

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

_____)	
In the Matter of)	
NextEra Energy Seabrook, LLC)	Docket No. 50-443
(Seabrook Station, Unit 1))	
_____)	

**C-10 RESEARCH AND EDUCATION FOUNDATION'S
PROPOSED FINDINGS OF FACT
AND CONCLUSIONS OF LAW**

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~~CONTAINS PROPRIETARY INFORMATION – SUBJECT TO PROTECTIVE ORDER~~

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**CORRECTED C-10 RESEARCH AND EDUCATION FOUNDATION’S
PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW**

I. INTRODUCTION AND SUMMARY

Pursuant to 10 C.F.R. § 2.1209, C-10 Research and Education Foundation (“C-10”) hereby submits its Proposed Findings of Fact and Conclusions of Law regarding the adequacy of NextEra Energy Seabrook, LLC’s (“NextEra’s”) license amendment request (“LAR”) to address the safety risks posed by the presence of the concrete-degrading phenomenon of alkali-silica reaction (“ASR”) in safety structures at the Seabrook nuclear power plant. This licensing proceeding is unique and momentous in three significant respects. First, NextEra seeks to re-establish the ongoing adequacy of its design basis for operating the Seabrook nuclear reactor in the face of ASR, a novel, complex and insidious threat to the integrity of a range of Seabrook safety structures. NextEra must demonstrate that these structures will be able to withstand an accident as predictable as a design basis earthquake. Second, the adequacy of NextEra’s LAR must be judged without the benefit or assistance of any NRC regulations or regulatory guidance for evaluating the risks posed by ASR. This places a high burden on NextEra to show as thorough an understanding of ASR as possible; and it also places a high burden on the NRC Staff of making an informed judgment on novel issues never before judged by the NRC Staff. Finally, this proceeding will affect not just the next ten years until expiration of NextEra’s operating

license, but our decision will also govern the safety of NextEra's operation during the 20-year license extension that was approved by the NRC eight months ago.

This panel of the Atomic Safety and Licensing Board ("ASLB") is tasked with assessing the testimony and exhibits presented by the parties and determining whether NextEra has satisfied its burden of proving that Seabrook can be safely operated for another 30 years from now (*i.e.*, the rest of the current operating license term plus a 20-year renewal term), despite the presence of ASR in a significant number of safety structures at the reactor. In particular, we must evaluate the LAR against C-10's claim that the Large-Scale Testing Program conducted at the Ferguson Structural Engineering Laboratory at the University of Texas, Austin ("LSTP"), relied on by NextEra as the linchpin for its assessment of ASR, is not representative of Seabrook as claimed by NextEra; and therefore it fails to provide an adequate basis for NextEra's proposed program for monitoring the progress of ASR over coming decades.

The discovery of ASR at Seabrook has presented NextEra and the NRC Staff with three unique and difficult problems. First, ASR is an exceptionally perverse phenomenon, rotting concrete from within. The webs of ASR-caused microcracks and delaminations inside a concrete structure can weaken a large building to the point that it is unable to withstand even a moderate earthquake. Second, the insidious effects of ASR are invisible to the naked eye and difficult to diagnose by any means. Webs of ASR-caused microcracks and larger delaminations lie beneath the surface, and may not be indicated by surface cracking. And these nefarious effects are not uniform within a concrete structure; instead, ASR is heterogeneous and dependent on such localized conditions as aggregate and sand geochemistry, temperature, and humidity. Third, while ASR has for decades been known to exist in numerous structures such as dams and bridges, and while ASR is the subject of a significant body of international research, it is not

regulated in the U.S. Instead, around the U.S. and internationally, ASR in major safety structures is studied and monitored, using sophisticated testing and analytical tools and following procedures such as use of multi-discipline expert teams and peer review to provide quality assurance of the work. Indeed the American Society of Civil Engineers has written:

Regulatory government agencies are frequently faced with decisions related to the seismic design of operating nuclear facilities... As new information becomes available, the design basis may be challenged. ... Because of its pervasive nature, an earthquake will “seek out” facility vulnerabilities...At issue is whether the changes can be accommodated within the inherent capacity of the original design or whether facility modifications are required.... current design practice does not provide a picture of the actual margin to failure, nor does it provide enough information to make realistic estimates of seismic risk...

Saouma Direct Testimony, § C.3.4.1.1 (Exh. INT001-R).

Hence, it would be reasonable to expect that NextEra would rise to the unique challenges posed by ASR by conducting a rigorous review of relevant literature, consulting multi-disciplinary ASR specialists with strong research and publishing credentials to review, advise and possibly complement an engineering solution; and obtaining an independent peer review of the LAR by a qualified team of experts. Yet, early in the process, NextEra decided against that approach. After a cursory review of the literature, NextEra determined that a standard heuristic and mundane engineering approach would be sufficient. Thus, NextEra hired “traditional” engineering consultants to fabricate and test specimen concrete beams and apply a standard engineering code (ACI 318-1971) to the data. And NextEra’s consultants used another reputable consultant with high level in-house expertise in advanced analyses -- but together they opted to pursue a very simplistic approach that was incapable of capturing the complexity of the ASR presence in a complex structure such as a containment enclosure building (“CEB”). To further aggravate the situation, in the hearing, NextEra presented only the testimony of employees and consultants who had prepared the LAR. As such, they were not independent of NexEra. Nor did

they have any expertise in ASR. Only one out of eight NextEra witnesses, Dr. Bayrak, had published a peer-reviewed paper on ASR, and his expertise was extremely limited. *See* Section VII.D.2 below. As a result of NextEra's incompetence and failure to seek peer review of its work, NextEra failed to understand or address the full complexity of the ASR problem, and among other things, but most importantly they discounted the potential for severe, extensive, and hidden micro-cracking and delamination.

As noted in *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-03-04, 57 N.R.C. 69, 140 (2003) ("*Private Fuel Storage I*"), we depend on the safety review of the NRC Staff in the hearing process for an "independent" and competent review of the license application. Unfortunately, the NRC Staff's witnesses did not demonstrate *any* level of expertise regarding ASR. And they were unable to show they had compensated with an independent expert review by the Advisory Committee on Reactor Safeguards ("ACRS"), because the ACRS also lacked any expertise in ASR.

The only independent expert review of the LAR to be presented in the case by a qualified ASR specialist was the expert testimony of Dr. Victor E. Saouma on behalf of C-10. Dr. Saouma, a leading international expert on ASR, conducted a comprehensive review of the LAR *pro bono*, out of his concern that the LAR was not conducted in a manner that followed sound scientific principles, including application of a high level of expertise or independent peer review. His testimony systematically and thoroughly demonstrates the gross inadequacy of the methodology used in the LAR to assess the current condition of ASR at Seabrook and thereby support any level of confidence that NextEra will be able to detect, let alone anticipate in a timely fashion, unacceptable ASR expansion before it happens. Thus, ASR could place the public at risk should the nuclear plant's concrete partially fail through unacceptable cracking

(notwithstanding the double wall design of the enclosure), thus leading to an “*uncontrolled release of radioactivity to the environment.*” NextEra Energy’s Evaluation of the Proposed Change Including Attachment 1 Markup of UFSAR Pages (Proprietary) (Enclosure 1 to Letter SBK-L-16071), § 4.1.2, criterion 16 (Aug. 1, 2016) (Exh. INT011) (emphasis added). While much of NextEra’s LAR focuses on a future monitoring program, Dr. Saouma’s professional opinion is that the testing and analyses carried out to date by NextEra and its consultants are “substandard and inadequate to support any conclusion that the ability of the Seabrook containment to withstand a design basis earthquake has not been unduly compromised by the presence of ASR.” Saouma, Review of Selected Documents Pertaining to the Structural Evaluation of Seabrook Nuclear Power Plant at 3 (Feb. 12, 2019) (Exh. INT007) (PROPRIETARY).

Dr. Saouma’s testimony also shows that the NRC Staff’s team of reviewers lacked any expertise in ASR, and therefore could not make a competent review. Nor did the ACRS members who reviewed the LAR have any expertise regarding ASR. Thus, the record of this proceeding does not include a competent and independent review by the NRC Staff. By itself, the Staff’s complete failure to present a competent safety review in this proceeding would be sufficient grounds for us to rule that NextEra has not satisfied its burden of proof and hold that the issuance of the LAR must be reversed. *Private Fuel Storage I*, 57 N.R.C. at 140. And even assuming for purposes of argument that NextEra could compensate for the lack of a competent NRC Staff safety review, NextEra has offered no independent review of its own. To the contrary, the “paucity” of NextEra’s own testimony leaves us unable to rule on its behalf. *Id.* Finally, we must rule against NextEra in light of Dr. Saouma’s highly credible and devastating testimony that the

LAR fails to demonstrate that NextEra has made a competent and representative assessment of ASR at Seabrook or that it has an adequate basis for its ASR monitoring program.

Therefore, we reverse the NRC Staff's issuance of the LAR. Given the direct dependence of the NRC's recent license renewal decision on the LAR, we also refer this issue to the Commission for a determination as to whether the license renewal decision should also be reversed.¹

II. FACTUAL AND PROCEDURAL BACKGROUND

A. Discovery and Investigation of ASR at Seabrook

This license amendment proceeding was triggered ten years ago, in 2009, by the discovery of ASR in the "B" Electrical Tunnel. *NextEra Energy Seabrook, L.L.C.* (Seabrook Station, Unit 1), LBP-17-7, 86 N.R.C. 59, 68 (2017), *aff'd*, CLI-18-4, 87 N.R.C. 59 (2018) ("LBP-17-7"). The NRC made an initial investigation that found ASR in more structures at the plant, including the Containment Enclosure Building, the RHR Equipment Vaults, EFW Pump House, the "B" Electrical Tunnel, and the Diesel Generator Fuel Oil Storage Rooms. Nevertheless, NextEra determined that the plant could safely operate on a day-to-day basis. 86 N.R.C. at 69.

¹ On September 24, 2014, C-10 submitted a rulemaking petition to the NRC, requesting the NRC to amend its regulations to establish standards and guidelines for ASR identification, including a prohibition against exclusive reliance on visual inspections, and a requirement for the use of petrography. The NRC did not act on the petition for more than five years, until yesterday when it issued a denial. NRC, 10 CFR Part 50, docket No. PRM-50-109; NRC-2014-0257, Improved Identification Techniques Against Alkali-Silica Reaction (ASR) Concrete Degradation at Nuclear Power Plants (Nov. 19, 2019). C-10 has not had an opportunity to review the decision in time for this filing, and intends to request a separate opportunity to address its relevance to this proceeding.

