UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PENNSYLVANIA 19406-2713

August 9, 2013

Mr. Kevin Walsh
Site Vice President
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael Ossing
P.O. Box 300
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT NO. 1 - CONFIRMATORY ACTION LETTER FOLLOW-UP INSPECTION - NRC INSPECTION REPORT 05000443/2012010

Dear Mr. Walsh:

On June 27, 2013, the U. S. Nuclear Regulatory Commission (NRC) completed a team inspection at Seabrook Station, Unit No. 1. The enclosed inspection report documents the inspection results, which were discussed with you and other members of your staff.

The team inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. Specifically, the team reviewed selected procedures and records, observed activities, and interviewed station personnel regarding the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures. The team reviewed selected Confirmatory Action Letter (CAL) 1-2012-002 commitments for adequacy and closure.

The NRC determined that the eleven actions committed to in the CAL have been satisfactorily completed. The team independently verified that NextEra had appropriately assessed and determined that all ASR-affected structures remain operable. The team also confirmed that your root cause evaluation was thorough and identified appropriate corrective actions.

Many important corrective actions necessary to resolve this issue are currently in progress and related commitments are documented in your ASR Project Corrective Action Program. These actions include your planned two-year test program of ASR-affected large scale concrete specimens at the University of Texas, Ferguson Structural Engineering Laboratory (FSEL). Therefore, while our review of the CAL items was completed during this inspection, the NRC will continue to provide oversight of both NextEra's testing program at the FSEL and onsite ASR-related activities. The NRC is in the process of evaluating the technical inspection results discussed in this report to inform our future regulatory decision regarding the status of the CAL. The results of our evaluation will be provided to NextEra in a future correspondence.

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and require additional consideration and information beyond that discussed in this report.

In accordance with 10 CFR 2.390 of the NRCs "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the NRC's document system (ADAMS). ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Raymond K. Lorson, Director
Division of Reactor Safety

Docket No. 50-443
License No: NPF-86

Enclosures:
1. Inspection Report No. 05000443/2012010
   w/ Attachment: Supplemental Information
2. Confirmatory Action Letter 1-2012-002
3. Revision to Confirmatory Action Letter 1-2012-002

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Enclosure

It should be noted that the inspection team results are based solely on Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 requirements. The NRC is currently in the process of conducting a separate review of the ASR issue as part of the license renewal process in accordance with 10 CFR Part 54. As such, certain aspects of the ASR issue discussed may also have applicability to the license renewal review and require additional consideration and information beyond that discussed in this report.

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Sincerely,

*/RA/*

Raymond K. Lorson, Director
Division of Reactor Safety

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**U.S. NUCLEAR REGULATORY COMMISSION**

**REGION I**

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|---|---|
| Docket No.: | 50-443 |
| License No.: | NPF-86 |
| Report No.: | 05000443/2012010 |
| Licensee: | NextEra Energy Seabrook, LLC |
| Facility: | Seabrook Station, Unit No. 1 |
| Location: | Seabrook, New Hampshire 03874 |
| Dates: | November 3, 2012 to June 27, 2013 |
| Inspectors: | W. Cook, Team Leader, Division of Reactor Safety (DRS)<br>S. Chaudhary, Reactor Inspector, DRS<br>W. Raymond, Senior Resident Inspector<br>A. Buford, Structural Engineer, Division of License Renewal (DLR), Office of Nuclear Reactor Regulation (NRR)<br>G. Thomas, Structural Engineer, Division of Engineering, NRR<br>A. Sheikh, Senior Structural Engineer, DLR, NRR<br>N. Floyd, Reactor Inspector, DRS |
| Approved by: | James Trapp, Chief, Engineering Branch 1<br>Division of Reactor Safety |

## SUMMARY OF FINDINGS

IR 05000443/2012010; 11/03/2012 - 06/27/2013; Seabrook Station, Unit No. 1; Confirmatory Action Letter (CAL) Follow-up Inspection Report.

This report covered several weeks of onsite inspection at Seabrook Station, two weeks of inspection at the Ferguson Structural Engineering Laboratory (FSEL) University of Texas – Austin, and periodic in-office reviews, over the past eight months, by region-based inspectors and headquarters reviewers to assess the adequacy of NextEra's actions to address the impact of Alkali-Silica Reaction (ASR) on reinforced concrete structures at Seabrook Station. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

**Cornerstone: Mitigating Systems**

During this second CAL follow-up inspection, the team examined the remaining six commitments documented in CAL No. 1-2012-002, dated May 16, 2012. The CAL items reviewed and closed during this inspection were 2, 4, 7, 8, 9 and 11. In addition, a number of observations documented in the first CAL follow-up inspection (NRC Inspection Report 05000443/2012009, Section 9.0) were reviewed and closed in this report. Closure of CAL Item 7 was administrative, in that, NextEra had withdrawn this commitment by letter dated December 13, 2012 (ML12362A323). NextEra's revision to this commitment was approved by the NRC as documented in the CAL revision letter, dated January 14, 2013 (ML13014A555).

The review and closure of each CAL item signifies the NRC's satisfactory assessment of NextEra's commitments and planned corrective actions to address the ASR non-conforming condition at Seabrook Station. However, the completion of the CAL follow-up inspections does not represent the completion of NRC review and oversight of NextEra's actions to address the ASR issue. As discussed in the team's review of CAL Item 4 and the revised ASR Project Corrective Action Plan (CAP), NextEra has planned a number of ongoing activities, in addition to the FSEL testing program, to address ASR-affected structures.

NextEra's root cause evaluation (CAL Item 2) appropriately identified the significant causal and contributing factors resulting in ASR impacting reinforced concrete structures at Seabrook Station. NextEra's ASR Project CAP (CAL Item 4), provided in a letter to the NRC (ML13151A328), sufficiently captures the corrective actions taken and planned to address the ASR non-conforming condition and will remain in place to track the resolution of ASR at Seabrook Station.

The Mortar Bar Testing (CAL Item 6, reference NRC Inspection Report 05000443/2012009) was successfully completed, and the results indicated sufficient reactive silica and alkali in the Seabrook structures to allow the progression of ASR for the foreseeable future. Consequently, NextEra withdrew its commitment for Prism Testing (CAL Item 7), and the NRC staff administratively closed this commitment. The team reviewed NextEra's large specimen testing program technical specifications (CAL Item 8) and anchor testing program description (CAL Item 11) and concluded that these programs were sufficiently developed and described to support an understanding of the testing plans and objectives.

NextEra implemented a number of enhancements to the Structures Monitoring Program (CAL Item 9) to adequately monitor the progression of ASR. The team concluded these monitoring actions were consistent with currently available industry practices.

Lastly, the team completed a follow-up and review of a number of observations discussed in the first CAL Follow-up Inspection Report, including: pending structural evaluations; containment prompt operability determination (POD) observations; core sample material property testing; quantification of pre-stressing effects of ASR expansion; additional rebar examinations; crack indexing use in the SMP; and the Phase 3 walkdown plans and schedule.

## REPORT DETAILS

### 1.0 Background

Alkali-Silica Reaction (ASR) is a chemical reaction occurring in hardened concrete that can change the physical properties of concrete and affect structural performance. In June 2009, NextEra identified potential degradation in below-grade concrete structures at Seabrook. In August 2010, NextEra completed petrographic evaluation of concrete core samples, which confirmed ASR as the degradation mechanism. The degraded condition in numerous Seabrook Category I structures was evaluated in the Corrective Action Program, and prompt operability determinations (PODs) were performed. NextEra revised the PODs as new information became available and improved analytical techniques were incorporated.

NextEra initially used the results of mechanical testing of concrete core samples to assess the degree of structural degradation due to ASR. This is a traditional method described in American Concrete Institute (ACI) 228.1R, "In-Place Methods to Estimate Concrete Strength," for assessing existing concrete structures. NextEra tested the cores for compressive strength and elastic modulus. NextEra used the methods defined in construction and design code ACI 318-1971, "Building Code Requirements for Reinforced Concrete," to evaluate the structural capacity (operability) of the ASR-affected structures. However, the mathematical relationships in ACI-318 are based on empirical data from testing of non-degraded concrete, and these relationships may not be valid for ASR-affected concrete.

