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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901



June 10, 2021

The Honorable Jennifer Granholm
Secretary of Energy
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Secretary Granholm:

The Defense Nuclear Facilities Safety Board has reviewed the Department of Energy's (DOE) implementation of the DOE Order 420.1C, *Facility Safety*, requirement to periodically assess the seismic hazard. For defense nuclear facilities, seismic accidents have the potential to cause significant safety consequences to the public. The required process for periodically assessing the seismic hazard ensures that credited seismic controls are analyzed using the latest information and will perform their safety functions when needed.

Based on its review of past implementation across DOE sites, the Board has identified the following issues: sites have not implemented the required unreviewed safety question (USQ) process to assess the impacts of an increased seismic hazard on safety controls; most site field offices have not approved seismic hazard assessments and subsequent analyses as required under DOE Order 420.1C; sites have been slow to analyze the impact of an increased seismic hazard on safety controls; and DOE's directives lack sufficient guidance and standardization on conducting seismic hazard assessments. These issues are discussed further in the enclosed report.

Pursuant to 42 United States Code (USC) § 2286b(d), the Board requests a report and brief addressing the following questions within 90 days:

- What actions does DOE plan to take to ensure that the USQ process is implemented and timely compensatory measures are identified in cases where a site identifies an increased seismic hazard from a probabilistic seismic hazard analysis (PSHA) update that exceeds seismic safety control qualification assumptions in the safety basis?
- What specific natural phenomenon hazards assessment evaluations, recommended update actions, and recommended upgrade plans require DOE approval to comply with DOE Order 420.1C? What actions does DOE plan to take to ensure that site and

field offices have established processes to ensure DOE Order 420.1C approvals are conducted?

- What actions does DOE plan to take to update DOE directives and documents to improve the existing guidance and standardization regarding seismic hazard assessments and the subsequent analyses (i.e., PSHA update and facility condition assessments) as it relates to the concerns discussed in the enclosed report?

Yours truly,

A handwritten signature in black ink that reads "Joyce L. Connery". The signature is written in a cursive, flowing style.

Joyce L. Connery
Chair

Enclosure

c: Mr. Joe Olencz

SEISMIC HAZARD ASSESSMENTS

Defense Nuclear Facilities Safety Board Technical Report



May 2021

SEISMIC HAZARD ASSESSMENTS



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EXECUTIVE SUMMARY

Members of the Defense Nuclear Facilities Safety Board's (Board) technical staff performed a complex-wide review of the process for implementing the natural phenomena hazards (NPH) assessment requirement from Department of Energy (DOE) Order 420.1C, *Facility Safety*, focusing specifically on the seismic hazard assessment process. The objective of the review was to ensure that implementation of the seismic hazard assessment and subsequent analyses at the sites adequately addressed seismic hazards. In addition, the staff team assessed how each site handled new information of an increased seismic hazard with respect to the unreviewed safety question (USQ) process. For this review, the staff team interacted with nine DOE sites that are required to periodically analyze the site-specific seismic hazard and the DOE Office of Nuclear Safety (AU-30). The staff team identified the following safety issues:

Lack of USQ Process Implementation for an Increased Seismic Hazard—The current seismic hazard assessment process does not require sites to implement the USQ process after completing a probabilistic seismic hazard analysis (PSHA) update that identifies an increased seismic hazard exceeding safety control qualification assumptions in the documented safety analysis. Title 10, Code of Federal Regulations, Part 830, *Nuclear Safety Management*, requires the use of the USQ process in situations where there is a “[p]otential inadequacy of the documented safety analysis because the analysis potentially may not be bounding or may be otherwise inadequate.” Proper use of the USQ process would ensure DOE evaluates the risk and considers compensatory measures for an increased seismic hazard while waiting for the results of the facility condition assessment (i.e., evaluations of seismic safety control performance during and after a seismic event), which can take years to complete. Of the sites reviewed, only Los Alamos National Laboratory (LANL) used the USQ process to evaluate an increased seismic hazard that impacted credited seismic control performance. As a result, LANL qualitatively analyzed the impact on each facility and identified compensatory measures.

Field Offices not Approving Seismic Hazard Assessments and Update Actions—DOE Order 420.1C states that one of the responsibilities of the head of a field element is to “Approve periodic NPH assessment evaluations, any recommended update actions, and any recommended upgrade plans.” Since 2012, six DOE field offices did not approve the seismic hazard assessment or subsequent analyses. The staff team notes that two field offices approved the seismic hazard assessment after interacting with the staff team on the subject. Without a formal approval of the assessments and updates, the field offices are not complying with DOE Order 420.1C, and DOE may not understand the safety risk associated with increased seismic hazards.

