July 14, 2016

MEMORANDUM TO: Ronaldo V. Jenkins, Chief
Licensing Branch 3
Division of New Reactor Licensing
Office of New Reactors

FROM: James Shea, Senior Project Manager **/RA/**
Licensing Branch 3
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: REGULATORY AUDIT REPORT FOR DOMINION VIRGINIA POWER, COMBINED LICENSE APPLICATION SITE-SPECIFIC SEISMIC DESIGN AND SUPPORTING ANALYSES

Enclosed is the U.S. Nuclear Regulatory Commission (NRC) staff's seismic audit-2 report for Dominion Virginia Power (Dominion) regarding the North Anna 3 Combined Operating License Application (COLA) (Docket No. 52-017). The staff performed site-specific design analyses of category I seismic structures used in support of the staff's review of the North Anna COLA Final Safety Evaluation Chapter 3 Section 3.8. This audit is the second of two audits completed by the staff as part of the applicant's seismic closure plan dated October 22, 2014. Audit-1 was completed on October 2, 2015.

The audit was conducted over five days, starting on March 21, 2016, at the General Electric-Hitachi Offices in Wilmington, North Carolina. The staff reviewed several applicant calculation reports and closed a number of significant action items as outlined in the enclosed report. No new significant issues were identified or requests for information were needed as a result of this staff audit.

Docket No. 52-017

Enclosure:
As stated

cc w/encl: See next page

CONTACT: James Shea, NRO/DNRL/LB3
301-415-1388

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DATE	07/08/2016	07/11/2016	07/13/16	07/14/2016	07/14/2016

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North Anna 3 Audit of Site-Specific Design Evaluation of Seismic Category I Structures (Final Safety Analysis Report Section 3.8)

Dates of Audit: March 21 – 25, 2016

Audit Location: GE Hitachi Office
3901 Castle Hayne Road 3901
Wilmington, NC 28401

Review Team: James Shea (NRC Project Manager)
Donald Brittner (NRC Project Manager)
Jim Xu (NRC SEB Branch Chief)
Manas Chakravorty (NRC Lead Technical Reviewer)
Jinsuo Nie (NRC Technical Reviewer)
George Wang (NRC Technical Reviewer)
Sunwoo Park (NRC Technical Reviewer)
Joseph Braverman (BNL, NRC contractor)

Audit Scope

The scope of this audit was to review the supporting information for the site-specific structural design evaluation of the Economic Simplified Boiling-Water Reactor (ESBWR) seismic Category I structures for the North Anna Unit 3 (North Anna 3) site and the applicant's responses to NRC staff's requests for additional information (RAIs) pertaining to the Final Safety Analysis Report (FSAR) Sections 3.7 and 3.8 (submitted in February 2015, July 2015, and December 2015).

Specifically, the staff reviewed supporting calculations, markups to the FSAR Tier 2, Sections 3.7 and 3.8, and other pertinent documents that were prepared to support the information submitted by Dominion in accordance with its seismic closure plan transmitted in letter North Anna 3-14-043 dated October 22, 2014. The major focus of the audit included the review of supporting information for addressing reconciliation of the North Anna 3 site-specific seismic demands with the corresponding ESBWR standard design demands/capacities including design changes made to accommodate demand exceedances. The staff also reviewed the process of how the site-specific bounding seismic demands described in FSAR Section 3.7 are translated into seismic load input to structural design analyses discussed in FSAR Section 3.8.

A list of reports and supporting calculations available for this audit is included in Table 1, "List of Reports and Supporting Calculations for North Anna 3 COLA Review Audit 2", which was provided by the applicant prior to the audit. Not included in Table 1, but made available by the applicant during or after the audit, are the following documents:

- Equipos Nucleares, S.A. (ENSA) Technical Note 5926ATN02, Revision 3, "ESBWR Fuel Building Pool bottom Synthesized SSE Accelerations Time Histories"

Enclosure

- Empresarios, 092-175-F-M-00003, Revision 1, “Design Report of the Spent Fuel Storage Racks in Reactor Building for North Anna 3”

- Empresarios, 092-322-F-M-00002, Revision 2, “Design Report of the New Fuel Storage Racks in the Reactor Building for North Anna 3”

- GEH Report SER-DMN-045, Revision 0, “Evaluation of Subgrade Stiffness Effects on Site-Specific Stress Analyses Results”

- GEH Report DBR-0018441, Revision 0, “Uplift Effect on North Anna 3 RB/FB Basemat Response”

Audit Summary

The Applicant for North Anna 3 Dominion Virginia Power (DOM) and its representatives from GE-Hitachi (GEH), Bechtel Corporation, Shimizu Corporation, and Fluor Corporation participated in the audit, including key technical personnel involved with the North Anna 3 site specific seismic analysis. A list of attendees including the NRC staff as well as its’ contractor from Brookhaven National Laboratory (BNL) is provided in Table 2.

The NRC staff made some introductory remarks regarding the audit background, scope, objectives, and agenda. Following these remarks, GEH presented an overview of the Reinforced Concrete Containment Vessel (RCCV) thermal analysis with respect to the difference between the design control document (DCD) method and the North Anna 3 method for site-specific evaluation of the thermal effect involving the use of the SSDP-2D computer program. The staff focused on the following areas:

- North Anna 3 site-specific seismic demands and their comparison with ESBWR standard design demands or capacities.

- Method of applying the enveloping seismic demands described in FSAR Section 3.7 to the detailed static structural model (NASTRAN) for seismic design evaluation.

- Site-specific structural evaluation of seismic Category I structures including Reactor Building/Fuel Building (RB/FB), RCCV, Containment Internal Structures (CIS), Control Building (CB), and Firewater Service Complex (FWSC). The review of the RCCV included the steel components of the containment and Passive Containment Cooling System (PCCS) condenser. Technical areas of review included analytical models, site design loads and load combinations, material properties, acceptance criteria, structural analysis, and structural design and design changes.

- Foundation stability (overturning, sliding), dynamic bearing pressure, and lateral soil pressure on exterior embedded walls.

- Site-specific structural evaluation of the new fuel pool and spent fuel pool (SFP) storage racks, and the fuel stored in the racks.

- Plant-specific seismic margin analysis (SMA) update including seismic fragilities and HCLPF values.

- Site-specific Inspection, Test, Analysis, and Acceptance Criteria (ITAACs) for Sesimic Category I Buried Piping, Conduits and Tunnels, seismic Category II structures (Turbine Building, Service Building, Ancillary Diesel Building, Access Tunnel), Radwaste Building and Radwaste Tunnel.

The audit concluded in an exit meeting with a list of technical issues that were reviewed and dispositioned by the NRC staff during the audit, as shown in Attachment 2. A detailed list of technical issues raised by the NRC staff before the audit is provided in Attachment 1. All technical issues were addressed and those issues involving FSAR changes are designated as "confirmatory" in Attachment 2 because the staff reviewed and accepted the applicant's draft FSAR markups but will need to confirm them in the final FSAR revision.

Following the audit, a clarification call with Dominion was made to convey a staff comment that Dominion submit the final versions of 002N8467 (North Anna 3 Fuel Storage Racks Report), 003N0526 (North Anna 3 Spent Fuel Report) and 002N8530 (North Anna 3 PCCS Condenser Report) to the NRC as these reports constitute an extension of the FSAR. In addition, the staff requested Dominion to make available, in the electronic reading room, the final revised design basis document DBR-0010229, "ESBWR Design Basis for PCCS Condenser RAI Response" which was referenced in 002N8530.

