chapter 3 of NUREG-1520, "Standard Review Plan (SRP) for the Review of a License Application for a Fuel Cycle Facility." The staff also used Interim Staff Guidance (ISG) No.: FCSE-ISG-15, “Natural Phenomena Hazards in Fuel Cycle Facilities” (ADAMS Accession No.: ML15121A044) for its review. The staff will perform an inspection using Temporary Instruction (TI) 2600/016, “Inspection Activities Associated with GL 2015-01” (ADAMS Accession No.: ML15317A506) to independently verify that Westinghouse is in compliance with the regulatory requirements and applicable license conditions regarding the treatment of NPH in its ISA. The inspection results from this TI will also be used to follow-up with previously identified Unresolved Items regarding the treatment of NPH and to inform the closure process of NRC GL 2015-01. The results of these regulatory activities will allow the staff to verify that Westinghouse demonstrates compliance with regulatory requirements and applicable license conditions regarding the treatment of NPH at the facility.

Westinghouse is located in Hopkins, South Carolina, about 10 miles south of Columbia, South Carolina. Westinghouse uses low enriched uranium to fabricate fuel assembled for commercial nuclear power plants. Existing processes at Westinghouse are not required to meet the requirements of 10 CFR 70.64(a), “Baseline design criteria” which applies to new facilities or new processes at existing facilities.

Enclosure

[redacted]

[redacted]

II. GL 2015-01 Requested Actions

In the GL, the staff requested that all addressees provide information to verify the assumptions in there facilities' ISAs regarding how each facility provides adequate protection against the occurrence of natural phenomena events. Specifically, the staff asked that addressees take the following actions:

a) Submit definitions of "unlikely," "highly unlikely," and "credible" in evaluating natural phenomena events in the ISA such as earthquakes, tornadoes, tornado missile impacts, floods, hurricanes, and other wind storms. (See Section III.1.0 on page 2).

b) Submit a description of the safety assessment for the licensing and design basis natural phenomena events, including the following information: (See Section III.2.0 on page 3).

   i. likelihood and severity of the natural phenomena events, such as earthquakes, tornadoes, floods, hurricanes, and other wind storms;

   ii. accident sequences as a result of natural phenomena event impacts to facility structures and internal components;

   iii. assessment of the consequences for the accident sequences from item ii that result in intermediate and/or high consequence events; and

   iv. items relied on for safety to prevent or mitigate the consequences of the events from items ii and iii.

c) For facilities subject to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 70, Subpart H requirements, submit a description of the results of the ISA review used to comply with 10 CFR 70.62(c), identifying the characteristics of the licensing and design basis natural phenomena events applicable to the site, that evaluates possible changes in the methodology, likelihood, and severity of natural phenomena events with those used in the original design/evaluation of the facility. (See Section III.3.0 on page 21).

d) Submit for staff review a summary of the results of any facility assessments or walk downs, if performed, to identify and address degraded nonconforming, or unanalyzed conditions that can affect the performance of the facility under natural phenomena and have available for NRC inspection the documentation of the qualifications of the team. (See Section III.4.0 on page 21).

III. Westinghouse's Response to GL 2015-01 and Staff Evaluation

1.0 <u>NRC GL 2015-01, Requested Action (1)a:</u> Submit the definitions of "unlikely," "highly unlikely," and "credible" in evaluating natural phenomena events in the ISA such as

[redacted]

2.0 earthquakes, tornadoes, tornado missile impacts, floods, hurricanes, and other wind storms.

Westinghouse submitted definitions of “unlikely,” “highly unlikely,” and “credible” that they applied in their ISA. These definitions do not prescribe specific criteria for NPH events. The staff verified that the definitions were consistently applied in the ISA analysis for NPH events. The results of the staff review can be found below. Therefore, the staff finds that Westinghouse has adequately responded to GL 2015-01 Requested Action (1)a.

2.0 NRC GL 2015-01 Requested Action (1)b: Submit a description of the safety assessment for the licensing and design basis natural phenomena events, including the following information (See Section III.2.1, III.2.2 and III.2.3):

i. likelihood and severity of the natural phenomena events, such as earthquakes, tornadoes, floods, hurricanes, and other wind storms;

ii. accident sequences as a result of natural phenomena event impacts to facility structures and internal components;

iii. assessment of the consequences for the accident sequences from item ii that result in intermediate and/or high consequence events; and

iv. items relied on for safety to prevent or mitigate the consequences of the events from items ii and iii.

Westinghouse submitted safety assessments for NPH events applicable to their site, including earthquakes, flooding, high winds, tornadoes, and hurricanes. A summary of Westinghouse’s assessments and the staff evaluations for selected NPH events are contained below.

