UNITED STATES
NUCLEAR REGULATORY COMMISSION
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April 25, 2019

Mr. Daniel G. Stoddard
Senior Vice President and
Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2 – STAFF REVIEW OF SEISMIC PROBABILISTIC RISK ASSESSMENT ASSOCIATED WITH REEVALUATED SEISMIC HAZARD IMPLEMENTATION OF THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC (EPID NO. L-2018-JLD-0003)

Dear Mr. Stoddard:

The purpose of this letter is to document the staff's evaluation of the North Anna Power Station, Units 1 and 2 (North Anna) seismic probabilistic risk assessment (SPRA) which was submitted in response to Near-Term Task Force (NTTF) Recommendation 2.1 "Seismic." The U.S. Nuclear Regulatory Commission (NRC) has concluded that the North Anna SPRA report meets the intent of NTTF Recommendation 2.1 "Seismic" and that the results and risk insights provided by the SPRA support the NRC's determination that no further response or regulatory actions are required.

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the NRC issued a request for information under Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (hereafter referred to as the 10 CFR 50.54(f) letter). The request was issued as part of implementing lessons-learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 1 to the 10 CFR 50.54(f) letter requested that licensees reevaluate the seismic hazards at their sites using present-day methodologies and guidance. Enclosure 1, Item (8), of the 10 CFR 50.54(f) letter requested that certain licensees complete an SPRA to determine if plant enhancements are warranted due to the change in the reevaluated seismic hazard compared to the site's design-basis seismic hazard.

By letter dated March 28, 2018 (ADAMS Accession No. ML18093A445), the Virginia Electric and Power Company (Dominion, the licensee), provided its SPRA report in response to Enclosure 1, Item (8) of the 10 CFR 50.54(f) letter, for North Anna. The SPRA report was later supplemented by letter dated March 7, 2019 (ADAMS Accession No. ML19071A114). The supplement letter included a regulatory commitment identified by the licensee.

The NRC staff assessed the licensee's implementation of the Electric Power Research Institute's (EPRI's) Report 1025287, "Seismic Evaluation Guidance - Screening, Prioritization, and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic" (ADAMS Accession No. ML12333A170), as endorsed by NRC letter dated February 15, 2013 (ADAMS Accession No. ML12319A074), through the completion of the reviewer checklist in Enclosure 1 to this letter. As described below, the NRC has

concluded that North Anna's SPRA report meets the intent of the NTTF Recommendation 2.1 "Seismic" and that the risk and safety insights provided by the SPRA support the NRC's determination that no further response or regulatory action is required.

BACKGROUND

The 10 CFR 50.54(f) letter requested, in part, that licensees reevaluate the seismic hazards at their sites using updated hazard information and current regulatory guidance and methodologies. The request for information and the subsequent NRC evaluations have been divided into two phases:

> **Phase 1**: Issue 10 CFR 50.54(f) letters to all licensees to request that they reevaluate the seismic and flooding hazards at their sites using updated seismic and flood hazard information and present-day regulatory guidance and methodologies and, if necessary, to request they perform a risk evaluation.
>
> **Phase 2**: Based upon the results of Phase 1, the NRC staff will determine whether additional regulatory actions are necessary (e.g., updating the design basis and structures, systems, and components (SSCs) important to safety) to provide additional protection against the updated hazards.

By letter dated March 31, 2014, Dominion submitted its reevaluated seismic hazard information for North Anna. The NRC performed a staff assessment of the submittal and issued a response letter on April 20, 2015 (ADAMS Accession No. ML15057A249). The NRC's assessment concluded that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance, appropriately characterized the site, and met the intent of the guidance for determining the reevaluated seismic hazard.

By letter dated October 27, 2015 (ADAMS Accession No. ML15194A015), the NRC documented a determination of which licensees were to perform: (1) an SPRA; (2) limited scope evaluations; or (3) no further actions based on a comparison of the reevaluated seismic hazard and the site's design-basis earthquake. As documented in that letter, North Anna was expected to complete an SPRA, which would also assess high frequency ground motion effects, and a limited scope integrity evaluation for the spent fuel pool (SFP). These seismic evaluations were submitted to the NRC by March 31, 2018, and December 14, 2017, respectively.

By completing the April 20, 2015, NRC staff assessment for the reevaluated seismic hazard and the scheduling of the North Anna SPRA report submittal described in the NRC's October 27, 2015, letter, the licensee fulfilled the Phase 1 process for North Anna.

In its March 28, 2018, letter, Dominion provided the SPRA report that initiated the NRC's Phase 2 decisionmaking process for North Anna. The NRC described this Phase 2 decisionmaking process in a guidance memorandum from the Director of the Japan Lessons-Learned Division to the Director of the Office of Nuclear Reactor Regulation (NRR) on September 21, 2016 (ADAMS Accession No. ML16237A103). This memorandum details a Senior Management Review Panel (SMRP) consisting of three NRR Division Directors that are expected to reach a screening decision for each plant submitting an SPRA. The SMRP is supported by appropriate technical staff who are responsible for consolidating relevant information and developing recommendations for the consideration of the panel. In presenting recommendations to the

SMRP, the supporting technical staff is expected to recommend placement of each SPRA plant into one of three groups:

1) **Group 1** includes plants for which available information indicates that further regulatory action is not warranted. For seismic hazards, Group 1 includes plants for which the mean seismic core damage frequency (SCDF) and mean seismic large early release frequency (SLERF) clearly demonstrate that a plant-specific backfit would not be warranted.

2) **Group 2** includes plants for which further regulatory action should be considered under the NRC's backfit provisions. This group may include plants with relatively large SCDF or SLERF, such that the event frequency in combination with other factors result in a risk to public health and safety for which a regulatory action is expected to provide a substantial safety enhancement.

3) **Group 3** includes plants for which further regulatory action may be needed, but for which more thorough consideration of both qualitative and quantitative risk insights is needed before determining whether a formal backfit analysis is warranted.

The evaluation process that was performed to provide the basis for the staff's grouping recommendation to the SMRP for North Anna is described below.

EVALUATION

Upon receipt of the licensee's SPRA report, a technical team of NRC staff and contractors performed a completeness review to determine if the necessary information to support Phase 2 decisionmaking had been included in the licensee's submittal. The technical team performing the review consisted of staff experts in the fields of seismic hazards, fragilities evaluations, and plant response/risk analyses. About a month after the completeness review started, the technical team determined that sufficient information was available to perform the detailed technical review in support of the Phase 2 decision.

The review of the North Anna SPRA submittal followed the generic audit plan in an NRC letter dated July 6, 2017 (ADAMS Accession No. ML17177A446), to assist in the timely and efficient closure of activities associated with the 10 CFR 50.54(f) letter. The generic audit plan follows the audit process described in Office Instruction LIC-111, "Regulatory Audits", dated December 29, 2008 (ADAMS Accession No. ML082900195). A summary of the audit supporting this assessment is provided in Enclosure 3 of this letter.

As described in the 10 CFR 50.54(f) letter, the staff's detailed review focused on verifying the technical adequacy of the licensee's SPRA such that an appropriate level of confidence could be placed in the results and risk insights of the SPRA to support regulatory decisionmaking associated with the 10 CFR 50.54(f) letter. As stated in its March 28, 2018, submittal, the licensee developed and documented the SPRA in accordance with the SPID guidance including performing a peer review against the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) Standard RA-S 2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications", including Addendum B, 2013.

Appendix A to the North Anna SPRA submittal provided a summary of the peer review completed by the licensee, and a description of the licensee's disposition of the peer review team facts and observations classified as findings.

On October 3, 2018, and November 28, 2018, the NRC staff (including technical support contractors) exercised the audit process in the form of conference calls. In preparation for the calls, the NRC staff developed questions to verify information in the SPRA submittal and to gain an understanding of non-docketed supporting information. The questions (ADAMS Accession Nos. ML18257A233, ML18282A150, ML18337A131, and ML19046A063, respectively) were sent to the licensee in advance of the calls. This was done to facilitate clear communication and to ensure that the appropriate licensee staff were available and ready for the discussion.

During the calls, the licensee and the NRC staff discussed aspects of the detailed work done in the areas of component and structural fragilities and plant response of the SPRA submittal. The licensee pointed out that supporting documents would be made available for audit in an online portal. After the calls, the NRC staff proceeded to audit these supporting documents to gain a better understanding of the licensee's detailed analysis supporting the SPRA submittal. An audit summary is provided in Enclosure 3 of this letter.

In response to clarification questions associated with significant risk contributors, the licensee self-identified and proposed operator actions, as well as corresponding changes to plant procedures and training to reduce the risk contribution from relay chatter. The NRC staff credited the proposed operator actions in its conclusions. Further, the proposed operator actions represented an update to the information presented in the licensee's submittal. For this reason, the licensee supplemented its SPRA submittal with a letter dated March 7, 2019 (ADAMS Accession No. ML19071A114), to document the proposed operator actions as a regulatory commitment for the licensee to implement and monitor under its regulatory commitment program.

Based on the staff's review of the licensee's submittals, the NRC staff concluded that the technical adequacy of the licensee's SPRA submittal was sufficient to support regulatory decisionmaking associated with Phase 2 of the 10 CFR 50.54(f) letter.

Following the staff's conclusion of the SPRA's technical adequacy, the staff reviewed the risk and safety insights contained in the North Anna SPRA submittal. The staff's review process included the completion of the SPRA Submittal Technical Review Checklist (SPRA Checklist) contained in Enclosure 1 to this letter. As described in Enclosure 1, the SPRA Checklist is a document used to record the staff's review of licensees' SPRA submittals against the applicable guidance of the SPID in response to the 50.54(f) letter. The SPRA Checklist also focuses on areas where the SPID contains differing guidance from standard industry SPRA guidance. Enclosure 1 contains the staff's application of the SPRA Checklist. As documented in the SPRA Checklist, the staff concluded that the SPRA met the intent of the SPID. The staff further concluded that the peer review findings have been addressed and the analysis used by the licensee in dispositioning these findings is acceptable for the purposes of this evaluation.

The staff also used the screening criteria described in the August 29, 2017 (ADAMS Accession No. ML17146A200), staff memorandum titled, "Guidance for Determination of Appropriate Regulatory Action Based on Seismic Probabilistic Risk Assessment Submittals in Response to Near Term Task Force Recommendation 2.1: Seismic" to determine in which Group the technical team would recommend placing North Anna to the SMRP. The criteria in the staff's guidance document describes thresholds to assist in determining whether to apply the backfit

screening process described in Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection", dated October 9, 2013 (ADAMS Accession No. ML12059A460), to the SPRA report review.

The North Anna SPRA report stated that the plant SCDF and SLERF were above the threshold value in the August 29, 2017, memorandum. As a result, the NRC staff assessed the North Anna SPRA report and other available information to complete a detailed screening with respect to the SCDF and SLERF. The staff's evaluation was discussed with the licensee to obtain licensee feedback and input. As noted above, the licensee self-identified and proposed operator actions and corresponding changes to procedures and training and supplemented its SPRA submittal with a letter dated March 7, 2019, where these actions are captured as a regulatory commitment. A discussion of the detailed screening evaluation completed by the NRC staff and contractors is provided in Enclosure 2 of this staff assessment letter.