<u>Detailed Review and Discussions</u>

1. Review of the site-specific bounding seismic demands and structural design evaluation of RB/FB

   GEH report SER-DMN-019, Revision 1, "RB/FB Seismic Analyses Bounding Results and ISRS," was reviewed during the audit. This report documents the North Anna 3 site-specific bounding seismic loads used for the design evaluation of the RB, FB, RCCV and CIS, which were all analyzed in the same model. The structural design evaluations of the RB and FB are documented in WG3-U71-ERD-S-0004, Revision 1, "Reactor Building Structural Design Report" and WG3-U97-ERD-S-0001, Revision 1, "Fuel Building Structural Design Report," respectively. The design reports for RCCV and CIS are discussed later in this report.

   The North Anna 3 site-specific bounding seismic loads envelop the variation of subgrade conditions at the North Anna 3 site (LB, BE, and UB) and bound the effects of soil separation (partial and full embedments) and structural stiffness variations (through the uncracked model UC100 with operating basis earthquake (OBE) damping, and cracked models CR50 and CR00 with SSE damping). The structure-soil-structure interaction (SSSI) effect of the CB on the RB/FB is considered to be negligible due to the fact that RB/FB complex is much heavier than CB.

   GEH report SER-DMN-019, Revision 1 provides the enveloping structural load demands, displacements, and ISRS. WG3-U71-ERD-0003, Revision 1, "North Anna 3 RB/FB Complex Stability Analysis Report," describes the site-specific lateral pressure demands, which are based on the design basis SSI analysis based on the UC100 model and the sliding stability analyses. Appendix B of WG3-U71-ERD-S-0001, Revision 4, "North Anna 3 RB/FB Complex Seismic Analysis Report," indicates that the reduction of structural stiffness can amplify:

(a) the response of the reactor shield wall (RSW), vent wall (VW), pedestal structures

(b) the response of RB/FB basemat

(c) the out-of-plane vertical loads of RB/FB slabs at Elev. -6.4 m and the D/F slab

(d) maximum horizontal displacements at higher floor elevations

(e) seismic lateral pressure (exceeding stability analysis and licensing basis analysis)

However, draft FSAR markup Section 3A.18 and GEH report SER-DMN-019, Revision 1 do not include the bounding dynamic lateral soil pressure that bounds the effect of stiffness variation. Therefore, the staff discussed this missing information with Dominion during the audit, and the applicant agreed to expand FSAR Section 3G.7.5.6 to include a table showing the final bounding lateral dynamic soil pressure. An FSAR markup was provided during the audit and the staff found it to be acceptable.

To account for the effect of concrete cracking on ISRS, any parts of the 5 percent damped ISRS exceeding the design basis cases by more than10 percent is considered by the applicant to be significant and is enveloped by the final North Anna 3 site-specific ISRS. The 10 percent criterion was considered to be acceptable because concrete members normally do not crack throughout the entire region where the 50 percent stiffness reduction was uniformly applied.

The design evaluation was performed for the RB/FB to satisfy both American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section III, 2004 and ACI 349-01, which is consistent with the DCD design criteria. Most of the DCD selected elements and the North Anna 3 additional selected elements satisfy both standards using the SSDP-2D computer program. However, there are a few elements that were found to exceed the ASME allowable stress using the SSDP-2D program. Therefore, the approach used to design non-containment reinforced concrete members was reviewed regarding the modification of the structural acceptance criteria identified in North Anna 3 FSAR Section 3.8.4. More specifically, the need to revise the criteria arose because the site-specific structural evaluations indicate that one segment of the FB external wall experiences compression stress demand under combined flexure and membrane forces that exceeds the acceptance criteria of the ASME BPVC for allowable compressive stress. This exceedance occurred as a result of using the SSDP-2D computer program which utilizes an approach for meeting ASME Code requirements for factored loads based on the linear concrete stress-strain relationship and concrete principal stress for comparing with the code allowable stress. This approach was followed in the standard design. As indicated by the applicant, this approach is more conservative than the parabolic or nonlinear stress distribution accepted by ASME BPVC, Section III, Division 2, Subsection CC.

The applicant indicated that in the site-specific stress evaluations for cases where an element exceeds ASME acceptance criteria using the conservative SSDP-2D analysis, additional reinforcing steel is added or the element is evaluated using axial load-moment interaction curves which satisfy both ACI 349-01 and alternative ASME acceptance criteria. The alternative approach allowed by the ASME code involves the parabolic concrete stress-strain relationship and applicable ASME allowable stresses for a cross section subjected to membrane loads and moments due to factored loads. This approach ensures that the more limiting acceptance criteria of the ASME Code and the ACI 349-01 Code are met. During the audit, the applicant discussed with the staff in more detail this alternative approach and the conservatism in the SSDP-2D program. The staff found the design evaluation procedure and design criteria acceptable. The applicant also provided FSAR markups that provide the above description and basis for the revised approach. Also, the staff reviewed GEH report WG3-U71-ERD-S-0004, Revision 1, and confirmed that the above approach was included. This technical issue was assigned Action Item 01151600D, and dispositioned as Confirmatory.

The RB Design Report WG3-U71-ERD-S-0004, Revision 1, Section 6.2.3.1, "Dead Load", states that "the crane is assumed to be positioned center of crane girders. The lifted loads are evaluated in the same manner of the crane weights, but they are applied to two columns of one side, conservatively." The staff had a question on how the effect of the lifted weight potentially being parked at the other side is considered. The applicant stated that the reinforcement in the walls at both ends of the crane is mirrored (and the columns have the same size) so this effect is conservatively considered.

The RB Design Report WG3-U71-ERD-S-0004, Revision 1, Section 6.2.3.2 "Live Load, Floor Live Loads", states that "floor live load for roofs are enveloping the snow load as shown in Table 6.2.3.2-1 and Figure 6.2.3.2-1." The staff had a question on how this method can distinguish the possibly different load factors for the roof live loads and snow load. The applicant stated that the roof live loads have the same load factor. As such, the staff found the use of the enveloping roof live load is acceptable.

The application of SHAKE2000 was checked by reviewing several supporting calculations. As indicated in FSAR 3C.7.7.3, SHAKE2000 was used to calculate the site responses in the SSI input soil profiles (LB, BE, and UB deterministic, strain-compatible soil profiles) subjected to the SSI input time-histories (enveloping the Final SSI Input Spectra that are FIRS enhanced to meet the NEI check and Title 10 *Code of Federal Regulations* Part 50, Appendix S minimum response spectrum). The site responses calculated using SHAKE2000 are the in-column motions that were used as input time histories in the SASSI SSI analysis. No soil degradations were needed in these calculation so there was no convergence issue. The results of these site response analyses are reviewed and considered acceptable to the staff. During the audit, the staff also examined some output files from SHAKE2000 stored on a CD. No concerns were identified. Since SHAKE2000 was used only for the simple 1D linear wave propagation problems, it is acceptable to the staff.

2. Review of the site-specific bounding seismic demands and structural design evaluation of the RCCV

During the first day of the audit, GEH made a presentation of the RCCV thermal analysis to describe the differences between the DCD method and the North Anna 3 method for site-specific evaluation of the thermal loading. In the standard design, the analysis method used 3D nonlinear analyses to obtain thermal ratios (reduction factors) when compared to the 3D linear thermal analyses. The thermal ratios are generally less than one because the high thermal forces at a particular section would redistribute to adjacent regions when cracking occurs. The thermal ratios are then utilized in the standard design using the SSDP-2D computer program to design the individual concrete sections. In the North Anna 3 approach, the 3D nonlinear analysis approach is not used for the site-specific structural evaluation. The thermal member forces from the 3D linear analysis are evaluated using the SSDP-2D program without thermal ratios. As indicated by the applicant, this approach is more conservative because it does not account for the redistribution of forces in locations of high thermal stresses to other regions with lower thermal forces. The staff also reviewed a draft update to the response to RAI 03.07.02-17 which is related to this issue to ensure it is consistent with the technical approach discussed above. In summary, this technical issue was assigned Action Item 020116001, and dispositioned as Confirmatory.