After further review of industry experience and literature pertaining to ASR, NextEra engineering concluded that the core test data was not indicative of structural performance of ASR-affected reinforced concrete structures. NextEra's engineering evaluation stated that once the cores are removed from the structure, concrete core samples are no longer subject to the strains imposed by the ASR-related expansion or restraints imposed by the steel reinforcing cage. The engineering evaluation also stated that confinement provided by steel reinforcing bars (rebar) and other restraints limit ASR expansion of the concrete within the structure and thereby limit the adverse impact on structural performance. Therefore NextEra engineering concluded that the reduction of mechanical properties observed in mechanical testing of cores was not representative of in-situ concrete performance. Based on this conclusion, NextEra suspended taking core samples to evaluate the concrete mechanical properties of structures impacted by ASR and revised the operability assessment approach. NextEra's current approach for assessing structural integrity and operability is to compare available design margins to an assumed reduction in structural capacity due to ASR.

NextEra's operability evaluations were based upon an examination of available design margins and a presumed ASR-caused reduction in structural design capacities. The details of this methodology and related assumptions were developed in NextEra's Interim Assessment (FP 100716). The assessment assumed lower-bound values of structural capacity for ASR-affected concrete for limit states based on research test data, primarily from small-scale test specimens. The assessment focused on the structural limit states that are the most sensitive to ASR effects (i.e., out-of-plane shear capacity, lap splice development length, and anchorage capacity). The assessment determined that even after applying lower-bound values to structural limit states to assume ASR effects, the structures were suitable for continued service. A final operability assessment will be conducted by NextEra following evaluation of

structural performance based on a proposed large-scale testing program of beam specimens representative of Seabrook reinforced concrete structures. The test program has been initiated at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin (UT-A), with some testing (anchors) commenced in 2013 and large beam testing scheduled to be completed by 2015. Based upon the slow progression of the ASR expansion, the current operability evaluations, coupled with the Structures Monitoring Program six-month combined crack indexing, provide reasonable assurance of continued structural operability.

## 2.0 Confirmatory Action Letter 1-2012-002

Confirmatory Action Letter 1-2012-002, dated May 16, 2012, was written to confirm commitments by NextEra (established during a meeting with NRC management and staff on April 23, 2012) with regard to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook Station. In response to the CAL, NextEra committed to provide information to the NRC staff to assess the adequacy of NextEra's corrective actions to address this significant condition adverse to quality. CAL 1-2012-002 and the revision to the CAL are provided as an Enclosure to this report. The NRC staff also formed a working group to provide appropriate oversight of NextEra's activities to address ASR and to coordinate NRC inspection and review activities. The ASR Working Group Charter (ML121250588) outlines the regulatory framework and general acceptance criterion for NRC oversight and review of this issue. As documented in NRC Inspection Report No. 05000443/2012009, dated December 3, 2012 (ML12338A283), CAL Items 1, 3, 5, 6, and 10 were closed. Based on the results of this inspection, the remaining six CAL Items 2, 4, 7, 8, 9, and 11 are closed.

## 3.0 Review of Alkali-Silica Reaction Root Cause Evaluation (CAL Item 2)

Inspection Scope

As documented in Inspection Report No. 05000443/2012009, the team reviewed NextEra's response to CAL Item 2, "Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012." The licensee submitted its root cause evaluation (RCE) in a letter to the NRC dated May 24, 2012 (ML12151A396). Based upon the team's initial review, the inspectors concluded that the second root cause identified was not sufficiently characterized in NextEra's May 24, 2012, submittal. Specifically, NextEra did not clearly describe the performance and organizational factors that contributed to inadequacies in the Structures Monitoring Program (SMP) and the failure of the Seabrook staff to have identified ASR degradation of reinforced concrete structures sooner. The team discussed this observation with the responsible Seabrook staff. NextEra determined that a revision to the RCE was warranted and revised the RCE to more appropriately develop and characterize this second root cause and the associated corrective actions.

NextEra submitted a revised RCE summary for NRC review in a letter dated May 1, 2013 (ML13151A328, Enclosure 1). The team reviewed the revised RCE summary for clarity and appropriateness of associated corrective actions, consistent with guidance outlined in 10CFR50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Corrective Action Program.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 2 is closed.

As documented in Enclosure 1 to the May 1, 2013 letter, NextEra summarized the two root causes as follows: RC1 – the ASR developed because the concrete mix design unknowingly utilized a coarse aggregate that would, in the long-term, contribute to ASR. Although the testing was conducted in accordance with American Society for Testing and Materials (ASTM) standards, those testing standards were subsequently identified as limited in their ability to predict slow reacting aggregate that produced ASR in the long-term; and RC2 – based on the long-standing organizational belief that ASR was not a credible failure mode due to the concrete mix design, dispositions for condition reports involving groundwater intrusion or concrete degradation, along with the structures health monitoring program, did not consider the possibility of ASR development. In addition, NextEra identified a contributing cause that its organization did not prioritize groundwater elimination or mitigation, resulting in more concrete area exposed to moisture.

The team verified that NextEra had appropriately identified the root cause(s). The ASTM concrete aggregate testing standards in effect at the time of plant construction were properly implemented, but later determined to be ineffective in identifying slow-reacting, ASR-susceptible aggregates. Those standards were subsequently revised by the industry and adopted by NextEra to prevent recurrence. NextEra's RCE concluded that the Structures Monitoring Program did not remain current with concrete industry operating experience and associated failure modes, such as ASR. Contributing to the shortcomings of the SMP in not identifying this concrete degradation mechanism earlier was the "organizational mindset" that the groundwater in-leakage was an operational nuisance and nothing more. Consequently, station and engineering staffs were insensitive to the potential detrimental effects of the groundwater infiltration and did not assess the long-term impact on station structures. NextEra's implementation of a broad periodic review process to ensure all systems and component monitoring programs remain current and effective was determined by the team to be an appropriate corrective action for this causal factor.

## 4.0 Integrated Corrective Action Plan (CAL Item 4)

Inspection Scope

CAL No. 1-2012-002 documented NextEra's commitment to submit, by June 8, 2012, a corrective action plan for the continued assessment of ASR in concrete structures at Seabrook Station, including development of remedial actions to mitigate the effects of ASR where

warranted. By letter dated June 8, 2012 (ML12171A227), NextEra submitted its integrated corrective action plan (CAP) for NRC review. The CAP outlined the major elements of diagnosis, evaluation, prognosis and mitigation of ASR-affected structures as understood at the time. Since June 8, 2012, NextEra has made considerable progress in refining the elements of this plan, implementing the initial phases, and more clearly defining and focusing future actions. NextEra provided an updated ASR Project CAP in a letter dated May 1, 2013 (ML13151A328, Enclosure 2) to document these plan changes.

During this inspection period, the team conducted numerous discussions, meetings, and conference calls with NextEra, as well as onsite inspections at both Seabrook Station and UT-Austin to review NextEra's actions to address the ASR-affected reinforced concrete structures. From these interactions, the CAP has developed greater clarity of the necessary steps (corrective actions) to address this non-conforming condition impacting safety-related reinforced concrete structures. As previously documented in Inspection Report 05000443/2012009 and detailed in other sections of this report, the team assessed the adequacy of completed and ongoing ASR-related activities identified in the integrated CAP, consistent with guidance outlined in 10CFR50, Appendix B, Criterion XVI, "Corrective Action," and NextEra's Quality Assurance Program.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 4 is closed. NextEra's ASR project staff stated that they plan to maintain the ASR Project CAP as a "living document" and will update it periodically to capture completion of activities and add new actions, as appropriate.

## 5.0 Prism Testing Commitment Withdrawn (CAL Item 7)

Inspection Scope

CAL Item 7 committed NextEra to "Complete long-term aggregate expansion testing (ASTM C 1293, Concrete Prism Test) by June 30, 2013." The purpose of this CAL item was to determine, in conjunction with the Mortar Bar Testing (CAL Item 6), if the coarse aggregate contributing to ASR in Seabrook reinforced concrete still contained sufficient reactive silica for the alkali-silica reaction to continue long-term under the existing environmental conditions. Alternatively, these tests could demonstrate that the progression of ASR at Seabrook could be self-limiting due to the depletion of reactive silica in the concrete. The Prism Test (as defined by ASTM C1293) involves monitoring the expansion (by measurement of specimen elongation due to ASR) of the test specimen (a molded concrete brick approximately 3 by 5 by 12 inches in length) over a one-year period. Expansion in excess of 0.04% is considered potentially deleterious and a positive test for slow-reactive aggregate. The Prism Test is similar to the Mortar Bar Test (reference ASTM C1260), but has a duration of 14 days and an expansion limit of 0.1%.