Prolonged Implementation of Facility Condition Assessments—DOE Standard 1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*, states that if the new seismic hazard exceeds the design values used in the facility's implemented documented safety analysis, then each control designated seismic design category 3 or higher needs to be evaluated to the new values. This evaluation is captured in the facility condition assessment. Five sites have not completed facility condition assessments in a timely manner after an updated PSHA identified an increased seismic hazard at a site. Without an updated facility condition assessment, DOE lacks assurance that seismic safety controls will perform their safety function during or after a seismic event.

Lack of Guidance in DOE Directives for Seismic Assessments—The staff team found that DOE directives do not always provide clear guidance or criteria for the required seismic hazard assessment and subsequent analyses. This has resulted in implementation that is varying and, in some cases, incomplete. The staff team identified the following, which AU-30 personnel noted that it will consider when it revises DOE Standard 1020-2016 and DOE Handbook 1220-2017, *Natural Phenomena Hazards Analysis and Design Handbook for DOE Facilities*:

- DOE Standard 1020-2016 does not clearly define significant changes in data, models, or analysis methods. The staff team found that most of the sites rely on engineering judgment from their seismic subject matter experts to informally assess the significance of a change. The staff team concludes that a lack of well-defined screening criteria could prevent a site from appropriately addressing significant changes in data, models, or analysis methods prior to the 10-year baseline.
- DOE directives do not provide guidance on how to formally track significant changes to data, models, and analysis methods. All the sites rely on federal and/or contractors' seismic subject matter experts to be involved in the seismic community in order to be aware of any significant changes. However, the staff team found that the level and formality of the involvement is not always defined. In addition, many sites rely on monitoring local seismicity to determine if there are significant changes to seismicity. However, local and recent seismic activity only account for a portion of changes to the site-specific seismic hazard.
- DOE Standard 1020-2016 provides broad criteria on when a seismic hazard update is needed. The staff team found that performing a sensitivity study on the site-specific seismic hazard during the assessment stage provides the best means for the site to understand the impact on the seismic hazard. Using a qualitative approach for the assessment could be adequate if there is a clear trend in the change to the seismic hazard from using updated information.
- AU-30 issued NFSP-2015-TD01, *Report on the Implementation of Periodic Natural Phenomena Hazards Assessment Reviews at Department of Energy Sites*, which included five recommendations for program/site offices to enhance the effectiveness and efficiency of NPH assessment reviews. DOE has since included these recommendations in DOE Handbook 1220-2017 as good practices. However, the staff team found that most sites have not adopted the practices.

Given that seismic-initiated accidents often have the highest potential dose consequences to the public for DOE defense nuclear facilities, properly evaluating changes to the seismic hazard at sites will give DOE assurance that credited controls will perform their safety function during and after a seismic event. In addition, implementation of the USQ process when a PSHA update results in an increased seismic hazard will allow for a structured management of risk by DOE and ensure appropriate risk reduction actions (e.g., compensatory measures) will be taken while impacts are being assessed.

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INTRODUCTION

Members of the Defense Nuclear Facilities Safety Board's (Board) technical staff performed a complex-wide review of the process for implementing the natural phenomena hazards (NPH) assessment requirement from Department of Energy (DOE) Order 420.1C, *Facility Safety* [1], focusing specifically on the seismic hazard assessment process. The objective of the review was to ensure that implementation of the seismic hazard assessment and subsequent analyses at the sites adequately addressed seismic hazards. In addition, the staff team assessed how each site handled new information of an increased seismic hazard with respect to the potential inadequacy of the safety analysis (PISA)/unreviewed safety question (USQ) process. The staff team conducted a teleconference with personnel from the following DOE sites that are required to periodically analyze the site-specific seismic hazard:

- Nevada National Security Site (NNSS) on December 18, 2019;
- Los Alamos National Laboratory (LANL) on January 23, 2020;
- Lawrence Livermore National Laboratory (LLNL) on March 10, 2020;
- Idaho National Laboratory (INL) on March 19, 2020;
- Y-12 National Security Complex (Y-12) on March 24, 2020;
- Oak Ridge National Laboratory (ORNL) on March 25, 2020;
- Savannah River Site (SRS) on April 1, 2020;
- Hanford Site on April 16, 2020; and
- Pantex Plant (Pantex) on April 30, 2020.

The staff team identified several issues with past execution of the seismic hazard assessment process at the sites. These issues include the following: four out of five sites did not implement the PISA/USQ process after identifying an increased seismic hazard¹; most field offices have not been approving seismic hazard assessments and subsequent analyses as required under DOE Order 420.1C; sites have been slow to implement facility condition assessments; and DOE's directives lack sufficient guidance on conducting seismic hazard assessments. The staff team discussed these findings with personnel from the DOE Office of Nuclear Safety (AU-30) on July 14, 2020.

