UNITED STATES
NUCLEAR REGULATORY COMMISSION
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September 6, 2019

Mr. Daniel G. Stoddard
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SUBJECT: VIRGIL C. SUMMER NUCLEAR STATION, UNIT 1 – 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-0013)

Dear Mr. Stoddard:

The purpose of this letter is to document the staff's evaluation of the Virgil C. Summer Nuclear Station, Unit 1 (V.C. Summer), 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 no further response or regulatory actions associated with NTTF Recommendation 2.1 "Seismic" are required for V.C. Summer.

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* (10CFR) Section 50.54(f) (hereafter referred to as the 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 50.54(f) letter requested that licensees reevaluate seismic hazards at their sites using present-day methodologies and guidance. Enclosure 1, Item (8), of the 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 September 28, 2018 (ADAMS Accession No. ML18271A109), South Carolina Electric & Gas (SCE&G, the licensee), a wholly owned subsidiary of SCANA Company (SCANA), acting for itself as an agent for South Carolina Public Service Authority (Santee Cooper) provided an SPRA submittal in response to Enclosure 1, Item (8) of the 50.54(f) letter, for V.C. Summer. The NRC staff assessed the licensee's implementation of the Electric Power Research Institute'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 the V.C. Summer SPRA submittal meets the intent of the SPID guidance and that the results and risk insights provided by the SPRA support the NRC's determination that no

further response or regulatory actions associated with NTTF Recommendation 2.1 "Seismic" are required.

BACKGROUND

The 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 50.54(f) letters to all operating power reactor 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 important to safety) to provide additional protection against the updated hazards.

By letter dated March 26, 2014 (ADAMS Accession No. ML14092A250), the licensee submitted the reevaluated seismic hazard information for V.C. Summer. The NRC performed a staff assessment of the submittal and issued a response letter on July 20, 2015 (ADAMS Accession No. ML15194A055). The NRC's assessment concluded that the licensee conducted the hazard reevaluation using present-day regulatory guidance and methodologies, 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, among other factors, a comparison of the reevaluated seismic hazard and the site's design-basis earthquake. As documented in that letter, V.C. Summer was expected to complete a limited-scope evaluation for the spent fuel pool and an SPRA, which would also assess high frequency ground motion effects. The limited-scope evaluation for the spent fuel pool was submitted by letter dated March 30, 2017 (ADAMS Accession No. ML17089A578). The staff provided its assessment of this evaluation of the limited-scope evaluation in a letter dated May 10, 2017 (ADAMS Accession No. ML17128A355). The V.C. Summer SPRA submittal was submitted to the NRC in a letter dated September 28, 2018 (ADAMS Accession No. ML18271A109).

The completion of the July 20, 2015, NRC staff assessment for the reevaluated seismic hazard and the scheduling of V.C. Summer SPRA submittal described in the NRC's October 27, 2015, letter marked the fulfillment of the Phase 1 process for V.C. Summer.

In its September 28, 2018, letter, the licensee provided the SPRA submittal that initiated the NRC's Phase 2 decisionmaking process for V.C. Summer.

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 the recommendation for the screening decisions for consideration by 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 results 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 performed to provide the basis for the staff's grouping recommendation to the SMRP for V.C. Summer is described below. Based on its evaluation, the staff recommended to the SMRP that V.C. Summer be classified as a Group 1 plant and therefore, no further regulatory action was warranted.

EVALUATION

Upon receipt of the licensee's September 28, 2018, SPRA submittal, a technical team of staff 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 analysis. On November 5, 2018, the technical team determined that sufficient information was available to perform the detailed technical review in support of the Phase 2 decisionmaking.

As described in the 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 50.54(f) letter. As stated in its September 28, 2018, submittal, the licensee developed and documented the SPRA in accordance with the SPID guidance, including performing a peer review against Part 5 of the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS), "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications." The peer review of the hazard technical element was against Part 5 of Addendum A of the PRA Standard (RA-Sa-2009) whereas the review of the fragility and plant response technical elements was against Part 5 of Addendum B of the PRA Standard (RA-Sb-2013). The NRC staff determined that the differences between the supporting requirements in the Addenda A and B of Part 5 for the hazard technical element

were not significant to impact the review and decision for this SPRA submittal. Appendix A of the licensee's submittal provided a summary of the full-scope peer review, including excerpts from the corresponding peer review report. Appendix A included the open SPRA finding level facts and observations (F&Os) along with licensee's dispositions which were reviewed by NRC staff in the context of the regulatory decisionmaking associated with the 50.54(f) 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 list of applicable licensees in Enclosure 1 of the July 6, 2017, letter included SCE&G as the licensee for V.C. Summer. The staff exercised the audit by reviewing licensee documents via an electronic reading room (ePortal) as documented in Enclosure 3 to this letter.

The staff developed questions to verify information in the licensee's submittal and to gain an understanding of non-docketed information that supports the docketed SPRA submittal. The staff's clarification questions (ADAMS Accession Nos. ML19105B165, ML19009A536, ML19095A658, ML19095A659, ML19095A665, and ML19095A667, respectively), were sent to the licensee to support the audit. The licensee subsequently provided answers to the questions in the ePortal, which the staff reviewed.

The staff determined that the answers to the questions provided in the ePortal served to verify statements that the licensee made in its September 28, 2018, SPRA submittal. The findings from the licensee's internal events PRA, which forms the base for the SPRA, were not provided in the submittal. As part of the audit, the NRC staff requested information on the internal events PRA findings. Based on the information provided by the licensee, the staff identified a set of findings which had the potential to impact the SPRA. The NRC staff requested, via the audit, additional information to verify the appropriateness and impact of the dispositions for this submittal. In response, the licensee provided relevant information, including the results of sensitivity studies. Based on its review, the staff determined that its decision on the SPRA in the context of this submittal would not be impacted by the dispositions of the relevant findings from the internal event PRA.

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 to V.C. Summer's submittal. As documented in the checklist, the staff concluded that the V.C. Summer SPRA met the intent of the SPID. The staff further concluded that the peer review was done in accordance with the ASME/ANS Standard RA-Sb-2013 process.

Based on the staff's review, 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 50.54(f) letter.

Following the staff's conclusion on the technical adequacy of the SPRA, the staff reviewed the risk and safety insights contained in the V.C. Summer SPRA submittal. 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," as part of its review and recommendation to the SMRP. The criteria in the staff's guidance document includes 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 submittal review. The V.C. Summer SPRA submittal demonstrated that the plant SCDF and SLERF were not below the initial screening values in the August 29, 2017, staff memorandum. As a result, the NRC staff utilized the V.C. Summer SPRA submittal and other available information in conjunction with the guidance in the August 29, 2017, memorandum to complete a detailed screening with respect to SCDF and SLERF for V.C. Summer. The detailed screening concluded that V.C. Summer should be considered a Group 1 plant because:

- Potential modifications and the corresponding reductions in SCDF and/or SLERF considered in this evaluation do not constitute substantial safety improvements based upon importance measures, available information, and engineering judgement;

- 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.