2.1 Earthquakes

2.1.1 ISA for Seismic Hazards

Westinghouse provided information regarding implementation of its ISA methodology to determine whether additional items relied on for safety (IROFS) are needed as a result of seismic induced accident sequences. Using the risk-targeted seismic hazard maps for the South Carolina region in the International Building Code 2012 (IBC 2012), Westinghouse performed a structural engineering evaluation of systems structures and components (SSCs) with loads from an earthquake hazard with 2 percent probability of exceedance in 50 years and equated those events to a frequency score of -4, “highly unlikely.” The structural engineering evaluation of equipment, building components, and piping showed failures during earthquake hazards more frequent than that of 2 percent probability of exceedance in 50 years. These more frequent earthquake hazards equate to 10 percent and 5 percent probabilities of exceedance in 50 years or return periods of around 500 and 1000 years, respectively. Therefore, Westinghouse applied 2E-3 earthquake per year as the initiating event frequency for all seismic induced accident sequences.

[redacted]

Taking into consideration the potential failure of SSCs as a result of seismic activity, Westinghouse identified nine criticality (Section III.2.1.4) and three non-criticality (Section III.2.1.3) accident sequences. [redacted]

Staff Evaluation:

The staff reviewed Westinghouse's responses, engineering evaluations, and the 2016 ISA Summary Update (ADAMS Accession No.: ML16026A052). Specifically, the staff evaluated Westinghouse's approach for considering seismic events within its ISA and the methodologies applied to determine likelihoods, consequences, and IROFS.

In general, Westinghouse's approach to analyzing seismic events within its ISA is similar to its approach for other process hazards. Specifically, Westinghouse estimated the likelihood of seismic induced accident scenarios, determined the consequences of those accidents and applied IROFS for unmitigated unlikely scenarios with at least intermediate consequences and for highly unlikely scenarios with high consequences.

The staff agrees that Westinghouse's approach to classify the likelihood of seismic induced events based on the definitions established within its ISA methodology is adequate for the following reasons. As previously mentioned, based upon a seismic analysis of equipment, building components, and piping, Westinghouse estimated the initiating event frequency of an earthquake that could cause damage to be 2E-3. Westinghouse arrived at this estimation by dividing the probability of exceedance by 50 years. The staff agrees that when the frequency of an event is significantly small over a given time period, similar to the frequency of rare events like earthquakes on the east coast, an adequate estimation of the value of the initiating event frequency is the probability of exceedance divided by the exceedance period, in this case 10 percent (0.10) divided by 50 years. Based upon Westinghouse's likelihood definitions, Westinghouse designated the likelihood of this event as "unlikely."

The staff reviewed Westinghouse's approach to determining the consequences of the aforementioned criticality and non-criticality accident sequences. Specifically, the staff noted that Westinghouse applied the results of the seismic analysis to qualify the extent of each accident sequence in terms of the worst case Emergency Response Planning Guidelines (ERPG) concentrations or amounts of SNM. In other words, depending on the equipment or component failure, Westinghouse analyzed the largest potential chemical release or accumulation of SNM, then determined the consequences based on those amounts. Because Westinghouse analyzed using the worst case scenarios for the assessments of releases, the staff agrees that Westinghouse's approach to determining the consequences of seismic induced accident sequences is conservative and adequate.

[redacted]

[redacted]

The staff reviewed Westinghouse's approach to identify IROFS required to prevent or mitigate seismic induced accident sequences. Similar to the approach to determine accident sequence likelihoods and consequences, Westinghouse applied the results of the seismic analysis to identify both safety-significant SSCs and necessary modifications to either prevent damage to those SSCs or mitigate the consequences in the event of a criticality or chemical release. Westinghouse implemented [redacted] IROFS equivalent to inspected passive safety devices, [redacted] of which are seismically qualified, and [redacted] administrative IROFS equivalent to protection by a trained operator performing a non-routine task. [redacted] of the administrative IROFS are diverse methods of protecting against a chemical release. Based on this, the staff agrees that Westinghouse's approach to identifying IROFS specific to seismic induced accident sequences is adequate.

The staff reviewed Westinghouse's approach to determining whether the IROFS identified adequately prevent or mitigate the seismic induced accident sequences. Westinghouse, after designating specific IROFS, calculated an Overall Likelihood Index (OLI) for each sequence. Each IROFS is prescribed a mitigative index, indicating the degree of protection the IROFS provides. These indices are similar to those in Table A-10, "Failure Probability Index Numbers" in NUREG-1520 Revision 2, which establishes mitigation indices based on the quantitative failure probability or qualitative description of the type of IROFS. For each accident sequence, the indices associated with the IROFS applied are summed and then added to the initiating event frequency index. Based on the results of that calculation, Westinghouse would consider an accident sequence adequately protected if the OLIs of highly unlikely, high consequence sequences are less than or equal to -4 (~1E-4 likelihood in events/year) or unlikely, intermediate consequences sequences are less than or equal to -3 (~1E-3 likelihood in events/year). Implementing this approach, Westinghouse concluded that the OLIs for each accident sequence meet the required likelihood criteria and therefore, the IROFS established provide adequate protection.