¹While these sites did not implement the PISA/USQ at the time when an increased seismic hazard was identified (approximately five to fifteen years ago), the staff team recognizes that these sites are currently evaluating the seismic hazard and its impact on facilities.

BACKGROUND

Seismic-initiated accidents often have the highest potential dose consequences to the public for high hazard defense nuclear facilities. To mitigate the potential dose consequences for seismic events, DOE often credits building structures and certain systems and components as safety-related controls in the facility safety basis. Safety class controls credited for seismic accidents whose dose consequences could challenge or exceed the Evaluation Guideline of 25 rem established in DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [2], are required to meet at least seismic design category (SDC)-3² (formerly performance category [PC]-3³) criteria, per DOE Standard 1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities* [5].

DOE Order 420.1C and DOE Standard 1020-2016 require existing hazard category 1, 2, and 3 facilities with controls credited as SDC-3/PC-3 or higher to perform a seismic hazard assessment, as part of the NPH assessment, at least every 10 years or whenever significant changes in NPH data, criteria, and assessment methods warrant updating the assessments. DOE Standard 1020-2016 and DOE Handbook 1220-2017, *Natural Phenomena Hazards Analysis and Design Handbook for DOE Facilities* [6], provide criteria and guidance for performing the required NPH assessment and subsequent analyses. For facilities designated SDC-3/PC-3 or higher, the results of the seismic hazard assessment are used to determine if the site-specific probabilistic seismic hazard analysis (PSHA) needs to be updated.

DOE Standard 1020-2016 requires a facility condition assessment if the PSHA update identifies an increased seismic hazard that is no longer bounded in facility safety basis documents. The facility condition assessment analyzes the credited seismic controls to the updated seismic hazard. This typically includes a facility structural analysis followed by equipment evaluations to determine seismic performance. By performing these periodic assessments, DOE has assurance that credited controls will perform their safety function during and after a seismic event.

In 2019, the Board's staff began a complex-wide review that focused on the following: the process for performing the required seismic hazard assessment; actions taken to address an increased seismic hazard; the process for evaluating facilities after updating the PSHA; and actions taken to address recommendations made by AU-30 in NFSP-2015-TD01, *Report on the Implementation of Periodic Natural Phenomena Hazards Assessment Reviews at Department of Energy Sites* [7]. The staff team limited the review to the sites with facilities that are required to have a site-specific PSHA.

² For new non-reactor facilities, safety class controls credited for seismic events are required to meet at least SDC-3 requirements per American National Standard Institute/American Nuclear Society 2.26-2004, *Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design* [3].

³ For most existing non-reactor facilities within the DOE complex, safety class controls are required to meet PC-3 requirements per DOE Standard 1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components* [4].

LACK OF USQ PROCESS IMPLEMENTATION FOR AN INCREASED SEISMIC HAZARD

As part of the review, the Board's staff team evaluated how each site handled new information on an increased seismic hazard with respect to the PISA/USQ process. Title 10, Code of Federal Regulations (CFR), Part 830, *Nuclear Safety Management* [8], requires contractors responsible for a hazard category 1, 2, or 3 nuclear facility to establish and implement a USQ process. DOE Guide 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements* [10], provides information to assist in the implementation of this requirement. The guide states, "Written USQDs [USQ determinations] are needed when a contractor identifies or is informed of a situation that indicates that the safety analyses that support the DOE-approved safety basis may not be bounding or may be otherwise inadequate."

Since 2007, five DOE sites have updated their site-specific PSHA and identified an increased seismic hazard from what is analyzed in the safety bases for facilities with credited safety class seismic controls. Table 1 presents the response from each site to the increased seismic hazard. Of the five sites, the staff team found that only LANL declared a PISA, following the requirements from 10 CFR, Part 830. As a result, LANL qualitatively analyzed the impact on each facility and issued a justification for continued operations [9], which identified compensatory measures. As for the other four sites, the basis for not declaring a PISA and performing the USQ process varied. By not performing the USQ process, the other sites may not fully understand the risk associated with the increased seismic hazard (i.e., whether these controls can perform their safety function during and after a seismic event). In addition, these sites have not considered implementing compensatory measures that may be necessary.