A discussion of the detailed screening evaluation completed by the NRC staff is provided in Enclosure 2 to this letter.

Based on its review of the V.C. Summer SPRA submittal, including the detailed screening evaluation, the technical team determined that recommending V.C. Summer be classified as a Group 1 plant was appropriate and additional review and/or analysis to pursue a plant-specific backfit was not warranted.

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 would be providing SPRA submittals. The technical review team provided the results of the V.C. Summer review to the TRB with the Phase 2 recommendation that V.C. Summer be categorized as a Group 1 plant. The TRB members assessed the information presented by the technical team and agreed with the team's recommendation for classification of V.C. Summer as a Group 1 plant.

Subsequently, the technical review team met with the SMRP and presented the results of the review including the recommendation for V.C. Summer to be categorized as a Group 1 plant. The SMRP members asked questions about the review, as well as the risk insights and provided input to the technical team. The SMRP approved the staff's recommendation that V.C. Summer 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 SPRA submittals associated with their reevaluated seismic hazard information. The NRC staff's audit for V.C.

Summer's SPRA response to the 50.54(f) letter included a review of licensee documents through an electronic reading room. An audit summary document is included as Enclosure 3 to this letter.

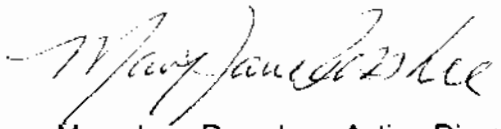
CONCLUSION

Based on the staff's review of the V.C. Summer submittal against the endorsed SPID guidance, the NRC staff concludes that the licensee responded appropriately to Enclosure 1, Item (8) of the 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 50.54(f) letter. Based on the results and risk insights of the SPRA submittal, 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 review 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,



Mary Jane Ross-Lee, Acting Director
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-395

Enclosures:
1. NRC Staff SPRA Submittal Technical Review Checklist
2. NRC Staff SPRA Submittal 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 satisfy NTTF 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/ANS Standard to the relevant guidance in the SPID. For most SRs, the SPID guidance does not differ from the requirement in the ASME/ANS Standard. However, because the guidance of the SPID and the criteria of the ASME/ANS 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/ANS 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/ANS 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/ANS Standard.

(iii) The SPID has some requirements that are not in the ASME/ANS 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's November 12, 2012, letter to NEI (NRC, 2012).

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/ANS 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).

- 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 Safe Shutdown Earthquake (SSE) to Ground Motion Response Spectrum (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, In-Structure Response Spectra (ISRS), and Fragilities
- Topic 8: Screening by Capacity to Select Structures, Systems, and Components (SSCs) for Seismic Fragility Analysis (SPID Section 6.4.3)
- Topic 9: Use of the Conservative Deterministic Failure Margin (CDFM)/HybridMethodology 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 Seismic Large Early Release Frequency (SLERF) (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 Seismic Hazard 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: None. 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 Probabilistic Seismic Hazards Analysis (SHA) requirements in the ASME/ANS 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 guidance in the SPID was followed for developing the probabilistic seismic hazard for the site.	Yes
• An alternate approach was used and is acceptable on a justified basis.	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: None. Deviation(s) or deficiency(ies) and Resolution: None. 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 SRs SHA-E1 and E2 in the ASME/ANS 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 development of PSHA inputs and base rock hazard curves meets the intent of the SPID guidance or another acceptable approach.	Yes
• 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.	Yes
• Although the licensee's development of a shear velocity (V_s) 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 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-GMRS comparison:	
A) If the SSE control point(s) is defined in the final safety analysis report (FSAR), it should be used as defined.	Yes
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.	N/A
C) An alternative method has been used for this site.	N/A
The control point used as input for the SPRA is identical to the control point used to establish the GMRS.	Yes
If yes, the control point can be used in the SPRA and the NRC staff's earlier acceptance governs.	
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: None. 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	Yes

to relate to the requirements in the SPID. No requirements in the ASME/ANS Standard specifically address this topic.	
• Although some peer review findings have not been resolved, the analysis is acceptable on another justified basis.	N/A
• The licensee's 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	No
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:

SPRA submittal Sections 4.3.1 to 4.3.3 and Table 4.3 provided information on structural models:

1. Existing structural model – Existing models were not used for any structures.
2. Enhanced structural models –
    a. SPRA Section 4.3.1, Diesel Generator Building represented as existing lumped-mass-stick model (LMSM) coupled to a 3-D finite element model (FEM) of the pile foundation. Analysis was performed using a fixed-base method.
    b. SPRA Sections 4.3.1 and 4.3.2, Auxiliary Building represented as an enhanced LMSM. Deterministic soil structure interaction (SSI) analysis conducted using the EKSSI computer program. Building response found to be equivalent to fixed base analysis with some reduction in high-frequency response.
    c. SPRA Sections 4.3.1 and 4.3.2, Reactor Building represented as an enhanced LMSM. Deterministic SSI analysis was conducted using the EKSSI code. Building response found to be equivalent to fixed base with some reduction in high-frequency response.
    d. SPRA Section 4.3.2, Service Water Pump House (SWPH) represented as an LMSM with SSI using EKSSI code including 135 feet (ft.) soil depth.
    e. SPRA Section 4.3.2, Condensate Storage Tank represented as a simplified LMSM with SSI using the EKSSI code including a 68 ft. soil depth.
3. New structural models –
    a. SPRA Sections 4.3.1 and 4.3.3, Control Building represented as a detailed 3-D FEM. A fixed-base analysis method was used.
    b. SPRA Sections 4.3.1 and 4.3.3, Intermediate Building represented as a detailed 3-D FEM. A fixed–base analysis method was used.
4. SPRA Section 4.3.1, No response analysis was performed for the Fuel Handling Building. Detailed analysis was not required because the seismic equipment list in the building was limited and judged to be rugged.

5. The SPID Section 6.3.1 Criteria 1-7 has been met:
    - The LMSM and FEM structural models can capture overall structural responses for both vertical and horizontal components of ground motion.

- For all SSI analyses, ground motion in three spatial directions were considered simultaneously (SPRA Section 4.3.2).
- LMSM and FEM structural models include structural mass and rotational inertia.
- The cutoff frequency for SSI was 50 Hertz (Hz) (SPRA Section 4.3.2)
- 3D models consider torsional effects including out-of-plane response and in-plane diaphragm effects.
- "One-Stick" model was not used.
- In-plane floor flexibility was used.

Based on the audit review of supporting documents, inclusion of in-plane floor rigidity in LMSM was adequately addressed.

Based on the audit review of supporting documents associated with SFR-D1 (F&O 24-7), the staff determined that the approach used by the licensee for evaluation of potential for liquefaction would not impact the decision in the context of this submittal.

