

VIRGIL C. SUMMER NUCLEAR STATION SAMA REVIEW AUDIT REPORT AND INFORMATION REQUESTS

Subject

Audit of the Severe Accident Mitigation Alternatives (SAMA) analysis portion of the Virgil C. Summer Nuclear Station Unit 1 (VCSNS) Subsequent License Renewal (SLR) Application Environmental Report (ER)

When

- May 14, 2024, 9:00 AM to 11:30 AM Eastern Time (Entrance Meeting, Virtual Tours, and General Topics)
- May 23, 2024, 12:00 PM to 4:00 PM Eastern Time (SAMA Audit Breakout Session)

SAMA Audit Discussion Participants (*may not be complete*)

Kim Conway	U.S. Nuclear Regulatory Commission (NRC)
Elijah Dickson	NRC
Steve Short	Pacific Northwest National Laboratory (PNNL)
Bill Ivans	PNNL
Karen Loomis	NRC
Caitlin Condon	PNNL
Dan Nally	PNNL
April Rice	Dominion Energy, Inc. (Dominion)
Tony Banks	Dominion
Keith Miller	Dominion
Creighton Adsit	Dominion
Ricky Summitt	Enercon Services, Inc. (ENERCON)
Steven Phillippi	ENERCON
Beth Baucom	ENERCON
Neil Johnson	ENERCON
Lisa Hendrick	ENERCON
Matthew Montz	ENERCON
Rachel Turney	ENERCON

Documents Reviewed on the Applicant's Portal

1. "VCSNS SAMA Basis Report Document," Revision 0, January 19, 2023
2. VCSNS SLR ER Audit Matrix, "SAMA Audit Needs, Document Requests & Responses"

Discussion

On August 17, 2023 (Agencywide Documents Access and Management System (ADAMS) ML23233A175), the NRC received the application for subsequent renewal of the operating license for VCSNS. In support of the application and in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51 and Part 54, Dominion also submitted an ER for VCSNS.

After a welcome and introductions on May 14, 2024, the plan and schedule for the audit were discussed. NRC, PNNL, and Dominion/ENERCON staff involved in the SAMA portion of the audit participated in an entrance meeting held on Tuesday, May 14, 2024, which also included other license renewal-related audit team members (non-SAMA related) and associated Dominion/ENERCON staff.

As stated in the audit plan accompanying the April 18, 2024, letter to Eric S. Carr, President, Nuclear Operations and Chief Nuclear Officer (ML24108A039), the goal of this portion of the audit was to review SAMA and postulated accident supporting information to complete the site-specific environmental impact statement for subsequent license renewal. During the audit, NRC, PNNL, and Dominion/ENERCON staff involved in the SAMA review discussed all the SAMA-related audit needs identified in the audit plan. Specifically discussed were the audit needs addressing the following topics:

1. Potentially new and significant information relevant to the SAMA analysis;
2. Assessment process of potentially new and significant information; and
3. Identification, qualitative pre-screening, and quantitative evaluation of risk reduction of industry and unimplemented Final Plant-Specific SAMAs.

As a result of the audit, NRC/PNNL staff identified requests for confirmation of information (RCIs) and requests for additional information (RAIs) for which further information will be needed on the docket to complete the site-specific environmental impact statement for subsequent license renewal. The following table summarizes the results of the audit by delineating the SAMA-related audit needs in the audit plan into: 1) those for which information is not needed on the docket; 2) those for which supplemental information is needed on the docket as RCIs; and 3) those for which supplemental information is needed on the docket as RAIs. The RCIs and RAIs are provided below.

A closeout meeting for the VCSNS subsequent license renewal environmental audit was held on June 4, 2024.

Audit Need	Information Needed on the Docket
SAMA-1	RCI
SAMA-2	Not Needed
SAMA-3	RAI
SAMA-4	RCI
SAMA-5	RCI
SAMA-6	RAI
SAMA-7	RAI
SAMA-8	RAI
SAMA-9	RAI
SAMA-10	RAI
SAMA-11	Not Needed
SAMA-12	Not Needed

RCIs

1) RCI SAMA-1

Section E4.15.2.2.1 of the VCSNS SLR ER states that “[t]he VCSNS internal events PRA [probabilistic risk assessment] model used to determine the significance of new information in the license renewal analysis has a CDF [core damage frequency] of approximately 2.72E-06/year.” Please confirm that the reported CDF for internal events includes the contribution from internal flooding events.