In addition, the NRC staff considered the actions taken by the licensee after the 2011 Mineral Earthquake, as documented in the closure letter dated December 24, 2015 (ADAMS Accession No. ML15015A575). Those actions and experience gained after the 2011 Mineral Earthquake provide additional assurance regarding North Anna's ability to handle a beyond design basis seismic event.

Based on the NRC staff evaluation of the SPRA submittals and associated regulatory commitment, the technical team recommended North Anna be classified as a **Group 1** plant because:

- No potential modifications that would result in substantial reductions in the SCDF and/or the SLERF were warranted based upon importance measures, available information, and engineering judgement. The licensee did, however, self-identify a safety improvement that was captured as a regulatory commitment;

- Additional consideration of containment performance, as described in NUREG/BR-0058, does not identify a modification that would result in a substantial safety improvement; and

- The staff did not identify any potential modifications that would be appropriate to consider necessary for adequate protection or compliance with existing requirements.

As such, additional refined screening, or further evaluation, was not required.

As a part of the Phase 2 decisionmaking process for SPRAs, the NRC formed the Technical Review Board (TRB), a board of senior-level NRC subject matter experts, to ensure consistency of review across the spectrum of plants that will be submitting SPRA reports. The technical team provided the results of the review to the TRB with the Phase 2 recommendation that North Anna be categorized as a Group 1 plant, meaning that no further response or regulatory actions are required and that a plant-specific backfit is not warranted. The TRB members assessed the information presented by the technical team and agreed with the team's Group 1 recommendation for North Anna.

Subsequently, the technical team met with the SMRP and presented the results of the review including the recommendation for North Anna to be categorized as a Group 1 plant. The SMRP members also asked questions and provided input to the technical team. The SMRP approved the staff's recommendation that North Anna should be classified as a Group 1 plant.

AUDIT REPORT

The July 6, 2017, generic audit plan describes the NRC staff's intention to issue an audit report that summarizes and documents the NRC's regulatory audit of licensee's submittals associated with reevaluated seismic hazard analyses. The NRC staff's audit of the North Anna SPRA submittal and supporting documents included a clarification call that took place on October 3, 2018, and the review of licensee documents through an electronic reading room. An audit summary document is included as Enclosure 3 to this letter.

REGULATORY COMMITMENT

In its supplement letter dated March 7, 2019, the licensee proposed a regulatory commitment to include operator actions and associated training to mitigate the risk associated with seismically induced relay contact chatter. With regard to regulatory commitments, the NRC staff notes that NEI 99-04 "Guidelines for Managing NRC Commitments" (ADAMS Accession No. ML003680088), as endorsed by the NRC in SECY-00-0045 "Acceptance of NEI 99-04, "Guidelines for Managing NRC Commitments"" (ADAMS Accession No. ML003679799), provides an acceptable method to manage commitments. If the licensee were to change this regulatory commitment, the staff expects to be informed in accordance with the process outlined in NEI 99-04, as endorsed by the NRC. If the commitment were to be changed, the staff may revisit its conclusion that no additional regulatory action is warranted.

CONCLUSION

Based on the staff's review of the licensee's submittal against the endorsed SPID guidance, the NRC staff concludes that the licensee responded appropriately to Enclosure 1, Item (8) of the 10 CFR 50.54(f) letter. Additionally, the staff's review concluded that the SPRA is of sufficient technical adequacy to support Phase 2 regulatory decisionmaking in accordance with the intent of the 10 CFR 50.54(f) letter. Based on the results and risk insights of the SPRA report, the NRC staff also concludes that no further response or regulatory actions associated with NTTF Recommendation 2.1 "Seismic" are required.

Application of this review is limited to the review of the 10 CFR 50.54(f) response associated with NTTF Recommendation 2.1 "Seismic" review. The staff notes that assessment of the SPRA for use in other licensing applications would warrant reviewing of the SPRA for its intended application. The NRC may use insights from this SPRA assessment in its regulatory activities as appropriate.

If you have any questions, please contact Milton Valentin at (301) 415-2864 or via e-mail at Milton.Valentin@nrc.gov.

Sincerely,

Louise Lund, Director
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket Nos. 50-338 and 50-339

Enclosures:
1. NRC Staff SPRA Submittal Technical Review Checklist
2. NRC Staff Executive Summary on Detailed Screening Evaluation
3. NRC Staff Audit Summary

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NRC Staff SPRA Submittal Technical Review Checklist

Several nuclear power plant licensees are performing seismic probabilistic risk assessments (SPRAs) as part of their required submittals to satisfy Near-Term Task Force (NTTF) Recommendation 2.1: "Seismic". These submittals are prepared according to the guidance in the Electric Power Research Institute – Nuclear Energy Institute (EPRI-NEI) Screening, Prioritization, and Implementation Details (SPID) document (EPRI-SPID, 2012), which was endorsed by the staff for this purpose (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12319A074). The SPRA peer reviews are also expected to follow the guidance in NEI 12-13 (NEI, 2012).

The SPID indicates that an SPRA submitted to satisfies Recommendation 2.1: "Seismic", must meet the requirements in the ASME-ANS Probabilistic Risk Assessment (PRA) Methodology Standard (the ASME/ANS Standard). Either the "Addendum A version" (ASME/ANS Addendum A, 2009) or the "Addendum B version" (ASME/ANS Addendum B, 2013) of the ASME/ANS Standard can be used.

Tables 6-4, 6-5, and 6-6 of the SPID also provide a comparison of each of the Supporting Requirements (SRs) of the ASME Standard to the relevant guidance in the SPID. For most SRs, the SPID guidance does not differ from the requirement in the ASME Standard. However, because the guidance of the SPID and the criteria of the ASME Standard differ in some areas, or the SPID does not explicitly address an SR, the staff developed this checklist, in part, to help staff members to address and evaluate the differences.

In general, the SPID allowed departures or differed from the ASME Standard in the following ways:

(i) In some technical areas, the SPID's requirements tell the SPRA analyst "how to perform" one aspect of the SPRA analysis, whereas the ASME Standard's requirements generally cover "what to do" rather than "how to do it".

(ii) For some technical areas and issues the requirements in the SPID differ from those in the ASME Standard.

(iii) The SPID has some requirements that are not in the ASME Standard.

The technical positions in the SPID have been endorsed by the U.S. Nuclear Regulatory Commission (NRC) staff, subject to certain conditions concerning peer review outlined in the staff November 12, 2012 (ADAMS Accession No. ML12321A280), letter to NEI.

The following checklist is comprised of the 16 "Topics" that require additional staff guidance because the SPID contains specific guidance that differs from the ASME Standard or expands on it. Each is covered below under its own heading, "Topic 1," "2," etc. The checklist was discussed during a public meeting held on December 7, 2016 (ADAMS Accession No. ML16350A181). The following checklist is prepared to support the review of the North Anna Power Station, Units 1 and 2 (North Anna, the site under review) SPRA submitted in response to Near-Term Task Force (NTTF) Recommendation 2.1 "Seismic."

- Topic 1: Seismic Hazard (SPID Sections 2.1, 2.2, and 2.3)
- Topic 2: Site Seismic Response (SPID Section 2.4)
- Topic 3: Definition of the Control Point for the SSE-to-GMRS-Comparison Aspect of the Site Analysis (SPID Section 2.4.2)
- Topic 4: Adequacy of the Structural Model (SPID Section 6.3.1)
- Topic 5: Use of Fixed-Based Dynamic Seismic Analysis of Structures for Sites Previously Defined as "Rock" (SPID Section 6.3.3)
- Topic 6: Use of Seismic Response Scaling (SPID Section 6.3.2)
- Topic 7: Use of New Response Analysis for Building Response, ISRS, and Fragilities
- Topic 8: Screening by Capacity to Select SSCs for Seismic Fragility Analysis (SPID Section 6.4.3)
- Topic 9: Use of the CDFM/H Methodology for Fragility Analysis (SPID Section 6.4.1)
- Topic 10: Capacities of SSCs Sensitive to High-Frequencies (SPID Section 6.4.2)
- Topic 11: Capacities of Relays Sensitive to High-Frequencies (SPID Section 6.4.2)
- Topic 12: Selection of Dominant Risk Contributors that Require Fragility Analysis Using the Separation of Variables Methodology (SPID Section 6.4.1)
- Topic 13: Evaluation of LERF (SPID Section 6.5.1)
- Topic 14: Peer Review of the SPRA, Accounting for NEI 12-13 (SPID Section 6.7)
- Topic 15: Documentation of the SPRA (SPID Section 6.8)
- Topic 16: Review of Plant Modifications and Licensee Actions

TOPIC 1: Seismic Hazard (SPID Sections 2.1, 2.2, and 2.3)

The site under review has updated/revised its probabilistic hazard seismic analysis (PSHA) from what was submitted to NRC in response to the NTTF Recommendation 2.1: Seismic 50.54(f) letter.	NO
Notes from staff reviewer: None. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes that: • the peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the SHA requirements in the Standard, as well as to the requirements in the SPID. • although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis. • the guidance in the SPID was followed for developing the probabilistic seismic hazard for the site. • an alternate approach was used, and is acceptable on a justified basis.	YES N/A YES N/A

TOPIC 2: Site Seismic Response (SPID Section 2.4)

The site under review has updated/revised its site response analysis from what was submitted to NRC in response to the NTTF Recommendation 2.1: Seismic 50.54(f) letter.	NO
Notes from staff reviewer: The guidance in the SPID was followed for developing a site profile for use in the analysis to develop control point seismic hazard curves (site response). Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes that:	
• the peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the supporting requirements SHA-E1 and E2 in the Standard, as well as to the requirements in the SPID.	YES
• although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• the licensee's development of PSHA inputs and base rock hazard curves meets the intent of the SPID guidance or another acceptable approach.	N/A
• the licensee's development of a site profile for use in the analysis adequately meets the intent of the SPID guidance or another acceptable approach.	N/A
• although the licensee's development of a V_s velocity profile for use in the analysis does not meet the intent of the SPID guidance, it is acceptable on another justified basis.	N/A

TOPIC 3: Definition of the Control Point for the SSE-to-GMRS-Comparison Aspect of the Site Analysis (SPID Section 2.4.2)

The issue is establishing the control point where the safe shutdown earthquake (SSE) is defined. Most sites have only one SSE, but some sites have more than one SSE, for example one at rock and one at the top of the soil layer. This control point is needed because it is used as part of the input information for the development of the seismic site-response analysis, which in turn is an important input for analyzing seismic fragilities in the SPRA. The SPID (Section 2.4.1) recommends one of two criteria for establishing the control point for a logical SSE-to- ground motion response spectra (GMRS) comparison:	
A) If the SSE control point(s) is defined in the final safety analysis report (FSAR), it should be used as defined.	N/A
B) If the SSE control point is not defined in the FSAR, one of three criteria in the SPID (Section 2.4.1) should be used.	YES
C) An alternative method has been used for this site.	
The control point used as input for the SPRA is identical to the control point used to establish the GMRS.	
If yes, the control point can be used in the SPRA and the NRC staff's earlier acceptance governs.	YES
If no, the NRC staff's previous reviews might not apply. The staff's review of the control point used in the SPRA is acceptable.	N/A

Notes from staff reviewer: None.

Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified.

Consequence(s): N/A

The NRC staff concludes that:	
• The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the requirements in the SPID. No requirements in the Standard specifically address this topic.	YES
• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's [The Virginia Electric and Power Company, Dominion] definition of the control point for site response analysis adequately meets the intent of the SPID guidance.	YES
• The licensee's definition of the control point for site response analysis does not meet the intent of the SPID guidance, but is acceptable on another justified basis.	N/A

TOPIC 4: Adequacy of the Structural Model (SPID Section 6.3.1)

The NRC staff review of the structural model finds an acceptable demonstration of its adequacy:	YES
Used an existing structural model	YES
Used an enhancement of an existing model	YES
Used an entirely new model	YES
Criteria 1 through 7 (SPID Section 6.3.1) are all met.	YES
Notes from staff reviewer: None. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes that:	
• The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the supporting requirements SFR-C1 through C6 in the Standard, as well as to the requirements in the SPID.	YES
• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's structural model meets the intent of the SPID guidance.	YES
• The licensee's structural model does not meet the intent of the SPID guidance, but is acceptable on another justified basis.	N/A

TOPIC 5: Use of Fixed-Based Dynamic Seismic Analysis of Structures for Sites Previously Defined as "Rock" (SPID Section 6.3.3)

Fixed-based dynamic seismic analysis of structures was used, for sites previously defined as "rock."	YES
If no, this issue is moot.	
If yes, on which structure(s)? Structure #1: Safeguard Building Structure #2: Auxiliary Feedwater Pump Houses Structure #2: Unit 1 Main Steam Valve House	
Structure #1: Safeguard Building If used, is V_S > about 5,000 feet/second (ft./sec)?	YES
If 3,500 ft./sec < V_S < 5,000 ft./sec, was peak-broadening or peak shifting used?	N/A
Structure #2: Auxiliary Feedwater Pump Houses If used, is V_S > about 5,000 ft./sec?	YES
If 3,500 ft./sec < V_S < 5,000 ft./sec, was peak-broadening or peak shifting used?	N/A
Structure #3: Unit 1 Main Steam Valve House If used, is V_S > about 5,000 ft./sec?	YES
If 3,500 ft./sec < V_S < 5,000 ft./sec, was peak-broadening or peak shifting used?	N/A
Potential Staff Finding:	
The demonstration of the appropriateness of using this approach is adequate.	YES

Notes from staff reviewer: Section 4.3.3 and Table 4-2 of the SPRA indicate fixed base analysis was used for structures founded on rock where shear wave velocity exceeded 5,000 ft./sec. Information is consistent with SPID Section 6.3.3. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes that:	
• The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the requirements in the SPID. No requirements in the Standard specifically address this topic.	YES
• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis	N/A
• The licensee's use of fixed-based dynamic analysis of structures for a site previously defined as "rock" adequately meets the intent of the SPID guidance.	YES
• The licensee's use of fixed-based dynamic analysis of structures for a site previously defined as "rock" does not meet the intent of the SPID guidance, but is acceptable on another justified basis.	N/A

TOPIC 6: Use of Seismic Response Scaling (SPID Section 6.3.2)

Seismic response scaling was used.	YES
If no, this issue is moot.	
If yes, on which structure(s)? Nuclear Steam Supply System (NSSS) components including reactor vessel, steam generators, coolant pumps, pressurizer and piping.	
Structure #1: NSSS Components	
Scaling based on:	
• Previously developed ISRS	YES
• Shapes of previous ultimate heat sink/review-level earthquake (UHS/RLE)	YES
• Shapes of new UHS/RLE	YES
• Structural natural frequencies, mode shapes, participation factors	YES
Potential Staff Findings:	
If a new UHS or RLE is used, the shape is approximately similar to the spectral shape previously used for ISRS generation.	NO
If the shape is not similar, the justification for seismic response scaling is adequate.	YES
Consideration of non-linear effects is adequate.	N/A

Notes from staff reviewer: During the audit, the NRC staff confirmed that scaling was not used to develop ISRS. Scaling was used for NSSS components and their supports. For a specific NSSS component and its support, the design basis earthquake (DBE)-to-GMRS ratio used in the scaling process was based on the appropriate fundamental modes of the component and its supports. Therefore, the DBE-to-GMRS ratio for specific component inherently includes the structural natural frequencies, modes shapes and participation factors. This is standard industry practice. During the audit of the SPRA submittal, the licensee conducted time history analysis of coupled model of the NSSS components using GMRS seismic demands. Results from the model studies corroborated that the fragilities calculated based on scaling approach are bounding and conservatively-biased. Lastly, there were no peer-review findings for supporting requirement SFR-C3. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): None.	
The NRC staff concludes that:	
• The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the supporting requirement SFR-C3 in the Standard, as well as to the requirements in the SPID.	YES
• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's use of seismic response scaling adequately meets the intent of the SPID guidance.	YES
• The licensee's use of seismic response scaling does not meet the intent of the SPID guidance but is acceptable on another justified basis.	N/A

TOPIC 7: Use of New Response Analysis for Building Response, ISRS, and Fragilities

The SPID does not provide specific guidance on performing new response analysis for use in developing ISRS and fragilities. The new response analysis is generally conducted when the criteria for use of existing models are not met or more realistic estimates are deemed necessary. The requirements for new analysis are included in the standard. See supporting requirements SFR-C2, C4, C5, and C6. One of the key areas of review is consistency between the hazard and response analyses. Specifically, this means that there must be consistency among the ground motion equations, the soil-structure-interaction analysis (for soil sites), the analysis of how the seismic energy enters the base level of a given building, and the in-structure-response-spectrum analysis. Said another way, an acceptable SPRA must use these analysis pieces together in a consistent way. The following are high-level key elements that should have been considered:	
1. Foundation Input Response Spectra (FIRS) site response developed with appropriate building specific soil velocity profiles. Structure #1 Reactor Containment Buildings (Rock) Structure #2 Service Water Pump House (Soil) Structure #3 Service Building (Rock/Soil) Structure #4 Service Water Valve House (Soil) Structure #5 Auxiliary Building (Rock/Soil) Structure #6 Safeguards Building (Rock) Structure #7 Auxiliary Feedwater Pump House (Rock) Structure #8 Unit 1 Main Steam Valve House (Rock) Structure #9 Unit 2 Main Steam Valve House (Soil) Structure #10 Fuel Oil Pump House (No dynamic analysis) Structure #11 Casing Cooling Pump House (No dynamic analysis) Variability in structural properties were considered in fixed base, deterministic soil-structure and probabilistic soil-structure analyses. For deterministic soils structure interaction analysis (Service Water Pump House and Service Water Valve House), soil foundation conditions considered low bound, best estimate, and upper bound	

soil properties and five sets of time histories, as identified in SPRA Sections 4.3.3 and 4.3.4. For the soil structure interaction analysis using probabilistic analysis (Reactor building, Service building, Auxiliary building and Main Steam valve house Unit -2), the rock/soil and some Rock foundation conditions included 30 SSI input profiles.	
2. Are all structures appropriately considered? 3. Are models adequate to provide realistic structural loads and response spectra for use in the SPRA? 4. Is the SSI analysis capable of capturing uncertainties and realistic? 5. Is the probabilistic response analysis capable of providing the full distribution of the responses?	YES YES YES YES
Notes from staff reviewer: During the audit, the NRC staff confirmed that probabilistic response analysis was used on buildings that house a large percentage of SSCs expected to be risk significant. The analysis included system ductility and inelastic energy absorption factors as appropriate. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes: • The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the supporting requirements SFR-C2, C4, C5, and C6, as well as to the requirements in the SPID. • Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis. • The licensee's FIRS modeling is consistent with the prior NRC review of the GMRS and soil velocity information. • The licensee's structural model meets the intent of the SPID guidance and the Standard's requirements. • The response analysis accounts for uncertainties in accordance with the SPID guidance and the Standard's requirements.	YES N/A YES YES YES

• The NRC staff concludes that an acceptable consistency has been achieved among the various analysis pieces of the overall analysis of site response and structural response.	YES
• The licensee's structural model does not meet the intent of the SPID guidance and the Standard's requirements, but is acceptable on another justified basis.	N/A

TOPIC 8: Screening by Capacity to Select SSCs for Seismic Fragility Analysis (SPID Section 6.4.3)

The selection of SSCs for seismic fragility analysis used a screening approach by capacity following Section 6.4.3 of the SPID. If no, see items D and E. If yes, see items A, B, and C. Potential Staff Findings:	NO
A) The recommendations in Section 6.4.3 of the SPID were followed for the screening aspect of the analysis, using the screening criteria therein.	N/A
B) The approach for retaining certain SSCs in the model with a screening-level seismic capacity follows the recommendations in Section 6.4.3 of the SPID and has been appropriately justified.	N/A
C) The approach for screening out certain SSCs from the model based on their inherent seismic ruggedness follows the recommendations in Section 6.4.3 of the SPID and has been appropriately justified.	N/A
D) The Standard has been followed.	YES
E) An alternative method has been used and its use has been appropriately justified.	N/A

Notes from staff reviewer: During the audit, the NRC staff confirmed that no SSCs were screened for the SPRA logic model based on seismic capacity. High seismic capacity SSCs were assigned a bounding HCLPF of 1.0 g. An evaluation was done for these SSCs to verify their capacities were greater than 1.0 g. The NRC staff saw supporting documents that confirmed these capacities.

Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified.

Consequence(s): N/A

The NRC staff concludes:	
• The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to supporting requirements SFR-B1 and B2 in the Standard, as well as to the requirements in the SPID.	YES
• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's use of a screening approach for selecting SSCs for fragility analysis meets the intent of the SPID guidance.	YES
• The licensee's use of a screening approach for selecting SSCs for fragility analysis does not meet the intent of the SPID guidance but is acceptable on another justified basis.	N/A

TOPIC 9: Use of the CDFM/Hybrid Methodology for Fragility Analysis (SPID Section 6.4.1)

The Conservation Deterministic Failure Margin (CDFM)/Hybrid method was used for seismic fragility analysis. If no, See item C) below and next issue. If yes: Potential Staff Findings:	YES
A) The recommendations in Section 6.4.1 of the SPID were followed appropriately for developing the CDFM High Confidence Low Probability of Failure capacities.	N/A
B) The Hybrid methodology in Section 6.4.1 and Table 6-2 of the SPID was used appropriately for developing the full seismic fragility curves.	YES
C) An alternative method has been used appropriately for developing full seismic fragility curves.	N/A

Notes from staff reviewer: Section 4.4.2 of the SPRA submittal states that the licensee followed EPRI NP-6041-SL, Revision 1, "A Methodology for Assessment of Nuclear Plant Seismic Margin," and EPRI 1019200, "Seismic Fragility Application Update Guide," to develop fragility using CDFM. During the audit, the NRC staff confirmed that the licensee's approach to use hybrid methodology to develop fragility is consistent with SPID guidance in Section 6.4.1. The same section states that uncertainty parameters (βr and βu) from SPID were used wherever possible. The NRC staff also confirmed that uncertainty parameters used for fragility development of structural and active components, and other SSCs using CDFM given in SPRA Tables 5.4-2 and 5.5-2 were based on Table 6-2 of the SPID.

Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified.

Consequence(s): N/A

The NRC staff concludes that:	
• The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the requirements in the SPID. No requirements in the Standard specifically address this Topic.	YES
• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's use of the CDFM/Hybrid method for seismic fragility analysis meets the intent of the SPID guidance.	YES
• The licensee's use of the CDFM/Hybrid method for seismic fragility analysis does not meet the intent of the SPID guidance, but is acceptable on another justified basis.	N/A

TOPIC 10: Capacities of SSCs Sensitive to High-Frequencies (SPID Section 6.4.2)

The SPID requires that certain SSCs that are sensitive to high-frequency seismic motion must be analyzed in the SPRA for their seismic fragility using a methodology described in Section 6.4.2 of the SPID. Potential Staff Findings: The NRC staff review of the SPRA's fragility analysis of SSCs sensitive to high frequency seismic motion finds that the analysis is acceptable. The flow chart in Figure 6-7 of the SPID was followed. The flow chart was not followed but the analysis is acceptable on another justified basis.	 YES NO YES
Notes from staff reviewer: Section 4.1.2 of the SPRA report states that relay chatter evaluation was performed in accordance with SPID Section 6.4.2 and Standard Section 5-2.2. Section 4.4.2 of the SPRA report states that a cut-off frequency limit of 40 Hertz was used for potentially high frequency components. During the audit, the NRC staff confirmed that the deterministic screening process for high frequency sensitive SSCs given in Figure 6-7 of the SPID was not applied for the North Anna SPRA. The NRC staff also confirmed that circuit analysis was performed consistent with SPID guidance. Where appropriate, more detailed seismic fragilities were calculated following acceptable methodologies. The high frequency evaluation included relays, contactors, process switches, and sensors or seal-in or lock-out circuits where contact chatter could result in unacceptable consequences. However, the licensee proposed operator actions to mitigate the risk contribution from seismically induced relay contact chatter in its supplement letter dated March 7, 2019 (ADAMS Accession NoML19071A114). There were no peer review findings under supporting requirement SFR-F3 of the Standard. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes that: • The peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to supporting requirement SFR-F3, as well as to the requirements in the SPID.	N/A

• Although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's fragility analysis of SSCs sensitive to high frequency seismic motion meets the intent of the SPID guidance.	YES
• The licensee's fragility analysis of SSCs sensitive to high-frequency motion does not meet the intent of the SPID guidance but is acceptable on another justified basis.	N/A

TOPIC 11: Capacities of Relays Sensitive to High-Frequencies (SPID Section 6.4.2)

The SPID requires that certain relays and related devices (generically, "relays") that are sensitive to high-frequency seismic motion must be analyzed in the SPRA for their seismic fragility. Although following the Standard is generally acceptable for the fragility analysis of these components, the SPID (Section 6.4.2) contains additional guidance when either circuit analysis or operator-action analysis is used as part of the SPRA to understand a given relay's role in plant safety. When one or both are used, the NRC reviewer should use the following elements of the checklist.	
i) Circuit analysis: The seismic relay-chatter analysis of some relays relies on circuit analysis to assure that safety is maintained. (A) If no, then (B) is moot. (B) If yes: Potential Staff Finding: The approach to circuit analysis for maintaining safety after seismic relay chatter is acceptable.	YES YES
ii) Operator actions: The relay-chatter analysis of some relays relies on operator actions to assure that safety is maintained. (A) If no, then (B) is moot. (B) If yes: See "Notes from staff reviewer" Potential Staff Finding: The approach to analyzing operator actions for maintaining safety after seismic relay chatter is acceptable.	YES YES
Notes from staff reviewer: There are no peer review findings for supporting requirements SPR-B6 or SPR-B4. The relay-chatter analysis completed by the licensee used shake table test data to determine the relays functional capacity. However, the SPRA concluded that relay chatter was a significant risk contributor. To mitigate the risk contribution from relay chatter, the licensee made a regulatory commitment (ADAMS Accession No. ML19071A114) to implement operating procedure changes and	

enhanced operator training to respond to seismic event-induced relay contact chatter. The NRC staff considered this regulatory commitment in its conclusions. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes that: • the peer review findings have been addressed and the analysis approach has been accepted by the staff for the purposes of this evaluation. The peer review findings referred to supporting requirements SPR-B6 (Addendum A) or SPR-B4 (Addendum B) in the Standard, as well as to the requirements in the SPID.	YES
• although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• the licensee's analysis of seismic relay-chatter effects meets the intent of the SPID guidance.	YES
• the licensee's analysis of seismic relay-chatter effects does not meet the intent of the SPID guidance, but is acceptable on another justified basis.	N/A

TOPIC 12: Selection of Dominant Risk Contributors that Require Fragility Analysis Using the Separation of Variables Methodology (SPID Section 6.4.1)

The CDFM methodology has been used in the SPRA for analysis of the bulk of the SSCs requiring seismic fragility analysis.	YES
If no, the staff review will concentrate on how the fragility analysis was performed, to support one or the other of the "potential staff findings" noted just below.	N/A
If yes, significant risk contributors for which use of separation of variables (SOV) fragility calculations would make a significant difference in the SPRA results have been selected for SOV calculations.	YES
Potential Staff Findings:	
A) The recommendations in Section 6.4.1 of the SPID were followed concerning the selection of the "dominant risk contributors" that require additional seismic fragility analysis using the separation-of-variables methodology.	NO
B) The recommendations in Section 6.4.1 were not followed, but the analysis is acceptable on another justified basis.	YES

Notes from staff reviewer: Section 4.4.2 of the SPRA submittal states that the CDFM approach was initially used for most SSCs in the seismic equipment list (SEL), and that a more refined fragility analyses using the SOV approach was used for "the top risk-important SSCs." The submittal further states that the CDFM approach was performed in one of two ways, using "variabilities" from the SPID or using detailed North Anna specific structural response "variabilities." Sections 5.4 and 5.5 and Tables 5.4-2 and 5.5-2 of the submittal show this to be the case but also indicate that a third approach was used to determine the fragility of certain risk-significant SSCs based on guidance from the EPRI Seismic PRA Implementation Guide issued in 2013 (SPRAIG, EPRI 3002000709). Representative fragilities from the SPRAIG were used for the Loss of Offsite Power and Loss of Coolant Accident (LOCA) (Large, Medium, Small and Small-Small) fragility groups. The NRC staff notes that it is highly unlikely that potential substantial safety improvements to address these risk contributors can be identified, regardless of the approach used for the fragility determination.

Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified.

Consequence(s): N/A

The NRC staff concludes:	
• the peer review findings have been addressed and the analysis approach has been accepted by the peer reviewers. The peer review findings referred to relate to the requirements in the SPID. No requirements in the Standard specifically address this Topic.	YES
• although some peer review findings and observations have not been resolved, the analysis is acceptable on another justified basis.	N/A
• the licensee's method for selecting the "dominant risk contributors" for further seismic fragilities analysis using the separation-of-variables methodology meets the intent of the SPID guidance.	YES
• the licensee's method for selecting the "dominant risk contributors" for further seismic fragilities analysis using the separation-of-variables methodology does not meet the intent of the SPID guidance, but is acceptable on another justified basis.	N/A

TOPIC 13: Evaluation of LERF (SPID Section 6.5.1)

The NRC staff review of the SPRA's analysis of LERF finds an acceptable demonstration of its adequacy.	YES
Potential Staff Findings: A) The analysis follows each of the elements of guidance for LERF analysis in Section 6.5.1 of the SPID, including in Table 6-3.	YES
B) The LERF analysis does not follow the guidance in Table 6-3 but the analysis is acceptable on another justified basis.	N/A

Notes from staff reviewer:

The submittal appears to be following the recommendations of Section 6.5.1 of the SPID.

Section 4.1 of the submittal describes the development of a SEL for both Units 1 and 2, including SSCs that support containment functions, and explains that the SSCs included in the SEL are included in the SPRA model. The SEL forms the basis for the seismic fragility and system analysis tasks.

Section 4.1.1 mentions that the Containment Building is one of the structures included in the SEL and that Containment Depressurization Actuation and Phase A and B Containment Isolation are two of the actuation systems that actuate safety systems and are included in the SEL. Section 4.1.1 states that SSCs are included in the SEL for containment functions and identified those functions (i.e., containment structure including pressure boundary, containment pressure suppression, containment isolation, Interfacing system loss of coolant accident (ISLOCA), hydrogen isolation, containment vacuum, containment heat exchanger pressure boundary). The LERF contributors listed in Table 6-3 of the SPID either had no significant seismic-induced impact (per Table 6-3); were determined by NRC staff not to apply to a pressurized-water reactor (PWR); or were judged by NRC staff to be addressed in Section 4.1.1 of the submittal.

Sections 5.1 and 5.5 of the submittal describe the SPRA LERF model and quantification results. In accordance with the SPID, the internal events PRA was adapted to include seismic-related basic events and the internal PRA Human Error Probabilities (HEPs) were adjusted to account for response during and following a seismic event (new HEPs were also developed for mitigating seismic failures of mitigating functions). Section 5.5 of the submittal presents importance values for risk-significant SSC seismic fragility failure groups, random component failures, and operator failures. None of the unresolved F&Os are associated with LERF.

Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified.