Based upon the results of the completed Mortar Bar Expansion Testing (reference NRC Inspection Report No. 05000443/2012009, Section 5.0), NextEra concluded that the available quantities of silica in the concrete would not be depleted in the near term and that additional confirmatory testing via the Prism Test method was not warranted. NextEra ran the Mortar Bar Test several weeks beyond the 14-day test (terminated after 103 days) and observed that the alkali-silica reaction was still progressing at the conclusion of the test, indicating the presence of sufficiently reactive aggregate to maintain ASR for a longer period of time. The team noted that the Mortar Bar Test involved the reuse of aggregates from Seabrook test cores (concrete that had already experienced appreciable ASR) and similar aggregate from concrete not affected by ASR. The side-by-side comparison of the test specimens showed no appreciable difference in ASR progression or observed expansion rates. Accordingly, NextEra concluded the Prism Test would add no significant knowledge to the condition assessment of Seabrook concrete. NextEra concluded that all Seabrook reinforced structures are or may be affected by ASR, unless specifically ruled out by further analysis, such as petrographic examination. By letter dated December 13, 2012, NextEra requested that CAL Item 7 be deleted. As documented in NRC letter dated January 14, 2013 (ML13014A555), the NRC accepted NextEra's technical basis for deleting CAL Item 7.

Findings and Observations

No findings were identified. CAL Item 7 is administratively closed.

## 6.0 Review of Technical Details of Large Specimen Testing Program (CAL Item 8)

Inspection Scope

CAL Item 8 committed NextEra to "Submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012." By letter dated June 21, 2012 (ML12179A281), NextEra submitted the Shear and Lap Splice Testing overview prepared by the Ferguson Structural Engineering Laboratory (FSEL) at the University of Texas at Austin, dated March 15, 2012. The purpose of the test program, as described in the FSEL document, is to provide sufficient data and insights to establish the current and future implications of ASR on Seabrook reinforced concrete structures. Since there is limited available literature or test data relative to the impact of ASR on walls without transverse shear reinforcements (i.e., the majority of Seabrook ASR-affected structures), destructive testing of ASR-affected test specimens is being conducted to evaluate the impact of ASR on out-of-plane shear strength and lap splice development. The test specimens being prepared at FSEL will be of representative scale and design such that the test results may be correlated to Seabrook structures.

The team reviewed the June 21, 2012, submittal and conducted a conference call on December 18, 2012, with the NextEra and UT-Austin FSEL staff to discuss the merits of the proposed test program. Based upon the complexity of the information discussed and follow-up inspection activities, NextEra prepared a test program overview document and a detailed test

specification to supplement the June 21, 2012, CAL response letter. By letter dated May 1, 2013 (ML13151A328 redacted and ML13151A291 un-redacted), NextEra provided the NRC with the "Seabrook Station - Specification for Shear and Reinforcement Anchorage Testing of ASR-Affected Reinforced Concrete," (Enclosures 3 & 4) and "Approach for Shear and Reinforcement Testing of Concrete Affected by Alkali Silica Reaction," (Enclosure 5 & 6). Each of these documents has a proprietary and non-proprietary version.

The team reviewed the revised testing specification and the associated overview document to verify that the overall test program approach and application of test results would reasonably address the Seabrook ASR-affected concrete non-conforming condition. The team discussed the test program with the FSEL, MPR and responsible NextEra engineering staffs.

Findings and Observations

No findings were identified. Based upon team review of the submitted testing program documents and related inspection activities, the team concluded that NextEra has provided an appropriate level of detail of the proposed large-scale specimen testing program, and CAL Item 8 is closed.

As documented in NextEra's ASR Project CAP (ML 13151A328, Enclosure 2), and assuming satisfactory outcomes, the acceptance of the testing results to resolve ASR concerns associated with design basis structural calculations may follow the regulatory process for approval and would include evaluations pursuant to 10CFR50.59 and 10CFR50.90. The submitted test plans satisfy NextEra's commitment to explain the scope and depth of the large-scale specimen testing program.

## 7.0 Review of Structures Monitoring Program (CAL Item 9)

Inspection Scope

CAL Item 9 committed NextEra to implement an update to the Maintenance Rule (10CFR50.65) Structures Monitoring Program (SMP) to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. NextEra issued Revision 2 to Structural Engineering Standard 36180, "Structural Monitoring Program," effective July 12, 2012. The primary changes incorporated in Revision 2 to the SMP were: 1) performing periodic (every six months) crack indexing measurements at 26 locations to collect quantitative information on the progression of ASR expansion/degradation; 2) establishing crack width (1.0 mm or greater) and Combined Crack Index (1.0 mm/m or greater) thresholds for conducting structural evaluations (reference Foreign Print 100716, Seabrook Station: Impact of ASR on Concrete Structures and Attachments); and 3) the addition of Federal Highway Administration (FHWA) document FHWA-HIF-09-004, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures," dated January 2010, as a reference.

The team reviewed the adequacy of these changes to the SMP to monitor ASR in Seabrook reinforced concrete structures. While not endorsed by the NRC or committed to by NextEra in Seabrook's licensing basis, the team used the American Concrete Institute (ACI) Committee Report 349.3R-96, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," as a reference to assess the adequacy of the revisions made to the SMP for monitoring the progression of ASR.

Based in part on NRC observations, NextEra issued Revision 3 to the SMP on April 30, 2013. The SMP enhancements are: 1) the addition of periodic (every 30 months) combined crack indexing (CCI) measurements at 72 discrete locations identified as Tier II (Acceptable with Deficiency) areas (CCI values between 0.5 mm/m and 1.0 mm/m, or crack widths greater than 0.2 mm, but less than 1.0 mm) to collect quantitative information on the progression of ASR expansion/degradation (this monitoring was being performed, but not documented in the SMP); and, 2) inclusion of the periodic groundwater sampling program for monitoring of chemical attributes detrimental to concrete structures. During a follow-up discussion with the NextEra staff, the team noted that NextEra is considering additional SMP revisions, dependent upon the results of the large specimen test program and further engineering evaluation. One of the revisions involves the installation of deep pins for monitoring of expansion in the out-of-plane direction (reference NextEra's May 1, 2013, Response to Confirmatory Action Letter (ML13151A328) Enclosure 2, ASR Project Corrective Action Plan).

Findings and Observations

The team identified no findings in this area. CAL Item 9 is closed.

The team noted that changes made to the SMP to address ASR were generally consistent with the evaluation and monitoring methods outlined in ACI 349.3R-96. The team confirmed that NextEra had incorporated a three-tiered visual inspection criteria, as outlined in Sections 5.1 through 5.3 of ACI 349.3R-96. NextEra has also augmented this visual inspection criteria with periodic (six-month and 30-month interval) CCI measurements and associated structural evaluation thresholds based upon direct measurement (CCI) results. The CCI monitoring, performed at 98 selected locations (including containment), was implemented by NextEra based upon this method being a readily measurable indicator of ASR-related progression and based, in part, upon endorsement by FHWA as outlined in FHWA-HIF-09-004.

The crack growth monitoring provides a visual indication of the progression of ASR within a reinforced concrete structure. The relative width and number of visible cracks may be correlated to the overall progression of ASR and may be used to evaluate ASR impact on structural performance. However, ASR cracking and crack propagation is closely associated with the specific reinforcement design and structural loading. Accordingly, the adequacy of CCI measurement as a long-term structures monitoring methodology for Seabrook structures is being further evaluated by NextEra as part of the UT-Austin FSEL testing program. The results of the UT-Austin testing program are intended to be used to validate this methodology for application at Seabrook.

With respect to the evaluation of infiltration water chemistry and groundwater monitoring, ACI 349.3R-96 discusses environmental monitoring and related effects of aggressive water chemistry, including the potential for leaching. Accordingly, NextEra has integrated the periodic monitoring of groundwater chemistry into the SMP (reference Revision 3, dated 4/30/2013, Attachment 4). NextEra plans to investigate the expansion of the water chemistry monitoring program (reference AR No. 1758920-40) to include periodic analysis of infiltrated water (i.e., water that has migrated through below-grade reinforced concrete walls). The establishment of an initial baseline analysis and continued periodic monitoring could provide some relative trend data for further evaluation and follow-up actions, as appropriate.