Deviation(s) or deficiency(ies) and Resolution: None

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 SRs Seismic Fragility Analysis (SFR)-C1 through C6 in the ASME/ANS 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 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: Control Building Structure #2: Diesel Generator Building Structure #3: Intermediate Building	
Structures #1, #2, and #3: If used, is V_S > about 5000 feet /second (ft./sec.)?	Yes
If 3500 ft./sec. < V_S < 5000 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: SPRA submittal Sections 4.3.1 to 4.3.3 and Table 4-1 indicate that fixed-base analysis was used for structures founded on rock where shear wave velocity exceeded 5000 ft./sec. Information is consistent with SPID Section 6.3.3. Fixed base structure analysis was coupled with SSI using the EKSSI code. Deviation(s) or deficiency(ies) and Resolution: None. 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 requirements in the SPID. No requirements in the ASME/ANS Standard specifically address this topic.	Yes
• Although some peer review findings 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. If yes, on which structure(s)? Structure #1: Service Water Pond Dam Structure #2: Nuclear Steam Supply System (NSSS) Components	Yes
Structures #1 and #2 Scaling based on: Previously developed ISRS Shapes of previous Uniform Hazard Spectra or Review Level Earthquake (UHS/RLE) Shapes of new UHS/RLE Structural natural frequencies, mode shapes, participation factors	 Yes Yes Yes Yes
Potential Staff Findings: Structure #1 If a new UHS/RLE is used, the shape is approximately like the spectral shape previously used for ISRS generation. If the shape is not similar, the justification for seismic response scaling is adequate. Consideration of non-linear effects is adequate. Structure #2 If a new UHS/RLE is used, the shape is approximately like the spectral shape previously used for ISRS generation. If the shape is not similar, the justification for seismic response scaling is adequate. Consideration of non-linear effects is adequate.	 Yes N/A N/A N/A Yes N/A

Notes from staff reviewer:

For Structure #1: Shape is similar within the 1 to 10 Hz limit of lower order modes for the Service Water Pond Dam.

For Structure #2: Separation of Variables (SOV) analysis was used for specific components with scaling done based on lower order modes of the NSSS Components. Although the shapes were not similar, independent scaling was done at the natural frequencies of components based on state-of-practice. Failure modes considered included structural integrity and support failures.
There are no peer review findings on SFR-C3.

Deviation(s) or deficiency(ies) and Resolution: None.

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 SFR-C3 in the ASME/ANS 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 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 ASME/ANS Standard. See SRs 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 SSI 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: Auxiliary Building, deterministic SSI using EKSSI Structure #2: Control Building, 3-D FEM fixed base Structure #3: Diesel Generator Building, 3-D FEM for pile foundation, fixed base Structure #4: Intermediate Building, 3D FEM fixed base Structure #5: Reactor Building, deterministic SSI Structure #6: SWPH, deterministic SSI Structure #7: Condensate Storage Tank, deterministic SSI Are all structures appropriately considered?	 Yes Yes Yes Yes Yes Yes Yes Yes
2. Are models adequate to provide realistic structural loads and response spectra for use in the SPRA? • Is the SSI analysis capable of capturing uncertainties and realistic? • Is the probabilistic response analysis capable of providing the full distribution of the responses?	Yes Yes N/A

Notes from staff reviewer:

SPRA submittal Section 4.3.3 and Table 4.3.1 provided information on response analysis. Best Estimate (BE), Lower Bound (LB), and Upper Bound (UB) soil properties were used for SSI analysis.

Based on the audit review of supporting documents, (1) use of bounding seismic demand for the 120 VOLT VITAL10 KVA UPS Cabinet were appropriate with a modest conservatism bias; (2) use of single set of time histories were adequately addressed by comparing SOV/CDFM capacity ratios; and (3) conservative estimates of LB and UB soil properties for SWPH foundation were as appropriate with modest conservatism and the impacted fragilities have minor effect on plant CDF.

Deviation(s) or deficiency(ies) and Resolution: None.

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 SRs SFR-C2, C4, C5, and C6 in the ASME/ANS 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 FIRS modeling is consistent with the prior NRC review of the GMRS and soil velocity information.	Yes
• The licensee's structural model meets the intent of the SPID guidance and the ASME/ANS Standard's requirements.	Yes
• The response analysis accounts for uncertainties in accordance with the SPID guidance and the ASME/ANS Standard's requirements.	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 ASME/ANS 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:	Yes
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.	Yes
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.	Yes
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.	Yes
D) The ASME/ANS Standard has been followed.	N/A
E) An alternative method has been used and its use has been appropriately justified.	N/A
Notes from staff reviewer: None. Deviation(s) or deficiency(ies) and Resolution: None. 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 SFR-B1 in the ASME/ANS 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 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 CDFM/Hybrid method was used for seismic fragility analysis.	Yes
If no, See item C) below and next issue.	
If yes:	
Potential Staff Findings:	
A) The recommendations in Section 6.4.1 of the SPID were followed appropriately for developing the CDFM High Confidence Low Probability of Failure (HCLPF) capacities.	Yes
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: None.	
Deviation(s) or deficiency(ies) and Resolution: None.	
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 requirements in the SPID. No requirements in the ASME/ANS Standard specifically address this Topic.	Yes
• Although some peer review findings 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.	Yes
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.	Yes
The flow chart in Figure 6-7 of the SPID was followed.	Yes
The flow chart was not followed but the analysis is acceptable on another justified basis.	N/A
Notes from staff reviewer: Fragilities of high frequency components are addressed in SPRA Section 4.1.2. Based on the audit review of supporting documents, relays for the emergency diesel generator (EDG) Fuel Transfer Pump were addressed by functional screening based on relay chatter analysis. Deviation(s) or deficiency(ies) and Resolution: None. Consequence(s): None.	
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 SFR-F3 in the ASME/ANS 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 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 ASME/ANS 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: Potential Staff Finding: The approach to analyzing operator actions for maintaining safety after seismic relay chatter is acceptable.	No N/A
Notes from staff reviewer: Supporting documentation provided in response to NRC audit questions indicates that circuit evaluations were completed using the guidance of EPRI NP-7148-SL.	

Deviation(s) or deficiency(ies) and Resolution: None. 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 SRs Seismic Plant Response Analysis (SPR)-B6 (Addendum A) or SPR-B4 (Addendum B) in the ASME/ANS 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 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 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 SOV methodology.	Yes
B) The recommendations in Section 6.4.1 were not followed, but the analysis is acceptable on another justified basis.	N/A

Notes from staff reviewer:

Sections 4.1.1, 4.4.1 and 4.4.2, and Appendix A.4.2 of the SPRA submittal explain that representative or bounding fragility values were initially assigned to all SEL equipment and structures using either CDFM calculations or bounding seismic capacity calculations based on seismic classification, building location, and/or elevation and scaling design basis or other available information. More refined analysis was then performed for the important risk contributors. The more refined approach also consisted of one of two approaches. One of the two refined fragility analysis approaches was a more detailed CDFM analysis with a focus on functionality (versus concerns like anchorage) and high importance systems. For example, relay chatter analyses were performed for important relays and included a failure modes and effects analysis to examine the impact of spurious changes of state on SSC functionality. The other more refined fragility analysis approach was application of the SOV approach. Accordingly, it appears that the intention of the licensee's approach was to achieve more detailed fragility analyses for dominant risk contributors using a more refined CDFM approach or a SOV approach.

