UNITED STATES
NUCLEAR REGULATORY COMMISSION
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December 21, 2016

Mr. Eric McCartney
Site Vice President
NextEra Energy Seabrook, LLC
P.O. Box 300, Lafayette Road
Seabrook, NH 03874

SUBJECT: ALKALI SILICA REACTION MONITORING AGING MANAGEMENT PROGRAM AUDIT REPORT REGARDING THE SEABROOK STATION, UNIT 1, LICENSE RENEWAL (CAC NO. ME4028)

Dear Mr. McCartney:

By letter dated May 25, 2010, NextEra Energy Seabrook, LLC submitted an application pursuant to Title 10 of the *Code of Federal Regulations* Part 54, to renew the operating license NPF-86 for Seabrook Station, Unit 1, for review by the U.S. Nuclear Regulatory Commission. During the week of October 24, 2016, the staff completed the on-site audit Alkali Silica Reaction Monitoring aging management program at Seabrook Station located in Seabrook, NH. The audit report is enclosed.

If you have any questions, please contact me by telephone at 301-415-3617 or by e-mail at Tam.Tran@nrc.gov.

Sincerely,

/RA/ ECS for

Tam Tran, Project Manager
Projects Branch 1
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket No. 50-443

Enclosure:
Audit Report

cc: Listserv

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Letter to Eric McCartney from Tam Tran dated December 21, 2016

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U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION, DIVISION OF LICENSE RENEWAL

SEABROOK ASR-MONITORING PROGRAM AUDIT REPORT

Docket No: 50-443

License No: NPF-86

Licensee: NextEra Energy Seabrook, LLC

Facility: Seabrook Station, Unit 1

Location: P.O. Box 300, Lafayette Road
Seabrook, NH 03874

Dates: October 24-28, 2016

Auditors: Angela Buford, Structural Engineer, Audit Team Leader, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR)
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Aging Management of Structures, Electrical, and Systems Branch
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Jessie Quichocho, Chief
Mechanical and Civil Engineering Branch
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Office of Nuclear Reactor Regulation

ENCLOSURE

SEABROOK ASR-MONITORING AND BUILDING DEFORMATION AGING MANAGEMENT PROGRAMS AUDIT REPORT

1. Introduction and Background

1.1 Introduction

The U.S. Nuclear Regulatory Commission (NRC) staff from the Office of Nuclear Reactor Regulation (NRR) Division of License Renewal and Division of Engineering performed an audit of the NextEra Energy Seabrook, LLC (NextEra, or the applicant) Alkali-Silica Reaction (ASR) Monitoring Aging Management Program (AMP) and Building Deformation AMP October 25-27, 2016. The audit was performed at the NextEra Energy Seabrook Station in Seabrook, NH and was focused on reviewing information related to the applicant's submittal dated August 9, 2016 (ADAMS Accession No. ML16224B079). The purpose of the audit was to (1) gain a better understanding of revisions to the applicant's plant-specific ASR Monitoring AMP, (2) review supporting documentation and technical bases information for the applicant's newly submitted Building Deformation AMP, and (3) identify the need for any additional information on the docket. These programs were submitted for the staff's review related to Open Item OI 3.0.3.2.18-1 in the safety evaluation report (SER) with Open Items (ADAMS Accession No. ML12160A374).

The regulatory bases for the audit were the requirements of Title 10 of the *Code of Federal Regulations*, Part 54 (10 CFR Part 54), "Requirements for Renewal of Operating Licenses for Nuclear Power Plants;" 10 CFR 54.17, "Filing of Application," which requires applicants for renewed licenses to send written correspondence to the NRC; 10 CFR 54.37, "Additional Records and Record Keeping Requirements," which requires that license renewal applicants maintain documents demonstrating compliance with the requirements of 10 CFR Part 54 in auditable and retrievable form. The audit provided the staff the opportunity to review supporting information retained as records under 10 CFR 54.37 that may not necessarily be required to be submitted as part of the license renewal application (LRA), but which provide additional information and technical bases for the submitted information. The staff performed its review in accordance with guidance provided in NUREG-1800, Revision 2, "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants" (SRP-LR), dated December 2010.