2) RCI SAMA-4

The Stage 1 assessment within Nuclear Energy Institute (NEI) 17-04, "Model SLR New and Significant Assessment Approach for SAMA, Revision 1," includes consideration of any unimplemented "Final Plant-Specific SAMAs," "whose status was determined through a cost-benefit analysis comparing plant-specific averted cost-risk to projected implementation cost." Section E4.15.3.2.2 of the ER references 18 VCSNS-specific SAMAs that were collected for evaluation in the SLR as part of the Stage 1 assessment. Please confirm that these SAMAs referenced are those from table G-3 of Appendix G to NUREG-1437, Supplement 15, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Regarding Virgil C. Summer Nuclear Station - Final Report," and that they include the 12 initial license renewal SAMAs and 6 alternate SAMAs suggested by the NRC staff, as discussed in Section G.4.0 of NUREG-1437, Supplement 15.

3) RCI SAMA-5

Section 3.2.2 of NEI 17-04 states that "an alternate quantification process is required for any SAMAs that reduce the consequences of accidents without reducing the CDF or release category frequencies." Based on Section E4.15.3 and table E4.15-1 of the ER, the quantitative screening of SAMAs within the Stage 1 assessment for SLR appears to have only considered the impact of SAMA implementation on the CDF and/or the Level 2 release category frequencies. Please confirm that an alternate quantification process, as discussed in Section 3.2.2 of NEI 17-04, was not applied within the applicant's Stage 1 assessment because the impact of SAMA implementation on the CDF and/or the Level 2 release category frequencies was adequate for demonstrating that unimplemented Final Plant-Specific and Applicable Industry SAMAs, as defined by NEI 17-04, would have averted cost-risk values that are less than 50 percent of the maximum benefit (MB).

RAIs

1) RAI SAMA-3

REQUIREMENT: Applicants for SLR are required by 10 CFR 51.53(c)(iv) to consider any new and significant information of which the applicant is aware that relates to its previous SAMA evaluation. As part of its review of the VCSNS SLR SAMA analysis, NRC staff evaluates the applicant's process for qualitative screening of industry and plant-specific SAMA candidates.

ISSUE: The requested information is needed for the NRC staff to reach a conclusion on the adequacy of the screening process and criteria used in the applicant's Stage 1 assessment.

Section E4.15.3.2.1 of the ER indicates that the SAMA evaluations, including consideration of qualitative screening criteria, were performed consistent with NEI 17-04. However, as noted below, the criteria employed as part of the applicant's Stage 1 assessment deviates from NEI 17-04 guidance. NEI 17-04 is endorsed as an acceptable technical approach for plant-specific reviews, and deviations to the approach in NEI 17-04 should have appropriate justification.

REQUEST: Please provide the following information relative to the qualitative screening of industry SAMA candidates and unimplemented Final Plant-Specific SAMAs:

- a. As part of the Stage 1 assessment, described in Section E4.15.3.2.2 of the ER, a total of 330 industry SAMAs and 18 VCSNS-specific SAMAs were collected for evaluation in the SLR, and all but 62 of these SAMAs (57 industry SAMAs and 5 VCSNS-specific SAMAs)

were qualitatively screened. However, during the audit, it was discussed how qualitative screening criteria, which included consideration of both implementation cost and risk impact, were inconsistent with those in NEI 17-04 and applied to both industry and unimplemented Final Plant-Specific SAMAs.

With regard to the pre-screening of industry SAMAs candidates, Section 3.2.1 of NEI 17-04 states that unlike the Phase 1 screening process in NEI 05-01, "Severe Accident Mitigation Alternatives Analysis Guidance Document," "SAMAs are not eliminated due to excessive implementation cost (because an updated MB is not developed for the Stage 1 analysis) and SAMAs with very low benefits are not exempted from an explicit risk reduction assessment". Additionally, under the NEI 17-04 Stage 1 assessment outlined in Section 3.2, unimplemented Final Plant-Specific SAMAs are not exempted from an explicit risk reduction assessment. Lastly, given that the VCSNS screening process and criteria deviate from NEI 17-04, it is not clear how "new information" relevant to the NEI 17-04 Stage 1 assessment is accounted for, in particular and as discussed in Section 3.1 of NEI 17-04, the latest risk models that are available for Internal Events (including internal flooding) and for each of the external events contributors (i.e., fire and seismic events).

Provide justification for the screening process and criteria employed as part of the Stage 1 assessment, demonstrating that any unimplemented Final Plant-Specific and Applicable Industry SAMAs, as defined by NEI 17-04, have averted cost-risk values that are less than 50 percent of the MB. Specifically, this justification should include those SAMAs that were screened using qualitative criteria that deviate from NEI 17-04 and that therefore lack an explicit risk reduction assessment addressing new information relevant to the Stage 1 assessment.