A review of GEH report SER-DMN-019, Revision 1, “RB/FB Seismic Analyses Bounding Results and In-Structure Response Spectra” was performed to identify the bounding loads for the site-specific seismic loads which need to be used as input to the RCCV structural evaluation. This report provides the site-specific seismic member forces and accelerations representing the envelope of responses for the variation of subgrade conditions, effects of soil separation, and structural stiffness variations. From the review of this GEH report, the staff confirmed that the tabulated envelope of seismic forces and vertical accelerations for the RCCV match the forces and accelerations used for the RCCV evaluation, which are presented in GEH report WG3-T11-DRD-S0001, Revision 1, “RCCV Structural Design Report.”

The review of the site-specific structural evaluation performed for the RCCV, concludes that even though in some cases the site-specific seismic loads exceed the standard design seismic loads, the stresses in the concrete and rebar were shown to be less than allowable values, and the areas of the primary and shear reinforcement satisfy required values.

For the PCCS condenser, which is part of the RCCV boundary, the North Anna 3 GEH report 002N8530, Revision 3, “North Anna 3 PCCS Condenser Seismic Analysis,” was reviewed. This report summarizes the analysis of the PCCS condenser using the site-specific North Anna 3, SSE response spectra. A comparison of the North Anna 3 site-specific response spectra to the standard design response spectra used previously was presented in the report. There were some increases in the North Anna 3 SSE spectra at certain frequency ranges, primarily in the vertical direction. Based on the seismic reanalysis, the component stresses are all below their allowable values. For the maximum reactions on the top slab penetration and support base plate anchor bolts, all loads remain below the DCD results presented in NEDE-33572P, Revision 3, “ESBWR ICS and PCCS Condenser Combustible Gas Mitigation and Structural Evaluation,” with one exception. The tension on the support saddle bolts increased, and thus, the support saddle bolts and embedment will be designed to withstand this increase in the anchor tension load. The staff also noted that FSAR Section 3G.7.5.4.1.5 was revised to summarize the evaluations performed for the PCCS condenser.

The staff noted inconsistencies in some corresponding entries between Table B-2b of NEDE-33572P, Revision 3 and Tables 1 and 2 of 002N8530, Revision 3. For example, in Table 1 (002N8530) for the upper header Pm stress category in Service Level C-1, the allowable stress is listed as 291.4 MPa whereas the corresponding allowable stress in Table B-2b (NEDE-33572P) is listed as 137.9 MPa (see Audit 2 AI Number 022616002 in Attachment –2). The applicant explained that during the design process of the standard plant while the material for the upper header was changed from 304L to XM-19, the allowable stress value in Table B-2b in NEDO-33572 was not revised to reflect the higher allowable corresponding to XM-19 material. North Anna 3 stress evaluation used the correct allowable stresses consistent with the revised upper header material. The staff also noted some inconsistency with the method of calculating the anchor bolt loads in Table 4 of 002N8530. The applicant indicated that the PCCS summary report 002N8530 and the supporting calculation DBR-0010229 will be revised to address the material inconsistency and the issues with calculation of the PCCS anchor bolt loads. The FSAR Section for the PCCS condenser will be revised to include the correct revision number for the reference GEH report 002N8530. The staff during the audit reviewed the proposed mark-up to the report and the FSAR and found them acceptable. This item is being tracked via Confirmatory Action Item 022616002.

3. Review of the site-specific bounding seismic demands and structural design evaluation of CIS

A review of GEH report SER-DMN-019, Revision 1, "RB/FB Seismic Analyses Bounding Results and In-Structure Response Spectra" was performed to identify the bounding loads for the site-specific seismic loads which need to be used as input to the CIS structural evaluation. This report provides the site-specific seismic member forces and accelerations representing the envelope of responses for the variation of subgrade conditions, effects of soil separation, and structural stiffness variations. From the review of this GEH report, the staff confirmed that the tabulated envelope of seismic forces and vertical accelerations for the VW and RSW, match the forces and accelerations used for the CIS evaluation, which are presented in GEH report WG3-T11-DRD-S0001, Revision 1, "RCCV Structural Design Report." The forces and accelerations applied to the CIS and the RCCV are contained in GEH report WG3 T11-DRD-S0001, Revision 1, because these structures, along with the RB/FB, are integrated into one combined RB/FB finite element model.

The review of the site-specific structural evaluation performed for the CIS, concludes that even though in some cases the site-specific seismic loads exceed the standard design seismic loads, the stresses in the structural members for the VW, RSW, RPV support bracket, Gravity Driven Cooling System (GDCS) Pool, and the anchorage reaction for the VW were all shown to be within code limits. In the case of the diaphragm floor (DF), with the exception of the DF radial web plate (upper and lower), the calculated stresses are less than allowable stresses. For the DF radial web plates, the approach in accordance with AISC N690 Section Q1.5.7.2 to evaluate primary plus secondary stresses was utilized. For this evaluation it was demonstrated that the calculated stresses are below allowable stresses corresponding to the permissible deformation limits. The description of the approach used for the evaluation of the DF radial web plates in FSAR Section 3.8.3.5.1 was not clear, and thus, the applicant provided a markup for the FSAR to address this item. This technical issue was assigned Action Item 022616005, and dispositioned as Confirmatory.

4. Review of the site-specific bounding seismic demands and structural design evaluation of CB

GEH report SER-DMN-032, Revision 3, "North Anna 3 Bounding Seismic Demands for CB and FWSC Site-Specific Evaluations" was reviewed during the audit. The staff reviewed CB bounding maximum response forces and moments, maximum accelerations, maximum accelerations at slabs and roofs, and maximum dynamic lateral pressures described in the bounding report, and confirmed that the bounding structural loads envelop the variation of subgrade conditions at the North Anna 3 site including effects of soil separation (full and partial embedments), and bound the effects of structural stiffness variations (concrete cracking), and SSSI. During the audit, the applicant clarified that at-rest static soil pressure loads and lateral dynamic pressure loads including maximum passive resistance pressures were applied in the NASTRAN finite element model. The staff reviewed these lateral pressure loads and found them acceptable. The staff also reviewed the bounding site-specific ISRS for CB and its criteria for enhancing site-specific ISRS. The staff found both bounding structural loads and site-specific ISRS acceptable and did not identify any new issues during the audit.

GEH report WG3-U73-ERD-S-0004, Revision 2, "Control Building Structural Design Report" was reviewed. The staff found that the analysis model and approach, industry codes and standards, structural materials and their properties, loads and load combinations, and the method of applying loads were consistent with those used in the ESBWR standard design, and the applicant applied site-specific Safe Shutdown Earthquake (SSE) loads combined with other non-seismic loads in the standard design to the same NASTRAN finite element model used for the standard design of the CB structure. According to the DCD Table 3.8-15, the acceptance criteria for CB section strength are based on the strength design method per ACI 349-01. The North Anna 3 structural design evaluation of CB utilizes the same methodology as the DCD and uses the same SSDP-2D computer program, which in addition to ACI 349-01, also follows the 2004 ASME code. The staff found the North Anna 3 structural design evaluation of CB is acceptable because the CB section design is conservatively taken to be more limiting of ACI 349-01 and 2004 ASME Section III, Division 2, Subsection CC requirements. During the audit, the staff identified a few missing loads from Tables 6.2-3 and 6.3-3 in the design report, and found that the applicant did consider these missing loads in the design evaluation of CB structure. The applicant provided these missing loads in the design report during the audit, and the staff found them acceptable. The staff also noticed some exceedances in vertical accelerations due to the FWSC or RB/FB SSSI effects on the CB structure. The staff reviewed the calculations and found that the exceedances in vertical accelerations due to the SSSI effects are less than 2 percent, which is negligible. This technical issue was assigned Action Item 032216001 and dispositioned as Closed. The staff further noticed the design change for one structural steel girder "SG23" at Elevation 4.65 m on Col-Row CB. The design change includes a change of flange plate size from 400x36mm (DCD) to 400x40mm (North Anna 3). The staff reviewed the design calculations for steel girder "SG23" and found it acceptable. No other issues were found.