This audit report documents the results of the staff's activities during the audit.

1.2 Background

By letter dated May 25, 2010, the applicant submitted its application for license renewal for Seabrook Station, Unit 1. NextEra's LRA requested renewal of the operating license for an additional 20 years beyond the current 40-year license, which expires on March 15, 2030. In its letter dated May 16, 2012, the applicant supplemented its application to include a plant-specific ASR Monitoring program to manage the effects of aging due to ASR. The NRC staff conducted audits of the plant-specific ASR Monitoring AMP in November 2013 and October 2015. On April 28, 2016, the staff and NextEra held a public meeting to discuss the applicants December 2015 submittal, and NextEra subsequently submitted a revision to the LRA regarding the ASR open item. This revision was submitted to the NRC by letter dated August 9, 2016,

and included a revised LRA Appendix B Section B.2.1.31A, “Alkali-Silica Reaction (ASR) Monitoring” AMP and a new LRA Section B.2.1.31B, “Building Deformation Monitoring” AMP.

2. LRA AMP B.2.1.31A, ASR MONITORING PROGRAM AND AMP B.2.1.31B, BUILDING DEFORMATION MONITORING PROGRAM AUDIT SCOPE

2.1 Summary of Information Provided by the Applicant

The applicant’s August 9, 2016, letter describes the ten elements in both the ASR Monitoring and Building Deformation Monitoring AMPs. For the ASR Monitoring AMP, the LRA update states that the program uses periodic visual inspections to identify structures in the scope of the program (i.e., structures that have visible indications that ASR may be present). Once locations are identified, the type and frequency of monitoring is chosen based on a tiered criteria of ASR severity. The severity of ASR is initially determined based on combined cracking index (CCI) measurements of total crack widths in the “x”- and “y”- (i.e., horizontal and vertical) surface directions and also on individual crack width. In the most severe (“Tier 3”) locations, the program states that cracking through the thickness of the concrete (“z”-direction or through-wall) will be monitored using borehole extensometers installed in drilled core bore holes. The applicant stated that it plans to monitor CCI in the in-plane directions at frequencies dictated by the “Tier” assignment based on ASR severity.

Acceptance criteria for monitoring through-wall thickness is based on data that NextEra obtained from a large-scale testing program it conducted at the University of Texas at Austin, Ferguson Structural Engineering Laboratory. The results of the large-scale beam and block tests are correlated to ASR impact on Seabrook structures. The applicant asserts that (1) the testing program validates the use of expansion to measure ASR severity and monitor ASR progression, and (2) that the testing program affirms that ASR has no adverse effect on structural performance up to the magnitude of ASR expansion tested.

The LRA states that the program will determine expansion to date at locations selected for instrument installation. The methodology is discussed in a report MPR-4153, Revision 2, titled “Seabrook Station – Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction,” (hereafter referred to as MPR-4153), which was originally submitted to the NRC on June 30, 2015, and subsequently resubmitted on September 30, 2016. In this report, the applicant describes the basis for the proposed methodology to quantitatively relate the extent of ASR in existing plant structures at Seabrook to the large-scale testing results. The approach includes correlating measured through-wall expansion in large-scale test specimens and a corresponding reduction in modulus of elasticity with comparable loss in modulus of elasticity of cores drilled from Seabrook structures.

For the Building Deformation Monitoring Program, the LRA update states that the program for monitoring of structures for building deformation will be implemented on a structure by structure basis. The program will use visual inspections associated with the Structures Monitoring Program and CCI measurements associated with the ASR Monitoring AMP to identify buildings that are experiencing deformation. The results of the visual inspections will be input into an analytical model which will determine the methods and frequency of required inspections. The LRA states that the program will use a three-step process to screen for deformation and analyze the effects on structures, and the process will result in identifying threshold parameters to be

monitored. The three steps are: Stage One – Susceptibility Screening Evaluation; Stage Two – Analytical Evaluation; and Stage Three – Detailed Evaluation. The analysis will also establish acceptance criteria ("threshold limits") on a structure by structure basis. Once the parameters to be monitored and acceptance criteria are established for each structure, periodic inspections will obtain location-specific measurements, and those measurements will be compared against location-specific acceptance criteria to evaluate the acceptability of the condition. Frequency of examination is based on the Stage of evaluation or analysis (Stage 1, 2, or 3) that was used to baseline the structure.