In the summer of 2012, recognizing the fact that ASR had never before been found in a U.S. nuclear power plant, the NRC Staff took a number of actions to gather more information. First, the Staff chartered a “Seabrook ASR Issue Technical Team” that was “envisioned to shape the long-term resolution and corrective actions of this issue at [Seabrook].” Charter for the Seabrook Alkali-Silica Reaction Issue Technical Team at 1 (July 9, 2012), attached to Memorandum from Eric J. Leeds, Office of Nuclear Reactor Regulation, to Those on Attached List, re: Seabrook Alkali-Silica Reaction Issue Technical Team Charter (July 9, 2012) (ML121250588). Exh.NRC045.

Second, in the fall of 2012, the Regional Administrator of Region 1 requested approval by the NRC’s Executive Director of Operations to “conduct additional inspections and assessments associated with the degradation of concrete due to [ASR] in safety-related structures at Seabrook.” Memorandum from William M. Dean to R.W. Borchardt, re: Request for Deviation from the Reactor Oversight Process Action Matrix to Provide Increased Oversight of the Alkali-Silica Reaction Issue at Seabrook (Sept. 5, 2012) (ML12242A370).

Finally, in 2014, the NRC contracted for independent research on ASR, including a \$700,000 grant to Dr. Saouma for “Experimental and Numerical Investigations of Alkali Silica Reaction at Nuclear Reactors.” Letter from Erika Eam to Dr. Victor Saouma, Ph.D, re: Grant No. NRC-HQ-60-14-G-0010. Saouma Testimony at 2 (Exh. INT004). Dr. Saouma conducted a three-year investigation and produced a four-volume report. *Id.* at 2. Exh. INT005. The NRC Staff also entered a \$7 million contract with the National Institute of Standards and Technology (“NIST”) for ASR research. And the U.S. Department of Energy (“DOE”) conducted research through the Oak Ridge National Laboratory (“ORNL”). Saouma Direct Testimony, § B.2

Finally, the ORNL gave Dr. Saouma 3 separate contracts to investigate impact of ASR on shear.

Id.

B. NextEra's License Renewal Application

On May 25, 2010, a year after discovering ASR at Seabrook in 2009, NextEra applied for renewal of its operating license, from 2030 to 2050. Letter from Paul O. Freeman, NextEra to U.S. NRC re: Seabrook Station Application for Renewed Operating License (ML101590099). While ASR was not addressed in the original license renewal application, subsequent amendments to the application clarified that the license renewal application would address the management of ASR. *See, e.g.*, Letter from Eric McCartney, NextEra to U.S. NRC, re: Seabrook Station, License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program (Aug. 9, 2016) (ML16224B079).

C. NextEra's License Amendment Request

In 2016, NextEra applied for the license amendment that is the subject of this hearing. Letter from Ralph A. Dodds to U.S. Nuclear Regulatory Commission re: Seabrook, License Amendment Request 16-03 - Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali- Silica Reaction (August 1, 2016) (ML16216A240) (Exh. INT010). NextEra proposed to "revise the Seabrook Station Updated Final Safety Analysis Report to include methods for analyzing seismic Category I structures with concrete affected by an alkali-silica reaction." A hearing notice was published in the Federal Register at 82 Fed. Reg. 9,604 (Feb. 7, 2017). The hearing notice included a "No Significant Hazards" determination that the license amendment could be issued *prior* to the hearing without jeopardizing public health and safety

D. C-10's Hearing Request and Admitted Contentions

On April 10, 2017, C-10 submitted a hearing request *pro se*, including ten contentions challenging the adequacy of NextEra's LAR to address ASR at Seabrook. C-10 Research and Education Foundation, Inc. Petition for Leave to Intervene: Nuclear Regulatory Commission Docket No. 50-443 ("Hearing Request"). In LBP-17-7, the ASLB admitted five of C-10's contentions:

- As admitted, Contention A states that "crack width indexing and extensometer deployment are not sufficient tools for determining the presence and extent" of ASR at Seabrook. 86 N.R.C. at 93-102.
- As admitted, Contention B states that: "[t]he LAR misconstrues expansion occurring within a reinforced concrete structure due to [ASR] because any mitigation of lost structural capacity, due to reinforcement, is temporary and unpredictable." 86 N.R.C. at 107.

- As admitted, Contention C states that:

Thorough petrographic analysis, including core sample testing of Seabrook's *in-situ* concrete, must be integral to NextEra's assessment of the advance of ASR. Because of the extreme danger imposed by the radioactive substances contained within their walls, petrographic analysis of concrete from the Containment structures and the Spent Fuel Pool should be required by NRC. NextEra's choice not to continue core sample testing -- especially for safety-related structures -- is based on spurious assumptions, leaves inspectors and the surrounding communities with an unnecessarily incomplete picture of the actual state of concrete degradation, and could endanger the public health and safety.

86 N.R.C. at 107-08, 111.

- As admitted, Contention D asserts:

The Large-Scale Test Program, undertaken for NextEra at the Ferguson Structural Engineering Laboratory (FSEL), has yielded data that are not "representative" of the progression of ASR at Seabrook Station, and therefore cannot be substituted for the required comprehensive petrographic analysis of in-situ concrete at the Seabrook reactor -- now many years overdue.

86 N.R.C. at 112, 121.

- As admitted, Contention H asserts that “[t]he proposed inspection intervals laid out in LAR 16-03 are too long to effectively measure the ongoing effects of ASR to structures at the Seabrook Nuclear Power Plant in a timely manner.” 86 N.R.C. at 121, 125.

The ASLB “reformulated” C-10’s five contentions as a single overarching contention which asserts:

The large-scale test program, undertaken for NextEra at the FSEL, has yielded data that are not “representative” of the progression of ASR at Seabrook. As a result, the proposed monitoring, acceptance criteria, and inspection intervals are not adequate.

LBP-17-7, 86 N.R.C. at 90. As summarized by the ASLB, “the key issue is Contention D’s challenge to the representativeness of the large-scale test program, and Contentions A, B, C, and H’s alleged consequences from its alleged lack of representativeness.” 86 N.R.C. at 127.

E. C-10’s Emergency Petition to NRC Commissioners

In the fall of 2018, C-10 retained Dr. Saouma to assist it with preparation of its evidentiary case on its admitted contentions. Early in 2019, Dr. Saouma informed C-10 that his review of the LAR and NextEra’s consultant reports raised grave concerns that the quality of the investigation into ASR at Seabrook and the resultant safety assessment and monitoring program were inadequate to demonstrate compliance with NRC safety regulations.

Around the same time, the NRC Staff notified the Commissioners that:

- 1) the NRC Staff had made a No Significant Hazards determination that the LAR could be issued before completion of the hearing,
- 2) issuance of the LAR was imminent, and
- 3) the NRC Staff was about to approve NextEra’s license renewal application, before the hearing on C-10’s admitted contentions had even begun.

Memorandum from Ho K. Nieh, Director, Office of Nuclear Reactor Regulation, to NRC Commissioners, re: Renewal of Full-Power Operating License for Seabrook Station, Unit 1,

attached to letter from Jeremy Wachutka to ASLB re: In the Matter of NextEra Energy Seabrook, LLC (Seabrook Station, Unit 1), Docket No. 50-443-LA-2, ASLBP No. 17-953-LA-BD01 (Jan. 10, 2019) (ML19011A356) (“Nieh Memorandum”). The Nieh Memorandum also noted the dependence of the license renewal decision on the LAR:

Four of the Seabrook license renewal aging management programs (i.e., the plant-specific Alkali-Silica Reaction (ASR) Monitoring Program, the plant-specific Building Deformation Monitoring Program, the Structures Monitoring Program, and the ASME Section XI, Subsection IWL aging management program) are based, in whole or in part, on the methodology submitted in the license amendment request.

Id. at 2.

Concerned that the NRC was about to take two major licensing actions based on faulty safety analyses and without first holding a hearing regarding the problems that had been raised in C-10’s contentions, C-10 submitted an Emergency Petition to the Commissioners on February 12, 2019. Emergency Petition by C-10 Research and Education Foundation for Exercise of Commission’s Supervisory Authority to Reverse No Significant Hazards Determination and Immediately Suspend License Amendment and License Renewal Decisions (Feb. 13, 2019) (ML19044A768). The Petition asked the Commissioners to take the following immediate actions:

- reverse the No Significant Hazards Determination, order the suspension of both the Staff’s LAR decision and its LRA decision,
- open an in-depth inquiry into best practices for assessing ASR, and
- provide guidance and instruction to the Staff for establishment of significantly more rigorous and sophisticated state-of-the-art methods and criteria for evaluating safety risks posed by ASR at Seabrook and other reactors.

Id. at 3-4, 16. C-10 supported its Emergency Petition with a declaration and detailed expert report by Dr. Saouma, *Review of Selected Documents Regarding the Structural Evaluation of Seabrook Nuclear Power Plant* (Feb. 12, 2019) (“Expert Report”) (Exh. INT007 (Proprietary)).

The Commission denied C-10's Emergency Petition in CLI-19-07 (July 25, 2019).

F. Issuance of License Amendment

On March 11, 2019, the NRC Staff gave formal approval to NextEra's LAR and issued the license amendment. Letter from Justin C. Poole, NRC, to Mano Nazar, NextEra, re: Seabrook Station, Unit No. 1 – Issuance of Amendment No. 159 re: Methodology for Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction (CAC No. MF8260; EPID L-2016-LLA-0007) (ML18204A291). The NRC Staff also made a No Significant Hazards determination, thereby permitting itself to issue the license amendment before the hearing. NRC Safety Evaluation at 1, Exh. IN024.

G. Renewal of NextEra's Operating License

On March 12, 2019, the NRC Staff renewed the Seabrook operating license for an additional twenty years, from 2030 to 2050. Letter from William F. Burton, NRC to Mano Nazar, NextEra (ML18345A121). Four of the renewed license's aging management programs were "based, in whole or in part, on the methodology submitted in the license amendment request." Nieh Memorandum at 2.

H. Hearing

After accepting written pre-filed testimony from the parties (*see* Section VI below), the ASLB held an adjudicatory hearing in the Town of Newburyport, Massachusetts on September 24-27, 2019. The ASLB held the hearing record open after the conclusion of the hearing, in anticipation of possible additional submissions by the parties. Tr. 1081 (Spritzer).

III. LEGAL STANDARDS

A. Burden and Standard of Proof

As provided by 10 C.F.R. § 2.325, “unless the presiding officer otherwise orders, the applicant or the proponent of an order has the burden of proof.” *See also Metropolitan Edison Co.* (Three Mile Island Nuclear Station, Unit 1), ALAB-697, 16 N.R.C. 1265, 1271 (1982); *La. Energy Servs., L.P.* (Claiborne Enrichment Center), (Claiborne Enrichment Center), CLI-98-3, 47 N.R.C. 77, 89 (1998).