Tables 5.4-3 and 5.4-4 in the SPRA submittal summarize the fragility groups with a Fussell-Vesely (F-V) importance value greater that 2% CDF and 2% LERF, respectively. However, NRC staff notes that the F-V importance values presented in the submittal were determined by "*multiplying the median capacity by a factor of five, then recalculating the failure probability at each ground motion interval, imposing those failure*

probabilities onto the cutsets, recalculating the CDF by ACUBE, and finally calculating the percent reduction of total CDF that the improved capacity affords." In a typical F-V value calculation, the failure of interest is assumed to be eliminated. Based on the information provided in response to NRC audit questions, the licensee presented a sensitivity study demonstrating that the impact of using their approach for F-V calculations was insignificant. In the sensitivity study, median capacity was varied by a factor of 1, 2, 3, 4, and 5 for the top 20 fragilities. The results of the study show that further increase in the median capacity has very little impact on CDF or LERF. Increasing seismic capacity to its maximum level is like eliminating the failure of interest. The NRC staff finds the licensee's approach to calculating F-V values acceptable for the decision related to this SPRA submittal because the difference in the F-V values is insignificant and because the licensee's approach for calculating the F-V value better approximates the impact of plant improvements. Based on the audit review of supporting documents, a realistic fragility for surrogate elements for the Intermediate Building was addressed based on additional SOV calculations that showed no significant change in CDF and LERF results. Deviation(s) or deficiency(ies) and Resolution: None. 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 requirements in the SPID. No requirements in the ASME/ANS Standard specifically address this Topic. • Although some peer review findings have not been resolved, the analysis is acceptable on another justified basis. • The licensee's method for selecting the "dominant risk contributors" for further seismic fragilities analysis using the SOV methodology meets the intent of the SPID guidance. • The licensee's method for selecting the "dominant risk contributors" for further seismic fragilities analysis using the SOV methodology does not meet the intent of the SPID guidance but is acceptable on another justified basis.	Yes N/A Yes N/A

TOPIC 13: Evaluation of SLERF (SPID Section 6.5.1)

The NRC staff review of the SPRA's analysis of SLERF finds an acceptable demonstration of its adequacy.	Yes
Potential Staff Findings:	
A) The analysis follows each of the elements of guidance for SLERF analysis in Section 6.5.1 of the SPID, including in Table 6-3.	Yes
B) The SLERF 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:

Table A-5 of the SPRA submittal identifies F&O 19-10 from the SPRA peer review as still open. This finding was prepared because the peer review team was unable to assess the impact of unresolved findings from the internal events PRA peer review on the SPRA. During the NRC audit review of the SPRA submittal, the licensee identified the open findings associated with the internal event LERF model, which is the base for the SPRA LERF model. In response to audit questions, the licensee explained how each of those findings has been dispositioned and further explained that none of the dispositions impact the SPRA used in the submittal. During the audit, the NRC staff's review of the dispositions specifically focused on findings related to the treatment of reactor coolant pump (RCP) seal loss of coolant accidents (LOCAs) leading to LERF scenarios, the process for identifying sequences that lead to large early release, and the use of generic analyses in the development of system success criteria impacting LERF scenarios. The NRC staff concluded that the licensee's dispositions of those findings were sufficient to support the technical adequacy of this SPRA submittal.

Section 5.5 of the submittal presents importance values for LERF-significant SSC seismic fragility failure groups.

Deviation(s) or deficiency(ies) and Resolution: None

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 SRs SFR-F4, SPR-E1, SPR-E2, and SPR-E6 (Addendum B only) in the ASME/ANS 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 SLERF meets the intent of the SPID guidance.	Yes
• The licensee's analysis of SLERF 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 Seismic Qualifications Utility Group 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 submittal. 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 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 three bullets. These three 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.	Yes

If no, go to (F). If yes, the "in-process" peer review approach is acceptable. Go to (G).	
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).	N/A
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 SPRA submittal describe the peer review process used to establish the technical adequacy of the SPRA. The technical adequacy of the internal events PRA that provides the foundation for SPRA is described in an August 29, 2018, request by the licensee to revise its National Fire Protection Association (NFPA) 805 program (ADAMS Accession No. ML18242A658). The August 29, 2018 submittal was used to inform this review.

A peer review of the seismic hazard (SHA) element of the SPRA was conducted in July 2017 against the CC-II supporting requirements of the ASME/ANS RA Sa-2009 along with clarifications from NRC Regulatory Guide 1.200 (Reference NRC, 2009) and against the ASME/ANS RA-Sb-2013 PRA Standard. This effort was part of the AP1000 SPRA review for units at the same site as Unit 1. Both reviews were conducted using the peer review process defined in NEI 12-13. A peer review of the seismic fragility analysis (SFR) element and seismic plant response (SPR) element of the Unit 1 SPRA was performed by the Pressurized Water Reactor Owners Group in April 2018 against the ASME/ANS RA-Sb-2013 PRA Standard using the peer review process defined in NEI 12-13.

In August 2018, an F&O closure review was performed by an Independent Assessment Team (IAT) to close-out finding-level SPRA F&Os in accordance with guidance accepted by the NRC with conditions provided in an NRC letter dated May 3, 2017 (Reference NRC, 2017). The SPRA submittal states that the IAT members met the required qualifications for peer reviewers based on requirements in Appendix X of NEI 12-13 and the ASME/ANS PRA Standard. The IAT determined that all the open finding-level F&Os except for the four F&Os presented in Table A-5 of the SPRA submittal were resolved. Concurrence on the resolution of each finding was based on a consensus process involving all members of the review team. The NRC staff reviewed the four remaining F&Os along with the licensee's dispositions for the SPRA submittal.

Due to the separate peer-reviews for the SHA element, the staff determined the peer-review approach performed by the licensee to be an "in-process" peer-review while recognizing that the peer-review of the SHA element was final and not an interim review.

Based on the information presented in the submittal, the NRC staff concluded that the SPRA findings in each peer-review were based on a consensus process. The IAT that performed the closure review for findings from all SPRA technical elements considered results from the SHA, SFR, and SPR peer-reviews. The IAT also retained a finding as open due to the corresponding technical issue's cross-cutting impact on SHA and SFR technical elements. As a result, for the technical adequacy determination of the SPRA to support the NRC staff's decision on this submittal, the staff assessed that the IAT review met the intent of the performance of a final review by the entire peer review team after the completion of the SPRA. Based on the information presented in the submittal, the staff also concludes that the independence of the peer-reviewers was maintained throughout the SPRA development activity including the IAT review.

The peer review of the hazard technical element was against Part 5 of Addendum A of the PRA Standard (RA-Sa-2009) whereas the review of the fragility and plant response technical elements was against Part 5 of Addendum B of the PRA Standard (RA-Sb-2013). The NRC staff determined that the differences between the supporting requirements in the Addenda A and B of Part 5 for the hazard technical element were not significant to impact the review and decision for this SPRA submittal.