The team concluded that the implemented and planned SMP enhancements provide NextEra with an improved program to assess the extent and degree of ASR progression and to more thoroughly monitor the environmental factors contributing to ASR. NextEra's initial SMP revision (Revision 2) was adequate; however, the SMP Revision 3 enhancements include multiple activities that are more closely aligned with ACI 349.3R guidance.

## 8.0 Review of Anchor Testing Program (CAL Item 11)

Inspection Scope

The micro-cracking caused by ASR may adversely impact the structural capacity of anchors that support safety-related piping, cable trays and other components. NextEra's initial operability determinations were supported by anchor performance testing conducted on available ASR-degraded specimens previously fabricated at or obtained by FSEL, UT-Austin (reference FP 100718). As documented in Inspection Report 05000443/2012009, the initial testing demonstrated satisfactory performance of the anchors in ASR-affected concrete during the earlier stages of ASR progression. NextEra's evaluation also stated that the eventual reduction in capacity due to ASR was sufficiently offset by established anchor manufacturer's design margins (FP 100716). However, based upon the limitations of the testing performed (on ASR-affected test specimens of different composition and compressive strength than Seabrook reinforced concrete structures), NextEra planned to conduct additional testing. The planned testing involves anchors installed (both during specimen fabrication and post-fabrication) in ASR-affected test specimens that more closely replicate the reinforced concrete structures and anchor configurations at Seabrook.

By licensee letter dated December 13, 2012 (ML12362A323), NextEra requested a revision to CAL Item 11 to address a schedule challenge to the targeted anchor testing program completion date. NextEra also proposed redefining CAL Item 11 to be consistent with the wording of CAL Item 8, regarding large-scale specimen testing. Specifically, NextEra revised its commitment to read, "Submit technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." The original commitment read, "Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete." Based upon unexpected specimen fabrication delays and the slow progression of accelerated ASR aging, NextEra identified that it would not be possible to complete the anchor testing per the original commitment date.

The NRC accepted NextEra's revised commitment, as documented in NRC letter dated January 14, 2013 (ML13014A555).

The team reviewed the details and adequacy of NextEra's anchor testing program as outlined in the proprietary "Anchor Testing Program Overview," dated February 26, 2013. The anchor testing program overview and associated testing specifications were docketed for NRC review via NextEra letter dated February 28, 2013 (ML13088A218 redacted and ML13088A229 un-redacted, dated March 15, 2013). The technical overview document and accompanying specifications outline the major elements of the proposed anchor testing program, including the key attributes of the fabrication of the test specimens, monitoring of the specimens as accelerated ASR aging progresses, and the details of the testing of individual anchor bolt configurations.

Findings and Observations

The team identified no findings. Based upon the team's review, CAL Item 11 is closed. During the team's visits to the UT-Austin FSEL, the team observed the conditions and controls implemented for the aging of the test blocks and testing of concrete sample cylinders for compressive strength and modulus of elasticity. The team witnessed appropriate implementation of the testing procedures by FSEL staff and proper oversight of these activities by the MPR staff.

At the conclusion of this inspection, the desired level of ASR progression in the test blocks had not been achieved to conduct the first round of ASR-affected anchor testing. The team reviewed the results of the control specimen anchor testing completed in November 2012. The purpose of the control specimen testing was to establish a baseline to determine the potential reduction in anchor bolt capacity due to ASR. Review of the test data (reference MPR Memorandum DRN 0326-0058-163, dated June 18, 2013) identified that all anchor bolt test results were in agreement with calculated capacities, and an appropriate baseline had been established for comparison during future testing.

## 9.0 Review of Previously Identified Issues of Interest

### 9.1 Structural Evaluations for 13 Locations

As documented in Inspection Report 05000443/2012009, NextEra identified 26 locations (including containment) as having patterned cracking with a CCI of greater than 1.0 mm/m. In accordance with the SMP, Revision 2, structures with a CCI of >1.0 mm/m require a structural evaluation. NextEra's Interim Assessment documented an engineering judgment that biased the performance of detailed structural evaluations to the 11 locations with a CCI > 1.5 mm/m. The locations with a CCI of between 1.0 and 1.5 mm/m (13 locations) were considered bounded by the 11 areas subjected to a detailed evaluation. The lack of a documented structural evaluation for the 13 locations with a CCI of between 1.0 and 1.5 mm/m was a minor

performance deficiency which NextEra entered into its Corrective Action Program (AR 1804477 and AR 1819080). During this inspection, the team reviewed Calculation C-S-10168, Revision 1, and FP 100716, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments," Revision 2, which incorporated the additional evaluations for the 13 locations.

The evaluation methodology included reviewing the original calculations that govern the design of the structures to determine the design parameters associated with the general area of ASR degradation. The structural member's load demand and capacity were then noted and the margin calculated for comparison against the potential reductions in load capacities caused by ASR. The assumed reductions in capacity were determined based on lower-bound values established in industry literature. A summary of the evaluation results was provided in Table 3 of FP100716, Revision 2. For areas where design margins were insufficient to offset assumed lower-bound reductions in capacity due to ASR, further review was performed to determine if analysis could show that there was additional margin. For each of these areas, the analysis either reduced load factors that were applied to the demand loads in the original design basis calculations, or used the 28-day compressive strength (based on field testing performed at the time of construction) to obtain a higher as-built structural capacity value. The analysis is described in Calculation C-S-1-10168, Revision 1. The team found the approach of reducing load factors to establish more representative demand loads in order to demonstrate additional margin to assure structural integrity acceptable for the current state of ASR degradation. NextEra plans to credit the load factors in the load demand calculation to establish full qualification per the Final Safety Evaluation Report (FSAR) licensing basis in the final operability determination, following completion of the testing program at UT-Austin.

The team concluded that NextEra's initial approach to perform a bounding analysis for areas with CCI >1.5 mm/m was not conservative, because the design margins vary in each structural member of each reinforced concrete structure. Once the impact of the ASR degradation on structural capacities is determined from the UT-Austin FSEL test program, NextEra plans to review the design calculations for each ASR impacted area to assure margins remain acceptable. The team concluded that the revised assessment appropriately completed the engineering evaluations for the 13 locations.

### 9.2 Review of Core Sample Material Property Testing

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC planned to reexamine the need of additional core sampling of Seabrook structures for the purpose of monitoring and assessing the condition of ASR-affected reinforced concrete. For the long-term, NextEra has elected to evaluate structural performance (operability) of the Seabrook ASR-affected reinforced concrete structures by developing a testing program involving large specimens that are fabricated to closely replicate the Seabrook concrete and reinforcement design. NextEra has pursued this method, instead of conducting detailed material properties testing of core samples, based upon available laboratory testing and data that indicates that measurable material properties of removed cores do not, under all circumstances, accurately represent the "in situ" mechanical properties of the concrete. The reason for the difference is that prior to removal of the core sample, that concrete specimen is subjected to the specific structural compressive stresses (dead loads, live loads, and hydrostatic loads) and inherent

restraint due to reinforcement bars. When removed from the structural member, that concrete specimen is unrestrained. In addition, as identified in the associated core sampling standard (ASTM C42, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete"), core sample test results may be "...affected by many factors such as the strength level of the concrete, the in-place temperature and moisture histories, the degree of consolidation, batch-to-batch variability, the strength-gain characteristics of the concrete, the condition of the coring apparatus, and the care used in removing cores."

The team's review of this issue has identified two general approaches to gaining an informed understanding of the impact of ASR on reinforced concrete structures. One approach is that being taken by NextEra to assess the overall structural performance of an ASR-affected structural member, much like (but not the same) as the performance of a load test prescribed by ACI 318, "Building Code Requirements for Structural Concrete," Chapter 20, "Strength Evaluation of Existing Structures." Whereas, the alternative approach involves analytical evaluations using as an input the measureable steel and concrete material property values derived from samples from the affected structure, also recognized by ACI 318, Chapter 20. NextEra is challenged to appropriately correlate the FSEL test program results to the Seabrook structures. Accordingly, NextEra plans to take additional core samples from both the test specimens and the Seabrook structures to better correlate the large specimen test results using petrography and mechanical testing. The team viewed additional core sampling as a positive means to better correlate FSEL test data to the plant structures.