During discussions with DOE, AU-30 personnel stated that it did not agree that identifying an increased seismic hazard requires the PISA/USQ process. AU-30 staff referred to a statement in DOE Guide 424.1-1B that states, "The USQ process is not applicable when new requirements are being implemented or different analysis methods that are used result in changed accident consequences or probabilities." AU-30 staff stated that an increase in the hazard analysis from a new PSHA is comparable to applying a new accident analysis code that yields higher accident consequences or probabilities. Therefore, AU-30 staff stated its position was that DOE Guide 424.1-1B excludes increased seismic hazard from a PSHA update from the PISA/USQ process. The staff team disagrees with this interpretation.

The staff team concludes that performing the seismic hazard assessment and subsequent PSHA update, if needed, is not a new requirement for the sites. Also, new information that becomes available through the assessment is not a different analysis method being implemented. A PSHA update is an improved understanding of the seismic hazard. This may result from the incorporation of new seismic models as input into the analysis or from updates to the seismic catalog that contribute to the computed hazard. It affects input to the analysis that, when updated, can challenge safety basis assumptions regarding a control's ability to meet credited seismic functions. Thus, the following statement from the USQ Guide applies, "The USQ process is applicable when the project identifies situations where it is apparent that the existing safety basis may not be bounding or may be otherwise inadequate." An increased seismic hazard

could mean that the seismic design for safety-related controls is no longer bounding from what is described in the safety basis.

DOE Standard 1020-2016 [5] requires a facility condition assessment if a PSHA update identifies an increased seismic hazard and the design values for controls credited to perform a seismic safety function are no longer bounded in facility safety basis documents. The staff team concludes that once DOE has determined this criterion has been met and a facility condition assessment is needed, DOE should also initiate the PISA/USQ process to evaluate the increased seismic hazard for the applicable facilities.

Lastly, the staff team notes that DOE Standard 1020-2016 references the USQ process in a footnote in section 9.3.4. However, this footnote only applies when a control is determined to be deficient during a facility condition assessment, which could be years after the increased seismic hazard has been identified. For example, LLNL declared a PISA after preliminary results from a facility assessment of Building 332 indicated that sections of the building would experience structural damage from an earthquake. However, it took LLNL three years from the completion of the PSHA update [11] to obtain the preliminary results and implement compensatory measures [12]. Over those three years, Building 332 continued to operate with no additional restrictions or controls.

Table 1. Site Actions Following the Discovery of an Increased Seismic Hazard		
Site	Update Year	Site Response
LANL	2007/2009 [13–14]	LANL declared a site-wide PISA, qualitatively analyzed the impact on each facility, implemented compensatory measures, and developed plans to address seismic deficiencies for each applicable facility.
NNSS	2007 [15]	Mission Support and Test Services, LLC (MSTS), could not provide a response as to why the previous management and operating contractor did not declare a PISA.
Pantex	2014 [16]	Consolidated Nuclear Security, LLC (CNS), considers the 2014 PSHA update to be limited, in that it incorporated the Central Eastern United States Seismic Source Characterization (CEUS-SSC) model, but used the ground motion model from the 1998 PSHA. CNS decided not to implement the limited PSHA due to the expectations that the Next Generation Attenuation Relationships for Central and Eastern North-America (NGA-East) ground motion model would be completed in the near-term. Lastly, CNS also concluded that the results of the 2014 PSHA update were excessively conservative. As a result, CNS did not declare a PISA. However, the staff team notes that the PSHA update was mature enough to result in new information, given that it used the latest information available at the time of the update.
SRS	2014 [17]	Savannah River Nuclear Solutions, LLC (SRNS), decided not to implement the PSHA due to the expectation that the NGA-East ground motion model would be completed in the near-term. As a result, SRNS did not declare a PISA.
LLNL	2016 [11]	Lawrence Livermore National Security, LLC (LLNS), initially concluded that the seismic hazard would not have an impact on Building 332. LLNS has since made more conservative changes to the methodology, which resulted in an increase in hazard. LLNS declared a PISA in 2019 after preliminary results from the Building 332 assessment indicated that the facility would experience structural damage due to the increased hazard.

FIELD OFFICES NOT APPROVING SEISMIC HAZARD ASSESSMENTS AND UPDATE ACTIONS

DOE Order 420.1C [1] states that one of the responsibilities of the head of a field element is to “Approve periodic NPH assessment evaluations, any recommended update actions, and any recommended upgrade plans, in accordance with Chapter IV of Attachment 2 of this Order.” While the wording associated with the periodic NPH assessment process in Chapter IV of Attachment 2 has been clarified between revisions of DOE Order 420.1C, this specific responsibility has been included in the order since its initial approval in December 2012. The Board’s staff team found that most site field offices were not reviewing and approving seismic hazard assessments and subsequent analyses and were unaware of this requirement.