- b. During the audit, it was discussed that in the VCSNS SAMA Basis Document, industry SAMA candidates related to fire and seismic considerations were screened as not being applicable to VCSNS on the basis that they are specific to the configuration of the plants for which the SAMAs were deemed potentially cost beneficial and that VCSNS-specific SAMAs related to external events were identified as part of the initial license renewal. Examples of screened, seismic-related industry SAMA candidates include, but are not limited to increasing the seismic ruggedness of batteries (VCSNS SAMA 11) and block walls (VCSNS SAMA 6); replacement of seismically vulnerable valve yokes (VCSNS SAMA 192); installation of seismically qualified connections to alternate water sources (VCSNS SAMA 209); and installation of seismically qualified relays (VCSNS SAMA 176). Fire-related examples include installation of fire barriers (VCSNS SAMAs 10, 32-35, 56, 69, and 110-111); use of lower amperage and/or redundant fuses (VCSNS SAMAs 67-68); protection and/or re-routing of cables/conduit (VCSNS SAMAs 31, 36-38, 55, 57-58, 191, and 301); modification of procedures (VCSNS SAMA 126); hydrogen explosion prevention (VCSNS SAMA 148); and installation or modification of suppression systems (VCSNS SAMA 70). Similar dispositions were also applied to industry SAMA candidates related to heating, ventilation, and air conditioning (HVAC), internal flooding, and external flooding considerations.

It is not clear that benefits provided by such industry SAMA candidates would not be applicable to or achievable at VCSNS as many represent general risk-reduction strategies to limit, for example, fire and seismic effects. Additionally, for industry SAMA candidates screened in this manner, it is not clear how "new information" relevant to the NEI 17-04 Stage 1 assessment, as described in Section 3.1 of NEI 17-04, is accounted

for, particularly the fire and seismic PRAs, which are referenced in the SLR ER and were developed after the initial license renewal.

Provide justification for why the benefits achieved by industry SAMA candidates, screened on the basis stated above, would not be applicable to or achievable at VCSNS. If any of these industry SAMA candidates remain screened based on criteria that deviate from NEI 17-04, provide justification for the screening process and criteria employed as part of the Stage 1 assessment consistent with Part (a) of this RAI.

2) RAI SAMA-6

REQUIREMENT: Applicants for SLR are required by 10 CFR 51.53(c)(iv) to consider any new and significant information of which the applicant is aware that relates to its previous SAMA evaluation. As part of its review of the VCSNS SLR SAMA analysis, NRC staff evaluates the applicant's process for combining or grouping identified SAMA candidates that are evaluated for risk reduction.

ISSUE: The requested information is needed for the NRC staff to reach a conclusion on the adequacy of the screening process and criteria used in the applicant's Stage 1 assessment.

Section E4.15.3.2.2 of the ER describes that the 62 SAMAs that were not qualitatively screened were subsequently grouped into 19 SAMA cases for quantitative screening and that "similarities in mitigation equipment or risk-reduction benefits" were considered.

REQUEST: Please provide information on the process and criteria used for grouping SAMAs, discussing how the defined SAMA cases bound the potential benefits of individual SAMAs associated with each group.

3) RAI SAMA-7

REQUIREMENT: Applicants for SLR are required by 10 CFR 51.53(c)(iv) to consider any new and significant information of which the applicant is aware that relates to its previous SAMA evaluation. As part of its review of the VCSNS SLR SAMA analysis, NRC staff evaluates the applicant's risk-reduction estimates based on the PRA models.

ISSUE: The requested information is needed for the NRC staff to reach a conclusion on the adequacy of the evaluation of risk reduction performed in the applicant's Stage 1 assessment.

Section E4.15.3.2.1 of the ER states that "[t]he current VCSNS PRA models (internal events plus flooding, fire, and seismic PRA models) were used to determine the level of significance of new information." However, Section E4.15.3.2.1 of the ER indicates that only "[the] current VCSNS PRA models (internal events plus flooding) were used in the quantitative evaluation of MB to determine the level of significance of new information" and that "[e]xternal hazard frequencies are calculated by applying a multiplier of 2 to the internal events benefits." During the audit, it was discussed that this multiplier approach was applied to all SAMA evaluation cases except one (i.e., "EFP"). However, the multiplier approach is not consistent with guidance in NEI 17-04 given that it does not make use of the latest risk models for external events contributors (i.e., fire and seismic) and thus does not appear to address "new information" relevant to the SAMA analysis.