### 9.3 Containment Prompt Operability Determination (POD) and Pre-stressing Effects of ASR

As discussed in Inspection Report 05000443/2012009, the team noted that the confinement provided by the steel reinforcement bar (rebar) cage restrains ASR expansion resulting in ASR-induced or "chemical" pre-stressing of affected structural members. The team observed that NextEra had provided a qualitative explanation of this condition in the Interim Assessment (FP 100716), and in the containment POD and structural evaluation (reference AR 1804477). The team had concluded that a quantitative evaluation of this condition may be warranted to address this aspect of the non-conforming ASR condition.

During this inspection, the team discussed the impact of ASR-induced pre-stressing on reinforced concrete structures with NextEra and reevaluated NextEra's assessment in AR 1804477. The effect of "chemical" pre-stressing is to both increase the compressive stresses in the concrete (within the rebar cage) and to increase the tensile stresses in the rebar, as long as the rebar cage restraint is sustained (i.e., the concrete remains anchored to the rebar). Similar to fabricated pre-stressed concrete structural members, the ultimate load carrying capacity of the reinforced member is not significantly changed by the ASR-induced pre-stress. Some studies have identified that the tensile stress in the reinforcing steel caused by the ASR expansion results in a corresponding compressive stress on the concrete that balances the added load and initially results in reduced deflections under load and a stiffer structural behavior. However, without the ability to quantify the effect and account for the chemical pre-stressing in engineering evaluations, the team concluded that even though the ASR-induced

pre-stressing may result in some beneficial effects in terms of structural stiffness, this cannot and should not be credited for the purpose of structural evaluation. It is possible that more advanced ASR conditions could result in the steel reinforcement strain limits being exceeded that could compromise the overall structural performance.

The team noted that although the combined crack index (CCI) had been measured at three locations on the outside surface of containment, absent quantitative analyses, NextEra had not shown that the containment reinforcements were below yield. Further, the team noted that the current design code for containment does not allow containment reinforcement strains to be above yield. The Seabrook containment was designed to ASME Section III, 1975 edition and used allowable stress design methodology. This methodology does not allow for stresses to exceed the elastic limit. Specifically, "in order to keep the containment basically elastic under service load conditions and below the range of general yield under factored primary loads, the allowable stresses and strains in this subsection shall not be exceeded." This issue was discussed with NextEra representatives who stated actions would be taken (reference AR 1804477) to determine the effects of ASR relative to the containment design code requirements. As this issue has been documented in the Seabrook CAP with an open operability determination, resolution of the issue will be monitored via the ROP baseline inspection activities.

The team concluded there was no significant safety concern with containment reinforcement strain at this time because: (1) the containment is heavily reinforced and ASR is highly localized affecting a small percentage of containment area; (2) the concrete strain (crack index) measured at the surface may not reflect the condition of the reinforcement; and, (3) the integrated leak rate test in 2010 showed the containment returning to pre-existing conditions. As documented in NextEra's containment POD, primary containment is fully operable and capable of meeting all its design basis functions, with some reduced margin.

### 9.4 Assessment of the Need for Further Rebar Examinations

As documented in Inspection Report 05000443/2012009, Section 3.2.9, the NRC reviewed the potential for ASR having an adverse impact on rebar. NextEra and its engineering consultants had concluded that rebar is unaffected by ASR-degraded concrete unless the cover concrete is severely damaged and the rebar is exposed. NextEra concluded that ample alkali remains in the concrete to maintain rebar passivity and to preclude a corrosive environment.

The team determined that NextEra's position was acceptable. Based upon the examination of a limited number of Seabrook rebar, and the review of available industry operating experience associated with concrete degradation mechanisms, the team concluded that at the current level of ASR there is no evidence to suggest that the reinforcing steel bars at Seabrook are corroding. In accordance with the Seabrook SMP and the referenced American Concrete Institute 349.3R-96, "Evaluation of Existing Nuclear Safety Related Concrete Structures," periodic visual inspections (signs of leaching, staining, spalling and pop outs) coupled with soil and groundwater testing for aggressive chemistry conditions (i.e., chlorides, sulfates and pH) provide appropriate monitoring and industry recommended detection methodology. Inspections conducted have not identified any iron oxide staining attributed to rebar corrosion on any ASR-

affected concrete structures at Seabrook. Consequently, the team has concluded that no additional rebar examinations (i.e., removing the cover concrete to expose rebar for visual inspection) are currently warranted.

### 9.5 Use of Combined Crack Indexing for Structures Monitoring Program

As previously documented in Inspection Report 05000443/2012009, Section 6.0, the team planned to examine NextEra's basis for using Combined Crack Indexing (CCI) as the primary SMP method to monitor the progression of ASR in Seabrook structures. The team noted that the basis for NextEra's selection of CCI for monitoring, as endorsed by the FHWA, is that CCI provides a direct visual and measurable method for the detection and monitoring of ASR progression. Although the objective of NextEra's UT-Austin testing program is to establish and correlate the degree of ASR progression to overall structural performance, the interim use of the CCI method and the 6-month interval measurements taken, to date, provide reasonable assurance that the level of degradation due to ASR remains essentially the same and that the progression rate is low. As such, the bounding engineering calculations and associated prompt operability determinations remain valid.

Best available information concerning the impact of ASR on a structural member indicates that the formation of ASR gel within the concrete matrix, and subsequent absorption of water by that gel, results in gel expansion that generates stresses within the concrete matrix. These expansion stresses are transferred to the concrete and relieved by cracking that is present in both the exterior cover concrete and inside the rebar cage. For structures that are not triaxially reinforced (this includes the majority of the walls at Seabrook Station that have no through-wall shear reinforcement), the potential exists for some undetected out-of-plane crack formation that could result in an adverse impact on structural performance. As documented in Section 6.0, the large-scale testing program is intended to provide additional insights to the overall performance of non-triaxially reinforced wall structures.

In support of the use of CCI, which is a two-dimensional concrete surface measurement, NextEra is developing plans to install deep pins in ASR-affected walls at Seabrook to better monitor ASR progression. The large-scale test specimens fabricated at the UT-Austin facility include three-dimensional through-wall pin placements which will provide a more comprehensive measurement of the ASR expansion and associated impact on structural performance. NextEra plans to install similar deep pins at the site in order to better correlate the UT-Austin testing results and the two-dimensional CCI data to actual structural performance.

As stated above, within the confines of the reinforcement cage, the ASR expansion is restrained and some of the expansion stresses are transferred to the reinforcing bars. The added stresses are carried by the steel rebar. As a result, within a reinforced concrete structure, the visible ASR patterned cracking will be smaller and finer since the rebar is carrying the load and providing restraint to the concrete. The amount of restraint provided by the rebar is dependent upon the type, size and design of the concrete section. More heavily reinforced structures would more readily resist ASR expansion and may depict a different level of CCI compared to a lightly or non-reinforced structure with a similar degree of ASR progression. The team concluded that the use of periodic CCI measurements to monitor ASR progression appears appropriate, pending the outcome of the UT-Austin testing.

## 9.6 Planned Regulatory Actions

As discussed in Section 6.0 of this report, and in NextEra's ASR Project CAP, the crediting of the FSEL test results for demonstrating current and longer term operability of ASR-affected reinforced concrete structures may be evaluated by NextEra pursuant to 10CFR50.59 (changes, tests, and experiments) and 10CFR50.90 (license amendment requests). The team concluded that this approach is appropriate and consistent with existing regulatory processes. The team notes that CCI may become the principle method used by NextEra for monitoring the progression of ASR in affected structures. Pending the results of the FSEL testing program, NextEra may propose the use of this methodology for assessing current and future operability of ASR-affected structures.

## 10.0 Review of Six-Month Combined Crack Indexing Data

Inspection Scope

The team reviewed the periodic concrete expansion measurements and observed field measurements for ASR-impacted Seabrook structures. Specifically, the team examined the supporting documentation for the ASR Crack Index Report, dated March 18, 2013 (FP 100811), and the ASR Expansion Measurements Report, dated March 18, 2013 (FP100812). The team also conducted interviews and discussions with the responsible NextEra engineering staff. The team used 10CFR50, Appendix B, Criterion XVI, "Corrective Action," and Criterion XI, "Test Control," as the regulatory guidance to assess the adequacy of NextEra's actions to address ASR-affected reinforced concrete structures.