The LRA states that inspections will also be performed to identify structures and components whose functionality may be affected by the building deformation of supporting structures and that these items will be entered into the Seabrook corrective action program.

2.2 Audit Activities

During its audit, the staff conducted interviews and discussion with the applicant's cognizant staff, consultants, and technical experts; performed walkdowns of the plant; and reviewed information generated by NextEra's contractor that provided detailed insights about the ASR Monitoring and Building Deformation Monitoring programs. In addition, the staff reviewed site implementing procedures, work orders, corrective action program issue reports, and periodic maintenance plans associated with the ASR issue. Specific activities included the following:

- Review of ASR Monitoring AMP implementation to date, including review of associated procedures and crack measurement results to date including document review, interviews with cognizant personnel, and walkdowns of areas that have installed extensometers in accordance with the program. The staff also witnessed sample testing of cores removed from areas of extensometer installation for modulus and compressive strength.

- Review of operating experience related to ASR-related macro cracking and building deformation in the residual heat removal (RHR) and core spray (CS) equipment vault, and methodology/plans for aging management. Staff also performed walkdowns of the RHR and CS equipment vault, fuel storage building, secondary containment exterior, and condensate storage tank area which have been or will be evaluated under the building deformation monitoring program.

- Review of recent operating experience related to ASR-related seismic gap reduction associated with a concrete missile shield and methodology/plans for aging management of the containment and containment enclosure building (CEB). Staff also performed a walkdown of the affected areas.

- Observed demonstration and review of a complete analysis that has followed the program methodology, including finite element analysis input and results; and consideration of the three-stage evaluation process approach to building deformation analysis (e.g., CEB).

- Observed demonstration and review of analyses being performed under each Stage of the Building Deformation Monitoring process for determining parameters monitored or

inspected and acceptance criteria (i.e., Containment Equipment Hatch Missile Shield, RHR vault, Condensate Storage Tank, and Containment Enclosure Building).

- Discussed status of large-scale testing program, reviewed documentation, and gained insights on the application of the testing program to the AMPs.

- The table below lists the documents that were reviewed by the staff and were found relevant to the audit. These documents were provided by the applicant.

Relevant Documents Reviewed

Document	Title	Revision / Date
1. EDS 36180	Structures Monitoring Program	Revision 9, 08/18/16
2. ES 1850.018	Structures Monitoring Program: Inspections, Data Gathering, and Evaluations	Revision 0
3. FP 100918	Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction	Revision 2, 09/08/16
4. FP 100985	Confirmation of As-Deformed CEB	Revision 1, 08/01/16
5. FP 101020	Seabrook Station Impact of Alkali-Silica Reaction on Structural Design Evaluations	Revision 0, 07/25/16
6. FP 101039	Development of ASR Load Factors For Seismic Category 1 Structures (Including Containment) At Seabrook Station	Revision 0, 08/01/16
7. FP 101050	Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali Silica Reaction	Revision 1, 07/25/16
8. MS0517.51	Installation of Geokon Snap-Ring Borehole Extensometers	Revision 3
9. Work Order 40494076 Task 01	SMP ASR Monitoring – Perform 6 Month Frequency CCI Measurements – “B” Train/Interior	
10. PM Requirement 00083478 01	SMP Building Deformation – Seismic Gap Data Collection Stage 3 Blds	
11. PM Requirement 00083486 01	SMP ASR Monitoring – Perform 6 Month Frequency CCI Measurements	
12. PM Requirement 00083479 01	SMP Building Deformation – Annulus Width Data Collection	

Document	Title	Revision / Date
13. PM Requirement 00083485 01	SMP Building Deformation – Evaluate Data Collected for CEB	
14. PEG-98	CEB Extent of Condition Equipment Walkdown	Revision 0
15. MS0517.53	Periodic Monitoring of Concrete Expansions Geokon Snap-Ring Borehole Extensometers	Revision 0

Audit Results. In its review of program elements one through ten against the corresponding guidance for each element described in SRP-LR, Appendix A.1, the staff found that for the "Scope of Program," "Parameters Monitored or Inspected," "Detection of Aging Effects," "Acceptance Criteria," and "Operating Experience" program elements, either (1) there is information audited by the staff (but was not on the docket) that is needed for the staff to make a safety conclusion regarding the adequacy of the program, or (2) sufficient information was not available to evaluate whether the AMPs were adequate for aging management. In order to obtain the information necessary to verify whether these program elements are adequate for sufficient aging management, the staff will consider issuing RAIs for the subjects discussed below.