In the context of NPH, evaluating an OLI as previously described could result in an incomplete analysis of natural phenomena hazards on the facility. The staff recognizes that NPH, such as earthquakes, are rare events with initiating event frequencies that could equate to likelihoods of highly unlikely. In other words, a licensee would consider the performance requirements met through the likelihood of the natural phenomena without the support of a structural analysis, the application of a structural code such as IBC 2012, or the implementation of any IROFS. Under those circumstances, according to Westinghouse's OLI approach, IROFS for high consequence sequences would not be necessary. Similarly, according to Westinghouse's approach, IROFS for intermediate consequence sequences would not be necessary for natural phenomena with initiating event frequencies equivalent to OLIs of -3 or less. This approach does not take into account the significant uncertainties associated with calculating an initiating event frequency for NPH. Furthermore, the example failure frequencies and probabilities in NUREG-1520 Revision 2 Table A-10, and similar to those used by Westinghouse, are not conditional seismic failure probabilities, and therefore, should not, without basis, be directly added to the initiating event frequency to demonstrate adequate preventive or mitigative IROFS. This includes using the likelihood indices for assessing the failure of equipment and components to perform safety functions for which they have not been designed under seismic loads. The staff discussed the concerns with this approach with Westinghouse. By letter dated July 6, 2016, (ADAMS

[redacted]

Accession No.: ML16189A005) Westinghouse committed to revise the ISA Summary in the next submission to the NRC.

The staff recognizes that under circumstances that involve rare events with significant uncertainty, implementation of a defense-in-depth strategy is an adequate approach to determining IROFS and qualitatively assessing the level of protection they provide. NUREG-1520, Revision 2, defines defense-in-depth as “the degree to which multiple IROFS or systems of IROFS must fail before the undesired consequences (e.g., criticality, chemical release) can result.” For seismic induced accident sequences, Westinghouse implemented several IROFS whereby, only through the failure of multiple IROFS, could intermediate or high consequences occur as defined in the performance requirements of 10 CFR 70.61 “Performance requirements.” As mentioned previously, these layers of protection include multiple inspected active safety devices or inspected passive safety devices with diverse administrative backups. For some accident sequences, Westinghouse implemented only diverse administrative controls. These controls, according to Westinghouse, involve proceduralized mitigation actions on which personnel are periodically trained.

Although the staff does not agree with Westinghouse’s approach for quantitatively assessing the overall likelihood of a seismic induced accident sequence, the staff does agree that, based on a seismic evaluation of the facility, as described in Sections III.2.1.3 and III.2.1.4 the IROFS Westinghouse identified represent an adequate defense-in-depth strategy to determining whether seismic induced accident sequences are adequately prevented or mitigated.

2.1.2 Seismic Evaluation of Building Structures and Equipment

<u>Building Structures</u>:

Westinghouse stated in response to GL 2015-01 and in Section 4.2.5 of their ISA Summary (Westinghouse, 2015b, ADAMS Accession No.: ML16026A052) that the original fuel manufacturing building was designed to comply with the Southern Standard Building Code, 1965 Edition, and was designed to meet Seismic Zone 1 criteria. Two other building additions constructed in 1978 and 1986, were designed to comply with the Southern Standard Building Code, 1976 and 1986 Editions, respectively.

In 2013, Westinghouse performed a seismic evaluation of the main manufacturing buildings and selected equipment. They performed structural analyses of the buildings using the finite element code ANSYS. The buildings are of steel frame construction, varying from one story to multi-story for the 1986 expansion. Floors consist of concrete floor slab on grade for the manufacturing area and mezzanine floors supported by the superstructure. The details of the building structures, including member section properties and material strengths, for seismic analyses have been obtained from a combination of original building drawings, original design calculations, various soil reports, walk downs, and applicable revisions of the American Institute of Steel Construction (AISC) manual.

Westinghouse stated that it used the 2002 version of DOE-STD-1020 (DOE, 2002a) and DOE-STD-1021 (DOE, 2002b) to identify the performance category of the facility. They applied the methodology specified in DOE-STD-1021 (DOE, 2002b) and determined the site as a Performance Category-2 (PC-2) facility. Per DOE-STD-1020-2002 (DOE, 2002a), a PC-2 facility is designed/evaluated as an essential facility in accordance with the IBC requirements using pseudo static earthquake analysis methods. Westinghouse evaluated the facility in accordance with IBC 2012, using an evaluation basis earthquake hazard for the structural analysis with load corresponding with an earthquake with a 2 percent probability of exceedance in 50 years and an importance factor of 1.5. This corresponds to seismic loads from earthquakes with a rate of exceedance of $4x10^{-4}$ or earthquake ground motions with a return period of about 2,500 years. The Direct Analysis Method procedure as specified in AISC 14th edition was performed using static equivalent seismic loads calculated from ASCE 7-10. Based on the structural analysis results (Westinghouse, 2013a), Westinghouse concluded that the main manufacturing buildings are stable and are not near a collapse state. [redacted]

[redacted]

Equipment:

Westinghouse conducted seismic response spectrum analyses for equipment and tanks using methodologies from the IBC 2012 and ASCE 7-10. The natural period of the equipment was calculated using finite element codes or by using equations given in ASCE 7-10. Westinghouse stated that the majority of the process equipment evaluated was found to remain stable from loads experienced from the evaluation basis earthquake. The seismic evaluation determined that the process equipment with identified failure modes due to the evaluation basis earthquake hazard were the [redacted]

Staff Evaluation:

The staff reviewed the structural analysis of the main manufacturing facility buildings and equipment. The staff agrees with the use of DOE-STD-1020-2002 as an acceptable methodology for the evaluation of earthquake hazards at the facility. DOE-STD-1020-2002 provides a methodology for the categorization of structures based on the risk of releases from hazardous materials. Specifically, the standard allows the facility to be classified as PC-2 when the radiological consequences are less than 25 rem offsite. The categorization of the structure establishes target performance goals for the system, and establishes the return period of the NPH event to which the SSC design will need to be evaluated and the codes to use for the seismic evaluation. The staff reviewed the assessment of the consequences used to determine the categorization of the facility as PC-2. Based on independent analysis, the staff agrees with Westinghouse's estimate of radiological consequences from [redacted] UF_6 cylinders each releasing UF_6 at the rate of [redacted] kg/sec. The staff's analysis also considered the chemical consequences of UF_6 releases from the [redacted] cylinders and concluded that the HF concentration at the site boundary from these UF_6 releases would be less than AEGL-1. The staff used the consequence thresholds as defined in the performance requirements of 10 CFR 70. 61(b) to conclude that a PC-2 categorization is still appropriate when considering the chemical effects of the release to offsite receptors. Based on this conclusion the staff agrees with Westinghouse that the facility can be categorized as a PC-2 facility and that the use of IBC with ASCE 7-10 loads corresponding with an earthquake with a 2 percent probability of exceedance in 50 percent years, soil site class D, and an importance factor of 1.5 is adequate to evaluate the seismic response of systems, structures and components. The use of the IBC 2012 [ICC, 2011; Figures 1613.3.1(1) and 1613.3.1(2)] with the new risk-targeted seismic map, 2 percent probability of recurrence in 50 years, provides a target risk of seismic induced structural collapse equal to 1 percent in 50 years based on a generic structural fragility.

The staff performed sample reviews of the building drawings and structural analysis reports to determine if the seismic evaluation was adequately performed. The staff also verified and determined that the seismic hazards curves and seismic input parameters that Westinghouse selected are the appropriate ground motion parameters for the seismic evaluation. Based on these reviews, the staff concludes that Westinghouse has adequately modeled, analyzed, and identified the failure modes of the structures, including the identification of collapse mode of failure of CMU under design basis seismic motion.

2.1.3 Seismically Induced Chemical Consequences

Following its evaluation of the seismic capability of buildings and equipment, Westinghouse identified NRC-regulated chemicals and the quantities of these chemicals that might be released as a result of the evaluation basis earthquake. [redacted]

Westinghouse estimated release quantities and consequences to both workers and individuals outside the controlled area were made using the RASCAL code for UF_6 releases and the ALOHA code for other chemicals. The estimates of offsite consequences were documented in calculation packages. The results of these Westinghouse calculations are presented in Table 1.

Table 1 Summary of Westinghouse Estimates of Consequences for Seismically Initiated Chemical Releases

Release	Estimated Consequences to Worker	Estimated Consequences to Public
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Staff Evaluation:

The staff reviewed Westinghouse's calculations and agrees that the parameters used by Westinghouse are consistent with the as-built physical characteristics of the facility (e.g., diked area) or conservative (e.g., immediate release, failure of all tanks in an area, conservative meteorology parameters, one hour exposure). The staff also made independent RASCAL and ALOHA calculations to independently verify the results of Westinghouse's analysis. Based on these calculations, the staff agrees with the assessment that estimated consequences to offsite individuals would be less than intermediate-consequence events as defined in 10 CFR 70.61(c).

Westinghouse did not conduct quantitative analysis of offsite concentrations for chemicals under circumstances where the quantities are limited, the vapor pressure is low, or the toxicity values are relatively high ([redacted]) in order to conclude that the offsite consequences are less than intermediate as defined in 10 CFR 70.61(c). The staff agrees with this approach because these factors are adequate to demonstrate that offsite consequences are limited. The staff reviewed specific cases where Westinghouse did not perform quantitative analysis of offsite concentrations and performed scoping calculations to verify the validity of Westinghouse's conclusions.

In reviewing seismic induced chemical release scenarios, the staff noted the uncertainty in the identification of failure modes to assess during the postulation of accident sequences. [redacted] The staff noted the generally conservative assumptions made by Westinghouse in the worker consequence assessment, particularly the immediate release of all the material and the one hour exposure assumptions. The staff finds that the Westinghouse estimates of consequences to workers from seismically initiated chemical spills that are summarized in Table 1 to be conservative and consistent with the consequence thresholds as defined in 10 CFR Part 70.61.