B. Safety Standards

We previously set forth the safety standards applicable to the LAR in LBP-17-7, 86 N.R.C. at 78-79; and they are also addressed in CLI-18-4, 87 N.R.C. at 91. In summary, NextEra’s LAR applies to concrete in Seismic Category I structures, “which include those Seabrook structures necessary to control the release of radioactive material or otherwise mitigate the consequences of an accident.” LBP-17-7, 86 N.R.C. at 78. At Seabrook, as many as twenty-six Seismic Category I structures are affected or could be affected by ASR. *Id.* These structures include the containment structure, whose purpose “is to confine radiation and fission products that might otherwise be released to the atmosphere in the event of an accident.” *Id.*

As a Seismic Category I structure, the Seabrook containment must “be able to withstand an earthquake and other natural disasters, within the design basis of the plant.” *Id.*, 86 N.R.C. at 79 (citing General Design Criterion (“GDC”) 2, “Design Bases for Protection Against Natural Phenomena”). GDC 2 requires, *inter alia*, that: “Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.” Other regulatory requirements for containment integrity are set forth in GDC 1, 4, 16, and 50; and Appendix B to 10 C.F.R. Part 50. Safety Evaluation Related to Amendment

No. 159 to Facility Operating License No. NPF-86 at 2 (March 11, 2019) (“NRC Safety Evaluation”) (publicly available version at ML18204A291) (Exh. INT024).

C. Lack of ASR Regulatory Standards or Guidance

The NRC has not established regulations or regulatory guides to specifically address ASR or its implications on serviceability and strength. Saouma Direct Testimony, § B.2. Even outside the nuclear industry, there are no established standards to perform a diagnosis and prognosis of existing structures with ASR. Saouma Direct Testimony, § B.2 (Exhibit INT001-R). The federal highway administration (“FHWA”) has published a number of reports (written by leading experts from Academia) addressing this problem and providing a road map on how to deal with ASR in highway bridges using modern tools. *See, for example, Fournier, et al., Report on the Diagnosis, Prognosis, and Mitigation of Alkali Silica Reaction (ASR) in Transportation Structures (2010) (Exh. INT013).* But the report makes clear that it does not set standards or guidelines: “Because every structure is different and because a structural engineer is required for this process, no firm guidelines are available herein that can be universally applied.” *Id.* at 48. *See also* tr. 325 (Saouma). Nor do the FHWA reports address how to perform a finite element analysis of a structure with ASR.

Nevertheless, ASR is regularly discovered in large structures, and Dr. Saouma testified to many examples of government agencies and institutions that monitor and assess the safety of ASR-affected structures for the purpose of protecting public safety. These include the Seminole Dam in the U.S., the Gentilly 2 and Ikatu nuclear containment structures in Canada and Japan, the Viaduct of Chillon in Switzerland, and the Mactacuaq Dam in Canada. *See, e.g., Saouma Direct Testimony, § C.7.*

IV. LEGAL REQUIREMENT FOR COMPETENT, INDEPENDENT SAFETY REVIEW BY NRC STAFF

The NRC Staff's safety review is "an important part of the hearing process." *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-05-29, 62 N.R.C. 635, 708 (2005) ("*Private Fuel Storage II*") (citing *Private Fuel Storage I*, 57 N.R.C. at 140). Licensing boards "have traditionally found it useful and desirable to rely on the staff's expertise for an evaluation of contested issues, especially technical ones." *Louisiana Power & Light Co.* (Waterford Steam Electric Station, Unit 3), ALAB-812, 22 N.R.C. 5, 55 (1985) (citing *Florida Power and Light Co.* (St. Lucie Nuclear Power Plant, Unit No. 2), ALAB-553, 10 N.R.C. 12, 14 n.7(1979); *South Carolina Electric and Gas. Co.* (Virgil C. Summer Nuclear Station, Unit 1), ALAB-663, 14 N.R.C. 1140, 1156 (1981), *review declined*, CLI-82-10, 15 N.R.C. 1377 (1982). Thus, it is Commission policy not to start a hearing before the Staff has issued its safety review; and in any event, the safety review must be completed before the hearing ends. *Statement of Policy*, CLI-98-12, 48 N.R.C. 18 (1998).²

While the Staff's testimony is "subject to the same scrutiny as that of the other parties," *Private Fuel Storage I*, 57 N.R.C. at 140, it plays a unique role by presenting the *independent and impartial expert opinion* of the government agency responsible for regulating the proposed licensed activity:

² As stated in CLI-98-12:

Any evidentiary hearing should not commence before completion of the Staff's Safety Evaluation Report (SER) . . . unless the presiding officer finds that beginning earlier, e.g., by starting the hearing with respect to safety issues prior to issuance of the SER, will indeed expedite the proceeding, taking into account the effect of going forward on the Staff's ability to complete its evaluations in a timely manner.

48 N.R.C. at 21. In other words, while a hearing may *start* before completion of the Staff's evaluation, it may not *conclude* before the SER is completed.

[U]nder the Commission’s time-tested licensing and hearing processes, the Staff’s evaluation of an applicant’s proposal – reached as it conducts its independent evaluation of an applicant’s proposal – is considered an integral part of the record that is developed regarding any contentions challenging what an applicant has put forward. Even though the Staff’s position may not prevail at trial, it is presumed that the development and exploration of a contested issue will benefit from the Staff’s analysis and presentation.

Id. 57 N.R.C. at 140-41. Thus, in *Private Fuel Storage I*, the ASLB refused to issue a decision that did not have the benefit of a complete NRC Staff safety evaluation and therefore the issues were not “fully developed.” *Id.*

Section VI. below contains our findings that the Staff’s testimony and safety review demonstrate insufficient competence or independence to play their required role of informing our decision with an independent and expert opinion by the NRC Staff regarding the adequacy of the LAR with respect to the issues contested by C-10. Therefore, we lack an essential element of the hearing record that must be in place before we can render any decision on behalf of NextEra. Under these circumstances, as a matter of law we are unable to rule for NextEra and approve the issuance of the LAR.

V. RULINGS ON PENDING MATTERS

A. NextEra’s Motion in Limine

NextEra has filed two motions in limine to strike portions of Dr. Saouma’s testimony: Motion in Limine to Exclude Testimony and Exhibits Regarding Structure Deformation Monitoring (Apr. 23, 2019); Motion in Limine to Strike or Exclude Portions of C-10’s Testimony and Exhibits (Sept. 9, 2019). C-10 opposed both motions: C-10 Research and Education Foundation’s Opposition to NextEra’s Motion in Limine (May 3, 2019); C-10 Research and Education’s Opposition to NextEra’s Second Motion in Limine (Sept. 19, 2019). On June 7, 2019, we denied NextEra’s first motion as premature; and on September 20, 2019, we

issued an Order (Deferring Ruling on NextEra’s Second Motion in Limine). Now that the hearing is completed, we will rule on the motions.

The issues raised by NextEra have been fully briefed by the parties, and the record of the oral hearing has provided further elucidation. We find that NextEra’s view of the scope of C-10’s contentions is overly narrow, and are not inclined to grant the motion. Our view is bolstered by the oral testimony, which showed that the evidence offered by C-10 fell within the “basis” or “envelope” of C-10’s contentions. *Calvert Cliffs Nuclear Project, LLC, and Unistar Nuclear Operating Services, LLC* (Calvert Cliffs Nuclear Power Plant, Unit 1), LBP-12-17, 76 N.R.C. 71 (2012). As we held there:

Where an issue arises over the scope of an admitted contention, NRC opinions have long referred back to the bases set forth in support of the contention. Information offered in evidence – even if not specifically stated in the original contention and bases – may be relevant if it falls within the “envelope,” “reach,” or “focus” of the contention when read with the original bases offered for it. Thus, as long as the facts relied on by [the Intervenor] fall within the “envelope of the contention, they are properly before the Board. A petitioner is not required to set forth all of its evidence or to prove its contentions at the admissibility stage.

Id. (footnotes omitted). As established in the briefing on the motions in limine, the evidence presented by C-10 fully satisfied this standard.

Some statements during the hearing also provided further support for C-10’s broad interpretation of its contentions. For instance, NextEra claims that the structure deformation monitoring program is outside the scope of C-10’s contentions. But in the hearing, Mr. Simons testified that expansion data from the ASR monitoring program (which is based on the LSTP) is used in the structural monitoring program. Tr. 320. And Mr. Bell testified that the structural deformation program is “used for corroboration.” Tr. 847. NextEra and the NRC Staff also explained that the corroboration study, which is used to confirm that the confines of NextEra’s

conceptual “box” have not been exceeded in the ASR assessment and monitoring program (*see* Section VIII.A below) “is what makes up the technical basis for the structure’s monitoring program.” Tr. 1009-10 (Carley, Lehman); tr. 1012 (Buford).

As Dr. Saouma has testified, these testing elements are intertwined: the input ASR expansion is determined from field measurement through the corroborative study which was itself an integral part of the work at the FSEL. The corroborative study, in turn, needs an experimental curve that relates expansion to reduction in elastic modulus. This curve was obtained at the Ferguson testing laboratory and did use the same concrete as the tested beams to extract cores for derivation of the method. Furthermore, the Structural Deformation Monitoring Program relies on the LSTP to make the determination that the shear strength has not been impacted by the expansion. Without both those tests, the monitoring program could not be performed. *See* Saouma Rebuttal Testimony, § D.2. Perhaps the most vivid illustration of this interdependence can be found in Figure 4 of MPR’s testimony, which shows a direct connection between “Large-Scale Testing” and “Structures Monitoring Program” and several indirect connections by which data from the LSTP contribute to the Structures Monitoring Program. Exh. NER0001, A90.

In addition, we find that to the extent that NextEra complains that C-10 presented evidence on outdated documents or belatedly reviewed and responded to the most up-to-date revisions, or should have been presented in his direct testimony in order to give NextEra an opportunity to respond, we find that overall, Dr. Saouma and C-10 were diligent in their review and mastery of a very large volume of technical documents provided by NextEra and the NRC Staff. Any delays that may have occurred in presenting evidence were cured by the full opportunity to present oral and written testimony that was provided by the ASLB. The ASLB did

not deny a single request by any party to present additional evidence where it was requested (and no request was made by NextEra.). Given the novelty and high safety significance of the issues presented here, we reasonably sought to ensure that we would have a complete and meaningful record to review, while treating all parties fairly. *Statement of Policy*, CLI-98-12, 48 NRC at 19.