5. Review of the site-specific bounding seismic demands and structural design evaluation of FWSC

The staff reviewed site-specific bounding seismic demands for the FWSC as reported in the FSAR markup Section 3A.18 and GEH report SER-DMN-032 "North Anna 3 Bounding Seismic Demands for CB and FWSC Site-Specific Evaluations," Revision 3. Specifically, the staff reviewed site-specific bounding seismic forces, bending and torsional moments, accelerations, water oscillator spring reactions, out-of-plane accelerations for slabs and roofs, and lateral forces for shear keys. The staff found that the reported structural loads envelop the variation of subgrade conditions at the North Anna 3 site and bound the effects of FWSC-CB SSSI, structural stiffness variations (concrete cracking), and separation between the concrete fill and surrounding soil. The staff also reviewed the bounding site-specific ISRS for FWSC and its criteria for enhancing site-specific ISRS. The staff found that both bounding structural loads and site-specific ISRS are acceptable and did not identify any new issues during the audit.

GEH report SER-DMN-032 presents in Tables 3.2-1 to 3.2-6 the FWSC concrete cracking amplification factors calculated as the ratio of the enveloped SSI analysis results from the cracked concrete model over those from the uncracked concrete model. The tables cover amplification factors for most seismic load demands but not for the shear key demand. Therefore, the staff requested the applicant to provide a table that shows enveloped lateral force demands for the FWSC shear keys obtained from SSI analyses of cracked and uncracked concrete models and their ratios. In response, Dominion provided a table showing a comparison between maximum driving forces obtained from analyses of cracked and uncracked concrete models, confirming a conclusion provided in Appendix B of FWSC Seismic Analysis Report (WG3-U63-ERD-S-0001) that uncracked models provide lateral force demands on shear keys that bound concrete cracking effects. The conclusion in Appendix B of the report WG3-U63-ERD-S-0001 is captured in FSAR markup Section 3A.17.9.3. During the audit, the staff asked how this comparison table will be documented and the applicant responded that the table will be placed in Appendix B of a revised report WG3-U63-ERD-S-0001. The staff tracked the issue as Action Item 2261606 and dispositioned it as Confirmatory at the conclusion of the audit.

The staff noted that the pre-audit FSAR Markup Section 3A.17.9.3 states, “To evaluate the effects of concrete cracking on the FWSC stability and dynamic bearing pressures, results from the analyses of the CR-SSE model and SSI envelope UC-SSE model for the seismic horizontal forces and overturning moments <u>on</u> the top of the basement together with the vertical accelerations are compared.” However, GEH report WG3-U63-ERD-S-0002 (FWSC Stability Analysis Report, Revision 1) uses the horizontal seismic driving forces calculated at the <u>bottom</u> of the basemat in foundation stability analysis against sliding. During the audit, the staff requested the applicant for a clarification of an apparent conflict in the above statements. The applicant acknowledged this conflict and proposed an FSAR markup that removes the phrase “on the top of the basemat” from the text, which was acceptable to the staff.

Originally, Dominion did not consider the effect of soil-separation in structural evaluation of the FWSC since the available design margins for FWSC walls and basemat at North Anna 3 site are sufficient to envelope any exceedances in load demands due to soil separation. Subsequently, in response to a staff’s question, Dominion revised GEH report SER-DMN-034, “Evaluation of FWSC Concrete Fill and Effects of Separation Between Concrete Fill and Surrounding Soil,” Revision 2, to document the evaluation of the effects of separation between the concrete fill and surrounding soil on FWSC sliding stability and lateral load demands for the shear keys. The staff reviewed information and calculations provided in the revised reports (SER-DMN-034, Revision 2 and WG3-U63-ERD-S-0003, Revision 1) as well as the proposed FSAR markups and found them acceptable. The staff tracked the issue as Action Item 092815A1005 and dispositioned it as Confirmatory at the conclusion of the audit.

The staff reviewed the site-specific design evaluation of the FWSC structures as reported in GEH report WG3-U63-ERD-S-0003, Revision 1 and documented in FSAR markup Section 3G.10. The staff found that the analysis model and approach, industry codes and standards, structural materials and their properties, loads and load combinations, and the method of applying loads were consistent with those used in the standard design. The staff also confirmed that site-specific seismic loads combined with other non-seismic loads used in the standard design are applied to the same NASTRAN model used for the standard design of the FWSC structures.

The staff, however, identified a statement missing in FSAR markup Section 3G.10.5.1 (Site Design Parameters) regarding the effect of soil separation on sliding stability. In response, Dominion proposed an FSAR markup that will move the discussion to Section 3G.10.5.5 (Foundation Stability) and include a statement, "The effects of separation between the concrete fill and surrounding soil on the sliding stability of the FWSC are discussed in Section 3A.17.14.5." The staff also identified a statement missing in FSAR markup Section 3G.10.5.4.3 (Foundation Mat) regarding a design change made to basemat reinforcement as a result of site-specific seismic demand exceedances. In response, Dominion proposed an FSAR markup that includes a statement, "Additional primary reinforcement is added to the basemat (Element 207 in Table 3G.10-204)." in FSAR Section 3G.10.5.4.3. The staff found these FSAR markups acceptable. The staff tracked the issue as Action Item 032316003 and dispositioned it as Confirmatory at the conclusion of the audit.

6. Review of the site-specific seismic analysis and structural evaluation of the new fuel pool and SFP storage racks, and fuel stored in the racks

The staff discussed some questions related to the fuel racks in the spent fuel pool, spent fuel racks in the buffer pool deep pit, and new fuel racks in the buffer pool. These questions are all related to GEH report 002N8467, Revision 2, "North Anna 3 Fuel Rack Seismic Analysis." The questions regarding the fuel stored in the racks are related to GEH report 003N0526, Revision 0, November 2015, "North Anna 3 Seismic Qualification of Spent Fuel in the Spent Fuel Racks."

<u>Fuel Storage Racks - Synthetic Time Histories</u>:

The first question was to demonstrate the adequacy of the synthetic time histories used to perform the nonlinear dynamic analyses of the fuel racks. During the audit, the applicant provided and the staff reviewed Equipos Nucleares, S.A. (ENSA) Technical Note "ESBWR Fuel Building Pool bottom Synthesized SSE Accelerations Time Histories," Document 5926ATN02, Revision 3. For the spent fuel racks in the spent fuel pool, this report showed a spectral comparison between the synthetic time histories and the required North Anna 3 floor response spectra for the spent fuel rack analysis. The staff noted that there were significant margins in the spectra comparison for the X (horizontal) direction for frequencies above the lowest rack frequency. In the Y (other horizontal direction) and Z (vertical) directions there were some small margins. The staff also noted that the stress results for the racks were substantially smaller than the allowable stress limits. Thus, the synthetic time histories were considered to be acceptable for the spent fuel rack time history analyses.

For the spent fuel racks in the buffer pool deep pit, the applicant explained that the spent fuel racks are anchored to the pool floor and thus, a response spectrum analysis is performed for evaluation of the racks. The time history analysis is only performed for evaluation of the fuel in the rack and to obtain the horizontal and vertical impact forces onto the rack due to the gaps between the fuel and the rack. For this set of time histories, the staff reviewed Empresarios “Design Report of the Spent Fuel Storage Racks in Reactor Building for North Anna 3,” Document 092-175-F-M-00003, Revision 1. Based on the spectral matching comparisons of the synthetic time histories and the required response spectra, the substantial margin in the rack bottom plate stress, and the margins in the acceleration values for the fuel, the synthetic time histories used as input in the time history analyses were considered to be acceptable.