ASR Monitoring Program

Parameters Monitored or Inspected

SRP-LR Section A.1.2.3.3 states that the "Parameters Monitored or Inspected" program element should identify the aging effects that the program manages and should provide a link between the parameter or parameters that will be monitored and how the monitoring of these parameters will ensure adequate aging management. The SRP-LR also states that the parameter monitored or inspected should be capable of detecting the presence and extent of aging effects. The staff noted that documentation regarding the applicant's large-scale testing program identifies volumetric expansion as a measure of ASR progression, but that the proposed ASR Monitoring AMP does not measure or evaluate volumetric expansion. In addition, the AMP states that combined cracking index will be used to measure the effects of rebar strain due to ASR expansion, but the AMP and audited information do not provide information on what actions will be taken to do this.

Detection of Aging Effects

SRP-LR Section A.1.2.3.4 states that the "Detection of Aging Effects" program element should describe "when," "where," and "how" program data are collected (i.e., all aspects of activities to collect data as part of the program). The staff noted that the ASR Monitoring AMP "detection of aging effects" program element does not specify the inspection interval planned for monitoring through-wall expansion using snap-ring borehole extensometers. The staff may request additional information to clarify the methods and frequencies of inspection(s) for "Tier 3" monitoring locations after the installation of extensometers.

Acceptance Criteria

The applicant's updated LRA submittal states in the "Element 6 – Acceptance Criteria" section, "[a] structural evaluation is needed when the CCI reaches what is classified as Tier 3 (CCI > 1 mm/m)." It is not clear to the staff to what the term "structural evaluation" is referring. Specifically, it is not clear whether this statement refers to the analysis referred to in Section B.2.1.31B (Building Deformation Monitoring Program), or if it refers to a different analysis that would be performed if a structure reaches "Tier 3" expansion as determined by CCI. Also, it is not clear what evaluation would be performed if the structure is not within the scope of Section B.2.1.31B and whether all structures within Section B.2.1.31B receive an analysis regardless of CCI. The staff may request that the applicant provide clarification on this issue.

Operating Experience

SRP-LR Section A.1.2.3.10 states that an applicant should commit to a future review of plant-specific and industry operating experience to confirm the effectiveness of its aging management programs or indicate a need to develop a new AMP.

The applicant's August 9, 2016, letter states that, with regard to large-scale testing:

- The results of the test program demonstrated that none of the assessed limit states are reduced by ASR when ASR expansion levels in plant structures are below those evaluated in the large-scale test programs.

- Results from the large-scale testing program are also used to support evaluations of structures subjected to deformation.

- Data from the structural testing programs have shown that expansion in the in-plane direction plateaus at low expansion levels, while expansion in the through-thickness direction continues to increase.

- A correlation relating expansion to reduction in elastic modulus was developed from the large scale testing program data. The correlation relating expansion to reduction in elastic modulus is applicable to reinforced concrete structures at Seabrook.

The staff noted that the methodology for computing through-wall expansion to-date is described in Report MPR-4135, which was submitted to the staff.

The "Operating Experience" program element of the ASR Monitoring AMP states "Seabrook will update the Aging Management Program for any new plant-specific or industry OE [Operating Experience]."

The applicant's statements indicate that there is an assumption that the actual structures subject to ASR at Seabrook will behave as observed in the test specimens. Although the test specimens have been created to be as "representative as practical" of Seabrook two-way reinforced concrete walls, the assumption that Seabrook ASR-affected concrete

will behave as seen in the test specimens has not been corroborated or validated. The staff has the following concerns:

- The methodology described in MPR-4135 has not yet been corroborated or validated. It is not clear whether the applicant plans to corroborate or validate, over sufficient time and prior to period of extended operation that the behaviors observed due to ASR in the testing specimens and assumed to correlate to Seabrook concrete structures are consistent.