All elements of the SPRA were peer reviewed, including those identified in Section 6.7 of the SPID. Finding-level seismic F&Os generated by the peer review that remain after the F&O closure review are documented in Table A-5 of the SPRA submittal along with dispositions for the submittal. Dispositions for open finding-level internal event F&Os were provided separately by the licensee during the audit review.

The NRC staff position #4 related to NEI 12-13 (ADAMS Accession No. ML18025C024) specifies that the SPRA peer review team is required to review all the relevant internal event F&Os and determine whether the resolutions were appropriate and in accordance with the PRA standard. The SPRA peer review team issued a finding level F&O (19-10) because of the number of open internal events F&Os and their potential impact on the PRA modeling. The peer review team concluded that the broad nature of the findings for the internal events PRA and the lack of actual resolutions resulted in the team not being able to assess the collective impact in relation to the SPRA model. The disposition to the F&O provided in Table A-5 of the submittal states that the IAT did not close this finding.

The NRC staff reviewed the licensee's dispositions for each of the 84 internal-event F&Os provided during the audit of supporting documents associated with the SPRA submittal. Based on the information provided by the licensee, the staff identified a set of findings which had the potential to impact the SPRA and for which additional information was considered necessary to determine the appropriateness of the dispositions for this submittal. As part of the audit, the licensee provided additional information, including sensitivity results, on how each of these findings has been dispositioned and further explained that none of the dispositions impact the SPRA submittal. The NRC staff's review of the dispositions during the audit specifically focused on findings related to high level requirement (HLR) elements on human reliability analysis (HR), success criteria (SC), large early release frequency analysis (LE), and system analysis (SY), each of which have multiple findings. The NRC staff's assessment of the licensee's dispositions of findings on the LE technical element is discussed under Topic 13 of this Checklist.

During the audit, the NRC staff's review of the dispositions of HR-related findings specifically focused on findings related to the dependency analysis performed for the SPRA and the quality of the HR of human failure events (HFEs) that were carried over

into the SPRA. The licensee discussed the results of a sensitivity analysis that showed that the HFEs carried over from the internal events PRA are insignificant contributors to seismic risk. Furthermore, the NRC staff identified no issues with the licensee's dispositions to the HR findings with respect to the NRC staff review of the SPRA submittal.

The NRC staff's audit review of the dispositions to SC-related findings specifically focused on findings related to mission times used in the development of the success criteria, the use of simulator training and generic analyses in assessing plant response, and methods used in performing reasonableness reviews of the success criteria. The licensee discussed the results of a sensitivity analysis that showed that not modeling a full 24-hour mission time for certain sequences is an insignificant contributor to seismic risk. The NRC staff assessed the impact of not modeling a full 24-hour mission time for certain sequences to be small and unlikely to affect the NRC staff's decisions related to this SPRA submittal. The licensee also explained that qualitative credit was given in the PRA for FLEX availability for scenarios that extend beyond 24 hours. The NRC staff assessed that qualitative credit for FLEX is only used for scenarios that extend beyond 24 hours and that the credit is unlikely to affect the NRC staff's decisions related to this SPRA submittal. The NRC staff determined, based on information provided by the licensee and the staff's judgement, that the licensee's dispositions of the SC findings would not impact the NRC staff's decision in the context of this SPRA submittal.

During the audit, the NRC staff's review of the dispositions to SY-related findings specifically focused on findings related to the process used to ensure that PRA revisions reflect the as-built, as-operated plant, the applicability to the SPRA submittal of sensitivity analysis results performed to disposition certain SY-related findings, and justification for crediting the availability of heating, ventilation, and air conditioning (HVAC) and/or operator actions to open doors to prevent failure of SSCs following seismic events. The licensee discussed the PRA model maintenance and update process used to ensure that the V.C. Summer SPRA model reflects the as-built, as-operated plant, which included incorporating the results of several plant walkdowns conducted since 2014 for seismic and other hazards. The licensee discussed the results of sensitivity studies to assess the screening of components and failure modes using outdated screening criteria and showed that incorporating the inappropriately screened components and failure modes in the PRA model had an insignificant impact on CDF and LERF. After its evaluation, the NRC staff concurs with the licensee's assessment. The licensee also discussed the results of a sensitivity study that removed credit for HVAC and operator actions to open a door if HVAC fails following a seismic event and showed that the impact on seismic risk was small (less than 7 percent increase in SCDF and less than 0.5 percent increase in SLERF). Furthermore, the NRC staff determined, based on information provided by the licensee, that the licensee's dispositions of the SY findings would not impact the NRC staff's decision in the context of this SPRA submittal.

During the audit, the licensee also showed the results of an aggregate sensitivity analysis of each of the sensitivity studies discussed above. The aggregate impact was less than 7.5 percent increase in SCDF and less than 0.5 percent increase in SLERF. While the licensee did not show updated risk results for each of the tables provided in the SPRA submittal, the NRC staff concludes that it is unlikely that the aggregate sensitivity analysis would significantly impact the importance analysis results reported in the SPRA submittal and that using the point estimate results for the aggregate sensitivity rather than the mean values will not impact the NRC's conclusions regarding the submittal.

In summary, the NRC staff prioritized the findings from the internal events PRA based on their expected impact on the SPRA. The NRC staff utilized licensee-provided information as well as sensitivities, and its judgement to conclude that the findings with the potential to impact the SPRA were dispositioned to the extent necessary to demonstrate that the NRC staff's decision for this SPRA submittal would not be impacted. The NRC staff's review of the findings from the internal events PRA was only in the context of the review of the 10 CFR 50.54(f) response associated with NTTF Recommendation 2.1 "Seismic". Deviation(s) or deficiency(ies) and Resolution: None Consequence(s): N/A	
The NRC staff concludes that: • 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. 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 Yes
Notes from staff reviewer: None of the licensee sensitivity studies had an impact significant enough to possibly affect the conclusions of the submittal, with a couple of possible exceptions. Refer to Topic 14 for the results of an HRA sensitivity analysis that the licensee discussed during the audit of the SPRA submittal. Several unresolved internal event F&Os are related to documentation issues in which insufficient documentation was provided to support an adequate peer review. The licensee's dispositions to each of these findings was reviewed by the NRC staff during the audit of the SPRA submittal. The NRC staff identified no issues with the licensee's dispositions to these findings with respect to the SPRA submittal. During the audit of the SPRA submittal, the licensee explained that the SPRA credits the installation of Flowserve Abeyance RCP seals, the modeling for which has not been reviewed by the NRC staff for approval or acceptability. The licensee discussed the results of a sensitivity study that removed credit for the Abeyance RCP seals from the SPRA model and which showed that the increase in both SCDF and SLERF is less than 0.1 percent. Based on this, the NRC staff concludes this is a negligible risk impact and that crediting the Abeyance RCP seals in the SPRA will not impact the NRC's conclusions regarding the submittal. As part of its review of the licensee's August 29, 2018 (ADAMS Accession No. ML18242A658), NFPA 805 revisions license amendment request, the staff noted an issue related to the modeling of Flowserve N9000 RCP seals (the model used if the Abeyance RCP seals are not credited) in the licensee's internal events PRA. Specifically, the timing of the operator action to trip the RCPs was different from that approved by the NRC for modeling N9000 seals. The NRC staff evaluated the impact of this issue on the SPRA submittal and the staff's decision with respect to the response to the 50.54(f) letter. The evaluation, discussed in Enclosure 2, concluded that the issue did not impact the NRC staff's conclusions regarding this submittal. Deviation(s) or deficiency(ies) and Resolution: None Consequence(s): N/A	
The NRC staff concludes that: • The licensee's documentation meets the intent of the SPID guidance. The documentation requirements in the	Yes