For the new fuel racks in the buffer pool, the fuel racks are also anchored to the pool floor and thus, a response spectrum analysis is performed for evaluation of the racks. The time history analysis is only performed for evaluation of the fuel in the rack and to obtain the horizontal and vertical impact forces onto the rack due to the gaps between the fuel and the rack. For this set of time histories, the staff reviewed Empresarios “Design Report of the New Fuel Storage Racks in the Reactor Building for North Anna 3,” Document 092-322-F-M-00002, Revision 2. Based on the spectral matching comparisons of the synthetic time histories and the required response spectra, the substantial margin in the rack bottom plate calculated stress, and the margins in the acceleration values for the fuel, the synthetic time histories used as input in the time history analyses were considered to be acceptable.

This technical issue was assigned Action Item 0910GEN02, and dispositioned as Closed based on information provided during the audit and a draft update to the GEH report 002N8467. Final updates to the FSAR and the GEH report that would be needed related to the fuel storage racks were assigned to Action Item 022616002 as a follow-up item.

<u>Fuel Storage Racks - Correlation Coefficients of Seismic Synthetic Time History</u>:

For the new fuel racks in the buffer pool, and the spent fuel in the buffer pool deep pit the seismic time history correlation coefficients were determined to be 0.14 which are less than the 0.16 value provided in SRP Section 3.7.1, and thus, are considered to be acceptable. However, for the spent fuel racks in the SFP some of the correlation coefficients are greater than 0.16. During the audit, the applicant provided additional technical information to address this issue, which will be included in updates to GEH report 002N8467. The information provides justification based on:

a. The 2D analyses consider one horizontal and vertical directions simultaneously and then the other horizontal and vertical directions simultaneously, as was used in the standard design. However, the configuration of the racks and fuel, and the small displacements between them due to the small gaps, suggests that the horizontal and vertical coupling will be small and the impact of somewhat non-independent time histories between the horizontal and vertical directions will thus be limited.

b. This is also evident based on the stiffness matrix for the 2D beam being used to model the fuel which shows that there is no coupling between horizontal direction and vertical direction. For rotation, some coupling is possible; however, for the small lateral displacements at the top of the beam, the coupling effect is limited.

c. Peak impact dynamic loads obtained from the time history analyses and applied to the finite element method (FEM) as static forces is considered to be conservative.

d. There are substantial margins in the calculated stresses.

This technical issue was part of Action Items 0910GEN02 and 020916003, and dispositioned as Closed based on the information provided during the audit and a draft update to the report, GEH report 002N8467, Revision 4, which was provided to the staff. Updates to the FSAR that would be needed related to the fuel storage racks were assigned to Action Item 022616002.

<u>Fuel Storage Racks - Use of Buffer Pool Response Spectra for Time History Analysis of Spent Fuel Racks in Buffer Pool Deep Pit</u>:

For the seismic time history analysis of the spent fuel racks in the buffer pool deep pit, the synthetic time histories were developed based on the response spectra of the buffer pool (at a higher elevation) rather than the elevation of the buffer pool deep pit, or the envelope of the two elevations of the two buffer pools. The applicant explained that based on the spectra comparison of the two elevations, exceedances in the spectra for the lower elevation occur only in the horizontal direction. Also, the time history analysis is only performed for evaluation of the fuel in the rack and to obtain the horizontal and vertical impact forces from the fuel onto the fuel rack due to the gaps between the fuel and the rack. The horizontal forces at the top of the rack are negligible, and the vertical spectrum used in developing the vertical time history was larger than the spectrum at the deep buffer pool elevation, and thus acceptable. Lastly, the stress analysis of the bottom plate of the rack shows substantial margin, and as discussed below, the fuel assembly qualification shows sufficient margin as well.

This technical issue was assigned Action Item 020916005, and dispositioned as Closed based on the information provided during the audit and the draft updated report, GEH report 002N8467, Revision 4, which was provided to the staff. Updates to the FSAR that would be needed related to the fuel storage racks were assigned to Action Item 022616002.

<u>Fuel Stored in the Racks</u>:

The staff reviewed GEH report 003N0526, Revision 0, November 2015, "North Anna 3 Seismic Qualification of Spent Fuel in the Spent Fuel Racks" and discussed with the applicant several questions that arose from this review. The seismic qualification methodology for the fuel was the same as the approach used in the standard plant except that the results were generated using the North Anna 3 site-specific seismic input. The results of this North Anna 3 site-specific analysis provided the maximum horizontal and vertical accelerations of the fuel in the rack and compared these demand accelerations with the acceleration limits previously determined for the fuel. In the horizontal direction, the maximum accelerations in the two perpendicular directions were combined by the SRSS method to obtain the resultant horizontal peak acceleration. To demonstrate adequacy of the fuel in the rack, Table 2 in the GEH report provides comparisons between the fuel (in the spent fuel pool and the buffer pool) and the GE14 fuel acceleration acceptance limits. The horizontal and vertical demand acceleration values were less than the corresponding acceleration acceptance limits. However, the staff requested the applicant to consider the potential for interaction of the horizontal and vertical demand acceleration values against the interaction acceptance limits that would exist for the GE fuel. As a result, the applicant provided a figure showing the interaction curve for the GE fuel acceptance limit. The calculated demand horizontal and vertical acceleration values fell well within the interaction acceptance curve demonstrating the fuel is qualified.

This technical issue was assigned Action Item 0910GEN02, and dispositioned as Closed based on the information provided during the audit and the draft updated report, GEH report 003N0526, Revision 1, which was provided to the staff. Updates to the FSAR that would be needed related to the fuel in the racks were assigned to Action Item 022616002.

7. Review of the method for translating seismic demands computed from lumped mass stick models (LMSMs) in FSAR Section 3.7 into input loads for detailed finite element models used in structural design evaluation in FSAR Section 3.8

In order to review how the site-specific seismic demands developed in FSAR Section 3.7 are translated into input loads for detailed finite element models used in structural design evaluation in FSAR Section 3.8, the staff requested the applicant to provide relevant information and explanation of the process involved. In response, Dominion made a presentation on how the site-specific bounding seismic demands obtained from seismic analyses using the LMSMs are applied to the NASTRAN finite element models for static stress analyses. Dominion explained that the methodology used to convert North Anna 3 site-specific seismic loads from LMSMs to NASTRAN FEMs is identical to the methodology used in the standard design. Dominion also explained that the loads applied to the NASTRAN models represent the same distribution of the seismic load demands as those presented in the bounding reports (SER-DMN-019, SER-DMN-032).

The staff noted that Section 6.2.3.9.1 of the RB structural design report (WG3-U71-ERD-S-0004) describes how seismic loads are developed from RB/FB LMSMs and applied to RB/FB finite element models and that the same methodology is used for CB and FWSC. The global seismic loads from LMSMs are applied to NASTRAN finite element models at floor elevations corresponding to the LMSM nodal elevations. Dynamic soil pressure loads are applied on external below-grade walls and hydrodynamic loads are applied on walls and slabs of pools at their corresponding elevations. Dominion showed comparisons between the demands calculated from LMSM seismic analyses and the loads actually applied to the NASTRAN finite element models, which provides a check that the LMSM to NASTRAN FEM load translations are acceptable.