Table 2 shows that, since December 2012, six site field offices did not approve an assessment or the updated site-specific PSHA. The two field offices that approved the seismic assessments did so after interacting with the staff team on this subject. During its review, the staff team found that most site field offices follow the progress of the seismic hazard assessment and subsequent analyses and stay informed of decisions that will have an impact on the seismic hazard. However, the staff team concludes that DOE field offices may not fully understand the risk associated with the seismic hazard without completing formal review and approval of seismic hazard assessments and subsequent analyses.

Site	Year	Activity	DOE Approved?
ORNL	2013 [18]	NPH Assessment	No
Pantex	2014 [16]	Limited PSHA Update	No
SRS	2014 [17]	PSHA Update	No
Hanford	2014 [19]	PSHA Update	No
LANL	2014 [20]	NPH Assessment	Yes*
INL	2015 [21]	PSHA Update	No
LLNL	2016 [11]	PSHA Update	No
NNSS	2016 [22]	NPH Assessment	Yes†

*The Los Alamos Field Office reviewed and approved the 2014 NPH assessment [23] after having the review interaction with the staff team in January 2020.

†The previous management and operating contractor completed the NPH assessment in 2016. However, the current contractor, MSTs, submitted the assessment to the Nevada Field Office (NFO) in 2018 [24] upon NFO’s request. NFO did not respond to the submittal until 2020, which was after the review interaction with the staff team in December 2019. In the 2020 response [25], NFO conditionally approved the assessment, subject to the resolution of several comments. MSTs addressed the comments and NFO approved the assessment with no conditions in 2021 [26]. The staff team notes that, as a result of the 2016 assessment, MSTs initiated an analysis in 2017 to determine if the seismic hazard at the Device Assembly Facility (DAF) needed to be updated. MSTs completed this effort in 2018 [27–28] and recommended that the PSHA did not need to be updated [29]. NFO reviewed the assessment and approved the recommendation in 2019 [30].

During discussions with DOE, AU-30 personnel noted that DOE Order 420.1C may not have been incorporated into the sites’ contracts at the time the assessments or PSHA updates were conducted and completed. While this could impact requirements implemented by the sites’

contractors, the staff team concludes that requirements for DOE field offices identified in an approved DOE directive shall be implemented in a timely manner. This intent is supported in DOE Order 251.1D, *Departmental Directives Program* [31], which states, “Requirements for Federal employees in new or revised directives must be fully implemented within twelve months of issuance, unless otherwise stated in the directive.”

PROLONGED IMPLEMENTATION OF FACILITY CONDITION ASSESSMENTS

Section 9.3 of DOE Standard 1020-2016 [5] describes facility condition assessments. A facility condition assessment is required if the new hazard value exceeds the design value used for facility controls in the current safety basis. This criterion is consistent with past revisions of DOE Standard 1020. The Board’s staff team found that sites were not completing the facility condition assessments in a timely manner after completing a PSHA update that identified an increased seismic hazard.

Table 3 below shows that two sites completed PSHA updates and found that the seismic hazard exceeded the design value used for the facility controls in the current safety basis. However, for each instance, the site decided to not implement the PSHA update, but rather to wait for the application of new models that might impact PSHA results. Both sites expected the models to be completed in the near term. However, the models were not completed until four to five years after the completion of the PSHA update. As a result, the sites never conducted the facility condition assessments.

Table 3. Sites Not Implementing a PSHA Update		
Site	Year	Basis for not Implementing PSHA Update
SRS	2007 [32]	SRNS requested to not implement the PSHA and, instead, to wait for the results of the CEUS-SSC model [33]. The CEUS-SSC model was completed in 2011.
	2014 [17]	SRNS incorporated the results of the CEUS-SSC model in this PSHA update and found that the vertical spectrum was significantly higher than what was used in many older designs. SRNS again did not implement this PSHA and decided to wait for the completion of the NGA-East ground motion model. The NGA-East model was completed in 2019. In January 2020, SRNS issued a statement of work to hire a subcontractor to update the PSHA [34]. The statement of work requires the subcontractor to review the results from the CEUS-SSC and NGA-East models.
Pantex	2014 [16]	CNS considers the PSHA update to be limited, in that it incorporated the CEUS-SSC model, but used the ground motion model from the 1998 PSHA. CNS found that the ground motions were approximately 1.5 to 2.7 times higher than those from the previous PSHA. CNS did not implement this limited PSHA and decided to wait for completion of the NGA-East ground motion model. CNS expects the ground motion to decrease after incorporating the NGA-East model. CNS has since hired a subcontractor to update the PSHA. As part of this update, the subcontractor is currently performing site characterization activities. The updated PSHA will incorporate the results from the CEUS-SSC and NGA-East models [35].