Findings and Observations

No findings were identified. The combined crack index (CCI) data indicated that there was some evidence of expansion caused by the ASR; however, the CCI data was inconsistent with the pin-to-pin measurements that indicated no measurable expansion, at the same monitored locations. There was no change in the CCI data for the containment, but the Electric Tunnel and the Primary Auxiliary Building/Residual Heat Removal (PAB/RHR) vault both showed an increasing trend in CCI value in the six months since June 2012. While this may be the result of seasonal effects, ASR degradation appears to be ongoing in some Seabrook structures as indicated by minor incremental crack growth. Collectively, the CCI measurements indicate essentially no structural changes, and therefore no challenges to the conclusions in the current ASR-affected structures' prompt operability determinations. The team noted NextEra's plans to continue the 6-month CCI measurements to establish a stable trend in observable ASR expansion for each uniquely ASR-affected structure. Continued periodic measurements should eliminate the potential influence of seasonal ambient temperature changes from the trend results.

CCI Measurements

In the ASR Crack Index Report (FP100811), NextEra measured CCI values for 26 locations in the monitoring program and compared the results to the data taken in June 2012. The December CCI data shows an apparent increase in most (19 of 26) of the monitored locations.

NextEra concluded the apparent increase in CCI values may be due to seasonal temperature variations because the concrete (in December) was significantly colder, which may cause the concrete to contract between the cracks, increasing the apparent crack widths.

As reported by NextEra, uneven cracking (total crack width in one direction is much larger than in the other direction) and measured larger cracks were identified in the horizontal direction compared to the vertical. The team observed that, over the long-term, averaging the horizontal and vertical CCI values may be an adequate representation of overall changes due to ASR of the specific structural member. However, the practice of averaging the horizontal and vertical CCI values is different than outlined by available industry guidance (FHWA-HIF-09-004) that recognizes the influence of reinforcements on crack growth. Thus, reporting an averaged CCI vice directional CCI values separately could mask the expansion in a preferred direction and hamper the identification of a trend in the short term. NextEra acknowledged this team observation and initiated a Condition Report (CR 1758920-41) to evaluate this issue.

The team also noted that NextEra revised the method of calculating CCI in the recent 6-month measurement report (December 2012). The CCI measurement reporting method was changed to account for the use of rectangular grids to determine crack index and thereby normalize index to the total number of lines in the both directions. In so doing, NextEra recalculated the CCI values for the December 2011 and June 2012 data to eliminate potential biasing errors. The team concluded that NextEra's more consistent use of a calculation method would aid the identification of apparent trends.

Structure Expansion Measurements

In the Expansion Measurement Report (FP100812), NextEra performed measurements between pins embedded in the surface of plant buildings at the 26 established CCI monitoring locations. The 26 monitored locations were selected from the 131 locations identified in the ASR Walkdown Report (reference FP100705) which exhibited the highest visible ASR-associated distress. NextEra noted a null result for expansion measurements between pins in most of the 26 monitored locations. Specifically, data recorded in most (436) measurement lines showed no significant changes compared to the baseline data. However, for 5 of the 436 measurement lines, NextEra noted length changes that were unexpected. NextEra plans to evaluate these locations further.

The team noted that the crack index data shows an apparent increase when expansion data in 2-dimensions shows no change. It appears that the CCI data better reflects expansion in the structure compared to the expansion measurements in only two dimensions, which may not be a complete indicator of changes in the structure. The team noted that NextEra plans to add deep pins to ASR-impacted walls in the monitored locations that will allow expansion measurements in the out-of-plane direction (reference CR 1758920-39).

## 11.0 Review of Adequacy of Revisions to the Phase 3 Walkdown Plans and Schedule

Inspection Scope

During the previous inspection, the team reviewed the overall thoroughness of NextEra's completed and planned ASR walkdown activities conducted in accordance with FP 100642, "ASR Walkdown Scope," Revision 1, and documented in FP 100705, "Seabrook Station: Summary of Alkali Silica Reaction Walkdown Results," Revision 0. At the time of the inspection, not all of the potentially affected structures had been examined and NextEra had drafted a tentative schedule for the completion of the Phase 3 (areas not readily accessible) walkdowns. During this inspection, the team assessed NextEra's final Phase 3 schedule for completeness and to ensure a timely examination of the extent of condition of ASR-affected structures.

Findings and Observations

No findings were identified.

NextEra's ASR extent of condition structures walkdown is being conducted in three phases. Phase 1 involved examination of readily accessible areas of interest; Phase 2 included examination of coated surfaces identified during Phase 1 inspections (coatings had to be removed to expose the concrete surfaces); and Phase 3 examines normally inaccessible structures and areas (e.g., high radiation, manholes, etc.) which have or will be inspected at the earliest opportunity (e.g., routine maintenance or outage activities). Team examination of the Phase 3 walkdown areas identified a minor documentation issue (in addition to the previously documented containment IWL inspection oversight) that the spent fuel pool (SFP) reinforced concrete walls were not included in the planned Phase 3 walkdown list even though NextEra was planning to do these inspections. The SFP walls pose a particular challenge to NextEra due to the limited accessibility of the concrete surfaces. At the conclusion of this inspection, NextEra was working to complete its evaluation of various methods to assess the SFP concrete walls (reference ASR Project Corrective Action Plan, revised April 2013). NextEra had already initiated plans to perform one shallow core bore in an area that was continuously wetted (SFP telltale sump) from borated water. This core will be examined for concrete degradation and to look for any degradation of rebar (reference ML 1227A023, Commitment No. 67).

The team assessed the Phase 3 walkdown schedule and concluded the target dates for completion were reasonable. With respect to completing a comprehensive examination of the containment structure, the team concluded that performing this inspection concurrent with the scheduled 2015 refueling outage IWL examination was appropriate and commensurate with the safety significance of the issue. The balance of the Phase 3 extent of condition walkdowns are scheduled for completion in mid-to-late 2013 and during the April 2014 refueling outage. In summary, the team concluded that NextEra's completed and planned extent of condition reviews for identification of ASR-affected reinforced concrete structures was appropriate.

## 12.0 Aircraft Impact Review

Inspection Scope

The team reviewed NextEra's evaluation of the aircraft impact study performed in response to the identification of ASR. The aircraft impact study for Seabrook containment is described in UFSAR Section 3.8.1.3 and Appendix 2P. As noted in the Updated Final Safety Analysis Report (UFSAR), the postulated aircraft impact load is not combined with any other containment transient design loading. Further, the study assumes the impact area to be on the dome just above the spring line.

Findings and Observations

No findings were identified.

The effects of an aircraft impact were found not to be controlling for overall containment design considerations. Also, the analysis assumes that the enclosure building fails when struck by the aircraft and deforms until the aircraft contacts the containment structure. The containment enclosure building design and analysis is described in UFSAR Section 3.8.4. NextEra's evaluation states that ASR has only been identified in below-grade elevations of the containment and containment enclosure buildings, where sufficient moisture has contributed to ASR progression. To date, no above-grade (or vicinity of the anticipated aircraft impact area) evidence of ASR has been identified on containment. Accordingly, NextEra has concluded that the Seabrook aircraft impact study remains valid and unaffected based upon engineering evaluations of other ASR-affected reinforced concrete structures completed to date.

## 13.0 UT-Austin Ferguson Structural Engineering Laboratory Visits

Scope of Review

On two separate occasions, members of the team visited the UT-Austin testing facility to observe ongoing activities and inspect general facility quality assurance and control measures. The team noted that NextEra has contractual agreements with MPR Associates and the UT-Austin Ferguson Structural Engineering Laboratory to oversee and conduct, respectively, the ASR large-scale testing program. The team toured the facility, including: main fabrication and testing areas with overhead crane lifting capabilities; outside exposed and protected (green house) specimen curing areas with continuous or cyclic wetting and drying capability; aggregate and sand storage yard; and office and laboratory spaces for storage and use of calibration and test equipment, as well as, environmentally controlled storage units for a variety of mortar bar, prism, and concrete cylinder test specimens. The team examined the large block anchor bolt test specimens, including the control specimen block which had been tested. The team also witnessed fabrication of the second large shear and lap splice test beam, and some testing of cylinders for compressive strength and Modulus of Elasticity determination.