During the March 3, 2016 public meeting, the applicant indicated that the shear stiffness of the circular sections such as the RCCV and pedestal was considered effectively for only half of the cross section in the SSI analysis because the perpendicular portions of the circular sections are not significant contributors to the in-plane shear stiffness. This approach is consistent with common practice and the staff considered it acceptable. However, the plots for the shear forces shown in the public meeting indicated that shear forces were applied at all nodes along the entire circumferential direction in the design evaluation analysis, which the applicant stated that the plots showed only the directions but not the magnitude. Therefore, the staff requested the applicant to provide information describing the magnitude of shear forces applied at each nodal location when they are applied to circular sections. During the audit, the applicant showed the shear forces applied to the RCCV that have essentially equal magnitude for all nodes along the RCCV. The shear forces applied to the model for design analysis appeared to be inconsistent with how they were calculated in the SSI analysis. The staff asked the applicant whether the shear forces were only applied at the floor levels, and the applicant confirmed that was the case. Since the floor in-plane shear stiffness is relatively large, the shear forces applied equally to the circular sections will be redistributed by the floors to the RCCV elements based on their shear stiffness contribution. Therefore, the staff considered the approach used to apply the shear forces to circular sections does not affect the results, thus it is acceptable.

The staff identified texts in FSAR markup Sections 3G.7.5.2, 3G.8.5.2, and 3G.10.5.2 that may cause a confusion with respect to the number of degrees of freedom of seismic loads taken into account in structural design evaluation. In response, Dominion proposed new FSAR markups that add a statement, “Overturning moment loads applied at each floor elevation are also considered to account for the effects of floor rocking on the wall axial forces” to each affected Subsection in FSAR Appendix 3G, which was acceptable to the staff. The staff tracked the issue discussed as Action Item 020116005 and dispositioned it as Confirmatory at the conclusion of the audit.

8. Review of the evaluation of soft-soil subgrade stiffness properties used in North Anna 3 site-specific design evaluation of seismic Category I structures

North Anna 3 site-specific structural evaluations are based on the results of NASTRAN static structural analyses that considered the same generic “soft-soil” subgrade stiffness properties as those used in the standard design. The staff requested the applicant to provide a justification for considering generic soft-soil subgrade stiffness in evaluating the ESBWR seismic Category I structures for North Anna 3 rock site.

In response, Dominion explained that the site-specific evaluations are based on the results of static analyses performed on NASTRAN finite element models that are identical to those used for the standard design described in DCD Section 3G.1.4. These models consider the stiffness of the subgrade by using the same linear elastic spring elements and subgrade stiffness properties as those used for the standard design as described in DCD Section 3G.1.4.2. These spring elements that represent the generic soft-soil subgrade stiffness provide design demands that envelop the effects of the stiffer site-specific rock subgrade and foundation uplift with a few exceptions that nevertheless do not affect the conclusions of the site-specific evaluations. The staff noted that the results of sensitivity evaluations showed that amplifications at some locations due to the higher site-specific subgrade stiffness and foundation uplift are small and that the basemat design has sufficient margin to envelop the effects of the small amplifications due to the higher site-specific subgrade stiffness or foundation uplift. The results of Dominion’s sensitivity evaluations are documented in GEH Report SER-DMN-045, Revision 0, “Evaluation of Subgrade Stiffness Effects on Site-Specific Stress Analyses Results,” and GEH Report DBR-0018441, Revision 0, “Uplift Effect on North Anna 3 RB/FB Basemat Response.” Both reports were provided after the audit through the applicant’s electronic reading room. The staff reviewed these two reports and confirmed that they are consistent with the information reviewed during the audit.

Dominion also referenced GEH’s response to the staff’s ESBWR DCD RAI 3.8-13 in which GEH provided a justification for the use of generic soft-soil subgrade stiffness properties for DCD NASTRAN static analyses based on an evaluation which showed that soft-soil subgrade stiffness provided results enveloping those obtained from a model with hard-rock subgrade stiffness with a few minor exceptions. GEH also explained that the design of the basemat for the soft-soil conditions is conservative because the reinforcement in a given region of the basemat is based on the maximum moments calculated in that region rather than specifying different reinforcement to closely match the moment diagram across the basemat. Dominion also proposed an FSAR markup that captures the conclusion of the study, which was acceptable to the staff. The staff tracked the issue as Action Item 022616007B and dispositioned it as Confirmatory at the conclusion of the audit.

9. Review of the site-specific stress evaluation for North Anna 3 selected elements

During the public meeting on November 20, 2014 on Dominion's Seismic Closure Plan, the staff discussed with Dominion that given the North Anna 3 seismic ground motion exceeds the CSDRS, whether some locations in addition to the DCD selected elements should be evaluated during the North Anna 3 design evaluation. Dominion presented in the March 3, 2016 pubic meeting and documented in GEH report SER-DMN-036, Revision 0, their design evaluation of additional elements in RB/FB and CB, particularly at locations where North Anna 3 site-specific bounding seismic loads exceed the corresponding DCD seismic loads. There was no need for additional North Anna 3 site-specific elements for RCCV, CIS and FWSC as the DCD elements evaluated for these structures are considered sufficient. Design evaluations were performed for a total of 96 additional elements (62 for RB, 27 for FB, and 7 for CB) and Dominion concluded that no changes to the standard design concrete member dimensions are necessary, although there are 3 elements in the RB that required the use of the parabolic concrete stress-strain relationship that is also allowed by ASME. Most of the elements were adequate by simply using the linear concrete stress-strain curve as used in DCD. In addition 12 new rebar schedules have been designed and incorporated into structural drawings. The FSAR markup was provided during the audit and was found to be acceptable.

10. Review of the plant-specific SMA update including seismic fragilities and HCLPF values

The calculations supporting GEH report 003N1084, Revision 1, "North Anna Unit 3 Site-Specific Seismic Margins Analysis Update," include (1) DBR-0013327, Revision 0, "RB/FB Seismic Fragility," (2) DBR-0013611, Revision 0, "RCCV Seismic Fragility," (3) DBR-0013616, Revision 0, "RPV Support brackets Seismic Fragility," (4) DBR-0013613, Revision 0, "RPV Pedestal Seismic Fragility", (5) DBR-0013328, Revision 1, "CB Seismic Fragility", (6) DBR-0013618, Revision 1, "FWS Seismic Fragility", and (7) DBR-0013619, Revision 1, "FPE Seismic Fragility". The staff reviewed the overall assumptions, methods used for seismic fragility calculation, failure modes, capacity factors, and HCLPF values/uncertainties. The staff did not find any issues with these calculations. However, Section 2.1, Assumptions, of GEH report 003N1084, Revision 1, states that "Structural dimensions and various input factors to the fragility section's formulations are assumed." These assumptions were not explicitly identified in the supporting calculations and the dimensions and most input factors should have known values at the COL stage. During the audit, at the staff's request, DOM explained that that statement in GEH report 003N1084 was not accurate and will be removed, and an FSAR markup was provided to reference the new revision of this report.

11. Review of the site-specific ITAACs for Sesimic Category I Buried Piping, Conduits and Tunnels; seismic Category II structures (Turbine Building, Service Building, Ancillary Diesel Building, and Access Tunnel); Radwaste Building and Radwaste Tunnel

The staff reviewed the updated site-specific ITAACs for seismic Category II structures (Turbine Building, Service Building, and Ancillary Diesel Building) and Radwaste Building, and found them acceptable. The staff also reviewed the ITAACs for sesimic Category I Buried Piping, Conduits and Tunnels; seismic Category II Access Tunnel; and Radwaste Tunnel. In addition, the staff requested the applicant to revise ITAACs for the seismic Category II Access Tunnel and Radwaste Tunnel to use the same approach as seismic Category I structures. The staff reviewed the proposed markups for those updated ITAACs during the audit and found them acceptable. No other issues were found.