Based on the risk estimates reported in the SLR ER (i.e., $2.72E-06$ /year for internal events, including internal flooding, $5.07E-05$ /year for fire, and $3.52E-05$ /year for seismic), it is observed that the combined risk from fire and seismic events represents approximately 97 percent of the total CDF and is approximately 31.6 times greater than internal events risk (including internal flooding events). Given that the relative magnitude of the fire and seismic risk compared to that from internal events, including internal flooding, and noting that fire and seismic PRA models address risk contributors that are not captured by the internal events PRA model, it is not clear that the evaluation of risk reduction based on the multiplier approach ensures that the full spectrum of plant risk, as discussed in Section 3.1 of NEI 17-04, is accounted for in the Stage 1 assessment.

REQUEST: Describe how each risk contributor (i.e., internal events, internal flooding, fire, and seismic) was addressed in the evaluation of risk reduction performed as part of the Stage 1 assessment. If one or more risk contributors were not explicitly considered, clarify the treatment applied. If the approach in NEI 17-04 is not followed, provide justification that the approach used similarly addresses new information relevant to the SAMA analysis and bounds the impact of SAMA implementation by demonstrating that unimplemented Final Plant-Specific and Applicable Industry SAMAs, as defined by NEI 17-04, would have averted cost-risk values that are less than 50 percent of the MB.

4) RAI SAMA-8

REQUIREMENT: Applicants for SLR are required by 10 CFR 51.53(c)(iv) to consider any new and significant information of which the applicant is aware that relates to its previous SAMA evaluation. As part of its review of the VCSNS SLR SAMA analysis, NRC staff evaluates the applicant's risk-reduction estimates based on the PRA models.

ISSUE: The requested information is needed for the NRC staff to reach a conclusion on the adequacy of the evaluation of risk reduction performed in the applicant's Stage 1 assessment.

Section E4.15.3.2 of the ER indicates that "bounding SAMA evaluations" were performed for the 19 SAMA cases considered in the evaluation of risk reduction. In one SAMA evaluation case ("EFPW"), however, a refined quantification was performed because the initial assessment showed that the SAMA would reduce the MB by 50 percent or more. This refined quantification assumed that "the additional EFW [emergency feedwater] pump [postulated by the SAMA] would have similar seismic capabilities and dependencies as the other EFW pumps and would be expected to be considered correlated to the existing pumps." Additionally, during the audit, it was further discussed how consideration of various assumptions (e.g., non-seismic qualification, 100 percent seismic correlation, requirement for manual actions) made in the evaluation of risk reduction for this SAMA, as presented in the VCSNS SAMA Basis Document, resulted in no credit being derived from the additional EFW pump within the seismic PRA. Lastly, it was observed that unlike other SAMA evaluation cases, there was no explicit consideration of individual Level 2 release categories for the EFPW.

As stated in Section 3.2.2 of NEI 17-04, "the approach [at this stage of the analysis] is to bound the impact [of a given SAMA] by demonstrating that SAMA implementation would not reduce the CDF or any of the Level 2 release category frequencies by 50 percent or more." Considering the benefit realized from this SAMA within the internal events and fire PRA models, as documented in the VCSNS SAMA Basis Document, it is not clear why zero benefit would be realized in the seismic PRA, particularly for those seismic initiators associated with lower

accelerations. Moreover, it is not clear how the assumption of 100 percent seismic correlation, even if conservative from the perspective of quantifying absolute seismic risk metrics, would yield a bounding benefit in the evaluation of risk reduction under NEI 17-04 given that it presupposes design vulnerabilities and recognizing that cost of implementation is not a consideration by NEI 17-04 at this stage of analysis.

REQUEST: Describe the refined quantification and how it differs from the initial assessment. Additionally, provide supporting information on how implementation of this SAMA would not reduce the CDF or any of the Level 2 release category frequencies by 50 percent or more.

5) RAI SAMA-9

REQUIREMENT: Applicants for SLR are required by 10 CFR 51.53(c)(iv) to consider any new and significant information of which the applicant is aware that relates to its previous SAMA evaluation. As part of its review of the VCSNS SAMA analysis, NRC staff evaluates the applicant's treatment of Level 2 release categories in its assessments of risk reduction from identified SAMA candidates.

ISSUE: The requested information is needed for the NRC staff to reach a conclusion on the sufficiency of the treatment of Level 2 considerations in the applicant's Stage 1 assessment.