B. C-10's Motion to Admit Post-Hearing Exhibits

We also have before us C-10's Motion to Submit Additional Exhibits Regarding Petrographic Observations and Analyses Of ASR at Seabrook (Oct. 28, 2019). C-10's motion seeks admission of WJE Report No. 2014-3453.2 (May 26, 2016) (proposed Exhibit INT050) ("WJE Report"), a report prepared by one of NextEra's consultants, Wiss, Janney, Elstner ("WJE"). The report documents the observation of ASR in at least one core sample taken from Seabrook, that was more severe in the interior of concrete structures than at the surface. WJE also concluded that the ASR was likely caused by factors in the interior of the concrete, not the surface. The motion was fully briefed by the parties. After reviewing the written record and the oral testimony, we conclude that the motion should be granted because it impeaches NextEra's testimony on the crucial question of whether surface cracking is a reliable indicator of the degree of ASR-caused cracking in the interior of a concrete structure. NextEra testified unequivocally that it had found "no substantive difference between near surface and what would be below the level of the reinforcing steel within the core of the structure." Tr. 456. Yet, its own consultant had found the opposite to be true. NextEra should have accounted for this information in its testimony. Regardless of the reason for NextEra's failure, we find it inexcusable and therefore grant the motion.

VI. WITNESSES AND EXHIBITS

A. Witnesses

NextEra submitted two separate pieces of written pre-filed testimony by employees of NextEra and the consultants who conducted the LSTP, analyzed the results, and prepared the LAR: MPR Associates (“MPR”) and Simpson Gumpertz & Heger, Inc. (“SGH”). Exhibit NER001 contains the testimony of Michael Collins, Director of Energy for Seabrook Station; John Simons, General Manager of Projects for MPR; Christopher Bagley, a Supervisory Engineer with MPR; Dr. Oguzhan Bayrak, Distinguished Teaching Professor in the Civil, Architectural, and Environmental Engineering Department at the University of Texas; and Edward J. Carley, a Nuclear Engineering Supervisor for Seabrook. Exh. NER004 contains the testimony by three “Senior Principals” at SGH: Dr. Said Bolourchi, Glenn R. Bell, and Matthew Sherman.

The NRC Staff also submitted two pieces of written pre-filed testimony. Exh. NRC001-R contains the testimony of three structural engineers in the NRC’s Division of Engineering (“RES”), Office of Nuclear Reactor Regulation (“NRR”), who prepared the Safety Evaluation for NextEra’s LAR: Angela Buford, Bryce Lehman, and George Thomas. Exh. NRC005 contains the testimony of Jacob Philip, a senior geotechnical civil engineer in the NRR’s Structural, Geotechnical, and Seismic Engineering Branch. Mr. Philip is also the project manager of the RES research project, “Structural Performance of Nuclear Power Plant (NPP) Concrete Structures affected by Alkali Silica Reaction (ASR)” at NIST.

C-10 submitted Exh. INT001-R, the testimony of Dr. Victor E. Saouma, Professor of Civil Engineering at the University of Colorado in Boulder and a leading international expert on ASR. C-10 also submitted Dr. Saouma’s rebuttal testimony (Exh. INT028) (nonproprietary version submitted as Exh. INT032); supplemental rebuttal testimony (Exh. INT030-R); and supplemental testimony (Exh. INT049-R).

B. Exhibits

C-10 submitted Exhibits INT001-R-INT050.³ C-10's motion for admission of Exhibits 49 and 50 is pending before the ASLB. *See* Section V.B above. NextEra submitted Exhibits NER001-NER076. The NRC Staff submitted Exhibits NRC001-NRC090.

VII. WITNESS QUALIFICATIONS, ASR EXPERTISE, AND INDEPENDENCE

A. Standard for Witness Qualifications and Weight of Testimony

In order for expert testimony to be admissible, it must: (1) assist the trier of fact and (2) be rendered by a properly qualified witness. *La. Power & Light Co.* (Waterford Steam Electric Station, Unit 3), ALAB-732, 17 N.R.C. 1076, 1091 (1983). *See also* Fed. R. Evid. 702; *Duke Power Co.* (William B. McGuire Nuclear Station, Units 1 & 2), ALAB-669, 15 N.R.C. 453, 475 (1982); *Philadelphia Elec. Co.* (Limerick Generating Station, Units 1 & 2), ALAB-808, 21 N.R.C. 1595, 1602 (1985).

In addition to determining a witness' qualifications, we must also assign appropriate weight to the witness' testimony, according to his or her level of expertise. *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), LBP-01-09, 53 N.R.C. 239, 251 (2001) (licensing boards should give expert testimony "due weight" proportionate to their expertise). *See also* *Burkhart v. Washington Metropolitan Transit Authority*, 112 F.3d 1207, 1212 (D.C. Cir. 1997) (lack of specialization by an expert witness does not disqualify the expert, but goes to the weight of the expert's testimony); *Amorgianos v. Amtrak*, 303 F.3d 256, 266 (2d Cir. 2002) (testimony based on data, methodology, or studies that are "simply inadequate to support the conclusions reached" is "unreliable opinion testimony.").

³ On September 16, 2019, we granted C-10's motion to file supplemental rebuttal testimony by Dr. Saouma (Exhibit INT030).

It is clear to us in this proceeding, as it generally is in other licensing proceedings, that the witnesses for NextEra were qualified to testify about the work they did on NextEra's behalf, as civil engineers. And all of the witnesses for the NRC Staff were qualified to describe the work they did to review the LAR, as civil engineers. But we must also decide how much weight to give their testimony, to the extent they claim expertise with respect to the adequacy of the LAR. Their testimony must be weighed in comparison to the testimony of Dr. Saouma, who is one of the world's most knowledgeable and well-published experts on the subject of ASR, and who also has significant civil engineering experience. In order to establish appropriate comparative weights, we will address, as a threshold matter, the need for particular expertise in ASR; and the need for independence.

In addition to expertise, witnesses who testify for the purpose of reviewing work prepared by others should establish their independence. *Metropolitan Edison Co., et al.* (Three Mile Island Nuclear Station, Unit 1), ALAB-772, 19 N.R.C. 1193 (1984) (“*Metropolitan Edison*”). In *Metropolitan Edison*, for example, a licensee applying for a license amendment approving a training program presented testimony by three expert witnesses regarding their independent review of the training program. *Id.*, 19 N.R.C. at 1120. The experts were an educational psychologist, an engineering psychologist and human factors specialist, and a nuclear engineer who was president of a consulting firm. *Id.* The Appeal Board ruled that the consultants had the requisite level of independence, although employees of the company would not have had an adequate level of independence *Id.* at 1121.

B. Threshold Determination: Requirements for ASR Expertise

The need for special expertise in ASR is disputed in this proceeding. NextEra did not offer the testimony of any expert who was highly educated, broadly versed, and published in the topic of ASR, and the NRC Staff offered the testimony of only three engineers who had no ASR expertise at all. The Staff testified that ordinary engineering expertise was sufficient to defend the address the problem. Tr. 1053 (Buford) (“I know we sound like a broken record here, but it’s the confidence we have on an engineering basis that we can rely upon the results of the testing”). And NextEra testified that the usefulness of scientific research on ASR was limited for purposes of determining the extent of ASR at Seabrook and the degree to which it has compromised the integrity of concrete safety structures. MPR Testimony, A32 (Exh. NER001).

Dr. Saouma disagreed strongly with this view, testifying that “[t]o address a problem as complex and potentially dangerous as ASR, it is essential to avail oneself of the best possible information and expertise.” Saouma Direct Testimony, § A.7. As an ASR expert, he found it disturbing that:

[N]either NextEra nor the NRC has sought to apply the current state of knowledge regarding ASR or to obtain independent review of their work. Instead, they have offered assurances of safety to the public that are based on simplistic analyses, erroneous assumptions, and data that are not representative of conditions at Seabrook. These analyses and data were far from adequate to give the NRC technical ground to continue to operate Seabrook during its current license term or to re-license Seabrook for another 30 years (*i.e.*, until 2050).

Id. Dr. Saouma also criticized the false dichotomy created by NextEra and the Staff between science and engineering.

As discussed below, we agree with Dr. Saouma that ASR is a complex phenomenon for which significant multi-disciplinary expertise is needed in order to have a reasonable assurance

that it has been characterized adequately. We also agree with Dr. Saouma that an expert witness' expertise should be demonstrated by multi-disciplinary research and publications in peer-reviewed journals. We also reject, as illogical and unsupported, the various rationales offered by NextEra and the Staff in defense of their failure to apply scientific expertise to the assessment of ASR at Seabrook.

1. Complexity of ASR and lack of standards demand a rigorous level of expertise.

a. High level of complexity of ASR

The complex characteristics of ASR are comprehensively described in Dr. Saouma's Direct Testimony, § B.1 (Exh. INT001-R). In summary, ASR is a chemical reaction in concrete caused by a pH imbalance. Cement and some aggregates are responsible for the alkalinity, and the silica inside aggregates provides acidity. Under conditions of high relative humidity (at least 80%), ASR results in the formation of a viscous gel (with calcium playing a major role in the viscosity of the gel). The expanding concrete first fills up voids, and then causes the concrete to expand. The kinetics of the reaction (that is the rate of expansion) is a function of time, temperature and concrete relative humidity. ASR is almost never homogeneously spread over a large structure, because reactive concrete tends to occur in "pockets" where silica-rich aggregates may have been used. Heterogeneous distribution of ASR (as is the case of Seabrook) is more problematic than homogeneous distribution, because it will cause gradients of expansion (think of the Tower of Pisa with unequal settlement).

If unimpeded, ASR expansion is volumetric and isotropic (*i.e.*, the same amount of expansion occurs in three directions or "planes"). However, confinement of the concrete will inhibit ASR expansion in those directions and reorient it along the direction of least confinement.

Confinement in Seabrook and other nuclear plants is lateral due to geometry, and vertical due to geometry and weight of the reactor; hence expansion will be mostly out of plane, that is radial.

The ultimate effects of ASR include both expansion and degradation of the concrete mechanical properties. This combination of expansion and degradation affects tensile and shear strengths along with elastic modulus. Tensile strength will control the formation of (undesirable) cracking, and the elastic modulus degradation will result in larger deformation and potential cracking. The decrease in shear strength can compromise the integrity of a containment during an earthquake.