The information supporting the development of the AEGL values for the chemicals of interest at this facility ([redacted] Given the expectation that the building would be standing following an evaluation basis earthquake and it would likely require some time (generally on the order of minutes) for a chemical leak to occur and a plume develop, the staff considers a reasonable chemical exposure scenario following a seismic event to involve workers noticing the spill and exiting the building before they experience a serious (i.e., life threatening) chemical exposure.

Based on the staff review of the structural robustness of the facility and the analysis of consequences of potential hazardous material releases, the staff agrees with Westinghouse's assessment that seismic events as severe as the evaluation basis earthquake hazard will not produce intermediate consequences to individuals outside the controlled area. The staff also finds that the Westinghouse assessment of consequences to workers is conservative. The staff considers Westinghouse's analysis to be acceptable.

2.1.4 Seismically Induced Criticality Consequences

Westinghouse's seismic evaluation determined that the process equipment [redacted] Criticality is a high-consequence event, and therefore must be "highly unlikely," which Westinghouse has defined as having a likelihood index of -4. The initiating event frequency of an earthquake hazard with 10 percent probability of exceedance in 50 years (capable of [redacted] was evaluated as 2×10^{-3}/yr, so that only a modest reduction in risk from facility design features or operator actions beyond the initiating event frequency is required to meet the performance requirements.

Criticality requires more than a critical mass, with sufficient geometry, moderation, and other conditions (e.g., reflection). A[redacted]

[redacted]

Staff Evaluation:

Scenarios #1, #2, #4 and #5:

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] There also appears to be considerable conservatism in the other above conditions assumed by Westinghouse.

[redacted]

[redacted] Westinghouse stated that it has designed the equipment and installed shielding to protect vulnerable components from falling debris. In addition, several other IROFS are credited to further reduce the risk of criticality. The staff does not agree with Westinghouse's determination of failure likelihood for several of these additional IROFS, but does consider that they provide defense-in-depth. [redacted]. The staff does not consider the credited failure likelihood of 10^{-1} to be adequately demonstrated. While this is consistent in Westinghouse's ISA methodology with an administrative control consisting of a trained operator performing a non-routine task, occurrence of an earthquake is so infrequent that it is likely operators may evacuate the building without [redacted]. Another example is that Westinghouse originally took credit for the likelihood that the [redacted] As mentioned earlier, the staff does consider that Westinghouse's approach to the identification of IROFS provides defense-in-depth because these IROFS are applicable and capable of providing some risk reduction. However, the application of likelihood indices for the failure of equipment and components performing safety functions for which they have not been designed under seismic loads has not been justified. The staff therefore considers these components to form part of a suite of multiple barriers that provide unspecified defense-in-depth. The staff also noted that Scenario #5 involves several cut sets where reference is made to controls to protect from falling debris, although this scenario does not involve failure of [redacted], and used the same seismic frequency for events causing pipe failure as for those causing failure of the [redacted], without technical justification.

The staff agrees with Westinghouse's conclusion of sufficient defense-in-depth to adequately protect workers and the public from the consequences of seismic induced criticality accident sequences. This is based on the likelihood of a sufficient earthquake to cause significant structural damage, passive and active barriers to provide defense-in-depth protection against the consequences of criticality, and conditional likelihoods associated with the conditions necessary for a [redacted]. These considerations are summarized in the table below. Given that the evaluation basis earthquake hazard has an initiating event frequency of 2×10^{-3}/yr, and that criticality is required to be "highly unlikely," which the staff considers equivalent to 10^{-4}/yr, a risk reduction factor of at least 20 is required. While the staff does not agree with Westinghouse's application of its ISA methodology to the analysis of natural phenomena hazards, the staff does agree that the multiple engineered and administrative barriers, and conditional likelihoods, discussed above are more than sufficient to provide adequate risk reduction to protect against the consequences of a seismic induced criticality accident sequences. Destructive natural phenomena are inherently dispersive in nature and therefore not conducive to the formation of critical configuration of SNM.

Event/Condition	Basis
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted] #3, #6 and #8

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]. However, the staff agrees with Westinghouse's conclusion that based on the structural analysis and design of the facility that accumulation of fissile solution to greater than a safe depth is not a concern [redacted]. While conditions cannot be entirely foreseen in the event of a seismic event [redacted] such occurrences would necessarily involve earthquake hazards less frequent that the evaluation basis earthquake hazard, further reducing the scenario likelihood.