ASME/ANS Standard can be found in HLR-SHA-J, HLR-SFR-G, and HLR-SPR-F. • 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.	No No No No
Plant will: • complete modifications by: • report completion of modifications by:	N/A N/A
Notes from the Reviewer: See Enclosure 2 for discussion. Deviation(s) or Deficiency(ies), and Resolution: None Consequences: N/A	
The NRC staff concludes that: • The licensee identified plant modifications necessary to achieve the appropriate risk profile. • The licensee provided a schedule to implement the modifications (if any) with appropriate consideration of plant risk and outage scheduling.	No N/A

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, Revision 2 "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment results for Risk Informed Activities," 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

NRC, 2017: Giitter, Joseph, and Ross-Lee, Mary Jane, U.S. Nuclear Regulatory Commission, letter to Krueger, Greg, Nuclear Energy Institute, "U.S. Nuclear Regulatory Commission Acceptance on Nuclear Energy Institute Appendix X to Guidance 05-04, 07-12, and 12-13, Close-Out of Facts and Observations (F&Os)," dated May 3, 2017 (ADAMS Accession No. ML17079A427)

SCE&G, 2018: Letter from George Lippard of South Carolina Electric & Gas Company (SCE&G) to NRC, "Virgil C. Summer Nuclear Station (V.C.SNS) Unit 1 Docket No. 50-395, Operating License No. NPF-12, License Amendment Request – LAR-16-01490 National Fire Protection Association (NFPA) Standard 805 Program Revision," dated August 29, 2018 (ADAMS Accession No. ML18242A658)

NRC Staff SPRA Submittal Detailed Screening Evaluation

Introduction

The Vigil C. Summer Nuclear Station Unit 1 (V.C. Summer) Seismic Probabilistic Risk Assessment (SPRA) submittal (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18271A109) indicates that the mean seismic core damage frequency (SCDF) is 4.8E-05/reactor-year (/rx-yr) and the mean seismic large early release frequency (SLERF) is 5.2E-06/rx-yr. The NRC staff compared these values against the guidance in NRC staff memorandum dated August 29, 2017 (ADAMS Accession No. ML 17146A200), 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" (hereafter referred to as the 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).

Because the SCDF and SLERF for V.C. Summer were above the initial screening values of 1.0E-5/rx-yr and 1.0E-6/rx-yr, respectively, the NRC staff performed a detailed screening following the SPRA Screening Guidance. The detailed screening results show that V.C. Summer should be considered a Group 1 plant because:

- Potential modifications and the corresponding reductions in SCDF and SLERF considered in this evaluation do not constitute cost-justified substantial safety improvements based upon importance measures, available information, and engineering judgement;

[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).

- 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.

The licensee, in performing its seismic analysis 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 action 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 V.C. Summer license, or with the rules and orders of the Commission. For these reasons, the licensee and the staff did not identify a potential modification necessary for adequate protection or compliance with existing regulations.

Detailed Screening

The detailed screening uses information provided in the V.C. Summer SPRA submittal, particularly the importance measures, SCDF, SLERF, and other information described below, to establish threshold and target values that are used to identify areas where potential cost-justified substantial safety improvements might exist. The detailed screening process makes several simplifying assumptions, similar to a Phase 1 SAMA analysis (NEI 05-01, ADAMS Accession No. ML060530203) 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 V.C. Summer 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 severe accident mitigation alternative (SAMA) analysis provided in the *Environmental Report for License Renewal, Virgil C. Summer Nuclear Station - License Renewal Application*, dated August 6, 2002 (ADAMS Accession Nos. ML022280229 and ML022280294), was used to calculate the RRW threshold. For this analysis, the NRC staff determined the RRW threshold from the SCDF-based MACR to be 1.065. 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.

Section 5 of the V.C. Summer SPRA submittal includes tables listing and describing the structures, systems, and components (SSCs) that are the most significant seismic failure contributors to SCDF and SLERF. The descriptions of the significant contributors included the F-V importance value for each. The NRC staff utilized the F-V values to calculate the RRW, the maximum monetary value of eliminating the failure, and the contribution to SCDF or SLERF of each contributor. The results are provided in Table 1 for the SCDF contributors and Table 2 for the SLERF contributors which have an RRW greater than 1.02.

These tables provide the following information by column: (1) Component name, (2) Description of the component, (3) Failure Mode, (4) RRW, and (5) maximum SCDF reduction (MCR) or SLERF reduction (MLR) from eliminating the failure.

A single SPRA model element or contributor exceeded the mean target RRW for SCDF and none for SLERF. This element was seismically-induced loss of offsite power (SF-LSP), which has an SCDF RRW of 2.169 and an SCDF contribution of 2.6E-5 /rx-yr. According to Section 5 of the V.C. Summer SPRA submittal, SF-LSP is also a contributor for all the top 15 accident sequences for SCDF and 7 of the top 15 accident sequences for SLERF. This contributor is dependent on several factors, some of which are outside the plant's boundary. During the audit, the licensee explained that a generic fragility was used for modeling SF-LSP that represents the contribution of seismic-induced failure modes in the switchyard, as well as seismic-induced failures of the offsite grid. Also, the licensee stated that monetary value of installing a seismically-qualified power source in the plant switchyard to provide offsite power or hardening the existing offsite power grid supply would clearly exceed the MACR and therefore, would not be cost-justified. Further, diverse and flexible coping strategies (FLEX) can also support the mitigation of a SF-LSP. Although the licensee did not quantitatively credit any FLEX equipment in its SPRA, the licensee stated in response to NRC audit questions that FLEX equipment expected to be available for such purposes at the licensee's site included a permanently-installed 480V (300 kW) FLEX diesel generator, three portable 480V (80kW) FLEX diesel generators, and two 7.2kV (1 MW) FLEX combustion turbine generators. For the reasons stated above, the NRC staff did not pursue potential improvements to SF-LSP.

During the audit, the licensee explained that the SF-VSLOCA fragility represents minor cracks or leaks in small piping connected to the reactor coolant system piping at many locations throughout the plant and that the fragility used in the SPRA is a single fragility used for all VSLOCA failures. Because the implementation cost to address multiple sources of VSLOCA failures is expected to far exceed the MACR, the NRC staff did not pursue potential improvements to SF-VSLOCA.