Table 4 below shows the facility condition assessment status for the other sites that have yet to complete the assessment. Table 4 excludes the two sites referenced in Table 3 that decided to not implement the PSHA update (resulting in the sites not performing the facility condition

assessments). The sites referenced in Table 4 have taken years to conduct the facility condition assessments. For example, NNSS identified an increased seismic hazard more than 13 years ago. While there are reasons for the delay at NNSS, it is still unknown how the increase will impact credited seismic controls at DAF. The Board communicated this concern to the Secretary of Energy in a letter dated March 21, 2019 [36].

Table 4. Status of Facility Condition Assessments		
Site	PSHA Update Year	Facility Condition Assessment Status
NNSS	2007 [15]	MSTS is still analyzing the impact to DAF structure as part of the DAF soil-structure interaction analysis. The long delay is partly due to issues, that have since been resolved, with the System for Analysis of Soil-Structure Interaction code [37–38] and the seismic hazard assessment that was completed in 2018 [27–28].
LANL	2007/2009 [13–14]	LANL has continuously performed studies to better understand the impact that the updated seismic hazard has on the Plutonium Facility (PF-4). While these studies have been prolonged, LANL has implemented upgrades to credited seismic controls.
LLNL	2016 [11]	LLNS, is still analyzing the impacts of the increased seismic hazard to Building 332. Based on preliminary results, LLNS discovered that the new seismic hazard would result in portions of the building experiencing structural damage. As a result, LLNS implemented compensatory measures after receiving the preliminary information in 2019 [12]. During its interaction with the staff team, LLNS stated that it considered the ongoing analysis for Building 332 to be a part of the PSHA update and not the facility condition assessment.

The staff team concludes that the intent of the periodic review requirement was no longer being met for the sites referenced above. While these sites identified an increased seismic hazard, most of them are continuing to rely on their older analyses in their safety basis documents⁴. The older seismic analyses rely on outdated information and a seismic hazard developed without a structured process, such as the Senior Seismic Hazard Analysis Committee process outlined in NUREG/CR-6372, *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts* [39]. The staff team notes that section 9.2.1.1 of DOE Standard 1020-2016 provides recommendations that the natural phenomena hazards assessment and subsequent analyses should be completed within three years. However, this version of the standard was not approved or in effect when the seismic hazard assessments at the DOE sites began.

Lastly, the staff team had the following additional observations:

⁴At PF-4, LANL used the results from the 2007/2009 PSHA to upgrade some controls (e.g., structural retrofits and upgrades for gloveboxes that support molten plutonium operations), while additional analyses and testing are ongoing to determine if additional seismic deficiencies exist due to the increased seismic hazard.

- For SRS and Pantex, both site field offices were aware of the decision to not implement the updated PSHA. However, there was no formal approval from either field office to deviate from the directives. DOE Standard 1020-2016 and its previous revisions do not include any provisions for a delay in adopting an increased seismic hazard due to external factors (e.g., waiting for seismic models to be updated).
- As noted in Table 4, LLNS considers the ongoing analysis for LLNL's Building 332 to be a part of the PSHA update and not the facility condition assessment. The staff team disagrees with LLNS's interpretation and concludes that the current building analysis is the facility condition assessment. The staff team believes that DOE Standard 1020 could be updated to provide clear definitions of NPH assessments, PSHA updates, and facility condition assessments in order to avoid future confusion.

LACK OF GUIDANCE IN DIRECTIVES FOR SEISMIC HAZARD ASSESSMENTS

The Board's staff team identified several areas where DOE directives do not provide sufficient guidance concerning the seismic hazard assessment process. As a result, sites are free to interpret directives, which results in varying implementation and interpretations. The areas with insufficient guidance are related to the definition of significant changes and how they are tracked, criteria for determining when a seismic hazard update is needed, and tracking the required NPH assessment. During discussions with DOE, AU-30 personnel noted that it will consider these observations when it revises DOE Standard 1020-2016 [5] and DOE Handbook 1220-2017 [6] in 2021.

Significant Changes. Section 9.2.1 of DOE Standard 1020-2016 states that a facility seismic hazard assessment shall be conducted whenever significant changes in data, models, or analysis methods have been identified (even if it is prior to the 10-year baseline). However, the standard does not clearly define significant changes in data, models, or analysis methods. Without a clear definition and screening criteria, sites have freedom to determine whether a change is significant or not. For example, the staff team found that Pantex relies on the engineering judgment from its seismic subject matter experts to informally assess the significance of the change. The staff team concludes that relying on an informal assessment that uses engineering judgment without well-defined screening criteria could prevent a site from performing the seismic assessment prior to the 10-year baseline.