In addition, although the performance requirements mandate that inadvertent criticality be prevented regardless of the dose to individuals, the risk to workers and the public would be significantly reduced due to evacuation and emergency response activities. The staff agrees with Westinghouse's approach to provide sufficient defense-in-depth to adequately protect workers and the public from the consequences of seismically induced criticality accident sequences. This assurance is based on the likelihood of a sufficient earthquake hazard to cause significant structural damage, the structural analysis of the building and the facility floor, the conditional likelihoods associated with the conditions necessary for accumulation of fissile solution to greater than a safe depth, and emergency response activities (though they would neither protect against prompt criticality or contribute to meeting the subcriticality portion of the performance requirements in 10 CFR 70.61(d)). These considerations are summarized in the following table:

[redacted]

Event/Condition	Basis
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

[redacted]

The staff agrees with Westinghouse's approach to implement multiple IROFS to provide sufficient defense-in-depth to adequately protect workers and the public from the consequences of seismically induced criticality accident sequences. This is based on the staff's evaluation of the likelihood of a sufficient earthquake hazard [redacted], the conditional likelihoods associated with the conditions necessary for accumulating and subsequently moderating the material, and the naturally dispersive nature of the involved phenomena.

[redacted]

[redacted] –

The staff does not consider this scenario to constitute a significant concern, as the [redacted] is designed to be flooded under normal conditions. Facility features [redacted] preclude a rearrangement of fuel assemblies sufficient to cause criticality. Westinghouse determined that the [redacted] is subcritical by geometry and there were no fault trees or cut sets that needed to be considered. Due to the passive geometry of [redacted], [redacted]

Additional Criticality Scenarios

The identification of the [redacted] scenarios was based on the results of the structural analysis, which identified those facility components vulnerable to an evaluation basis earthquake hazard. Westinghouse evaluated those scenarios in accordance with its usual ISA methodology. The staff did not agree with the application of that methodology for the analysis of seismic induced criticality. However as discussed above, the staff concluded there was adequate defense-in-depth to protect against the consequences of criticality.

The staff also considered whether there were any additional scenarios that had not been evaluated by Westinghouse. [redacted] The staff therefore agrees with Westinghouse that credible scenarios resulting in seismic induced criticality have been identified or have been bounded by previously evaluated scenarios.

As stated in Section III.2.1.1 of this evaluation report, the staff does not agree with Westinghouse's quantitative assessment of likelihood for the described seismically induced criticality scenarios. However, based on the initiating event frequency for an evaluation basis earthquake hazard, the conditional likelihood of attaining the right combination of mass, moderation, and geometry for criticality, and defense-in-depth measures, the staff agrees with Westinghouse's conclusion that the facility is adequately protected against the consequences of a seismically induced criticality accidents.

[redacted]

2.1.5 Seismically Induced Fire Consequences

Westinghouse examined the consequences from seismically induced fires and explosions. The analysis concludes that in the event of an earthquake, [redacted] Westinghouse's analysis concluded that [redacted] were bounded by existing accident sequences analyzed in the ISA. As an additional safety measure, Westinghouse [redacted]

Staff Evaluation:

The staff reviewed the analysis performed by Westinghouse. The seismic evaluation concluded that the process equipment that failed [redacted]. The staff also reviewed Westinghouse's submittal and ISA summary. The staff finds that the evaluation of seismic induced fire consequences to be adequate. The staff agrees with Westinghouse's conclusion that the existing fire ISA accident sequences use the conservative assumption that their [redacted] In addition, Westinghouse installed [redacted]

2.2 <u>Flooding</u>

Westinghouse stated in response to GL 2015-01 and Section 4.2.3 of their ISA Summary that the facility is situated above the estimated 100 year and 500 year flood elevations. The 100 year flood is 130 feet based on the U.S. Army Corps of Engineers flood map. The floor of the main manufacturing building sits at 142 feet above Mean Sea Level (MSL). Westinghouse also stated that a large flood could impact the low-lying, undeveloped areas of the site but concluded that it is highly unlikely that a large flood would result in uranium releases or a nuclear criticality accident. Should a large rainfall event result in flooding in the area, sufficient time would be available to take appropriate preventive and emergency management measures, including evacuating employees and shutting down manufacturing operations, if necessary. Westinghouse evaluated the potential of flooding from upstream dam failure and concluded that it was highly unlikely.

Staff Evaluation:

The staff reviewed the floodplain data to verify that the flood levels will not impact the manufacturing areas of the plant. Based on current data available for the site location, the staff agrees with Westinghouse that the site is located outside the 1 percent (100 year flood) and 0.2 percent (500 year) annual chance floodplains.

[redacted]

With regard to chemical safety analysis, the staff examined the potential for floods at the site that could result in the release of hazardous chemicals and result in high or intermediate acute exposure. The staff agrees with Westinghouse's assessment that flooding-induced releases of uranium (and chemical solutions containing uranium) are highly unlikely because of the elevation of the site. The staff recognizes the slow development of a flooding scenario which allows time for plant workers to reduce the material, including hazardous chemicals that are at risk of being released by a flood. The staff also notes that the flooding scenario that could cause a release of hazardous chemicals would also make it very difficult for individuals to be near the release point such that there could be an acute exposure that would result in high or intermediate consequences as defined in 10 CFR 70.61. Overall, the staff found the information provided by Westinghouse adequately supports the position that it is highly unlikely that flooding could result in any high or intermediate acute chemical exposure events as defined in 10 CFR 70.61.