Many tests have shown an increase in structural shear strength in reinforced concrete beams (through the so-called prestressing effect) because of ASR. However, what is seldom mentioned is that this is not a panacea without a price. Chemical prestressing increases the demand in the beam (additional stresses in the concrete and reinforcement) for which it was not designed. Thus, the beam cannot be relied on without undertaking a comprehensive analysis. Saouma Rebuttal Testimony, INT028, § D.5.1.

b. Expertise should include multi-disciplinary research and publications in peer-reviewed journals.

The extraordinary complexity of the phenomenon of ASR, combined with the lack of any standards by which one could address ASR in a rote or simplistic way, establishes the need for a rigorous level of expertise, including familiarity with all applicable disciplines: theoretical, numerical (deterministic/probabilistic, static/dynamic), experimental (material and structural). Saouma Direct Testimony, § A.3 (Exh. INT001-R). Given the complexity of the subject, a team of experts may be necessary. Experts should demonstrate that they have published research results in peer-reviewed publications. *Id.*, § A.9.

c. NextEra and the Staff's claim that ASR may be adequately addressed by applying engineering expertise alone is not credible.

We give no credit to the argument made by NextEra and the NRC Staff that scientific expertise regarding ASR was not relevant or necessary to the preparation of the LAR because the ASR at Seabrook was an “engineering” problem soluble by engineering principles alone, and that the “scientific” understanding of ASR gained through multi-disciplinary research and study was a separate category of inquiry that was irrelevant and unnecessary. For instance, the LAR states:

The need for Seabrook-specific testing was driven by limitations in the publicly available test data related to ASR effects on structures. *Most research on ASR has focused on the science and kinetics of ASR, rather than engineering research on structural implications.* Although structural testing of ASR-affected test specimens has been performed, the application of the conclusions to a specific structure can be challenged by lack of representativeness in the data (e.g., small-scale specimens; poor test methods; different reinforcement configuration). The large-scale test programs undertaken by NextEra provided data on the limit states that were essential for evaluating seismic Category I structures at Seabrook Station. *The data produced from these programs were a significant improvement from the data in published literature sources, because test data across the range of ASR levels were obtained using a common methodology and identical test specimens.* The results were used to assess the structural limit states and to inform the assessment of design considerations.

Exhibit INT010, LAR, Enclosure 7, § 3.2.1 (emphasis added). We find no rational basis for such a dichotomy. As Dr. Saouma observed, engineering codes always start with academic research.

Tr. 310. The FHWA report relied on by NextEra, for example, was written by university professors who were eminent researchers. *Id.* As Dr. Saouma testified, “when we have a problem as complex as Seabrook, which goes beyond code, we have to go back to the root – where this equation came from. What was the assumption behind those codes? What are the limitations? What are its advantages?” Tr. 311. Under these circumstances, it is appropriate to consult the expertise of university professors. *Id.* To leave such a complex problem entirely in the hands of engineers who do not fully understand ASR is dangerous, because ASR may pose an extreme danger to public health and safety if misdiagnosed and therefore ignored. Throughout his

testimony, Dr. Saouma testified to the “danger” posed by NextEra’s and the Staff’s poor understanding of multiple aspects of the characteristics and behavior of ASR and the “false sense of confidence” that goes with it. Tr. 511. *See also* tr. 363, 400, 492, 493, 574, 607, 728, 863, 940, 1058, and 1162.

d. The Staff’s distinction between scientific research as “long term” and engineering as “short term” is arbitrary and unjustified.

According to Mr. Philip, the grants to Dr. Saouma and NIST were “not meant for licensing purposes and the state of the art, it’s looking even beyond that to see if there are some new techniques and people can come out to it.” Tr. 699. But his rationale is utterly illogical because, in fact, there are no “old techniques” for assessing ASR in nuclear reactors. NextEra “devised its own methodology.” LBP-17-7, 86 N.R.C. at 70. His rationale is also illogical in light of the fact that the stated “impetus” for Dr. Saouma’s research grant was “the apparent challenge confronting the NRC in assessing safety issues pertaining to the Seabrook nuclear power plant which suffers from Alkali Silica Reaction (ASR), and in particular NRC request that the licensee determines the long term safety of the plant within the framework of [the Seabrook Working Team ASR Charter].” Grant Award, Experimental and Numerical Investigation of Alkali Silica Reaction in Nuclear Reactors at 4 (2014), Exh. INT004.

It would also be sheer absurdity to characterize as “long term,” and therefore premature to consult in the present time, operations that don’t begin until after the remainder of the operating license term (10 year) plus the recently-approved license renewal term (20 years) have ended. By that time, many of the people now at risk from ASR at Seabrook will be dead. ASR is a current risk that must be addressed with the utmost rigor in the current time.

Finally, it is absurd to say that Dr. Saouma's research would not yield results in time to inform the Seabrook LAR review. As he testified, Dr. Saouma completed his four-volume report in 2017. Saouma Direct Testimony, § A.4. His research was also peer-reviewed by multiple reviewers, was published, and has been cited on multiple occasions. Tr. 882-83. There is nothing contingent or unfinished about it.

2. Lack of NRC standards or guidance warrants particular rigor.

As discussed above in Section III.C, the NRC lacks standards or guidance for the assessment of ASR in nuclear power plants. Thus, the NRC Staff and licensees must work together to develop adequate methodologies. And even if guidance existed, the effects of ASR in any given structure are unique and must be studied case-by-case. *See* discussion of FHWA reports in Section III.C above. And therefore, it is essential to consult ASR experts who are qualified in the multiple disciplines that must be brought to bear on the problem to have a reasonable assurance that ASR is adequately assessed and addressed.

In addition, given the complex nature of ASR and its unique characteristics in each case, peer review is essential. As Dr. Saouma testified:

Independent peer review is a cornerstone of engineering practice. It is of paramount importance that the reviewers be sufficiently detached from the project organization, *i.e.*, they do not ultimately report to the same hierarchy. And peer reviewers should be familiar with the literature. Finally, they should have a degree of scientific expertise and rigor that is sufficient to enable them to credibly comment.

Saouma Direct Testimony, § C.9.

C. Dr. Saouma Was the Only Witness to Demonstrate Any Degree of Expertise or Independence.

The only witness who has provided a review of the LAR that was both independent and expert in this proceeding was C-10's expert witness, Dr. Saouma. As a consultant retained by C-

10, Dr. Saouma has the degree of independence required by the NRC. *Metropolitan Edison*.

Here, Dr. Saouma's credentials as an independent reviewer are particularly strong, given that (a) he is an extraordinarily experienced and highly qualified academic who has decades of experience in the practice of peer review; (b) he published numerous peer-reviewed journal articles related to ASR (including a book) and conducted a study of ASR on behalf of the NRC; and (c) he has no economic ties whatsoever to C-10, having provided his review of the LAR *pro bono* out of his concern as "a scientist and a citizen, about the inadequacy of the work that has been done on ASR at Seabrook." Saouma Direct Testimony, § A.7. As he explained:

To address a problem as complex and potentially dangerous as ASR, it is essential to avail oneself of the best possible information and expertise. Therefore, it disturbs me that neither NextEra nor the NRC has sought to apply the current state of knowledge regarding ASR or to obtain independent review of their work.

Id.

As discussed below in Section D.1, Dr. Saouma's ASR-related credentials are on a much higher level than any other witness who testified in the hearing. In addition, in his written testimony and on the witness stand, Dr. Saouma showed a much greater understanding of the complex behaviors of ASR and the reasons for it. He continuously gave compelling, well-reasoned and well-supported testimony demonstrating that NextEra has grossly oversimplified or mischaracterized the characteristics and behavior of ASR, such that its program for testing and assessing the degree of ASR present at Seabrook is completely inadequate and unreliable. On every issue raised by C-10's contentions, we are unable to conclude that NextEra has overcome Dr. Saouma's forceful evidence and reasoning.

In contrast to Dr. Saouma, most of NextEra's witnesses had no ASR expertise whatsoever. And they lacked the requisite degree of independence because they acted as agents of NextEra, defending the work they had done on the LAR. *See Metropolitan Edison*, 16 N.R.C.

at 1271. Only Dr. Bayrak had some limited ASR expertise, but like the other NextEra witnesses, he was in the position of defending the LAR, not providing an independent review. Unlike the licensee in *Metropolitan Edison*, NextEra failed to retain any independent experts. And while NextEra testified to some conversations they had with ASR expert Prof. Folliard, no systematic or formal peer review was conducted. Saouma Rebuttal Testimony, §§ A.12, B.6. By the same token, briefings given by or attended by EPRI, the U.S. Department of Energy, and the NRC's Office of Research do not constitute formal peer reviews.

Ordinarily, we would look to the NRC Staff for an independent expert review of a license application. But in this case, the NRC had no ASR expertise whatsoever. And while NRC claimed to obtain an independent peer review from the ACRS, Ms. Buford conceded during the hearing that "none of [the ACRS reviewers] are specifically familiar with alkali-silica reaction." Tr. 267. Thus, there is no competent NRC review in the record of this proceeding that we could rely on. *Private Fuel Storage I*, 57 N.R.C. at 141.

We find it curious and disturbing that the Staff seemed to go out of its way to avoid obtaining expert assistance for its Seabrook review. For instance, the Staff barely spoke with Dr. Saouma during the three years of his research grant, and he was even told he would not be given data about Seabrook and was not to mention Seabrook in his report. The Staff reviewers did not even read his four-volume report. Tr. 878 (Buford). Nor did the Staff recruit any other ASR experts from academia or other institutions to assist with the safety review of the LAR. And while the Staff had a history of employing ASR experts such as Herman Graves or Abdul Sheik, there was no indication that they or any engineers with their level of expertise had been consulted. Tr. 804.

With respect to other reviews that were performed by NRC staff and employees of the national laboratories, there is no indication that anyone of them had the technical background to fully capture the ASR problem. Dr LePape from the ORNL was not one of the reviewers; nor was Herman Graves or Abdul Sheikh, formerly at NRC; or Dan Nauss, formerly at ORNL. All of these individuals would have had the proper technical background for such a task. Saouma Rebuttal Testimony, § B.6.

As a result, the Staff gave NextEra no effective support or guidance, and its review effectively constituted a rubber stamp of an LAR that is very poorly articulated. In short, the Staff seems to have abdicated its role as a regulator. While supervision of the Staff is not within our realm, we note our significant concern about this lack of independence or rigor from the staff, which has echoes of the recent disastrous regulatory failure of the Federal Aviation Administration (“FAA”) with respect to the Boeing 737 MAX Flight Control System in the face of increasingly complex problems that are not covered by government regulations. *See* letter from Christopher A. Hart , Hart Solutions LLC, to Ali Bahrami, FAA (Oct. 11, 2019), enclosing Joint Authorities Technical Review Team’s Observations, Findings, and Recommendations on the Boeing 737 MAX Flight Control System, https://www.faa.gov/news/media/attachments/Final_JATR_Submittal_to_FAA_Oct_2019.pdf.