As discussed in Section 3.2.1 of NEI 17-04, the Stage 1 assessment involves "demonstrating that SAMA implementation would not reduce the CDF or any of the Level 2 release category frequencies by 50 percent or more." Furthermore, NEI 17-04 clarifies that "as an alternative to calculating the percent reduction in each Level 2 release category frequency subgroup..., it would be sufficient to group release category results into high level categories" and that "[a]nother alternative, if a technical basis is provided that demonstrates the overall risk reduction for the plant can be adequately quantified using a subset of Level 2 release categories, would be to perform the demonstration for that subset of the Level 2 release categories."

Section E4.15.3.2.2 of the ER indicates that Intact, Small Early Release Frequency (SERF), Large Early Release Frequency (LERF), and Late release categories were evaluated; however, in table E4.15-1, only values for total Level 2 results, i.e., "Total L2 (Intact, LEF, LRF)," are presented. During the audit, it was discussed that at least one SAMA evaluation case presented in the VCSNS SAMA Basis Document (i.e., SAMA SGTR) had a LERF estimate above the NEI 17-04 frequency threshold of 50 percent (i.e., 61.02 percent). It is thus not clear that unimplemented Final Plant-Specific and Applicable Industry SAMAs, as defined by NEI 17-04, have averted cost-risk values that are less than 50 percent of the MB. Additionally, during the audit, it was discussed how at least one stated release category (i.e., SERF) was not considered to be a significant risk contributor and was thereby excluded from the evaluations of risk reduction.

REQUEST: Clarify the approach for evaluating Level 2 release category frequencies and provide a technical basis that demonstrates that the overall risk reduction for the plant is adequately quantified using the selected Level 2 release categories consistent with NEI 17-04. In doing so, address the following:

- a. Describe the Level 2 release categories explicitly considered in the evaluation of risk reduction. In doing so, provide justification for treatment (or exclusion) of Level 2 release categories, discussing whether the approach is consistent with guidance in NEI 17-04.

- b. Explain whether the results of the risk reduction analysis (inclusive of CDF and all applicable Level 2 release category frequencies) for unimplemented Final Plant-Specific and Applicable Industry SAMAs are below NEI 17-04 frequency threshold and thus ensure that evaluated SAMAs have averted cost-risk values that are less than 50 percent of the MB.
- c. If the CDF and/or any applicable Level 2 release category frequency is reduced by more than 50 percent for an evaluated SAMA, identify the associated SAMAs and provide justification that the SAMA's averted cost-risk would still be less than 50 percent of the MB.
- d. During the audit, it was discussed that the total Level 2 result for SAMA evaluation case "RWST" was reported as 47.66 percent in the SLR ER and 40.54 percent in the VCSNS SAMA Basis Document. Explain this discrepancy.

6) RAI SAMA-10

REQUIREMENT: Applicants for SLR are required by 10 CFR 51.53(c)(iv) to consider any new and significant information of which the applicant is aware that relates to its previous SAMA evaluation. As part of its review of the VCSNS SLR SAMA analysis, NRC staff evaluates the applicant's latest risk models.

ISSUE: The requested information is needed for the NRC staff to reach a conclusion on the adequacy of the screening process and criteria used in the applicant's Stage 1 assessment.

The "base" value presented in table E4.15-1 of the ER for all but one of the SAMA evaluation cases is $2.75\text{E-}06/\text{year}$, and for the one SAMA evaluation case ("EFPW") that involves a refined quantification owing to external events considerations, a "base" value of $9.38\text{E-}05/\text{year}$ appears. These "base" values exceed the internal events CDF of $2.72\text{E-}06/\text{year}$ and the estimated all-hazards CDF of $8.86\text{E-}05/\text{year}$ ($2.72\text{E-}06/\text{year}$ for internal events + $5.07\text{E-}05/\text{year}$ for fire + $3.52\text{E-}05/\text{year}$ for seismic) obtained from Section E4.15.2.2 of the ER. During the audit, it was discussed that the internal events, seismic, and total CDFs reported in the VCSNS SAMA Basis Document were similarly higher (i.e., $2.75\text{E-}06/\text{year}$, $4.04\text{E-}05/\text{year}$, and $9.38\text{E-}05/\text{year}$, respectively).

REQUEST: Describe these differences and confirm that all aspects of the SLR ER make use of "the latest risk models that are available for internal events (including internal flooding) and for each of the external events contributors", as discussed in Section 3.1 of NEI 17-04.