The NRC staff considered combinations of basic events in accordance with the SPRA Screening Guidance. It is not the intent of that aspect of the guidance to aggregate several disparate basic events that individually have RRW values close to the threshold. One combination of basic events that could achieve a SCDF reduction of at least 1.0E-05/rx-yr, excluding consideration of SF-LSP and SF-VSLOCA for the reasons previously discussed, are the relay chatter basic events Relay_0.11AC and Relay_0.11BD. During the audit, the licensee explained that elimination of the risk of these relay chatter failures would require replacement of the electro-mechanical type relays with non-chatter sensitive relays, such as solid-state devices or micro-processor-based protection systems. Since these relay replacement options would also require extensive circuit and protection logic changes, the licensee explained that the implementation cost of this plant change is much greater than the MACR and therefore, not cost-justified. However, the licensee also explained that the existing V.C. Summer Emergency Operating Procedure (EOP) for loss of all AC power already includes specific operator actions for EDG recovery, including a procedural step to clear the chatter induced relay contact and allow the EDG to be able to start. These operator actions are not credited in the SPRA; however, the licensee discussed the results of a sensitivity study that showed that crediting this operator action would reduce the risk contribution of these relay chatter events to less than 1.0E-05/rx-yr (point estimate). It should also be noted that the RRW and MCR values for the relay chatter basic events in Table 1 do not include credit for the operator actions to clear the chatter induced relay contact currently proceduralized in the V.C. Summer EOP for loss of all AC power.

Based on the information provided in response to NRC audit questions, another combination of basic events that could achieve a SCDF reduction of at least 1.0E-05/rx-yr are the human failure events SH3-OAEFC and SH4-OAEFC (operator fails to continue emergency feedwater after

battery depletion). During the audit, the licensee explained that these operator actions involve manually throttling flow control valves outside the control room.

The licensee identified that one option to reduce this risk is for operators to shed electrical loads to extend battery life and explained that this operator action is already proceduralized but not modeled in the SPRA. However, only minimal risk reduction could be gained from modeling this action because of the high failure probability of performing the ex-control room action at high seismic accelerations where such actions will be important. The licensee also stated that a plant modification to install a seismically-qualified 24-hour battery (replacing the current 4-hour battery) would require a building expansion to accommodate the additional batteries resulting in an implementation cost much greater than the MACR.

In response to NRC audit questions, the licensee explained that all individual SLERF basic events are screened based on the safety improvement from relevant modifications for each basic event. The NRC staff also considered combinations of potential modifications that could achieve a SLERF reduction of at least 1.0E-06/rx-yr. The NRC staff's assessment of the potential SLERF basic event combinations concluded that there is no apparent synergies or implementation cost efficiencies to be gained from the combinations.

As part of its review of the licensee's August 29, 2018 (ADAMS Accession No. ML18242A658), NFPA 805 revisions license amendment request, the staff noted an issue related to the modeling of Flowserve N9000 RCP seals (the model used if the Abeyance RCP seals are not credited) in the licensee's internal events PRA. Specifically, the timing of the operator action to trip the RCPs was different from that approved by the NRC for modeling N9000 seals. The NRC staff evaluated the impact of this issue on the SPRA submittal and the staff's decision with respect to the response to the 50.54(f) letter. The NRC staff concluded that changing the timing for operator action to trip the RCPs could result in those operator actions as well as RCP seal LOCAs becoming more important in the SPRA as compared to their current importance. This would lead a decrease in the importance of the current dominant risk contributors because the importance measure is a relative metric. The decrease in the importance of the current dominant risk contributors would further support the conclusions on potential modifications discussed above. Potential modifications related to the increased importance of RCP seals would be inclusion of low-leakage RCP seals (such as the Abeyance seals), alternate seal injection system, and operator actions to prevent RCP seal leakage. Each of these potential modifications is already present at V.C. Summer. Therefore, the NRC staff concludes that the issue related to the timing of operator actions relevant to the Flowserve N9000 RCP seal modeling in the licensee's internal events PRA does not change the staff's decisions for this SPRA submittal.

Based on the analysis and information described above, 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 to reduce SCDF and SLERF because a potential cost-justified substantial safety improvement was not identified.

In accordance with Section 3.3.2 of NUREG/BR-0058, Revision 4, the NRC staff further evaluated V.C. Summer 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 SCDF and related SLERF of those sequences. All the

dominant failures are already evaluated, as described above.

Based on the available information and engineering judgement, the NRC staff concluded 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 considered insights from the individual plant examination of external events (IPEEE) and SAMA analyses previously completed for V.C. Summer to understand previous work done to identify substantial safety improvements and to further inform this review. Based on previous evaluations and based on the detailed screening completed as part of this review, no potential improvements were found.

Conclusion

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

- The staff did not identify a potential modification necessary for adequate protection or compliance with existing regulations;
- no cost-justified substantial safety improvement was identified based on the estimated achievable reduction in SCDF and/or 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 enhancement.

Table 1: Importance Analysis Results of Top Contributors to SCDF

Fragility Group/Event	Description	Failure Mode	RRW	MCR (/rx-yr)
SSC Fragility Groups – Seismically Failed				
SF-LSP	Seismic-induced loss of offsite power	Yard-Centered Loss of Offsite Power	2.169	2.58E-05
Relay_11AC	Relay Fragility Group	Chatter	1.230	8.96E-06
SF-VSLOCA	Very Small LOCA Fragility	Structural failure of impulse lines	1.170	6.95E-06
Realy_11.BD	Relay Fragility Group	Chatter	1.117	5.03E-06

Table 2: Importance Analysis Results of Top Contributors to SLERF

Fragility Group/Event	Description	Failure Mode	RRW	MLR (/rx-yr)
SSC Fragility Groups – Seismically Failed				
SF-XVT2662B	RB IA Suction HDR Isolation Valve	Functional	1.159	7.14E-07
SF-XBA1	DC Distribution Bus Battery	Functional	1.089	4.27E-07

AUDIT SUMMARY BY THE OFFICE OF NUCLEAR REACTOR REGULATION RELATED TO VIRGIL C. SUMMER NUCLEAR STATION, UNIT 1 SUBMITTAL 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-0013)

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 pursuant to 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 made a determination of which licensees were to perform: (1) a Seismic Probabilistic Risk Assessment (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. (Note: Some plant-specific changes regarding whether an 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 letter issued pursuant to Title 10 CFR Part 50, Section 50.54(f). The list of applicable licensees in Enclosure 1 to the July 6, 2017, letter included South Carolina Electric & Gas (SCE&G, the licensee), a wholly owned subsidiary of SCANA Company (SCANA), acting for itself as an agent for South Carolina Public Service Authority (Santee Cooper), for Virgil C. Summer Nuclear Station, Unit 1 (V.C. Summer).