Consequence(s): N/A

The NRC staff concludes that:	
• the peer review findings have been addressed and the analysis approach has been accepted by the staff for the purposes of this evaluation. The peer review findings referred to relate to the SR requirements SFR-F4, SPR-E1, SPR-E2, and SPR-E6 (Addendum B only) in the Standard as well as to the requirements in the SPID.	YES
• although some peer review findings have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's analysis of LERF meets the intent of the SPID guidance.	YES
• The licensee's analysis of LERF does not meet the intent of the SPID guidance but is acceptable on another justified basis.	N/A

TOPIC 14: Peer Review of the SPRA, Accounting for NEI 12-13 (SPID Section 6.7)

The NRC staff review of the SPRA's peer review findings, observations, and their resolution finds an acceptable demonstration of the peer review's adequacy.	YES
Potential Staff Findings: A) The analysis follows each of the elements of the peer review guidance in Section 6.7 of the SPID.	YES
B) The composition of the peer review team meets the SPID guidance.	YES
C) The peer reviewers focusing on seismic response and fragility analysis have successfully completed the SQUG training course or equivalent (see SPID section 6.7).	YES
In what follows, a distinction is made between an "in-process" peer review and an "end-of-process" peer review of the completed SPRA report. If an in-process peer review is used, go to (D) and then skip (E). If an end-of-process peer review is used, skip (D) and go to (E).	
D) The "in-process" peer-review process followed the "in-process" peer review guidance in the SPID (Section 6.7), including the three "bullets" and the guidance related to NRC's additional input in the paragraph immediately following those 3 bullets. These 3 bullets are: • The SPRA findings should be based on a consensus process, and not based on a single peer review team member • A final review by the entire peer review team must occur after the completion of the SPRA project • An "in-process" peer review must assure that peer reviewers remain independent throughout the SPRA development activity. If no, go to (F). If yes, the "in process" peer review approach is acceptable. Go to (G).	N/A
E) The "end-of-process" peer review process followed the peer review guidance in the SPID (Section 6.7). If no, go to (F). If yes, the "end-of-process" peer review approach is acceptable. Go to (G).	YES

F) The peer-review process does not follow the guidance in the SPID but is acceptable on another justified basis.	N/A
G) The licensee peer-review findings were satisfactorily resolved or were determined not to be significant to the SPRA conclusions for this evaluation.	YES

Notes from staff reviewer:

Section 5.2 and Appendix A of the submittal describe the peer review process used to establish the technical adequacy of the SPRA and internal events PRA. A full-scope peer review of the SPRA was conducted in July 2017 against the CC-II supporting requirements of Addenda B to the ASME/ANS PRA Standard RA-S-2008 (ASME/ANS Addendum B, 2013), which is consistent with Tables 6-4 through 6-6 of the SPID, and in accordance with Regulatory Guide 1.200, Revision 2 (NRC, 2009) and the peer review process guidelines in NEI 12-13 (NEI, 2012). The qualifications of each of the eight peer review members is described, with the combined experience of all spanning the three technical elements of the SPRA: hazards analysis, fragility analysis, and plant response. One member was designated as the team leader.

All elements of the SPRA were peer reviewed, including those identified in Section 6.7 of the SPID, and the results of the peer review (including 28 Finding-level F&Os) are documented in a licensee report. The complete text of each Finding from this peer review (confirmed during the audit), the basis for the Finding, and the resolutions suggested by the peer review are provided in Table A-2 of the submittal. Table A-2 also includes the licensee's dispositions to each Finding. The submittal explains that, where necessary, the SPRA model and documentation were updated to resolve 27 of the 28 Findings, which are delineated as follows: (1) SHA – 9 Findings, (2) SFR – 10 Findings, and (3) SPR – 9 Findings (the submittal also identifies three maintenance and update findings not associated with specific SRs). The NRC staff reviewed these Findings and associated resolutions by the licensee, confirmed during the audit that the Findings for 27 of the F&Os have been adequately resolved for the 10 CFR 50.54(f) submittal review.

For the one F&O that has not been resolved, F&O 25-9 (i.e., Lack of a focused scope peer review of the modeling of the new low-leakage RCP seals), the submittal explains that the PRA modeling of the RCP seals was based on the peer reviewed RCP seal models of the "nearly identical" seals for a similar plant. The submittal also explains that the licensee reviewed these F&Os and determined that they were either not applicable to the North Anna seal model or they have no impact on the SPRA results. During the audit, the licensee provided the results of a sensitivity analysis that substantially increased the probability of failure of the RCP seals. The results of the sensitivity analysis showed that the increase in seismic CDF and LERF is not significant. The licensee also explained that the dominant risk contributors are not expected to change because the RCP seal failure basic events are in cutsets in which all associated SSCs are already risk significant. Based on these results, NRC staff concludes that F&O 25-9 is not expected to change the staff's conclusions on this submittal.

The internal events PRA (including internal flooding), which is the foundation for the SPRA, was peer reviewed in November 2013 by the PWR Owners Group against the CC-II supporting requirements of the ASME/ANS PRA Standard RA-Sa-2009

(ASME/ANS Addendum A, 2009) and in accordance with RG 1.200, Rev. 2 (NRC, 2009). A total of 35 Findings were issued by the peer review team, each of which is provided in Table B.1 of the North Anna license amendment request to extend the intervals for the primary containment integrated leak rate tests (ADAMS Accession No. ML14183B318). The submittal states that the resolutions to 13 Findings that impact the PRA have been incorporated into the PRA, that these resolutions were reviewed and determined to not impact the SPRA, and that the remaining unresolved Findings are documentation issues that were determined to not impact the PRA. During the audit, the licensee provided dispositions to address internal event PRA findings that could affect the SPRA submittal. As part of the audit, the NRC staff reviewed these Findings and associated dispositions by the licensee to determine if there was any potential impact on the SPRA model and the staff's conclusions on this submittal. Based on this review, the NRC staff did not identify any concerns with the licensee's disposition to the Findings in the context of the SPRA which would change the staff's conclusions on this submittal. Deviation(s) or deficiency(ies) and Resolution: No deviations or deficiencies identified. Consequence(s): N/A	
The NRC staff concludes: • The licensee's peer-review process meets the intent of the SPID guidance. • The licensee's peer-review process does not meet the intent of the SPID guidance but is acceptable on another justified basis.	YES N/A

TOPIC 15: Documentation of the SPRA (SPID Section 6.8)

The NRC staff review of the SPRA's documentation as submitted finds an acceptable demonstration of its adequacy.	YES
The documentation should include all the items of specific information contained in the 50.54(f) letter as described in Section 6.8 of the SPID.	YES

Notes from staff reviewer:

The submittal appears to follow the recommendations of Section 6.8 of the SPID. Tables 2-1 and 2-2 of the submittal provide a cross-reference of information required by the 50.54(f) letter and specified in Section 6.8 of the SPID to the sections of the submittal where the information can be found. The level-of-detail of the information provided appears to be generally consistent with that specified in Section 6.8 of the SPID. It is noted, however, that not all the information identified in Section 6.8 of the SPID, with regard to what was submitted for the Individual Plant Examination of External Events (IPEEE) program, is included in the submittal (e.g., all functional/systemic event trees). However, the SPID only identifies this IPEEE information as guidance for consideration in the 50.54(f) response.

Deviation(s) or deficiency(ies) and Resolution:

Section 5.7.4 of the submittal provides the results of a sensitivity study where the failure rates of the FLEX diesel generators (DGs) are increased by a factor of five over that assumed in the baseline SPRA, which are based on the industry failure rates for safety-related emergency diesel generators (EDGs). The NRC staff questioned the licensee's modeling of the FLEX DGs because 1) while industry failure rates for portable FLEX equipment are not yet available, they are expected to be greater than the failure rates for permanently installed equipment; and 2) the failure rates for the safety-related EDGs are an order-of-magnitude less than the failure rates for the Station Blackout DGs which are not safety related.

In its supplement dated March 7, 2019 (ADAMS Accession No. ML19071A114), the licensee provided the results of an updated sensitivity study in which the FLEX DG failure rates and the HEPs associated with the failure of FLEX operator actions were increased. The supplement provides updated Fussell-Vesel (FV) importance values for seismic CDF and LERF for each of the risk significant fragility groups, non-seismic failure basic events, and HEPs. The licensee's sensitivity analysis substantially reduces the credit for FLEX in the SPRA, which provides reasonable basis to support Phase 2 regulatory decisionmaking for this submittal in accordance with the intent of the NRC's 50.54(f) letter.

Consequence(s): None.

The NRC staff concludes: • The licensee's documentation meets the intent of the SPID guidance. The documentation requirements in the Standard can be found in HLR-SHA-J, HLR-SFR-G, and HLR-SPR-F.	YES
• The licensee's documentation does not meet the intent of the SPID guidance but is acceptable on another justified basis.	N/A

Topic 16: Review of Plant Modifications and Licensee Actions, If Any

The licensee: • identified modifications necessary to achieve seismic risk improvements • provided a schedule to implement such modifications (if any), consistent with the intent of the guidance • provided Regulatory Commitment to complete modifications • provided Regulatory Commitment to report completion of modifications.	YES YES YES YES
North Anna will: • complete modifications to plant procedures by March 2020 • report completion of modifications in accordance with licensee's regulatory commitment program	
Notes from the Reviewer: In its letter dated March 7, 2019 (ADAMS Accession No. ML19071A114), the licensee provided a regulatory commitment to include operator actions as well as corresponding procedure changes and training to mitigate the risk contribution from seismically induced relay contact chatter. Refer to Enclosure 2 for detailed evaluation. **Deviation(s) or Deficiency(ies), and Resolution:** None. Refer to Enclosure 2 for detailed evaluation.	
The NRC staff concludes that the licensee: • identified plant modifications necessary to achieve the appropriate risk profile • provided a schedule to implement the modifications (if any) with appropriate consideration of plant risk and outage scheduling	YES YES

REFERENCES

ASME/ANS Addendum A, 2009: Standard ASME/ANS RA-Sa-2009, Addenda A to ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," American Society of Mechanical Engineers and American Nuclear Society, 2009

ASME/ANS Addendum B, 2013: Standard ASME/ANS RA-Sb-2013, Addenda B to ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," American Society of Mechanical Engineers and American Nuclear Society, 2013

EPRI-SPID, 2012: "Screening, Prioritization and Implementation Details (SPID) for the Resolution of Fukushima Near-Term Task Force Recommendation 2.1: Seismic," Electric Power Research Institute, EPRI report 1025287, November 2012, ADAMS Accession No. ML12333A170

NEI, 2012: NEI 12-13 "External Hazards PRA Peer Review Process Guidelines," Nuclear Energy Institute, August 2012, ADAMS Accession No. ML12240A027

NRC, 2009: Regulatory Guide 1.200, "An Approach For Determining The Technical Adequacy of Probabilistic Risk Assessment Results For Risk-Informed Activities," U.S. Nuclear Regulatory Commission, March 2009 ADAMS Accession No. ML090410014

NRC, 2012: "U.S. Nuclear Regulatory Commission Comments on NEI 12-13, 'External Hazards PRA Peer Review Process Guidelines' Dated August 2012," NRC letter to Nuclear Energy Institute, November 16, 2012, ADAMS Accession No. ML12321A280

Executive Summary on Detailed Screening Evaluation

Introduction

The Virginia Electric and Power Company (Dominion, the licensee), in performing its Seismic Probabilistic Risk Assessment (SPRA) report (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18093A445) for North Anna Power Station, Units 1 and 2 (North Anna) in response to the Near-Term Task Force Recommendation 2.1, and the NRC in conducting its review, did not identify concerns that would require actions above and beyond existing regulations to maintain the level of protection necessary to avoid undue risk to public health and safety. In addition, there were no issues identified as non-compliances with the North Anna licenses, or the rules and orders of the Commission. For these reasons, the licensee and the staff did not identify a potential plant modification necessary for adequate protection or compliance with existing requirements.