TABLE 1:
Seismic Reports and Supporting Calculations for Audit 2
Dominion North Anna 3 COLA Review

Row #	Doc Type	Document No.	Rev	Title	Primary or supporting	Notes
1	Report	S/VTR-SAS	I	Validation Test Report for SASSI 2010 Version 1	Supporting	
2	Report	SER-DMN-020	2	Validation Summary Report for SASSI 2010	Supporting	
3	Report	SER-DMN-011	1	Benchmarking of SASSI2010 MSM Results from NA3 Site-Specific SSI Analysis	Supporting	
4	Report	SER-DMN-014	1	Additional Oscillators for fully cracked model for RAI 3.7.2-14(f) Response	Supporting	
5	Report	SER-DMN-019	1	RB/FB Seismic Analyses Bounding Results and In-Structure Response Spectra	Primary	
6	Report	SER-DMN-032	3	North Anna 3 Seismic Soil-Structure Interaction Analyses Results for CB and FWSC Structural	Primary	
7	Report	SER-DMN-033	1	Evaluation of the Adequacy of the Frequencies Used for Seismic Response Analyses	Supporting	
8	Report	SER-DMN-034	2	Effects of Soil Separation of FWSC	Primary	
9	Report	WG3-U71-ERD-S-0001	4	Reactor/Fuel Building Complex Seismic Analysis Report	Primary	
10	Report	WG3-U71-ERD-S-0003	1	Reactor/Fuel Building Complex Stability Analysis Report	Primary	
11	Report	WG3-U73-ERD-S-0001	2	Control Building Seismic Analysis Report	Primary	
12	Report	WG3-U73-ERD-S-0002	6	Control Building and Firewater Service Complex Seismic Structure-Soil- Structure Interaction Analysis Report	Primary	
13	Report	WG3-U73-ERD-S-0003	2	Control Building Stability Analysis Report	Primary	
14	Report	WG3-U73-ERD-S-0005	3	Control Building and Reactor/Fuel Building Complex Seismic Structure-Soil-Structure Interaction Analysis Report	Primary	
15	Report	WG3-U63-ERD-S-0001	3	Firewater Service Complex Seismic Analysis Report	Primary	
16	Report	WG3-U63-ERD-S-0002	1	Firewater Service Complex Stability Analysis Report	Primary	

TABLE 1:
Seismic Reports and Supporting Calculations for Audit 2
Dominion North Anna 3 COLA Review

17	Report	002N8467	2	North Anna 3 Fuel Rack Seismic Analysis	Primary	Revision 3 will be issued on 03/21/2016
18	Design Information	TODI WG3-3-A25-TDI-0004	0	North Anna 3 Maximum Ground Water Level	Supporting	
19	Design Information	TODI WG3-3-A25-TDI-0005	5	North Anna 3 Power Block Excavation/Backfill Drawings, Concrete Backfill Properties and Plot Plan	Supporting	
20	Design Information	TODI WG3-3-A25-TDI-0006,	0	North Anna 3 Best Estimate Elevation of Top of Zone III Rock and Top of Zone III-IV Rock for RB/FB, CB and FWSC Structures	Supporting	
21	Design Information	TODI WG3-3-A25-TDI-5002	0	North Anna 3 OBE Damping Values for RPV Components	Supporting	
22	Design Information	TODI WG3-A25-TDI-S-0004	0	North Anna 3 RB/FB, CB and FWSC SSI Analyses EPRI 2013 GMPE Based Inputs	Supporting	
23	Design Information	TODI WG3-A25-TDI-S-0005	0	North Anna 3 RB/FB, CB and FWSC Distances from Adjacent Structures and Sheet Piling	Supporting	
24	Design Information	TODI WG3-A25-TDI-S-0006	0	North Anna 3 RB/FB, CB and FWSC Outcrop SSI Design Motion Time- Histories	Supporting	
25	Design Information	TODI WG3-3-A25-TDI-0007	0	North Anna 3 Engineering Properties of Subsurface Material for Sliding Stability Analysis	Supporting	
26	Design Information	TODI WG3-A25-TDI-S-0003	0	North Anna 3 Rock Allowable Bearing Pressure for Lateral Loading Conditions for the RB/FB, CB and FWSC	Supporting	
27	Design Information	TODI WG3-3-A25-TDI-0009	0	1E4 and 1E5 Digitized Site Amplification Factors from Bore Hole B-901, B- 907 and B-909 Soil Columns	Supporting	
28	Design Information	TODI WG3-A25-TDI-S-0002	1	Digital Data for Design Response Spectra Curves	Supporting	

TABLE 1:
Seismic Reports and Supporting Calculations for Audit 2
Dominion North Anna 3 COLA Review

29	Calculation	DBR-0006613	1	Site-Specific Seismic Soil-Structure Interaction Analysis of Reduced Stiffness RB/FB Models for Best Estimate and Upper Bound Full Columns	Supporting	
30	Calculation	DBR-0009791	5	Soil-Structure Interaction Absolute Acceleration Transfer Functions With Respect to Outcrop Motion and Design Motion Power Spectral Densities For RB/FB SSI, CB SSI, FWSC SSI, and CB-FWSC SSSI Analyses	Supporting	
31	Calculation	092-322-F-M-00001 DBR-0011230)	1	Design Report of the Spent Fuel Storage Racks in the Fuel Building for North Anna 3	Supporting	
32	Calculation	092-322-F-M-00002 (DBR-0011230)	2	Design Report of the New Fuel Storage Racks in the Reactor Building for North Anna 3	Supporting	
33	Calculation	092-322-F-M-00003 (DBR-0011230)	1	Design Report of the Spent Fuel Storage Racks in the Reactor Building for North Anna 3	Supporting	
34	Specification	26A7032AA	0	Fuel Storage Rack Design Specification.	Supporting	
35	Report	WG3-U71-ERD-S-0004	1	Reactor Building Structural Design Report	Primary	
36	Report	WG3-U73-ERD-S-0004	2	Control Building Structural Design Report	Primary	
37	Report	WG3-T11-DRD-S-0001	1	RCCV Structural Design Report	Primary	
38	Report	WG3-U97-ERD-S-0001	1	Fuel Building Structural Design Report	Primary	

39	Calculation	DBR-0016782	0	ESBWR NA3 FWS Seismic Fragility Sensitivity Study	Supporting	
40	Calculation	DBR-0016783	0	ESBWR NA3 FPE Seismic Fragility Sensitivity Study	Supporting	
41	Report	SER-DMN-037	0	NA3 Firewater Service Complex Structural Design Sensitivity Study	Supporting	
42	Report	SER-DMN-036	0	Site-Specific Stress Evaluation for NA3-Selected Elements	Supporting	
43	Calculation	DBR-0013618	1	FWS Seismic Fragility	Supporting	
44	Calculation	DBR-0013619	1	FPE Seismic Fragility	Supporting	
45	Report	003N1084	1	North Anna Unit 3 Site-Specific Seismic Margins Analysis Update	Primary	
46	Report	WG3-U63-ERD-S-0003	1	NA3 Firewater Service Complex Structural Design Report SUNSI version	Primary	
47	Report	DE-ES-0097	0	NA3 Fatigue Evaluation for Metal Parts of RCCV	Supporting	
48	Report	DE-ES-0087	0	Buckling Evaluation for Equipment Hatch	Supporting	
49	Report	DE-ES-0092	0	Buckling Evaluation for Drywell Head	Supporting	

TABLE 1:
Seismic Reports and Supporting Calculations for Audit 2
Dominion North Anna 3 COLA Review