D. Weight Assigned to Witness Testimony

1. Dr. Saouma

Dr. Saouma is one of the world’s leading ASR experts, if not the foremost international expert, in ASR. Exh. INT001-R, § A.3; Exh. INT003. He has studied virtually every aspect of ASR in depth, across multiple disciplines for the past 15 years. Tr. 263. He has written approximately 15 peer-reviewed articles on ASR and related topics (out of a total of over 100),

and has written the only book on numerical modeling of ASR. The topics of his research have covered a great breadth and depth, including theoretical, numerical (deterministic/probabilistic, static/dynamic), and experimental (material and structural) aspects of ASR. Dr. Saouma is currently on a three-year project with Reclamation to ultimately assess the safety of Seminole dam that is suffering from ASR. He is currently editing an 800 page book on Diagnosis and Prognosis of ASR while chairing an international committee on these topics. His ASR model,” is probably the most widely referenced and copied model for ASR in the world. He has served, and currently serves, on numerous scientific organizations, committees, and panels devoted to the study of ASR. *Id.* Dr. Saouma testified that he is providing testimony for C-10 *pro bono*, because he is very concerned, both as a scientist and a citizen, about the inadequacy of the work that has been done on ASR at Seabrook. Saouma Direct Testimony, § A.3, Exh. INT001-R.

Furthermore, Dr. Saouma has knowledge and experience in classical structural analysis and reinforced concrete design. Those are the basic principles of engineering applied by NextEra and the NRC. Thus, he had a high level of competence to evaluate the adequacy of NextEra’s diagnosis of the locations and extent of ASR at Seabrook and its proposed methods for monitoring ASR in the future. We find Dr. Saouma’s testimony well-reasoned and well-supported by the breadth and depth of his expertise in research and experimentation. Therefore his testimony is highly credible, and we give it great weight in comparison with the total lack of ASR expertise by most of NextEra’s witnesses and all of the NRC Staff’s witnesses.

2. NextEra witnesses

In contrast to Dr. Saouma, all but one of the witnesses for NextEra had no expertise at all on the subject of ASR. While all showed familiarity with basic principles of civil engineering, and certainly had enough engineering experience to describe the work they did, only Dr. Bayrak

had any pre-Seabrook experience with ASR that could have given him any independent basis for assessing the adequacy of the ASR-related work that was done to support the Seabrook LAR.

Yet even Dr. Bayrak's experience was very narrow and limited. Dr. Bayrak has studied the impact of ASR on the response of bridges in Texas *See* Exh. NER010. But the focus of his work has been large-scale laboratory testing with special emphasis on shear. There is no indication in his curriculum vitae that ASR was the topic of these investigations, only that it was one parameter amongst others. Nor does Dr. Bayrak's curriculum vitae demonstrate that he has done any scientific, peer-reviewed research in any aspect of ASR or any publication on Finite Element simulation. Saouma Direct Testimony, § A.12 (Exh. INT001-R).

During the hearing, Dr. Bolourchi claimed to have "spent many years" studying the structural effects of ASR (tr. 309), but he did not provide any examples and his curriculum vitae (Exh. NRC033) does not describe any experience with ASR. Exh. NER031. Mr. Sherman testified that he had worked on ASR his "entire career," including designing a transportation program for response to ASR, and evaluating many structures with ASR. Tr. 330. Mr. Sherman's curriculum vitae indicates that his "ASR related research" is either "monitoring" ASR in pavements or "coordinating" testing for ASR in Kentucky. He does not show that he has done any research at all on ASR, let alone research of depth and breadth with results published in peer-reviewed literature. Thus, Mr. Sherman has not demonstrated the level of expertise needed to assess the adequacy of the LAR to address ASR.

Accordingly, we give the testimony of NextEra's witnesses very little weight based on non-existent-to-low level of ASR-related expertise. In making this determination, we also take into consideration the fact that NextEra did not provide a single piece of testimony presenting an independent review of the work done by its consultants, MPR and SGH. Instead, NextEra

presented the consultants' testimony describing and defending their own work. But these consultants had a vested interest in defending their work and their employer on the witness stand. They were not in a position to provide an independent analysis.

NextEra testifies that it submitted MPR's analysis and recommendation for a large-scale testing program (MPR-3727) to EPRI as an "independent third party reviewer." MPR Testimony, A.86, Exh. NER001. But EPRI is an industry-funded research institute. As such, it is not truly independent of the nuclear industry, including NextEra; and therefore it does not qualify as a peer reviewer. In any event, unless there have been some recent significant changes in the EPRI staff, it does not have the in-house expertise to fully assess ASR-affected structures. Saouma Rebuttal Testimony, § B.6.

3. NRC Staff witnesses

Ordinarily, NextEra's failure to provide its own independent expert review of its work would be compensated for by the NRC Staff's independent review in the Safety Evaluation (Exhibit INT024) and the Staff's testimony (NRC001). But the Staff was even less informed than NextEra about ASR.

The NRC Staff's witnesses showed a basic level of engineering experience, but demonstrated no expertise with ASR at all. Mr. Philip "was asked to do independent peer review of the large scale test program." Tr. 799. Mr. Philip's curriculum vitae states that he has "developed and managed research" in ASR since 2012. Exh. NRC006 at 4. But Mr. Philip is also a "Senior Geotechnical Engineer" (discipline far removed from ASR) and he has identified no research or publications of any kind on the subject of ASR, let alone peer-reviewed research. His experience with ASR-related project management does not demonstrate any level of

competence with the complex characteristics and behavior of ASR. Thus, the Board gives no weight to the Staff's testimony regarding the adequacy of the LAR to address ASR at Seabrook.

VIII. EXAMPLES OF NONCONSERVATIVE AND ERRONEOUS CONCEPTS, ASSUMPTIONS AND ANALYSES

The record of this proceeding shows that the LAR and the NRC Staff's safety review are riddled with nonconservative and erroneous concepts, assumptions and analyses establishing that the LSTP was not representative of Seabrook concrete and did not provide an adequate basis for NextEra's program to monitor and timely detect unacceptable ASR expansion during the next 30 years of operation. Among many, the following are some of the most egregious and illustrative examples. In effect, as Dr. Saouma noted, this hearing constituted "the very first peer evaluation" of the LAR. Tr. 798.

At the outset, we would note an unusual imbalance in resources and quality of testimony. The LAR was defended by eight lawyers and eleven witnesses, while the intervenor relied on only one lawyer and one witness to present their case. Yet, the intervenor's witness had an extraordinary degree of expertise in contrast to NextEra and the NRC Staff, who had virtually none between them. Finally, the intervenor's witness spoke with brevity, clarity and focus, while NextEra's and the Staff's witnesses filled the record with verbose rationalizations and convoluted explanations.

A. "Box" Concept Based on Nonconservative Assumptions.

Perhaps the most egregious example of NextEra's dangerously simplistic approach to ASR was its reduction of the ASR assessment and monitoring program to the concept of a "box." At the hearing, NextEra summed up the LAR as creating a "box that's defined by the [LSTP] test program that shows we're still inside that design basis." Tr. 331 (Sherman). The edges of the box are established by the expansion limits in Table B-1 of MPR-4273 (Exh. INT021,

PROPRIETARY). The expansion limits are [REDACTED] % PROPRIETARY] for volumetric expansion and [REDACTED] % PROPRIETARY] for through-thickness expansion. Staying inside this box was “the whole point . . . of this entire project.” *Id.* According to Mr. Sherman:

We’re not trying to understand where we may go in the future and what the effects might be. The fundamental piece of trying to stay within the design basis and the law that governs it is to see where we are now and within a reasonable amount of growth – that’s exactly what the LSTP was designed to do – to define that box where we understand the properties of the concrete, we understand what’s happening, and then we make sure that we stay within that box.

Tr. 376.

Thus, according to Mr. Sherman, the box concept allowed NextEra to avoid having to predict ASR behavior in the Seabrook concrete:

To that end, knowing what would happen to a piece if I subjected it to very high temperature or hydroxide concentrations to accelerate it, doesn’t help us because we need to stay within that box. Just like the shear testing. The reason we didn’t have to do a whole bunch of mechanical modeling of the effect of that is we knew from the large scale testing program that if we stay within the box, there was no effect on the concrete shear performance. That’s the fundamental difference of the approach, long term versus the box.

Tr. 376-77. As summarized by the NRC Staff, “they calculate what it’s going to be and make sure that it is within the bounds by the end of the license.” Tr. 1129 (Buford).

The “box” concept poses a number of problems. First and foremost, the limits are completely based on the LSTP, and no rationale was presented as to how they were determined. Tr. 446 (Thomas). Their applicability to field conditions has not been verified. The structural response of a large structure like the CEB cannot be compared to the response of a small beam in a laboratory. This is discussed extensively in Dr. Saouma’s Direct Testimony, §§ C.2.2 and C.2.3 and his Rebuttal Testimony, §§ D.3.1, D.3.2, and D.6.

Second, there is no government or industry guidance for extrapolating the results of laboratory tests of ASR effects to large nuclear structures – despite NextEra’s and the Staff’s

misleading references to “code acceptance criteria” as though there is some industry code that contains acceptance criteria for ASR. *See, for example*, LAR § 3.5.1, (Exh. INT010); Safety Evaluation at 32 (Exh. INT024). Thus, a range of dissimilarities between laboratory conditions and field conditions, including aggregate characteristics, heat and humidity, and relative size and design, must be addressed without recourse to regulations or guidance.

As Dr. Saouma testified, further actions are needed in order to establish the reasonableness of the limits. They include accelerated expansion tests, damage rating index (“DRI”) measurements, detailed petrographic studies, and modern computational methods. Saouma Direct Testimony, § B.2. Accelerated expansion tests are the “only way” to assess the potential for future expansion. Tr. 505-6 (Saouma). And they would have allowed a comparison to verify the applicability of beam testing to field conditions. Tr. 373 (Saouma). *See also* tr. 384 (pointing out lack of consistency in NextEra’s statement that core samples could be taken for some purposes but not purpose of accelerated expansion tests), tr. 386-7 (time period needed); Saouma Direct Testimony, § C.2; Saouma Rebuttal Testimony § B.1, B.2, B.3. Dr. Saouma testified that the use of accelerated expansion tests, combined with periodic damage rating index (“DRI”) measurements, detailed petrographic studies, and modern computational methods, have been “demonstrably effective (for example, Hydro-Quebec), in contrast to the demonstrably ineffective measures used by NextEra.” *Id.*, § B.2.