With regard to criticality safety analysis, Westinghouse did not identify any credible flood-induced accident scenarios leading to criticality. A flood would not be of concern in the solution areas of the facility, which have already been evaluated assuming optimum moderation and full reflection. Introduction of floodwaters would not increase reactivity beyond what has already been analyzed, and could over-moderate the optimally moderated solution. A flood only constitutes [redacted] Loose fuel rods and fuel assemblies would not be a significant concern, for reasons discussed above in Section III.2.1.1.4, Scenario #9. The staff has determined that the likelihood of accidental criticality as the result of flooding the facility is very low. The facility lies above the 500-year flood level, justifying an initiating event frequency of 2×10^{-3}/yr. While some uranium oxide powder and pellets may be stored in containers at or near floor level, most of it is stored significantly above the floor, so an even higher flood is needed for floodwaters to contact the material. Powder is hydroscopic and therefore normally stored within sealed containers to protect it from atmospheric humidity, providing some protection against the intrusion of floodwater. In the event powder or pellets are intimately mixed with floodwaters, the staff considers it likely that the flood would cause rearrangement of material that would tend to disperse, rather than accumulate it in a manner not conducive to criticality. The staff considers that the conditional likelihoods of the above conditions would provide sufficient defense-in-depth against the occurrence of a flood-induced criticality accident.

Despite this defense-in-depth, the staff acknowledges that the conditions resulting from a flood of sufficient depth and force to cause significant moderation of dispersible powder and pellets cannot be entirely foreseen or protected against. The possibility of a criticality involving bulk quantities of powder and pellets cannot be entirely dismissed. However, with the exception of a dam failure (which has been evaluated to be highly unlikely by Westinghouse), a flood would provide sufficient warning time to secure material, remove containers to higher elevations, and evacuate the facility. Criticality is a local phenomenon, such that any workers more than about fifteen feet from the reacting material would not be in danger of receiving a lethal dose. Given that the facility would be evacuated, and the floodwaters would themselves provide substantial shielding against the consequences of criticality, the risk to workers or the public from a

[redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted].

Staff Evaluation:

The staff evaluated Westinghouse's approach for considering high wind events within its ISA process and the methodologies applied to determine likelihoods, consequences, and IROFS. The staff reviewed Westinghouse's likelihood estimation of a tornado strike and the wind speed data from other high wind events. Based on the data in Appendices A, B, and C of NUREG-CR/4461, Revision 2, the staff agrees that a tornado strike of the main site building is highly unlikely. The staff further agrees that Westinghouse's approach to analyze the potential effects of other high wind events is adequate given that the data provided in the 2016 ISA Summary and the National Centers for Environmental Information Storm Events Database show the likelihood of exposure to high winds to be highly unlikely.

The staff notes that Westinghouse does not identify specific accident sequences associated with high winds due to the design of the building. However, Westinghouse, for other accident sequences, does postulate worst case releases from chemical storage tanks. Furthermore, Westinghouse states the weight and robust design of the U.S. Department of Transportation (DOT) approved uranium shipping containers and UF_6 cylinders protects them against wind-blown debris. The staff agrees that Westinghouse's approach to bound consequences based upon other applicable worst case accident scenarios is adequate. The IROFS designated for those scenarios would then apply. The staff does not agree, however, that the approach of assuming the weight and robust design of DOT-approved uranium shipping containers and UF_6 cylinders protects them against wind-blown debris is adequate.

The staff recognizes that the primary accident sequences of concern related to the uranium shipping containers and UF_6 cylinders [redacted]. [redacted] In other words, qualitatively, there would need to be a sequence of unlikely to highly unlikely events beyond Westinghouse's control for a criticality to occur. Therefore, although the staff does not agree with the adequacy of Westinghouse's approach of assuming the design of the containers alone protects them from wind-blown debris, the staff does agree with the eventual conclusion that additional IROFS need not be applied to accident sequences that require several unlikely or highly unlikely external events before intermediate or high consequences can occur.

The staff examined the potential for tornados at the site to result in the release of hazardous chemicals and result in high or intermediate acute chemical exposures. The staff agrees with Westinghouse's assessment that tornado-induced releases of uranium and chemical solutions containing uranium are highly unlikely. The staff recognizes, that among other factors, there is generally some level of warning available before a tornado which allows time for plant personnel to reduce the amount of materials, including hazardous chemicals that are at risk of being released due to a tornado or tornado-generated missiles. The staff also notes that as stated in NUREG-1140, "A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees," a tornado would rapidly dilute and disperse any released hazardous material making it even more unlikely that there could be a high or intermediate acute exposure consequences as defined in 10 CFR 70.61. Overall, the staff found the information provided by Westinghouse adequately supports the position that there is a low probability that a tornado or tornado-generated missiles could result in any high or intermediate acute chemical exposure events as defined in 10 CFR 70.61.