- The effects of ASR degradation are being addressed as a first-of-a-kind issue in the United States nuclear power industry without a widely-accepted or standardized approach to addressing it, and the applicant's AMP is based primarily on the scope and data of one "plant-specific" large-scale test program. It is not clear if and how the AMP will corroborate or validate assumptions made once there is data available from implementation of the program to confirm the effectiveness of the ASR Monitoring AMP to manage aging effects for which it is credited.

The staff may consider requesting that the applicant explain whether and how the ASR Monitoring AMP will corroborate or validate assumptions (e.g., petrographic characteristics, reduction of elastic modulus at a given expansion, 'plateau' behavior of in-plane expansion, dominant out-of-plane expansion, lack of evidence of in-plane cracking) about how structures at Seabrook would behave under ASR expansion based on observations from the testing program and if not, to provide technical basis.

Building Deformation Monitoring Program

Scope of Program

SRP-LR Section A.1.2.3.1 states that the "Scope of Program" program element should include the specific structures and components, the aging of which the program manages. The applicant's August 9, 2016, submittal states "[t]he Seabrook Building Deformation Monitoring Program provides for management of the effect of building deformation on Seismic Category 1 structures and associated components within the scope of license renewal." Also included is a list in Section B.2.1.31A of concrete structures within the scope of the license renewal structures monitoring program that will be monitored by the ASR Monitoring AMP and a list in Section B.2.1.31B of structures that will be managed by the Building Deformation program. The staff reviewed implementing documentation and a list of structures to be evaluated under the Building Deformation program and found discrepancy between the structures listed in the implementing documentation and the August 9, 2016, submittal. Specifically, the Seismic Category 1 Control Building, Diesel Generator Building, and Service Water Access (Inspection) Vault were not captured in the implementing documentation. It is not clear whether those structures are included in implementation of the Building Deformation program. It is also unclear why the list of structures managed does not match between Section B.2.1.31A and Section B.2.1.31B; specifically, why the non-Category I structures in the ASR Monitoring AMP are not included in the Building Deformation Program. The staff may request that the applicant confirm whether the Seismic Category 1 Control Building, Diesel Generator Building, and Service Water

Access (Inspection) Vault are included in the Building Deformation Program or explain why not. In addition, the staff may request that the applicant explain why the non-Category I structures in the ASR Monitoring AMP are not included in the Building Deformation Program.

Parameters Monitored or Inspected/Detection of Aging Effects/Acceptance Criteria

SRP-LR Section A.1.2.3.3 states that the "Parameters Monitored or Inspected" program element should identify the aging effects that the program manages and should provide a link between the parameter or parameters that will be monitored and how the monitoring of these parameters will ensure adequate aging management. The SRP-LR also states that the parameters monitored or inspected should be capable of detecting the presence and extent of aging effects. SRP-LR Section A.1.2.3.4 "Detection of Aging Effects" states that the program element describes "when," "where," and "how" program data are collected. For a condition monitoring program the discussion should provide justification that the [monitoring] method and frequency are adequate to detect aging effects before a loss of SC-intended function. SRP-LR Section A.1.2.3.6 "Acceptance Criteria" states that the acceptance criteria, against which the need for corrective actions are evaluated, could be specific numerical values or could consist of a discussion of the process for calculating specific numerical values of conditional acceptance criteria to ensure that the structure- and component-intended function(s) will be maintained under all current licensing basis (CLB) conditions.

In Section B.2.1.31B of its updated LRA, the "Parameters Monitored or Inspected" program element describes a methodology for identifying parameters to monitor for each in-scope structure. The methodology includes three "Stages" of analysis or evaluation, one or more of which will be applied to each structure, that will result in threshold parameters to monitor, each with threshold limits (i.e., monitoring acceptance criteria), and a specified monitoring frequency depending on the "Stage" of analysis that was applied to the structure. The applicant stated that "[a] set of monitoring elements (consisting of strain measurements, deformation measurements, seismic gap measurements, and/or other quantifiable behaviors) is established along with threshold limits for each monitoring element." The building deformation monitoring frequency for structures for each stage are provided in Table 1 of Enclosure 4 of the August 9, 2016, submittal.