Third, the “box” concept assumes “slow” growth of ASR that will take “decades.” Tr. 714 (Collins). As Dr. Saouma testified, however, ASR grows on a sigmoid or “S” curve. Saouma Direct Testimony, Fig. 18, tr. 386 (Saouma). It is unclear where Seabrook is on the curve now, but there is a significant potential that expansion will speed up at some point in the process if Seabrook is still low on the curve. Tr. 386, Saouma Rebuttal Testimony, § C.1. *See also* tr. 400

(Saouma) (Noting that if Seabrook ASR is in the phase where the curve is climbing, “[w]e are in a dangerous zone.”) It is important to know where Seabrook is on the sigmoid curve “because it would have an influence on monitoring progress, anticipated problems.” Tr. 413 (Saouma).

The only method to determine where Seabrook is on the S curve is through accelerated expansion tests as described in EPRI Report 3002013192, Exhibit NER018. Saouma Rebuttal Testimony, § C.1. Dr. Saouma considers it essential for NextEra to have a more accurate sense of how close Seabrook is to the “edges of that box” by using accelerated expansion tests. Tr. 772. It is a “simple question” that requires an “[e]asy test.” Tr. 400 Saouma). Under the circumstances, we question why such a test was not done.

Furthermore, NextEra testified that by using a corroboration study, “we know where we are on that curve.” Tr. 400 (Sherman). The corroboration study was performed by doing an elastic modulus calculation in the laboratory and comparing it with the original elastic modulus calculation done on cores taken when Seabrook was built. Tr. 414-15 (Saouma). But NextEra fails to account for how much the corroboration study depends on approximating quantitative values related to ASR. Saouma Rebuttal Testimony, § D.9. As shown in Figure 22 of Dr. Saouma’s Rebuttal Testimony, there is a substantial margin of error in this procedure that has not been acknowledged by NextEra. In addition, the increased compressive strength of concrete during the first two years further aggravates the margin of error and undermines the reliability of the corroboration study. *See* Exh. INT030 and Figure 3.

We agree with C-10 that NextEra’s reliance on the simplistic “box” concept does not provide an adequate basis for assessing the condition of ASR at Seabrook, in light of the danger posed by ASR, and in light of the more effective measures that were readily available to NextEra. Indeed, it is inexplicable that NextEra would take such a simplistic approach when it

could have obtained so much more information about the current state of ASR at Seabrook and its potential for expansion. As Dr. Saouma testified, it is a “rearview mirror” approach to addressing a problem that could mushroom unexpectedly and impose significant safety risks, “because the consequences are enormous.” Tr. 718.

By the same token, we are also very concerned by the contrast between the importance of the role played by the “box” limits in NextEra’s LSTP scheme, and the rather offhand way that NextEra discussed the potential for “adjusting” those limits in the future. As Mr. Carley testified, if measured ASR levels get too close to the limits in the future, the limits can be “adjusted”:

So we would look at what those points were, and as Mr. Bagley said, if one or two of those were out of, we'd enter into the corrective action program and evaluate.

It may be that it's a, we need to adjust the curve so it's, I don't want to throw out numbers here because we're crossing into proprietary. But we made that correction factor we talked about yesterday may need to be higher. And then we have to apply that and backfit it. There's a lot of scenarios that could occur.

Tr. 1009-10 (Carley). Our concern has three related elements. First, as Dr. Saouma testified, the limits set in Table B-1 are high in his experience, and there is no safe margin for increasing them. Second, and related to our first concern, we are disturbed by the lack of public accountability for future “adjustments” to the limits that could compromise public safety. Table B-1 is not referenced in the LAR itself, and thus it does not appear that a publicly noticed proposed license amendment would be required in order for NextEra to change the limits. Thus, there would be no opportunity for the public to question the change. Finally, NextEra’s casual reference to changing these limits indicates that overall, NextEra does not appreciate the seriousness of the safety risk posed by ASR. It is reasonable – and disturbing – to attribute this inappropriate lack of concern to the dearth of expertise or independence of NextEra’s consultants.

B. The Design of the LSTP was Based on the Unsupported Assumption That the B Tunnel Was Representative for its Conservatism.

During the hearing, it became clear that the LSTP was designed based on “structural details” of the B (“Bravo”) Tunnel. Tr. 1045 (Bayrak). The NRC Staff testified that the Staff and NextEra “agreed” that it would be “reasonable to use the B Tunnel to model ASR because “that was the worst ASR area.” Tr. 1047 (Buford).

This issue is a good example of the lack of competence and expertise that concerns us overall. We agree with C-10 that the B Tunnel was not demonstrated to be the worst (and therefore not bounding or representative of the rest of the Seabrook concrete) in several respects. First, if visual observation is the primary tool for assuming that ASR is “worst” in the B Tunnel, it is equally significant that Dr. Saouma visually observed extensive visible cracking “through the entire base” of the CEB during the ASLB’s recent site tour. Tr. 1157 (Saouma).

Second, if the concept of “worst” includes the nature of the stress on the safety structure, NextEra and the Staff presented no evidence other than Dr. Bolourchi’s unsupported assertion during the hearing that a hydrostatic load is “significantly larger” than a seismic load. Tr. 1048-49. Dr. Saouma responded to this bald assertion with surprise (tr. 1049, “that’s news to me”) because the designs of the B Tunnel and CEB suggest otherwise: while the B tunnel is designed to withstand a stress of 3,000 psi, the CEB is designed to withstand a stress of 4,000 psi. Tr. 1145-46. As he noted, “this is an indication that the electric tunnel may not necessarily be subjected to such a high state of stresses as enclosure building.” Tr. 1146. Indeed, a seismic load “is more likely to affect the CEB than a tunnel.” Tr. 1047 (Saouma). We take judicial notice that a tunnel is laterally supported by the surrounding soil/rock and is not prone to major (if any) lateral excitation in an earthquake. In contrast, a free-standing building (such as the CEB) has no

such lateral support. *See also* tr. 1068 (Saouma) (the “weak point” of the CEB is not below grade).

Third, if the concept of “worst” includes the comparative safety functions of the B Tunnel and the CEB, First, NextEra and the Staff had no evidence on which to elevate the B Tunnel over the CEB. The two safety systems perform very different roles, which should be taken into account. The B Tunnel conveys heated water away from the plant. The CEB contains radioactivity during an accident. As Dr. Saouma noted, the CEB is the “last barrier in case of seismic load,” and therefore it constitutes the “Achilles’ heel of the whole structure.” Tr. 1047. That role of radioactivity containment cannot reasonably be deemed less important than the safety function of the ultimate heat sink.

Finally, NextEra and the Staff failed to support their claim that the B Tunnel was geometrically representative of other structures such as the CEB. The Staff testified that the B Tunnel had less reinforcement than the CEB. Tr. 1047 (Buford) (CEB has triaxial reinforcement “up to a certain height”). As Dr. Saouma observed, however, the CEB did not have reinforcement throughout, and the “weak point is not below grade.” Tr. 1068. Thus, a seismic excitation could cause or exacerbate cracking in the unprotected area. *Id.*

To the extent that the LSTP attempted to account for the effects of reinforcement, it also used a value that was greater than the actual reinforcement ratio in the CEB, thus adding another element of non-conservatism and non-representativeness. As Dr. Saouma noted in his written testimony, the reinforcement ratios in the test beam were different on the longitudinal axis x [(REDACTED)% PROPRIETARY] and the transverse axis 7 [(REDACTED)% PROPRIETARY]. Saouma Rebuttal Testimony, § D.3.1. In contrast, the reinforcement ratio for the CEB is [(REDACTED)% PROPRIETARY] on both axes. Tr. 276 (’Saouma). Dr. Saouma testified that the LSTP’s

assumption of a greater longitudinal reinforcement than was present in the CEB made the test nonconservative and non-representative for the CEB. Tr. 277 (Saouma). *See also* tr. 277 (Saouma) (explaining that the lack of conservatism arises from the fact that there is “a load which is present in the field, which is not present in the test.”) We find this level of non-conservatism and non-representativeness unacceptable.

We are also disturbed by evidence adduced during the hearing that the LSTP’s assumptions about reinforcements in the B Tunnel were not even representative of the B Tunnel, let alone the CEB. During the hearing, Dr. Bayrak testified that in reality, the longitudinal reinforcement ratio in the B Tunnel is [REDACTED]%, not [REDACTED]% PROPRIETARY] as assumed in the test. Tr. 278, NextEra raised it to [REDACTED]% PROPRIETARY] in the LSTP to avoid failure of the specimen “in flexure as implied by ACI 318.” *Id.* As Dr. Bayrak explained:

In an effort to study shear, what we do in our shear testing programs and Seabrook testing is not an exception to this, the quantity of that reinforcement has to be adjusted where flexural failure is precluded and as per ACI 318 definition, a shear crack is observed which informs what concrete contribution to shear strength is. So that does necessitate adjusting the longitudinal ratio.

Tr. 278-79. Thus, in order to ensure shear failure (as opposed to flexural failure), the LSTP assumed conditions that were not conservative for either the B Tunnel or the CEB.

NextEra’s intentional variation of supposedly representative assumed conditions, in order to achieve certain test results, is a matter of significant concern to us. While NextEra’s consultants may have had expertise in how to alter assumptions for purposes of staying within the ACI 318 code limits, they did not show a sufficient level of understanding of ASR to determine whether the changes in the assumptions were appropriate, or whether they would mask real problems with the test.

Finally, while NextEra testified that it had done a scaling analysis, that scaling analysis was done only for the B Tunnel, and not for the CEB. Tr. 609-10 (Bayrak). And the NRC Staff did no scaling analysis at all in the course of its review to support its claim of representativeness. Tr. 1047 (Buford). As Judge Trikouros suggested during the hearing, their reasoning was puzzlingly circular: “You didn’t do a scaling analysis, but you reach conclusions regarding the representativeness and I don’t quite understand.” Tr. 1051.

Taken together, NextEra’s reliance on a scaling analysis that was only applicable to the B Tunnel and not the CEB; and the Staff’s failure to conduct a scaling analysis altogether, concerns us greatly. As Dr. Saouma testified:

The failure to scale the test models to the dimensions of the prototype prevents it from being representative in the significant respect of introducing the potential for an erroneous failure mechanism (a beam may fail by bending, or a combination of bending and shear; the degree of which depends on the relative dimensions and location of shear reinforcement). Under these conditions, the corresponding load will not be representative.