50	Report	DE-ES-0088	0	Buckling Evaluation for Personnel Airlock	Supporting	
51	Report	DE-ES-0086	0	Buckling Evaluation for Wetwell Hatch	Supporting	
52	Report	003N0526	0	North Anna 3 Seismic Qualification of Spent Fuel in the Spent Fuel Racks	Primary	
53	Report	DE-ES-0096	0	NA3 RCCV Liner Anchorage Evaluation	Primary	
54	Report	DE-ES-0090	0	NA3 Local Analysis Model for GDCS Pool	Primary	
55	Calculation	DBR-0013327	0	North Anna Unit 3 RB/FB Seismic Fragility	Supporting	
56	Calculation	DBR-0013616	0	North Anna Unit 3 RPV Support Brackets Seismic Fragility	Supporting	
57	Calculation	DBR-0013613	0	North Anna Unit 3 RPV Pedestal Seismic Fragility	Supporting	
58	Calculation	DBR-0013611	0	North Anna Unit 3 RCCV Seismic Fragility	Supporting	
59	Calculation	DBR-0013328	1	North Anna Unit 3 CB Seismic Fragility	Supporting	
60	Report	WG3-T11-DRD-S-0002	0	NA3 ESBWR Structural Design Report for Containment Liner Plate	Primary	

TABLE 1:
Seismic Reports and Supporting Calculations for Audit 2
Dominion North Anna 3 COLA Review

61	Report	002N8530	3	NORTH ANNA 3 PCCS CONDENSER SEISMIC ANALYSIS	Primary	
62	Report	WG3-T12-ERD-S-0001	0	ESBWR Structural Design Report for Containment Internal Structures	Primary	Revision 3 will be issued on 03/21/2016
63	Report	DEES0084	0	NA3 Stress Analysis Report for Wetwell Hatch	Supporting	
64	Report	DEES0085	0	NA3 Stress Analysis Report for Personnel Airlock	Supporting	
65	Report	DE-ES-0082	0	NA3 Local analysis model for drywell head	Supporting	
66	Report	DE-ES-0081	0	NA3 Stress Analysis Report for Equipment Hatch	Supporting	
67	Report	WG3-T11-DRD-S-0003	0	NA3 Structural Design Report for Containment Metal Components	Primary	
68	Report	DEES0089	0	NA3 ESBWR Stress Analysis Report for Drywell Head	Supporting	
69	Report	002N8005	1	North Anna 3 Control Rod Seismic Analysis Report	Primary	
70	Report	WG3-002N9544	0	North Anna Unit 3 Site-Specific Supplement to NEDC-33240P-A, GE14E Fuel Assembly Mechanical Design Report	Primary	
71	Calc	25161-G-018	6	Engineering Properties of Subsurface Materials [Static]	Supporting	

72	Calc	25659-000-K0C-0000-00010	0	Soil Profile Simulation for RB/FB and CB	Supporting	Input to multiple FSAR 3.7 calcs Input to GEH analyses
73	Calc	25659-000-K0C-0000-00014	1	SSI Input Profiles for ESBWR RB/FB and CB	Supporting	Input to GEH analysis
74	Calc	25659-000-K0C-0000-00015	0	Soil Profile Simulation for FWSC	Supporting	Input to calc 25659-000-K0C-0000-00029
75	Calc	25659-000-K0C-0000-00026	1	Site Response Analysis, GMRS and FIRS for ESBWR RB/FB and CB - 2013 GMPE	Supporting	Input to GEH analysis
76	Calc	25659-000-K0C-0000-00027	0	Acceleration Time History Matching for RB/FB and CB FIRS Spectra, EPRI 2013 GMM	Supporting	Input to GEH analysis
77	Calc	25659-000-K0C-0000-00029	1	SSI Inputs for ESBWR RB/FB and CB - 2013 GMPE	Primary	Input to GEH analysis Input to GEH analysis Supporting (Input) Calcs/Docs: 25161-G-018 25659-000-K0C-0000-00010 25659-000-K0C-0000-00014 25659-000-K0C-0000-00026 25659-000-K0C-0000-00027 25659-000-V14-CY05-00033
78	Calc	25659-000-K0C-0000-00030	0	Site Response Analysis and FIRS Calculation for ESBWR FWSC - 2013 GMPE	Supporting	
79	Calc	25659-000-K0C-0000-00031	0	Development of Spectrum Compatible Time Histories for the FWSC Spectra at Elevations 220 ft. and 282 ft. EPRI 2013 GMM	Supporting	Input to GEH analysis

TABLE 1:
Seismic Reports and Supporting Calculations for Audit 2
Dominion North Anna 3 COLA Review

80	Calc	25659-000-K0C-0000-00033	0	SSI Inputs for FWSC - 2013 GMPE	Primary	Input to GEH analysis Supporting (Input) Calcs/Docs: 25659-000-K0C-0000-00015 25659-000-K0C-0000-00030 25659-000-K0C-0000-00031
81	Calc	25659-000-K0C-0000-00036	0	Sensitivity Analysis for SSI Input Time-histories in H1 Direction for CB Partially Embedded Analysis	Primary	Input to GEH analysis Supporting (Input) Calcs/Docs: 25161-G-018 25659-000-K0C-0000-00026 25659-000-K0C-0000-00027 25659-000-K0C-0000-00029
82	Calc	25659-000-V14-CY05-00033	V2	Deaggregation of 10-4, 10-5, and 10-6 Rock Hazard for North Anna using Updated Seismicity Files, 1000km Inclusion Distance, and the 2013 Ground Motion Model (LCI Calculation NAP001-PC-09, Rev. 1)	Supporting	

TABLE 2:

Dominion North Anna 3 NRC Seismic Audit March 21 through March 25, 2016, GEH Offices, Wilmington, North Carolina
Participants

Last name	First Name	Organization	Title
Brittner	Donald	NRC	Project Manager
Braverman	Joseph	NRC Contractor (BNL)	Technical Reviewer
Chakravorty	Manas K	NRC	Lead Technical Reviewer
Nie	Jinsuo	NRC	Technical Reviewer
Park	Sunwoo	NRC	Technical Reviewer
Shea	James	NRC	Lead Project Manager, North Anna 3
Wang	George	NRC	Technical Reviewer
Xu	Jim	NRC	Branch Chief
Borsh	Regina (Gina)	Dominion	Reg Affairs, Overall Dominion Team Lead
Hegner	Joseph (Joe)	Dominion	Licensing Manager
Waddill	John	Dominion	Technical Audit Support
Kemp	Douglas	Bechtel	Bechtel Lead
Hashemi	Alidad	Bechtel	Technical Audit Support
Hicks	Tom	Bechtel/Excel	Reg Affairs Audit Support
Schumitsch	Walter (Skip)	GEH	Project Management Overall GEH Lead
Kirby	Tanya	GEH	Engineering Management Technical Management Lead
Campbell	Patricia	GEH	Reg Affairs Audit Support
Dougherty	Lee	GEH	Reg Affairs Audit Support
Blake	Taylor	GEH	Technical Audit Support
Heiser	Matthew	GEH	Technical Audit Support
Liu	Ai Shen	GEH	Technical Audit Support
Todorovski	Luben	GEH	Technical Audit Support
Heiser	Mathew	GEH	Technical Audit Support
Johnson	Brian	GEH	Technical Audit Support
Wang	Richard	GEH	Technical Audit Support
Yawaew	Peter	GEH	Technical Audit Support
Lee	Kyung-Silk	GEH	Technical Audit Support
Moen	Stephen	GEH	Technical Audit Support
Tsutsumi	Junchi	GEH	Corporate Tokyo
Ikeda	Ryosuke	Shimizu	Technical Audit Support
Tsukada	Takaaki	Shimizu	Technical Audit Support
Gaillard	Pete	Fluor	Reg Affairs Audit Support
Suzuki	Ayako	HGNE	Technical Audit Support
Imamura	Yuichiro	HGNE	Technical Audit Support
Kanemaki	Yoshihiro	HGNE	Technical Audit Support

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