The North Anna SPRA report indicates that the mean seismic core damage frequency (SCDF) is 6.3E-05/reactor-year (/rx-yr) and the mean seismic large early release frequency (SLERF) is 1.9E-05/rx-yr for both units. The NRC staff compared these values against the guidance in NRC staff memorandum dated August 29, 2017, titled, "Guidance for Determination of Appropriate Regulatory Action Based on Seismic Probabilistic Risk Assessment Submittals in Response to Near Term Task Force Recommendation 2.1: Seismic" (ADAMS Accession No. ML17146A200; hereafter SPRA Screening Guidance), which establishes a process the NRC staff uses to develop a recommendation on whether the plant should move forward as a Group 1, 2, 3 plant.[1]

The SPRA Screening Guidance is based on NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," (ADAMS Accession No. ML042820192), NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook," (ADAMS Accession No. ML050190193), and NUREG-1409, "Backfitting Guidelines," (ADAMS Accession No. ML032230247), as informed by Nuclear Energy Institute (NEI) 05-01, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document" (ADAMS Accession No. ML060530203). To determine the significance of proposed modifications in terms of safety improvement, NUREG/BR-0058 uses screening criteria based on the estimated reduction in core damage frequency, as well as the conditional probability of early containment failure or bypass. Per NUREG/BR-0058, the conditional probability of early containment failure or bypass is a measure of containment performance and the purpose of its inclusion in the screening criteria is to achieve a measure of balance between accident prevention and mitigation. The NUREG/BR-0058 uses a screening criterion of 0.1 or greater for conditional probability of early containment failure or bypass. In the context of the SPRA reviews, the staff guidance uses SCDF and SLERF as the screening criteria where SLERF is directly related to the conditional probability of early containment failure or bypass. Following NUREG/BR-0058, the threshold for the screening criterion in the staff guidance for SLERF is (1.0E-6/rx-yr), or 0.1 times the threshold for the screening criterion for SCDF (1.0E-5/rx-yr).

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[1] The groups are defined as follows: regulatory action not warranted (termed Group 1), regulatory action should be considered (termed Group 2), and more thorough analysis is needed to determine if regulatory action should be considered (termed Group 3).

The NRC staff found that because the SCDF and SLERF for North Anna were above the initial screening values of 1.0E-5/rx-yr and 1.0E-6/rx-yr, respectively, a detailed screening following the SPRA Screening Guidance was performed. The detailed screening shows that North Anna should be considered a Group 1 plant because:

- No potential modifications that would result in substantial reductions in the SCDF and/or the SLERF were warranted based upon importance measures, available information, and engineering judgement. The licensee did, however, self-identify a safety improvement that was captured as a regulatory commitment;

- Additional consideration of containment performance, as described in NUREG/BR-0058, does not identify a modification that would result in a substantial safety improvement; and

- The staff did not identify any potential modifications that would be appropriate to consider necessary for adequate protection or compliance with existing requirements.

As such, additional refined screening, or further evaluation, was not required.

Detailed Screening

The detailed screening uses information provided in the North Anna SPRA report, particularly the importance measures, SCDF, and SLERF, as well as other information described below, to establish threshold and target values that are used to identify areas where potential substantial safety improvements might be identified. The detailed screening process makes several simplifying assumptions, similar to a Phase 1 SAMA analysis (NEI 05-01) used for license renewal applications. The detailed screening process uses risk importance values as defined in NUREG/CR-3385, "Measures of Risk Importance and Their Applications" (ADAMS Accession No. ML071690031). The NUREG/CR-3385 states that the risk reduction worth (RRW) importance value is useful for prioritizing feature improvements that can most reduce the risk. The North Anna SPRA report provides Fussell-Vesely (F-V) importance values, which were converted to RRW values by the NRC staff for this screening evaluation using a standard relationship formulation. Data used to develop the maximum averted cost-risk (MACR) for the SAMA analysis provided in the *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants Regarding North Anna Power Station Units 1 and 2*, NUREG-1437, Supplement 7, dated May 2002 (ADAMS Accession Nos. ML023380542 and ML023380567), was also used to calculate the RRW threshold. For this analysis, the NRC staff determined the RRW threshold from the SCDF-based MACR to be 1.028 for Unit 1 and 1.026 for Unit 2. The RRW threshold corresponds to the minimum monetary value of $100,000 dollars associated with eliminating the failure. The MACR calculation includes estimation of offsite exposures and offsite property damage, which captures the impact of SLERF. Therefore, separate SLERF-based MACR calculations were not performed. The target RRWs based on the mean and 95th percentile SCDF and SLERF were also calculated by the NRC staff and ranged between 1.94 and 1.98 for both units. Since the RRW threshold is more limiting than the target RRWs, the RRW threshold (1.028 for Unit 1 and 1.026 for Unit 2) is used for this evaluation.

Section 5 of the North Anna SPRA report included tables listing and describing the fragility groups or structures, systems, and components (SSCs) that are the most significant seismic failure contributors to SCDF and SLERF. Similar tables were also provided for the most significant contributors due to non-seismic failures or random failure of SSCs and due to failure

of operator actions. The descriptions of the significant contributors included the corresponding F-V importance measures. The NRC staff utilized the F-V values to calculate the RRW and the maximum risk reduction credit for eliminating the failure. The results for both units are provided in Table 1 for the SCDF contributors and Table 2 for the SLERF contributors. These tables provide the following information by column: (1) Fragility Group, Basic Event, or Human Failure Event, (2) Description, (3) Failure Mode, (4) RRW for both units, and (5) maximum SCDF or SLERF reduction (MCR or MLR, respectively) from eliminating the failure for both units. The failures presented in Tables 1 and 2 that are not shaded in gray have MACR estimated to exceed the minimum cost ($100,000) of a plant modification according to the SPRA Screening Guidance, if the corresponding failure were eliminated. Failures shaded in gray are only provided for completeness and their MACR are less than $100,000 but are caused by relay chatter or were found to exceed the RRW threshold after the sensitivity study on FLEX equipment completed by the licensee during the audit. In a supplement to the submittal (ADAMS Accession No. ML19071A114), the licensee provided the results of a sensitivity analysis that substantially decreased credit for FLEX equipment and associated operator actions in the SPRA. The licensee reported that this reduced credit increased the SCDF and SLERF reported in the submittal by approximately 15 percent and 3 percent, respectively. These results do not change the conclusions of this NRC staff evaluation.
A single SPRA model element or contributor exceeded the RRW threshold for SCDF and three contributors exceeded the RRW threshold for SLERF. The common contributor for both SCDF and SLERF was seismically-induced loss of offsite power (SEIS-LOOP), which has an SCDF RRW of 3.236 and an SCDF contribution of 4.4E-5 /rx-yr for Unit 1 (Unit 2 has similar values). According to Section 5 of the North Anna SPRA report, SEIS-LOOP is also a contributor for all top five accident sequences for SCDF, representing approximately 85 percent of the SCDF, and five of the top six accident sequences for SLERF, representing approximately 70 percent of the SLERF. During the audit, the licensee explained that SEIS-LOOP represents seismic-induced loss of offsite power from both the plant switchyard and from outside the plant's boundary and that the fragility value used in the analysis is the same for both. As a result, the NRC staff did not pursue potential improvements to SEIS-LOOP.

The other two individual SLERF contributors that exceed the SLERF threshold are seismically-induced small LOCAs (SEIS-SLOCA) and seismically-induced relay chatter of the inside recirculation spray (RS) pumps (SEIS-RS-P-1AB-RLY). During the audit, the licensee explained that mitigation of SEIS-SLOCA would not be cost-justified because this would require installation of redundant water injection systems with dedicated seismically qualified power supply, or hardening the Containment Building to increase design pressure capability or provide pressure relief. Regarding SEIS-RS-P-1AB-RLY, the licensee explained during the audit that replacing the relay with chatter-resistant solid-state relay would not be cost-justified. As discussed later, the licensee made a regulatory commitment to implement operating procedure changes and enhanced operator training to mitigate the risk contribution from relay chatter events.

The NRC staff considered combinations of basic events in accordance with the SPRA Screening Guidance. However, it is not the intent of the guidance to aggregate several disparate failure events that individually have RRW values close to the threshold. The total SCDF and SLERF associated with the elimination of these failures, as shown in Tables 1 and 2, is about 2.1E-05 per year (Unit 1 SCDF), 2.2E-5 per year (Unit 2 SCDF), 8.5E-06 per year (Unit 1 SLERF) and 8.3E-06 per year (Unit 2 SLERF). A review of these failure events reveals that there are several combinations of two dominant contributors whose elimination can achieve a SCDF reduction of at least 1.0E-05 per year and a SLERF reduction of at least 1.0E-06 per year. Therefore, any modification or set of modifications to achieve a SCDF reduction of at

least 1.0E-05 per year or SLERF reduction of at least 1.0E-06 per year will have to mitigate or prevent multiple failure types (e.g., seismically-induced failures and/or failure of operator actions) and/or failure modes (e.g., seismically-induced structural failures of multiple SSCs and/or seismically-induced functional failures of multiple SSCs). The NRC staff reviewed these multiple failure combinations to identify plant modifications that could achieve the screening risk reduction values for the cost of the aggregate MACR but was unable to identify such plant modifications. However, in its supplement letter (ADAMS Accession No. ML19071A114), the licensee made a regulatory commitment to implement operating procedure changes and enhanced operator training to mitigate the power supply breaker spurious lockout relay chatter events (which includes SEIS_EE-BKR-HJ8-RLY, SEIS-SW-P-1AB-RLY, and SEIS-CH-P-1ABC-RLY) and the spurious start of the outside RS pumps.

As indicated earlier, the risk significant SSCs and their respective importance measures were updated in a sensitivity study on the impact of crediting FLEX equipment (i.e., DGs and RCS injection pumps) and corresponding operator actions. This information was provided in the supplement to the submittal. The NRC staff utilized the updated F-V values from the sensitivity study to calculate the RRW and the maximum risk reduction credit for eliminating the failure. The results for both units are provided in Table 3 for the SCDF contributors and Table 4 for the SLERF contributors that have an RRW greater than about 1.005. These tables provide the following information by column: (1) Fragility Group, Basic Event, or Human Failure Event, (2) Description, (3) Failure Mode, (4) RRW for both units, and (5) maximum SCDF or SLERF reduction (MCR or MLR, respectively) from eliminating the failure for both units. As done for Tables 1 and 2, failures presented in Tables 3 and 4 that are not shaded in gray have MACR values estimated to exceed the minimum cost ($100,000) of a plant modification according to the SPRA Screening Guidance, if the corresponding failure were eliminated. Failures shaded in gray are only provided for completeness and their MACR values are less than $100,000 but are caused by relay chatter or were found to exceed the RRW value during the FLEX sensitivity analysis.

NRC staff evaluated the results of the sensitivity study and determined that they do not change the conclusions of the NRC staff evaluation, because although the F-V importance values of certain seismic failure events went up and the importance values of others went down, the set of risk significant seismic failure events were about the same and had about the same MACR. There were, however, a few additional failures in the FLEX sensitivity study model whose risk importance exceeded the RRW threshold value.