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 NRC staff developed questions to verify information in the licensee's submittal and to gain understanding of non-docketed information that supports the docketed SPRA submittal. The

staff's clarification questions (ADAMS Accession Nos. ML19105B165, ML19009A536, ML19095A658, ML19095A659, ML19095A665, and ML19095A667, respectively) were sent to the licensee to support the audit.

The licensee provided clarifying information in the following areas:

- Supporting information associated with structural modeling, scaling, structural response analysis, fragility analysis, capacities of relays sensitive to high frequencies, and selection of significant risk contributors.

- Resolution of internal events probabilistic risk assessment finding level facts and observations (F&Os) and associated peer review reports.

- The independent assessment report completed following the guidance in Nuclear Energy Institute (NEI) Standard 12-13, Appendix X, "Close-out of Facts and Observations," (ADAMS Accession No. ML17086A431).

- Resolution of SPRA finding level F&Os in the August 29, 2018 National Fire Protection Association Standard 805 (NFPA 805) program revision submittal (ADAMS Accession No. ML18242A658).

- Consideration of single failures and combination(s) of failures which if eliminated could result in a reduction in seismic core damage frequency (SCDF) of 1E-05 per year or a reduction in seismic large early release frequency (SLERF) of 1E-06 per year.

- Credit for the Abeyance reactor coolant pump seals in the SPRA submittal results.

- Circuit analysis to support the relay-chatter evaluation.

- Confirmation of whether voltage sensing relays in the Diesel Generator Control Cubicle were replaced with solid-state relays, or not.

The licensee's response to the questions aided in the staff's understanding of the V.C. Summer SPRA docketed submittal. Following the review of the licensee's response and the supporting documents provided by the licensee on the ePortal, the staff determined that no additional documentation or information was needed to supplement V.C. Summer docketed SPRA submittal.

DOCUMENTS AUDITED

- PWROG Letter OG-18-180, Subject: Transmittal of PWROG-18037-P, Revision 0, "Peer Review of the V.C. Summer Unit 1 Seismic Probabilistic Risk Assessment", per PA-RMSC-1476, July 2018.

- Westinghouse Letter LTR-ECOE-OPB-18-022, Revision 0, "AP1000 V.C. Summer 2 & 3 At-Power Seismic PRA 2017 Peer Review Using ASME/ANS PRA Standard Requirements," November 2017.

- PWROG-18050-P, Revision 0, "Independent Assessment of Facts & Observations Closure of the V.C. Summer Unit 1 Seismic Probabilistic Risk Assessment," August

2018.

- PWROG-16051-P, Revision 0, "Peer Review of the V.C. Summer Nuclear Station Internal Events and Internal Flood Probabilistic Risk Assessment," February 2017.
- PWROG-18037-P, Revision 0, "Peer Review of the V.C. Summer Nuclear Station Unit 1 Seismic Probabilistic Risk Assessment," July 2018.
- Stevenson and Associates Calculation 13C4188-CAL-006, Revision 1, "Auxiliary Building Seismic Model," April 2015.
- Stevenson and Associates Calculation 13C4188-CAL-009, Revision 0, "Seismic Response Analysis – Auxiliary Building," August 2014.
- Stevenson and Associates Calculation 13C44188-CAL-018, Revision 1, "Seismic Fragility of Service Water Pond Dam System," July 2015.
- Stevenson and Associates Calculation 13C44188-CAL-024, Revision 1, "HCLPF Seismic Capacity Evaluations for Selected Structures and Equipment," June 2018.
- Stevenson and Associates Calculation 13C44188-CAL-025, Revision 2, "HCLPF Seismic Capacity Evaluations for Selected Reactor Building Equipment," July 2017.
- Stevenson and Associates Calculation 13C44188-CAL-028, Revision 5, "Summary of Relay Screening for VCSNS Unit 1 S-PRA," June 2018.
- Stevenson and Associates Calculation 13C44188-CAL-035, Revision 3, "Summary of Seismic Fragility Parameters," June 2018.
- Stevenson and Associates Calculation 13C44188-CAL-039, Revision 1, "Detailed Fragility Analyses for Selected Equipment," May 2018.
- Stevenson and Associates Calculation 13C44188-CAL-043, Revision 0, "Seismic Capacity of Intermediate Building Fire Service Components," November 2017.
- Stevenson and Associates Calculation 13C44188-CAL-044, Revision 0, "Auxiliary Building Floor Diaphragm Rigidity Study," June 2018.
- Steven and Associates Project Memo 13C4188-MEM-0018, Revision 0, "VC Summer S-PRA Electrical Review of Relay Chatter," dated January 2015.
- GEI Project Report 1411090, Liquefaction Evaluation of Foundation Soils at the Service Water Pumphouse and Related Structures V.C. Summer Nuclear Station Jenkinsville, South Carolina," December 2014.
- Stevenson and Associates Calculation 13C4188-LSC-028, Revision 3, "V.C. Summer Nuclear Station Unit 1 SPRA – Relay Chatter Analysis," October 2015.
- Westinghouse Calculation CN-RAM-14-035, Revision 2, "V.C. Summer Unit 1 Internal Events PRA, Level 2 Notebook," January 2019.

- Westinghouse Calculation CN-RAM-14-036, Revision 0, "V.C. Summer Unit 1 Internal Events Gap Closure Project," November 2016.

- Westinghouse Calculation CN-RAM-17-018, Revision 1, "Virgil C. Summer Nuclear Station Seismic Probabilistic Risk Assessment Modeling Notebook," June 2018.

- Westinghouse Calculation CN-RAM-17-019, Revision 1, "V.C. Summer Nuclear Station Seismic Probabilistic Risk Assessment Quantification Notebook," March 2018.
- Westinghouse Calculation CN-RAM-18-002, Revision 0, "V.C. Summer Unit 1 F&O Resolution – Success Criteria Cross Reference and Justification Review," March 2018.

- Table, "VC Summer Internal Events F&O impact on SPRA," December 2018.

- Westinghouse Letter LTR-RAM-16-12 from Matthew Degonish to Gerald Loignon, "V.C. Summer Nuclear Station Unit 1 PRA Model Results Comparison," May 2016.

- Westinghouse Letter LTR-RAM-19-45 from Rachel Christian to File, "Responses to Selected V.C. Summer Nuclear Station Seismic Probabilistic Risk Assessment NRC Review Comments – Part 1," June 2019.

- Westinghouse Letter LTR-RAM19-65 from Reed Labarge to File, "V.C. Summer Seismic PRA Sensitivity Study: No Credit for Abeyance Seal," May 2019.

OPEN ITEMS AND REQUEST FOR INFORMATION

There were no open items identified by the NRC staff that required proposed closure paths and there were no requests for information discussed or planned to be issued based on the audit.

DEVIATIONS FROM AUDIT PLAN

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

AUDIT CONCLUSION

The issuance of this document, containing the staff's review of the SPRA submittal, concludes the SPRA audit process for V.C. Summer.

SUBJECT: VIRGIL C. SUMMER NUCLEAR STATION, UNIT 1 – 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-0013) DATE: SEPTEMBER 6, 2019

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