The staff team also found that none of the sites have a formal process for being informed of significant changes to data, models, and analysis methods. Some of the sites, such as the Hanford site, Pantex, and NNS, rely on monitoring of local seismicity as a means to determine if there are significant changes to seismicity. However, local and recent seismic activity only account for a portion of changes to the site-specific seismic hazard. All the sites rely on federal and/or contractors' seismic subject matter experts to be involved in the seismic community in order to be aware of any significant changes. However, the staff team found that the level and formality of the involvement is not always defined.

PSHA Update Determination. Section 9.2.1.2 of DOE Standard 1020-2016 provides broad criteria on when a seismic hazard update is needed. The staff team concludes that clear criteria are needed to determine whether an update to the PSHA is necessary. Since 2012, three sites have performed the seismic hazard assessment and determined that the seismic hazard did not need to be updated. NNS [27–28] performed sensitivity studies to support the assessment and its results were compared to the design spectra of the previous analysis [15]. Y-12 [40] and ORNL [18] performed qualitative studies during their assessments. This approach could be adequate if there is a clear trend in the seismic hazard. However, if a qualitative analysis does not provide a clear trend, performing a sensitivity study can confirm if the hazard warrants a full PSHA update.

The staff team found that performing a sensitivity study on the site-specific seismic hazard during the assessment stage (which incorporates all the data, model, and analysis method changes to seismic sources, ground motion prediction equations, and site conditions) provides

the best means for the site to understand the impact on the seismic hazard. It also provides an adequate technical basis for not updating the seismic hazard.

Tracking NPH Assessments. The staff review team found variances in how the sites track the required NPH assessments. Some sites use a formal system that has a notification mechanism to inform the appropriate individuals to begin the assessment. Other sites do not have a formal system but rely on individuals to be aware of when the assessment is due as part of their job responsibilities. DOE Handbook 1220-2017 recommends maintaining a log of scheduled periodic review dates as a good practice. However, the staff team found that many sites were not implementing this practice.

For example, during its January 23, 2020, interaction with LANL, the staff team found that there was disagreement among LANL personnel on when the next NPH assessment was due. On May 22, 2020, Triad National Security, LLC (Triad), formally transmitted a letter to the Los Alamos Field Office clarifying the status of LANL's requirement related to conducting the next NPH assessment [41]. In the letter, Triad stated an assessment was completed in 2014 [20] and that it planned to complete the next assessment within the next three years but not to exceed the 10-year milestone date of September 2024. After providing this clarification, the Los Alamos Field Office then approved the 2014 NPH assessment [23]. The staff team concludes that using a formal system to track the NPH assessment would provide better assurance that the sites will complete the assessment at the appropriate time.

Recommendations from an AU-30 Report. AU-30 conducted a review on the implementation of periodic NPH assessment reviews across the DOE weapon complex and issued a final report, NFSP-2015-TD01 [7], in April 2015. The final report states that the purpose of its review was to determine and evaluate the current field practices, their effectiveness, and identify any challenges in executing the DOE requirement for periodic reviews of NPH assessments. The final report included five recommendations for program/site offices to enhance the effectiveness and efficiency of NPH assessment reviews. However, AU-30 did not require the sites to respond to the recommendations. DOE has since included these recommendations in DOE Handbook 1220-2017 as good practices.

The staff team found that none of the sites formally addressed these recommendations. Even with the recommendations included in DOE Handbook 1220-2017, the staff team found that most sites have not adopted the practices. Based on informal assessments, some sites noted that the recommendations were already sufficiently covered within existing programs. The staff team found the following for each recommendation (note that the italicized bullets are quotes of the recommendations from the AU-30 report):

- *Develop written procedures to guide the conduct of NPH assessment reviews in a consistent, efficient, and effective manner.*
 - The staff team found that most sites do not have written procedures to guide the conduct of NPH assessments. The basis for not having written procedures varied between the sites. For example:

- ORNL acknowledged that it does not have a robust NPH program and does not think it is necessary, given its reliance on the Y-12 program.
 - Y-12 and Pantex both stated that the guidance in DOE Standard 1020-2016 and DOE Handbook 1220-2017 is sufficient and a specific written procedure is not needed.
- The staff team concludes that without written procedures, each site is left to decide how to implement the seismic hazard assessment, including the level of detail and level of peer review.
- *Maintain a single document containing summaries of all NPH analyses and a log of scheduled periodic review dates. This document will be particularly valuable for sites with multiple nuclear facilities, as it can be incorporated by reference in different facility specific DSAs [documented safety analyses], simplifying the DSA maintenance at large sites.*
 - The staff team found that most sites have not developed a single document containing summaries of all NPH analyses and a log of scheduled periodic review dates. Some sites, such as LLNL and INL, pointed to the PSHA as a document containing a significant amount of data. Y-12, Pantex, and SRS referenced the site-wide DSA. While these documents contain sufficient information describing the seismic hazard, the staff concludes that these documents are not effective for tracking periodic review dates.
- *Consider undertaking early peer reviews and discussions with the technical experts, DOE management, and other stakeholders on the respective site's evaluation and recommendations regarding existing NPH analyses before embarking on new ones. This can be done as part of the periodic assessment review process, and ideally lead to an upfront consensus and avoid future rework.*
 - Since the issuance of the AU-30 report, the staff team found that the sites have met this recommendation. For example, both INL [21] and NNSS [27–28] used an expert peer review team during the assessment process. Also, Pantex [35], Y-12 [42], and SRS [34] plan to use the Senior Seismic Hazard Analysis Committee process, which includes a peer review team, for their upcoming PSHA updates.
- *Establish continuous NPH data collection programs (e.g. subsurface, regional flooding, meteorological, seismic monitoring data) as part of an over-arching site-wide NPH program plan to ensure that up-to-date data will be available when performing a periodic review of the NPH assessment or initiating a new hazard analysis. Program Offices and Sites Offices should coordinate access to expertise across DOE on NPH related matters to overcome a shortage of such expertise.*
 - The staff found that some sites have not established continuous NPH data collection programs as part of an over-arching site-wide NPH program plan.

Some sites, such as Hanford and NNSS, have subcontracts with universities to monitor seismic activity. However, as noted above, local and recent seismic activity only accounts for a portion of changes to the site-specific seismic hazard. Also, most sites rely on other government and state agencies that collect seismic related data needed for the seismic hazard updates. The staff team concludes that by following this approach the sites may not be aware if a significant change has occurred and a potential change in seismic hazard would not be analyzed until the data are requested, which would likely be when the next assessment is due.

- *For sites with facilities under the control of multiple Program Offices, the Program/Site Offices should collaborate on their NPH review assessment effort.*
 - DOE has several sites with multiple field offices. The staff team found that these sites do not have a formal process to collaborate between the field offices on seismic hazard assessments or PSHA update activities. These field offices typically rely on informal interactions to communicate the status of these activities. In addition, the staff team found the following:
 - The Hanford site has multiple DOE offices and prime contractors. Consequently, DOE chooses to manage NPH assessments and subsequent analyses (e.g., the PSHA) with the support of selected contractors. Results are shared and made available to site prime contractors for their evaluation and use. In some cases, the lack of a defined process has resulted in delays in the accomplishment of necessary evaluations.
 - The ORNL site response analysis [43] uses the seismic rock hazard that was calculated in the Y-12 PSHA [44] to derive the current design basis earthquake for ORNL. Therefore, ORNL needs to be aware of Y-12 seismic assessments and PSHA updates to determine whether its seismic hazard needs to be reevaluated.
 - At SRS, SRNS is the prime contractor and responsible for performing the NPH assessments and PSHA updates. Therefore, Savannah River Operations Office (DOE-SR) is responsible for providing oversight of seismic-related activities. The National Nuclear Security Administration Savannah River Field Office relies on the expertise of DOE-SR.
 - The staff team concludes that having a formal process would provide better assurance that all field offices and contractors will be aware when a significant change has been identified. As a result, all site contractors would be able to reevaluate the seismic hazard for the appropriate facilities, if needed, to ensure that their credited seismic controls will perform their safety function during and after a seismic event.

CONCLUSION

During its review, the Board's staff review team identified several issues with past execution of the seismic hazard assessment process. Most sites did not implement the PISA/USQ process after identifying an increased seismic hazard that exceeds the safety control qualification assumptions in the safety basis; most site field offices have not been approving seismic hazard assessments and subsequent analyses; sites have been slow to implement facility condition assessments; and DOE's directives lack sufficient guidance and standardization on conducting seismic hazard assessments. Given that seismic-initiated accidents often have the highest potential dose consequences to the public for DOE defense nuclear facilities, properly evaluating changes to the seismic hazard at sites will give DOE assurance that credited controls will perform their safety function during and after a seismic event. In addition, implementation of the PISA/USQ process when a PSHA update results in an increased seismic hazard will allow for a structured management of risk by DOE and ensure appropriate risk reduction actions (e.g., compensatory measures) will be taken while impacts are being assessed.

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