For the FLEX sensitivity study model, the risk importance value for SEIS-EE-BKR-HJ2-RLY, which concerns EDG output breakers relays, exceeds the RRW threshold value. However, its SCDF MCR is only about 2.3E-06 per year and therefore its elimination would need to be grouped with the elimination of other relay failures to have a significant impact on seismic risk. The licensee has already evaluated groups of seismic relay failures and the consideration of this additional failure would not change the results of that evaluation. The risk importance value for HEP-C-FLEX-RIP exceeds the RRW threshold value for the FLEX sensitivity study model, but its SCDF MCR is only about 1E-06 per year. Moreover, the FLEX sensitivity study already increases all FLEX related operator failures. The risk importance value for HEP-C-ALIG N-TDAFW, which concerns aligning the turbine driven AFW pump, exceeds the RRW threshold value for Unit 2, but its SCDF MCR is only about 1.7E-06 per year. Moreover, there are not enough other risk significant operator failures to group the elimination of this failure with to reduce SCDF reduction by 1.0E-05 per year or SLERF by 1.0E-06 per year. The risk importance value for SEIS-BLDG-RC, which concerns the Reactor Containment Building, exceeds the RRW threshold value, but the MACR for this failure is clearly far exceeded by the

cost of strengthening containment. The risk importance value for SEIS-BY-B-1-24, which concerns structural failure of the station batteries, exceeds the RRW threshold value but the MACR is insufficient to cover the hardware fixes associated with safety related functions. Accordingly, consideration of the FLEX sensitivity study results did not change the NRC conclusions about the SPRA submittal.

After considering the information described above, and the analysis performed with the RRW, MACR, and MCR/MLR values, the NRC staff concludes that no modifications are warranted in accordance with Title 10 of the Code of Federal Regulations (10 CFR) Section 50.109, "Backfitting," to reduce SCDF and SLERF because no other potential substantial safety improvement was identified. The staff acknowledges the reduction in seismic risk associated with the actions identified by the licensee as a regulatory commitment in its supplement letter.

In accordance with Section 3.3.2 of NUREG/BR-0058, Revision 4, the NRC staff further evaluated North Anna accident sequences impacting the conditional probability of early containment failure or bypass (CPCFB) for seismic events to determine if any substantial safety improvements would reduce the seismic CDF and related seismic LERF of those sequences. All the dominant LERF sequences include one or more of the failures identified above as having RRW values close to the threshold. All these failures were already evaluated, as described above and neither the licensee nor the NRC staff were able to identify other substantial safety improvements that would be cost-justified.

Based on the available information and engineering judgement, the NRC staff concludes that there were no further potential improvements to containment performance that would rise to the level of a substantial safety improvement or would warrant further regulatory analysis.

Additionally, the NRC staff reviewed the results of the IPEEE and SAMA analyses previously completed for North Anna to identify additional substantial safety improvements that would be cost-justified. No other potential improvements were found based on this review.

Conclusion

Based on the analysis of the submittal and supplemental information, the NRC staff concludes that no modifications are warranted under 10 CFR Section 50.109 because:

- The staff did not identify a potential modification necessary for adequate protection or compliance with existing requirements;
- no potential cost-justified substantial safety improvements were identified based on the estimated achievable reduction in SCDF and SLERF; and
- additional consideration of containment performance, as described in NUREG/BR-0058 and assessed via SLERF, did not identify a modification that would result in a substantial safety improvement.

Table 1. Importance Analysis Results of Top Contributors to Unit 1 and 2 SCDF

Fragility Group / Basic Event / Human Failure Event	Description	Failure Mode	Unit 1		Unit 2	
			RRW	MCR (/rx-yr)	RRW	MCR (/rx-yr)
SSC Fragility Groups – Seismically Failed						
SEIS-LOOP	Seismic-induced Loss of Offsite Power	Generic	3.236	4.37E-05	3.226	4.36E-05
SEIS-SSLOCA	Seismic-induced Small-Small LOCA	Generic	1.105	6.01E-06	1.114	6.45E-06
SEIS-EE-BKR-HJ8-RLY	4KV to 480V Bus breaker – Relay chatter	Functional	1.073	4.27E-06	1.074	4.36E-06
SEIS-SW-P-IAB-RLY	Service Water pumps - Relay chatter	Functional	1.040	2.43E-06	1.041	2.50E-06
SEIS-CH-P-IABC-RLY	Charging pumps – Relay chatter	Functional	1.038	2.29E-06	1.039	2.37E-06
SEIS-SLOCA	Seismic-induced Small LOCA	Generic	1.034	2.10E-06	1.035	2.13E-06
SEIS-VB-INV-1234	120 VAC VITAL Bus inverters	Functional	1.034	2.06E-06	1.033	2.04E-06
SEIS-SI-P-IAB-RLY	Low Head pump - Relay chatter	Functional	1.029	1.79E-06	1.029	1.79E-06
SEIS-FW-P-3AB-RLY	Motor-driven AFW pumps - Relay chatter	Functional	1.027	1.67E-06	1.027	1.67E-06
SEIS-EE-BKR-HJ2-RLY	EDG output breakers – Relay chatter	Functional	1.019	1.20E-06	1.020	1.23E-06
SEIS-EDG-HJ-RLY	Emergency Diesel Generators – Relay chatter	Functional	1.011	6.89E-07	1.011	6.89E-07
Significant Operator Errors						
HEP-C-OSW-CHP-ALT	Restore Cooling to the Charging Pumps from Fire Protection or Primary Grade Water systems	—	1.071	4.18E-06	1.074	4.36E-06
HEP-C-ALIG N-TDAFW	Align turbine-driven AFW Pump to the Band C SGs	—	1.027	1.64E-06	1.027	1.68E-06
HEP-C-FLEX-RIP	Install and Start FLEX RCS Injection Pump	—	1.015	9.54E-07	1.016	9.80E-07

Table 2. Importance Analysis Results of Top Contributors to Unit 1 and 2 SLERF

Fragility Group/Event	Description	Failure Mode	Unit 1		Unit 2	
			RRW	MLR (/rx-yr)	RRW	MLR (/rx-yr)
SSC Fragility Groups – Seismically Failed						
SEIS-LOOP	Seismic-induced Loss of Offsite Power	Generic	2.004	9.67E-06	2.020	9.75E-06
SEIS-SLOCA	Seismic-induced Small LOCA	Generic	1.100	1.75E-06	1.101	1.77E-06
SEIS-RS-P-1AB-RLY	Inside RS Pump – Relay chatter	Functional	1.058	1.05E-06	1.055	1.01E-06
SEIS-BLDG-RC	Reactor Containment Building	Structural	1.046	8.49E-07	1.045	8.32E-07
SEIS-RS-P-2AB-RLYSS	Outside RS Pumps Spuriously Start due to Relay Chatter	Functional	1.030	5.67E-07	1.029	5.42E-07
SEIS-FW-P-3AB-RLY	Motor-driven AFW pumps – Relay chatter	Functional	1.025	4.69E-07	1.018	3.47E-07
SEIS-EE-BKR-HJ8-RLY	4KV TO 480V Bus breakers – Relay chatter	Functional	1.022	4.21E-07	1.022	4.25E-07
SEIS-EE-BKR-HJ2-RLY	EDG Output breakers – Relay chatter	Functional	1.011	2.03E-07	1.010	1.97E-07
SEIS-CH-P-1ABC-RLY	Charging Pumps – Relay chatter	Functional	1.008	1.44E-07	1.007	1.41E-07
SEIS-EDG-HJ-RLY	EDGs – Relay chatter	Functional	1.007	1.37E-07	1.007	1.38E-07
SEIS-SW-P-IAB-RLY	Service water pumps – Relay chatter	Functional	1.006	1.20E-07	1.006	1.15E-07
SEIS-RS-P-2AB-RLYLO	Outside RS pumps fail to start due to Lockout Relay	Functional	1.005	9.82E-08	1.005	8.96E-08
Significant Operator Errors						
HEP-C-RCSDEP	Depressurize the RCS Per SAMGs		1.028	5.23E-07	1.026	4.94E-07

Table 3. FLEX Sensitivity Study Importance Analysis Results of Top Contributors to Unit 1 and 2 SCDF

Fragility Group / Basic Event / Human Failure Event	Description	Failure Mode	Unit 1		Unit 2	
			RRW	MCR (/rx-yr)	RRW	MCR (/rx-yr)
SSC Fragility Groups – Seismically Failed						
SEIS-LOOP	Seismic-induced Loss of Offsite Power	Generic	3.717	4.62E-05	3.704	4.61E-05
SEIS-SSLOCA	Seismic-induced Small-Small LOCA	Generic	1.064	3.79E-06	1.069	4.07E-06
SEIS-EE-BKR-HJ8-RLY	4KV to 480V Bus breaker – Relay chatter	Functional	1.153	8.41E-06	1.159	8.66E-06
SEIS-SW-P-IAB-RLY	Service Water pumps - Relay chatter	Functional	1.026	1.61E-06	1.027	1.67E-06
SEIS-CH-P-IABC-RLY	Charging pumps – Relay chatter	Functional	1.024	1.50E-06	1.039	2.37E-06
SEIS-SLOCA	Seismic-induced Small LOCA	Generic	1.021	1.27E-06	1.025	1.56E-06
SEIS-VB-INV-1234	120 VAC VITAL Bus inverters	Functional	1.018	1.12E-06	1.018	1.12E-06
SEIS-SI-P-IAB-RLY	Low Head pump - Relay chatter	Functional	1.018	1.14E-06	1.019	1.16E-06
SEIS-FW-P-3AB-RLY	Motor-driven AFW pumps - Relay chatter	Functional	1.017	1.05E-06	1.017	1.07E-06
SEIS-EE-BKR-HJ2-RLY	EDG output breakers - Relay	Functional	1.038	2.31E-06	1.039	2.38E-06
SEIS-EDG-HJ-RLY	Emergency Diesel Generators – Relay Chatter	Functional	1.009	5.52E-07	1.009	5.59E-07
Significant Operator Errors						
HEP-C-OSW-CHP-ALT	Restore Cooling to the Charging Pumps from Fire Protection or Primary Grade Water systems	—	1.042	4.18E-06	1.074	4.36E-06
HEP-C-ALIG N-TDAFW	Align turbine-driven AFW Pump to the Band C SGs	—	1.017	1.64E-06	1.027	1.68E-06
HEP-C-FLEX-RIP	Install and Start FLEX RCS Injection Pump	—	1.055	9.54E-07	1.016	9.80E-07

Table 4. FLEX Sensitivity Study Importance Analysis Results of Top Contributors to Unit 1 and 2 SLERF