The staff examined the potential for hurricanes at the site to result in the release of hazardous chemicals and result in high or intermediate acute chemical exposure. The staff recognizes the generally slow development of a hurricane scenario (generally on the order of days) which allows time for plant personnel to reduce the material that is a risk of being released by the hurricane. Overall, the staff found the information provided by Westinghouse demonstrates that there is a low probability that a hurricane could result in any high or intermediate acute chemical exposure events as defined in 10 CFR 70.61. Therefore, the staff agrees with Westinghouse's assessment that hurricane-induced releases of uranium (and chemical solutions mixed with uranium) are highly unlikely.

Overall Staff Evaluation for NRC GL 2015-01 Requested Action (1)b:

Based on the staff evaluations for earthquakes, floods, high winds, tornados, and hurricanes, the staff finds that Westinghouse has adequately responded to GL 2015-01 Requested Action (1)b. The staff expects that Westinghouse will continue to apply its existing configuration management process to assure that the impacts of changes to the facility do not negatively affect its performance under natural phenomena hazards.

3.0 <u>NRC GL 2015-01 Requested Action (1)c</u> For facilities subject to 10 CFR Part 70, Subpart H requirements, submit a description of the results of the ISA review used to comply with 10 CFR 70.62(c). This requested documentation should have identified the characteristics of the licensing and design basis NPH applicable to the site. Additionally, the documentation should have evaluated possible changes in the methodology, likelihood, and severity of natural phenomena events with those used in the original design, evaluation, and licensing of the facility.

Westinghouse stated in response to GL 2015-01 that the seismic analysis was reassessed. The facility was evaluated to determine which parts met the current requirements of the IBC 2012, and for the parts of the facility that did not meet the current requirements, to identify their stress state and assess whether these members can still perform their original intended function. The analysis included an assessment of internal components. The consequence of failure of the member(s) was addressed in the ISA.

The staff reviewed the seismic analysis and the staff evaluation is included in Section III.2.1.2 above. Based on the staff evaluation the staff finds that Westinghouse has adequately responded to NRC GL 2015-01 Requested Action (1)c.

4.0 <u>NRC GL 2015-01 Requested Action (1)d</u> Submit for staff review a summary of the results of any facility assessments or walk downs, if performed, to identify and address degraded, nonconforming, or unanalyzed conditions that can affect the performance of the

[redacted]

facility under natural phenomena and have available for NRC inspection the documentation of the qualifications of the team.

Westinghouse stated that it contracted with external engineering experts to perform a seismic structural evaluation of the facility. They walked down the buildings to confirm the structural models and to evaluate the as-built condition of the facility. The staff will inspect samples of the results of the walkdowns during the implementation of TI 2600/016 “Inspection Activities Associated with NRC GL 2015-01.” Therefore, the staff finds that Westinghouse has adequately responded to NRC GL 2015-01 Requested Action (1)d.

IV. Conclusion

The staff evaluated the response to the requested actions of the generic letter, the response to the request for supplemental information, and onsite calculations and determined that Westinghouse adequately addressed the potential consequences of NPH events in the ISA. While the staff does not agree with specific aspects of the application of Westinghouse’s ISA methodology for NPH events, the staff does agree that, based on an evaluation of the selected NPH events for the facility, the IROFS Westinghouse identified represent an adequate defense-in-depth strategy to adequately prevent or mitigate consequences of accidents. By letter dated July 6, 2016, Westinghouse committed to revise the ISA Summary by January 31. 2017, to incorporate their responses as specified in Westinghouse’s letter dated June 21, 2016. Westinghouse also committed to enhance its evaluation for the “Earthquake Initiated Failure of UN Bulk Storage Tanks Accident Sequence Flow Diagram.” This enhanced evaluation will demonstrate that the performance requirements are met for this accident sequence using an earthquake initiating event frequency of -3. Consistent with the guidance in NUREG-1520, unless the natural phenomena is not credible, the approach should not rely on its likelihood to eliminate the need for IROFS. The approach, however, can consider the results of engineering analyses and qualitative, quantitative, or semi-quantitative analyses to determine IROFS and assess whether the performance requirements of 10 CFR 70.61 have been met. Therefore, the staff finds that Westinghouse adequately responded to Requested Actions (1)a through (1)d of the GL.

The staff will perform an inspection using Temporary Instruction (TI) 2600/016, “Inspection Activities Associated with GL 2015-01” to independently verify that Westinghouse is in compliance with the regulatory requirements and applicable license conditions regarding the treatment of NPH in its ISA. The inspection results from this TI will also be used to follow-up with previously identified Unresolved Items regarding the treatment of NPH, and to inform the closure process of GL 2015-01. The results of these regulatory activities will allow the staff to verify Westinghouse demonstrates compliance with regulatory requirements and applicable licensee conditions regarding the treatment of natural phenomena hazards at the facility.

V. References

DOE. Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities. DOE-STD-1020-2002. Washington, DC: U. S. Department of Energy. January 2002.

[redacted]

DOE. Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components. DOE-STD-1021-2002. Washington, DC: U. S. Department of Energy. April 2002.