Findings and Observations

No findings were identified. The team observed appropriate oversight and quality control practices being implemented. Direct oversight by both UT-Austin supervisory staff and MPR engineers was evident and effective.

## 14.0 Meetings, Including Exit

On June 27, 2013, the team conducted an exit meeting to discuss the preliminary findings and observations with Mr. Kevin Walsh, Site Vice President, and other members of Seabrook Station staff. The inspectors verified that no proprietary information was retained by the inspectors or documented in this report.

## SUPPLEMENTAL INFORMATION

## KEY POINTS OF CONTACT

Licensee Personnel
B. Brown, Design Engineering Manager
A. Chesno, Performance Improvement Manager
K. Chew, License Renewal Engineer
R. Cliché, License Renewal Project Manager
M. Collins, Design Engineering Manager
J. Connolly, Site Engineering Director
R. Noble, Project Manager
M. O'Keefe, Licensing Manager
T. Vassallo, Principal Design Engineer
M. Ossing, Licensing Manager
K. Walsh, Site Vice President
P. Willoughby, Licensing Engineer

## LIST OF ITEMS OPENED, CLOSED, DISCUSSED, AND UPDATED

Updated
None

Opened
None

Closed
None

## LIST OF DOCUMENTS REVIEWED

Procedures
Maintenance Rule Scoping Document, Revision 0
EDS 36180, Structures Monitoring Program, Revisions 1, 2, 3

Corrective Action Documents (AR)
1651969, 1629504, 574120, 581434, 1636419, 1673102, 1647722, 1664399, 1677340, 1687932, 1692374, 1698739, 1755727, 1757861, 1819080, 1804477, 1819069

Drawings

Licensing and Design Basis Documents and Calculations
Seabrook Station UFSAR, Revision 14
ACI 318-71
Calculation CD-20; Calculation CD-18; and Calculation C-S-1-10168

Miscellaneous Documents
FP 100348, Statistical Analysis-Concrete Compression Test Data (PTL)
FP 100642, Scope for Alkali-Silica Reaction Walkdowns
FP 100641, Procedure for ASR Walkdowns and Assessment Checklist
FP 100661, Compression Testing Concrete Cores (WJE)
FP 100696, Material Properties of ASR-Affected Concrete
FP 100700, Field Investigation
FP 100705, Structure ASR Walkdown Report (MPR 0326-0058-58)
FP 100714, Three Dimensional Dynamic Analysis of Containment Enclosure Building
FP 100715, ASR Impact Study on Containment Enclosure Building
FP 100716, Interim Assessment: Impact of ASR on Structures (MPR-3727)
FP 100717, ACI 318-71 Perspectives
FP 100718, Anchor Test Report (MPR-3722)
FP 100720, Crack Index and Expansion Measurement
FP 100738, Measurements for ASR Crack Indexing on Concrete Structures
FP 100697, MPR 0326-0058-53, White Paper on Structural Implications of ASR: State of the Art, Revision 1
MPR 0326-0058-83, Shear Screening Criteria Used in MPR-3727
FHWA-HIF-09-004, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction in Transportation Structures."
ASME III, Division 2, 1975 Edition, Winter '77 Addenda

**Documents Reviewed at FSEL**

Purchase Order No. 0326 – 0058 -25, dated December 1, 2011 and change order Nos. 1, dated March 21, 2012; No. 2, dated March 27, 2012; No. 3, dated July 23, 2012; and No. 4, August 2, 2012 between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Anchor Testing Program

Contract No. 02293285, dated June 6, 2011, and Amendment Nos. 1, dated October 25, 2011; No. 2, dated December 17, 2011; No. 003, dated January 3, 2012; No. 004, dated February 27, 2012; Amendment 6, dated July 26, 2012, between NextEra and MPR Associates Inc.

MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Notice of Intent to Contract for Testing of Anchors in ASR-affected Concreter – authorizing FSEL to develop project-specific quality system manual, implementing procedures for testing and perform initial characterization of the ASR degradation on girders.

MPR Letter to Ferguson Structural Engineering Laboratory, dated December 1, 2011, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated March 27, 2012, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated July 23, 2012, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated August 2, 2012, Research on Performance of Anchors in ASR-affected Concrete

MPR Letter to Ferguson Structural Engineering Laboratory, dated October 26, 2012, Research on Performance of Anchors in ASR-affected Concrete

Purchase Order No. 0326 – 0063 -01, dated June 4, 2012, between MPR Associates Inc. and Ferguson Structural Engineering Laboratory as applied to Beam Testing Program

Contract No. 02207204, dated April 27, 2012, NextEra and MPR Associates Inc., related to ASR Concrete Beam Testing Program (for Shear and Lap-splice anchorage)

Project Plan 0326 – 0062 -01, Revision 0, dated May 1, 2012, by MPR Associates Inc. as applied to Beam Testing Program

## LIST OF ACRONYMS

| | |
|---|---|
| ACI | American Concrete Institute |
| ADAMS | Agencywide Documents Access and Management System |
| AR | Action Request |
| ASME | American Society of Mechanical Engineers |
| ASR | Alkali-Silica Reaction |
| ASTM | American Society for Testing and Materials |
| CAL | Confirmatory Action Letter |
| CAP | Corrective Action Plan |
| CCI | Combined Crack Index |
| CFR | Code of Federal Regulations |
| CR | Condition Report |
| DLR | Division of License Renewal |
| DRP | Division of Reactor Projects |
| DRS | Division of Reactor Safety |
| FHWA | Federal Highway Administration |
| FP | Foreign Print |
| FSAR | Final Safety Analysis Report |
| FSEL | Franklin Structural Engineering Laboratory |
| MPR | MPR Associates, Inc. |
| NRC | Nuclear Regulatory Commission |
| NRR | Office of Nuclear Reactor Regulation |
| PAB | Primary Auxiliary Building |
| PARS | Publicly Available Records |
| POD | Prompt Operability Determination |
| RCE | Root Cause Evaluation |
| RHR | Residual Heat Removal |
| SFP | Spent Fuel Pool |
| SMP | Structures Monitoring Program |
| SRI | Senior Resident Inspector |
| UFSAR | Updated Final Safety Analysis Report |
| UT-A | University of Texas at Austin |

**UNITED STATES**
**NUCLEAR REGULATORY COMMISSION**
**REGION I**
2100 Renaissance Boulevard
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

May 16, 2012

CAL No. 1-2012-002

Mr. Paul Freeman
Site Vice President, North Region
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael O'Keefe
P.O. Box 300
Seabrook, NH 03874

SUBJECT: CONFIRMATORY ACTION LETTER, SEABROOK STATION, UNIT 1 - INFORMATION RELATED TO CONCRETE DEGRADATION ISSUES

Dear Mr. Freeman:

This letter confirms recent commitments by NextEra Energy Seabrook, LLC (NextEra) in regard to planned actions for the degradation of concrete in certain structures due to an Alkali-Silica Reaction (ASR). The ASR is a chemical reaction in concrete, which occurs over time in the presence of water, between the alkaline cement paste and reactive non-crystalline silica that is found in some common coarse aggregates. In the presence of water, the ASR forms a gel that expands, causing micro-cracks that can change the physical structural properties of the concrete. NextEra's completion of these commitments will ensure important information is provided to the NRC staff to determine if the licensee is taking adequate corrective actions for a significant condition adverse to quality.

In June 2009, NextEra initially identified concrete degradation of below grade concrete structures at Seabrook. In August 2010, NextEra completed core sample analyses for petrograhic evaluation, compressive strength, and modulus of elasticity. These analyses identified a change in material properties due to ASR for the "B" electrical tunnel in the control building (CB), with reductions reported in the concrete compressive strength and modulus of elasticity from expected values. NextEra evaluated these parametric reductions to determine the impact on the design basis of the "B" electrical tunnel. By its process, the licensee performed both an immediate and a prompt operability determination and concluded that the "B" electrical tunnel was operable. As additional information was obtained, including observed degradation of other structures through an extent of condition review, later revisions of the operability determinations concluded that the "B" electrical tunnel and other structures were operable but degraded.

Enclosure

NRC expert review determined the ASR affected structures remained capable of performing their safety-related functions. This determination was based in part by the following: 1) conservative safety load factors in controlling load conditions and engineering conservatisms in design provide reasonable expectation that affected structures can perform their safety function, despite the current licensing and design bases design margin being reduced by the change of mechanical properties; 2) field walk-downs confirmed no visible indication of significant deformation, distortion, or displacement of structures, or rebar corrosion; 3) ASR identified limited to localized areas in the concrete walls; 4) progression of ASR degradation is occurring slowly based on existing operating experience and NextEra continues to monitor the affected structures.