Fragility Group/Event	Description	Failure Mode	Unit 1		Unit 2	
			RRW	MLR (/rx-yr)	RRW	MLR (/rx-yr)
SSC Fragility Groups – Seismically Failed						
SEIS-LOOP	Seismic-induced Loss of Offsite Power	Generic	2.088	1.01E-05	2.119	1.02E-05
SEIS-SLOCA	Seismic-induced Small LOCA	Generic	1.094	1.66E-06	1.094	1.66E-06
SEIS-RS-P-1AB-RLY	Inside RS Pump – Relay chatter	Functional	1.054	9.90E-07	1.051	9.38E-07
SEIS-BLDG-RC	Reactor Containment Building	Structural	1.043	7.95E-07	1.041	7.68E-07
SEIS-RS-P-2AB-RLYSS	Outside RS Pumps Spuriously Start due to Relay Chatter	Functional	1.028	5.33E-07	1.027	5.04E-07
SEIS-FW-P-3AB-RLY	Motor-driven AFW pumps – Relay chatter	Functional	1.024	4.54E-07	1.017	3.28E-07
SEIS-FW-P-2	Turbine-driven AFW pump	Functional	1.022	4.17E-07	1.023	4.28E-07
SEIS-EE-BKR-HJ8-RLY	4KV TO 480V Bus breakers – Relay chatter	Functional	1.033	6.08E-07	1.034	6.27E-07
SEIS-MS-TV-111AB SEIS-MS-TV-211AB	Main Steam trip valves to turbine-driven AFW pump	Functional	1.014	2.59E-07	1.003	5.73E-08
SEIS-SSLOCA	Seismic-induced Small-Small LOCA	Generic	1.013	2.53E-07	1.014	2.66E-07
SEIS-EE-BKR-HJ2-RLY	EDG Output breakers – Relay chatter	Functional	1.017	3.22E-07	1.017	3.17E-07
SEIS-CH-P-1ABC-RLY	Charging Pumps – Relay chatter	Functional	1.007	1.39E-07	1.007	1.33E-07
SEIS-CV-TV-150ABCD	Containment Vacuum Isolation Trip Valves	Functional	1.007	1.28E-07	1.006	1.24E-07
SEIS-EDG-HJ-RLY	EDGs – Relay chatter	Functional	1.008	1.55E-07	1.008	1.45E-07
SEIS-BY-B-1-24	Station Batteries 1-11 AND 1-IV	Structural Failure of Rack	1.063	1.15E-06	1.008	1.51E-07
SEIS-SW-P-IAB-RLY	Service water pumps – Relay chatter	Functional	1.006	1.22E-07	1.006	1.16E-07
SEIS-RS-P-2AB-RLYLO	Outside RS pumps fail to start due to Lockout Relay	Functional	1.005	9.61E-08	1.004	8.47E-08
Significant Operator Errors						
HEP-C-RCSDEP	Depressurize the RCS Per SAMGs	—	1.024	5.23E-07	1.026	4.50E-07

AUDIT SUMMARY BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO NORTH ANNA POWER STATION, UNITS 1 AND 2 SUBMITTAL OF SEISMIC PROBABILISTIC RISK ASSESSMENT ASSOCIATED WITH REEVALUATED SEISMIC HAZARD IMPLEMENTATION OF THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC (EPID L-2018-JLD-0003)

BACKGROUND AND AUDIT BASIS

By letter dated March 12, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12053A340), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (hereafter referred to as the 50.54(f) letter). Enclosure 1 to the 50.54(f) letter requested that licensees reevaluate the seismic hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits and combined licenses.

By letter dated October 27, 2015 (ADAMS Accession No. ML15194A015), the NRC staff determined that licensees were to perform: (1) an SPRA [seismic probabilistic risk assessment], (2) limited scope evaluations, or (3) no further actions based on a comparison of the reevaluated seismic hazard and the site's design-basis earthquake. (Note: Some plant-specific changes regarding whether a SPRA was needed or limited scope evaluations were needed at certain sites have occurred since the issuance of the October 27, 2015, letter.)

By letter dated July 6, 2017 (ADAMS Accession No. ML17177A446), the NRC issued a generic audit plan and entered into the audit process described in Office Instruction LIC-111, "Regulatory Audits", dated December 29, 2008 (ADAMS Accession No. ML082900195), to assist in the timely and efficient closure of activities associated with the 50.54(f) letter. The North Anna Power Station, Units 1 and 2 (North Anna) was included in the list of applicable licensees. On March 28, 2018, the Virginia Electric and Power Company (Dominion, the licensee), submitted NAPS's SPRA for NRC staff review (ADAMS Accession No. ML18093A445). The NAPS's SPRA submittal was later supplemented with a letter dated March 7, 2019 (ADAMS Accession No. ML19071A114).

REGULATORY AUDIT SCOPE AND METHODOLOGY

The areas of focus for the regulatory audit are the information contained in the SPRA submittal and all associated and relevant supporting documentation used in the development of the SPRA submittal including, but not limited to, methodology, process information, calculations, computer models, etc.

AUDIT ACTIVITIES

The North Anna audit took place at the NRC Headquarters in Rockville, MD. Licensee personnel participated remotely, via telephone, from their respective offices. The following table provides a list of audit participants:

NRC and Contract Support Personnel		Licensee Personnel	
Name	**Title**	**Name**	**Title**
Milton Valentín	Project Manager	Diane Aitken	Consulting Engineer Nuclear Regulatory Affairs
Shilp Vasavada	Risk Analyst	Marc Hotchkiss	SPRA Lead Project Engineer
Courtney St. Peters	Risk Analyst	Catherine Tiernan	Generation Project Manager
David Heeszel	Geophysicist	Thomas John	PRA Consulting Engineer
Kaihwa Hsu	Mechanical Engineer	William Webster	Nuclear Risk Informed Operations Strategic Advisor
Mehdi Reisi Fard	Risk Analyst	Thomas Jaeger	Supervisor Nuclear Engineering - PRA
Garill Cole Steve Short	Risk Analysts (Pacific Northwest National Laboratory)	Joe Vasquez	Nuclear Engineering - Engineering Mechanics Consulting Engineer
Biswajit Dasgupta Daniel Pomerening	Fragility Engineers (Southwest Research Institute)	Brian Derreberry	Supervisor Nuclear Engineering - Engineering Mechanics
		Craig Sly	Manager Nuclear Regulatory Affairs

The NRC staff and the licensee participated in two clarification calls that took place on October the 3, 2018, and November the 29, 2018. In preparation for the calls, the staff developed questions to verify information in the licensee's submittal and to gain understanding of non-docketed information that supports the docketed SPRA report. The staff's clarification questions (ADAMS Accession Nos. ML18257A233, ML18282A150, ML18337A131, and ML19046A063, respectively) were sent to the licensee in advance of the call to facilitate clear communication and to ensure that the appropriate licensee personnel was available to answer questions in various technical areas.

During the calls, the licensee provided clarifying information in the following areas:

- component and structural fragilities
- resolution of peer review findings
- plant response for various scenarios modeled in the SPRA
- combination of risk contributors
- sensitivity studies on FLEX equipment and associated human error probabilities
- determination for including operator actions and associated training in plant procedures to reduce the risk contribution from relay chatter to the SCDF and SLERF
- effect of internal event PRA findings
- closure of peer review findings

The licensee's response to the questions aided in the staff's understanding of the SPRA docketed submittal. After the call, the licensee added supporting documents to an electronic reading room. Following the clarification call and review of the supporting documents and information, the NRC staff had no further questions. As explained in Enclosure 2, the licensee supplemented the SPRA report with its letter dated March 7, 2019, including a self-identified regulatory commitment to implement actions to mitigate the risk contribution from relay chatter. The supplement letter provided information to support the NRC staff recommendation associated with Phase 2 of the 50.54(f) letter.

DOCUMENTS AUDITED

The staff audited portions of the following supporting documents:

- Bechtel Earthquake Engineering Center Document 25784-000-G97-GEG-00001-000, "SB and SWPH – Validation of the Extended Subtraction Method," November 15, 2017
- Dominion Calculation CE-2051, Revision 0, "Structural Fragility Analysis of Auxiliary Feedwater Pump House Building," (MC-AA-CLC-301, Attachment 7), February 15, 2018.
- Excerpt from Dominion NOTEBK-PRA-NAPS-SA.1, Revision 2, Probabilistic Risk Assessment Model Notebook, Category SA - Seismic Analysis, Volume SA.1 - Seismic PRA Quantification Results, Attachment 6 - Sensitivity Studies.
- Dominion Position Paper 16, Revision 0, "Assessment of Seismically-Induced Turbine Building Structural Damage," dated March 2018.
- Excerpt from Dominion NOTEBK-PRA-NAPS-HR.12, Revision 1, Probabilistic Risk Assessment Model Notebook, Category HR - Human Reliability, Section 3.6 - HEP Dependency Analysis.
- Excerpt from Dominion NOTEBK-PRA-NAPS-SA.4, Revision 2, Probabilistic Risk Assessment Model Notebook, Category SA - Seismic Analysis, Volume SA.4 - Seismic Equipment List, Section 4.0 - Fire and Flood Evaluation.
- Excerpt from Dominion NOTEBK-PRA-NAPS-SA.4, Revision 2, Probabilistic Risk Assessment Model Notebook, Category SA - Seismic Analysis, Volume SA.4 - Seismic Equipment List, Section 2.2.11 - Traveling Screens.
- Westinghouse Report PWROG-17028-P, Revision 0, "Peer Review of the North Anna Units 1 & 2 Seismic Probabilistic Risk Assessment," dated December 2017.
- Westinghouse Letter LTR-RAM-II-14-001, Revision 0, "North Anna Nuclear Plant RG 1.200 Internal Events and Internal Flooding PRA Peer Review Report," dated April 7, 2014 (Westinghouse Proprietary Class 2).
- Westinghouse Letter LTR-RAM-18-112, Revision 0, to Mr. Thomas Jeager (Dominion), "Release of Probabilistic Risk Assessment (PRA) Peer Review Reports to Third Parties (North Anna Units 1 & 2)," dated August 16, 2018.
- Dominion NOTEBK-PRA-NAPS-SA.7, Revision 1, Probabilistic Risk Assessment Model Notebook, Category SA - Seismic Analysis, Volume SA.7 - Seismic PRA Supporting Documentation.
- Dominion NOTEBK-PRA-NAPS-SA.7, Revision 2, Probabilistic Risk Assessment Model Notebook, Category SA - Seismic Analysis, Attachment 5 – Internal Events PRA Peer Review.xlsx.

OPEN ITEMS AND REQUEST FOR INFORMATION

During the audit period, the NRC staff generated audit questions for the licensee to address. All staff questions were responded to during the audit period. No open items or requests for information were generated during the audit.

DEVIATIONS FROM AUDIT PLAN

There were no deviations from the July 6, 2017, generic audit plan.

AUDIT CONCLUSION AND EXIT MEETING

The issuance of this document, containing the staff's review of the SPRA submittal, concludes the audit process for the North Anna SPRA associated to the 50.54(f) letter.

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2 – STAFF REVIEW OF SEISMIC PROBABILISTIC RISK ASSESSMENT ASSOCIATED WITH REEVALUATED SEISMIC HAZARD IMPLEMENTATION OF THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC (EPID NO. L-2018-JLD-0003) DATE: APRIL 25, 2019

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ADAMS Accession No.: ML19052A522 ***via email**

OFFICE	NRR/DLP/PBMB/PM	NRR/DLP/PBMB/LA*	OGC (NLO)*	NRR/DLP/PBMB/BC (A)
NAME	MValentin	SLent	BHarris	BTitus
DATE	2/22/19	2/25/19	3/18/19	3/8/19
OFFICE	NRR/DORL/D	NRR/DRA/D	NRR/DLP/D	
NAME	CErlanger	MFranovich	LLund	
DATE	4/8/19	3/25/19	4/25/2019	

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