The staff reviewed implementing documentation for the Building Deformation monitoring program and interviewed cognizant staff. The staff noted that the program does not have one set of parameters monitored or acceptance criteria, but that the applicant establishes a set of parameters to monitor and acceptance criteria for each structure. The staff also noted that the baseline structural evaluations to establish the criteria for each structure's individual building deformation monitoring were not complete for all structures in the scope of the program, and therefore the applicant could not provide the parameters monitored and monitoring method(s) for all of the structures. The staff was also not provided comprehensive documentation of the process for performing the evaluations, including, but not limited to: (1) a detailed list of the possible monitoring parameters and monitoring method(s) for those parameters; (2) the process for determining what stage of analysis will be used for a given structure; (3) the process for determining that another analysis (different stage) is necessary; and (4) the process for

selecting what parameters will be monitored and their monitoring method(s). For example, the section titled “Stage Two: Analytical Evaluation” states that “additional inspections are performed to measure structural strains and deformations at a broader range of critical locations of the structure.” It is not clear to the staff whether there is a procedure for performing the additional inspections, including location and number of additional inspections, or a repeatable process for determining when adequate information has been gathered.

Without either the list of parameters monitored for each structure or comprehensive understanding of the procedures and methodology for determining the parameters to be monitored and monitoring method(s) such that it is clear that the process is repeatable, the staff is not able to verify that the “parameters monitored or inspected” and “detection of aging effects” program elements are adequate in accordance with the SRP-LR. The staff may request that the applicant provide, for each structure, a list of parameters monitored and their monitoring method(s), or provide a comprehensive discussion of the processes and procedures for determining the parameters to monitor and monitoring method(s) for structures within the scope of the Building Deformation Program in a manner that would demonstrate repeatability of the process.

Aging Management Review (AMR)

The staff also identified the need for additional information applicable to the applicant’s AMR. NRC regulations in 10 CFR 54.21(a)(3) state that for each structure and component (SC) subject to an AMR, as identified in an applicant’s integrated plant assessment, the applicant must demonstrate that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation. The applicant stated in the “Scope of Program” program element that the Building Deformation AMP “provides for management of the effect of building deformation on Seismic Category 1 structures and associated components within the scope of license renewal. Program scope includes components within the scope of license renewal contained in concrete structures within the scope of the Structures Monitoring Program.” However, the LRA submittal does not include Table 2 AMR line items for those components.

It is not clear whether the applicant identified whether building deformation would result in aging effects not previously considered in the LRA and if the applicant evaluated the need to revise the LRA AMR tables associated with the affected SCs such that management for this aging effect would be captured in the LRA. In addition, it is not clear if the other program(s) that manage any affected components employ the methods and frequency of inspection to bound those of the Building Deformation program to ensure adequate aging management for affected components.

Therefore, the staff may consider requesting that the applicant provide the results of any evaluation in accordance with the requirements of 10 CFR 54.21(a) that demonstrates that for all SCs affected by building deformation caused by ASR expansion, that either (1) the Building Deformation program will specifically inspect and manage for the effects of building deformation; (2) building deformation will not result in behavior of supported SCs that was not previously considered; or (3) the other AMPs that manage aging of the

SCs are adequate to ensure that the effects of building deformation do not prevent the SCs from performing their intended functions.

2.3 Exit Meeting

A final briefing was held with the applicant on October 27, 2016, to discuss the results of the ASR Monitoring and Building Deformation Monitoring AMP audit.

3. AUDIT PARTICIPANTS

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- Brian Wittick, Branch Chief, DLR, NRR
- Angela Buford, Audit Team Lead, DLR, NRR
- George Thomas, Senior Structural Engineer, DLR, NRR
- Bryce Lehman, Structural Engineer, DE, NRR
- Benjamin Beasley, Acting Deputy Director, DLR, NRR

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- Ken Browne, NextEra Energy Seabrook (NEE-SBK)
- Edward Carley, NEE-SBK
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