By letters dated May 3 and May 10, 2012 (Agencywide Documents and Management System (ADAMS) Accession Numbers ML12125A022 and ML12131A479, respectively), you described the actions that you will be taking to address the degraded conditions as well as to ensure that Seabrook meets its current licensing basis as a result of the ASR issue. More specifically, it is our understanding that you will be establishing a bounding operability determination for all ASR-affected buildings as well as interim monitoring actions to ensure the degradation is effectively managed. The commitments addressed below are expected to be completed as indicated:

1. Revise the prompt operability determination (POD) associated with AR581434, 'Reduced Concrete Properties Below Grade in "B" Electrical Tunnel Exterior Wall,' by May 25, 2012. NextEra Energy Seabrook will notify the site NRC Resident Inspector upon completion of this action.

2. Submit the root cause for the organizational causes associated with the occurrence of ASR at Seabrook Station and related corrective actions by May 25, 2012.

3. Submit the evaluation, "Impact of ASR on Concrete Structures and Attachments," (Foreign Print 100716) by May 25, 2012.

4. Submit the corrective action plan for the continued assessment of ASR in concrete structures at Seabrook Station including development of remedial actions to mitigate the affects of ASR, where warranted, by June 8, 2012.

5. Revise the POD associated with AR1664399, 'Reduced Concrete Modulus of Elasticity Below Grade in Containment Enclosure Building, RHR Equipment Vaults, EFW Pump House, and Diesel Generator Fuel Oil Storage Rooms,' by June 30, 2012. The expanded scope buildings will be included in this POD. NextEra Energy Seabrook will notify the site NRC Resident Inspector upon completion of this action.

6. Complete short term aggregate expansion testing (ASTM C 1260 Mortar Bar Expansion Test) by June 30, 2012. Results will be available for NRC review approximately 30 days after testing is complete.

7. Complete long term aggregate expansion testing (ASTM C 1293 Concrete Prism Test) by June 30, 2013. Results will be available for NRC review approximately 30 days after testing is complete.

8. Submit the technical details of the testing planned at the contracted research and development facility by June 30, 2012.

9. Update the Maintenance Rule Structures Monitoring Program to include monitoring requirements for selected locations in areas that exhibit ASR by July 15, 2012. NextEra Energy Seabrook will notify the site NRC Resident Inspector upon completion of this action.

10. Perform the initial six-month interval crack measurements and crack indexing at 20 locations in areas that exhibit the highest crack indices by July 15, 2012. Crack measurement will be performed at six-month intervals until a reliable trend of ASR progression is established. NextEra Energy Seabrook will notify the site NRC Resident Inspector upon completion of these periodic measurements.

11. Complete anchor test program by December 31, 2012. Results will be available for NRC review approximately 30 days after testing is complete.

Pursuant to Section 182 of the Atomic Energy Act, 42 U.S.C 2232 you are required to:

1) Notify me immediately if your understanding differs from that set forth above;

2) Notify me if for any reason you cannot complete any of the actions and commitments within the specified schedule and advise me in writing of your modified schedule in advance of the change; and,

3) Notify me in writing when you have completed all the actions and commitments addressed in this Confirmatory Action Letter (CAL).

Issuance of this CAL does not preclude issuance of an Order formalizing the above commitments or requiring other actions on the part of NextEra, nor does it preclude the NRC from taking enforcement action for violations of NRC requirements that may have prompted the issuance of this letter. Failure to take the actions as described in this CAL may also result in an Order if the NRC determines that failure to meet that action or action(s) would result in a loss of reasonable assurance of the protection of public health and safety or the common defense and security.

This CAL will remain in effect until the NRC has concluded that all actions listed above have been satisfactorily completed. We note that, regarding the ASR issue, license renewal is a separate licensing action before the Commission and the NRC may require the submittal of further information as part of the licensee renewal application review beyond that provided in response to this CAL.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any), will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records System (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). To the extent possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If safeguards information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

After reviewing your response, the NRC will determine whether further action is necessary to ensure compliance with regulatory requirements. If you have any questions, please contact Richard J. Conte at (610) 337-5183 or e-mail richard.conte@nrc.gov.

Sincerely,

William M. Dean
Regional Administrator

Docket No. 50-443
License No. NPF-86

cc: Distribution via ListServ

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**UNITED STATES**
**NUCLEAR REGULATORY COMMISSION**
**REGION I**
2100 Renaissance Boulevard
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

January 14, 2013

CAL No. 1-2012-002 (Revision 1)

Mr. Kevin Walsh
Site Vice President, North Region
Seabrook Nuclear Power Plant
NextEra Energy Seabrook, LLC
c/o Mr. Michael O'Keefe
P.O. Box 300
Seabrook, NH 03874

SUBJECT: REVISION TO CONFIRMATORY ACTION LETTER, SEABROOK STATION, UNIT 1 - INFORMATION RELATED TO CONCRETE DEGRADATION ISSUES

Dear Mr. Walsh:

This letter confirms receipt of your letter of December 13, 2012, related to the NRC Confirmatory Action Letter (CAL) issued to NextEra Energy Seabrook, LLC (NextEra) on May 16, 2012 (ADAMS Accession Number ML12125A172). The CAL confirmed actions planned to be taken by NextEra in regard to the degradation of concrete in certain structures due to an Alkali-Silica Reaction (ASR). In the December 13, 2012, letter, you requested changes to two of the commitments (CAL Items Nos. 7 and 11). We accept your proposed changes as discussed below:

CAL Item No. 7 - You requested the deletion of this commitment, which required that NextEra conduct a long term aggregate expansion test (ASTM C 1293 Concrete Prism Testing) by June 30, 2013. Your letter states that the Mortar Bar Expansion testing conducted in accordance with CAL Item No. 6 identified that the coarse aggregates contain sufficient reactive silica for the ASR reaction and expansion to continue long-term under existing environmental conditions. Therefore, the results of the Mortar Bar Expansion Testing have obviated the need to conduct additional aggregate expansion testing. Further information regarding this issue is provided in NRC Inspection Report No. 05000443/2012009, Section 5 (ADAMS Accession Number ML12338A283). Accordingly, the NRC has concluded that NextEra's commitment to complete long term aggregate expansion testing by June 30, 2013, may be deleted.

CAL Item No. 11 – You requested that the NRC change this commitment from completing the anchor test program by December 31, 2012, to "submit the technical details of the anchor test program planned at the contracted research and development facility by February 28, 2013." You requested this change because the anchor testing program, while in progress, would not be complete by December 31, 2012. NextEra's committed date for completing the anchor testing was based on the best available projected test schedule in May 2012, and did not fully anticipate all the complexities involved in completing the test program. NextEra has completed some limited testing of anchor performance of ASR-affected concrete as described in

Enclosure

Section 2.3.6, of NRC Inspection Report No. 05000443/2012009. These tests results demonstrated satisfactory performance of the anchors and were used to support NextEra's prompt operability evaluation. Based on our findings regarding anchor performance, the NRC finds the requested commitment change acceptable.

The original Confirmatory Action Letter 2012-002 issued May 2012 remains in effect except as modified for CAL Items 7 and 11, above.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any), will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records System (PARS) component of NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room). To the extent possible, your response, if you choose to provide one, should not include any personal privacy, proprietary, or safeguards information so that it can be made available to the public without redaction. If proprietary information is necessary to provide an acceptable response, then please provide a bracketed copy of your response that identifies the information that should be protected and a redacted copy of your response that deletes such information. If you request withholding of such material, you must specifically identify the portions of your response that you seek to have withheld and provide in detail the bases for your claim of withholding (e.g., explain why the disclosure of information will create an unwarranted invasion of personal privacy or provide the information required by 10 CFR 2.390(b) to support a request for withholding confidential commercial or financial information). If safeguards information is necessary to provide an acceptable response, please provide the level of protection described in 10 CFR 73.21.

If you have any questions, please contact Richard J. Conte at (610) 337-5183 or e-mail richard.conte@nrc.gov.

Sincerely,

William M. Dean
Regional Administrator

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License No.: NPF-86

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