Saouma Direct Testimony, 2.2.1 (Exh. INT001-R). The failure to perform this fundamental confirmation of representativeness in a thorough and accurate manner prevents us from finding that the LSTP was representative.

C. NextEra’s Unsupported, Informal and Unprofessional Characterization of Structure Cracks in Test Specimens as an Unimportant “Edge Effect.”

We agree with C-10 that NextEra and the Staff showed a significant lack of expertise and professionalism in assessing or diagnosing the nature and significance of the “structural crack that formed on the side faces of all of our [LSTP] specimens.” Tr. 360 (Bayrak). NextEra cut a test specimen with a saw “in an effort to take a look at what we ended up calling an edge effect.” Tr. 565 (Bayrak). NextEra apparently gave the cracks this colloquial name because to the naked eye, it appeared that “the cracking only went down a couple of inches, about to where the rebar started.” Tr. 1138 (Buford). And based on this visual inspection, NextEra dismissed the

possibility that the cracks could constitute ASR-caused delamination which would have been visible should have they waited a few more months for the ASR to grow further.

NextEra's and the Staff's relatively casual dismissal of the significance of the cracking that occurred in *every LSTP test specimen* reflects a significant lack of expertise, professionalism and let alone intellectual curiosity in understanding what may have caused such blatant damage to a specimen about to be tested to assess impact of ASR on the shear strength of a nuclear structure. As Dr. Saouma testified, "a crack in concrete is very pernicious. It's not something we can take a look at it and say I see a crack, I don't see a crack. There are special procedures to capture a crack." Tr. 572. And only a part of a crack can be seen with the naked eye. Tr. 571 (Saouma). "There is a lot of small microcracks which can certainly be measured or detected. So it is misleading to say well the cracks stop at this point." *Id.* As he stressed, "In concrete, we have to be very careful as to how we characterize a crack because a crack – is composed of two parts, one part which is visible and one part which is not visible. And the part which is not – visible is where we have a small transfer of stresses, but much less than the tensile stress." Tr. 571. Mere visual examination is far from sufficient:

Microcracks -- the definition of micro is they don't see them with the naked eye.

What kind of investigation, petrographically, direct tension, or other, have they done to assess whether there was microcracks besides let's take a look at this? We saw a slide from a PowerPoint with two yellow lines. A crack in concrete is not as simple as a crack in metals.

It is mentioned as -- it's a side effect. What caused it? What is a side effect? What is the cause of that? They don't say it. It's cracked. What is the explanation? What is a physical explanation? What caused it? I have a very simple one. The concrete wants to expand. It is confined in two directions. The only free direction is in the vertical one, in the free direction. Just so it cracks, visible crack on the surface, microcracks inside. Wait another couple of years, the visible crack becomes even deeper and deeper. Wait another five years, you would have complete delamination, you can see through the crack. What is a side crack? I'm curious. What caused it physically?

Tr. 1140-41. When confronted with the above, the Judge gave the floor to Dr. Bayrak for (presumably a more scientific) explanation. Tr. 1141. But NextEra was not able to respond. Tr. 1141 (Bayrak). In contrast, we note that Dr. Saouma presented a scientific explanation of what has happened based on a nonlinear finite element analysis (reported in Fig. 11 and 12 of Dr. Saouma's Rebuttal Testimony, Exh. INT-028), and showed that it was caused by the unrestrained expansion of the concrete. He also pointed out that a similar cracking could occur in Seabrook as a delamination. Tr. 572.

For recovered cores, Dr. Saouma explained that it is possible to make a determination regarding the existence of microcracking and potential for delamination beneath the surface through a direct tension test. Tr. 573. In his professional opinion, NextEra had no basis for ruling out the potential that the crack in the LSTP specimen showed that potential for delamination. Tr. 572.

We are also concerned that the Staff readily accepted NextEra's unjustified reliance on visual examination of the crack in the LSTP specimen to clear the specimen – and by analogy, Seabrook – of the potential for delamination:

We were on site when the applicant cut the blocks to show that the cracking only went down a couple of inches, about to where the rebar first started, and confirmed that was, indeed, an edge effect. We're less concerned with Seabrook structures because the edges of the large-scale test specimens, at the very top and bottom, were unrestrained. The ASR was able just to expand freely. In the restrained in between the rebar cage, we didn't see that crack. At Seabrook, the structures are not large-scale beams. They are contiguous structures that don't have that free expansion. We wouldn't expect to see that at Seabrook.

Tr. 1138-39 (Buford). The Staff showed a profound lack of knowledge regarding the effect of restraints on microcracking. As Dr. Saouma explained: delamination can occur:

when there is two planes of reinforcement and no reinforcement in between. We start with microcracking, which eventually can coalesce into microcracks. So, this is one of the bases for which I have been saying we have to be really careful about the potential for delamination. It's not hypothetical.

Tr. 891. *See also* tr.890 (citing published research on the causes and characteristics of microcracking and delamination).

D. NextEra's Failure to Assess the Role of In-Plane Shear

As Dr. Saouma testified, seismic excitation of the CEB will be resisted through two mechanisms: (a) out of plane shear at the azimuth along the earthquake and (b) in-plane shear at 90 degrees. A combination of the two in between may also occur. Saouma Direct Testimony, § 3.2. Despite the importance of in-plane shear as a failure mechanism, the LSTP did not test for the in-plane shear mode. This was because the out-of-plane shear failure mode was judged to be more critical than in-plane shear mode, due to the fact that the nominal permissible out-of-plane shear stress in concrete per the ACI 318-71 code is $2\sqrt{f'_c}$ versus allowable total shear stress of $10\sqrt{f'_c}$ for in-plane shear. Exh.NRC001 at 55. *See also* Exh. NER001, A202 (As discussed in the literature review presented in MPR-3727, NextEra demonstrated through review of published literature that one-way shear with reinforcement was not a concern for Seabrook.”).

As Dr. Saouma testified, however, the fact that the ACI 318-71 code allows 10 times the square root of the compressive strength for in plane shear, as opposed to only two times the square root of the compressive strength for out of plane, is irrelevant. In both cases, the relative loss in strength will be equal to the square root of the fraction of the loss, because the 2 and the 10 cancel out. Exh. INT028, § D.4.1. As Dr. Saouma testified, this is a significant flaw in the LSTP because “the analysis of the container is not accounted for in this loss.” *See also* tr. 909 (“Yes, in-plane, we have also the benefit of additional reinforcement, but let's not forget that this additional reinforcement has been subjected to additional stresses due to the ASR expansion as a prestressing effect.”).

NextEra conceded that it had not tested in-plane shear, but asserted that the failure mode of in-plane shear “is explicitly addressed in our reinforcing bar anchorage testing programs.” Tr. 915 (Bayrak). An examination of the document where anchorage testing is described, MPR-3727, Rev. 1, Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments” (Jan. 2014) (Exh. NER018) shows that MPR’s evaluation of in-plane shear is ambiguous. On the one hand, MPR-3727 states that out-of-plane one-way shear “envelopes in-plane shear.” *Id.* at 48. On the other hand, the report states that in-plane shear “is more sensitive to the affects (sic) of ASR.” *Id.* at 49. No data are provided to harmonize these contradictory statements.

Thus, we are left to weigh three pieces of testimony: Dr. Saouma’s very clear written and oral testimony that in-plane shear testing was not done but necessary for adequate conservatism; the NRC Staff’s oral confirmation that in-plane testing was not done; and Dr. Bayrak’s oral testimony, given for the first time during the hearing, that in-plane testing *was, in fact*, performed, along with an internally contradictory document purported to support Dr. Bayrak’s new claim. We must also accord appropriate weight to Dr. Saouma’s far greater level of expertise. Therefore, we find that NextEra has not satisfied its burden on this issue.

E. NextEra’s Application of Erroneous Boundary Conditions

According to NextEra, the presence of confinement is a central factor for the effect of ASR on structural performance. Reinforcing steel, loads on the concrete structure (e.g., deadweight), and the configuration of the structure (i.e., restraint offered by the structural layout) provide confinement that restrains in-situ expansion of the ASR gel and limits the resulting cracking in concrete. Structural testing of full-scale specimens simulates the in-situ confinement and therefore provides much more representative results than simpler approaches that do not account

for confinement (e.g., material property testing). MPR-4273, Rev. 0, Seabrook Station – Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction at 2-2 (July 2016), Exh. NRC008.

Despite the importance of boundary conditions to the assessment of ASR effects on structural performance, Dr. Saouma found that the boundary conditions applied by NextEra on the LSTP test specimens were erroneous. Saouma Direct Testimony, § B.3. Whereas the lateral confinement can (to some extent) be replicated by the large number of transversal rebars, the axial force exercised by the self-weight (i.e. weight of the structure above the point under consideration) of the containment structure (*see* Fig. 3(b) in Saouma Direct Testimony), is not modeled by NextEra. Given that the ASR expansion will induce (structurally) some beneficial confining forces, those may be negligible compared to those exercised by the (non-modeled) axial ones. *Id.*

NextEra testified that in the LSTP beam testing, “what happens is we are coming out with a highly idealized boundary conditions that we refer to as simple supports and the beam itself is called a simply supported beam.” Tr. 282 (Bayrak). Dr. Bayrak himself pointed out the differences between the beam specimen and the prototype (Seabrook): “No portion of Seabrook, to my knowledge, involves simple supports. So the boundary conditions are quite different. Boundary conditions commonly constrain or restrain the movement of a particular beam, wall segment, slab, and the like such that the element itself is confined.” *Id.*

Dr. Saouma was highly critical of this rationalization:

Most if not all the cracks addressed in the ACI code are flexural shear cracks. That is, they start as a vertical crack at the bottom due to flexure and then it curves into shear. When you have such a high reinforcement ratio you inhibit the formation of so-called flexural shear cracks.

Second point I'd like to make, when you have a structure as high as a nuclear containment structure, it is relatively flexible. So boundary conditions applied are not necessarily conservative. We are talking about only a 36-inch deep section, which is about 30 meters high. So by then it is, for all practical purposes, a so-called simply supported structure and there is no additional safety factor introduced by some perceived restraints.

Tr. 283-84. Thus, not only are the boundary conditions applied not representative of the axial force in the CEB, but NextEra's assertion that they are conservative is not valid. We also note that this lack of conservatism is exacerbated by the fact that NextEra was testing a beam that was modeled on a tunnel, rather than focusing on the CEB, a structure more vulnerable to seismic stresses. *See* Section VIII.B above.

F. Limitations of the Prestressing Effect

We agree with NextEra's assertion that ASR will increase the shear strength of reinforced concrete beam. However, we also agree with C-10 that there are two important mitigating factors. First the increase in shear strength is accompanied by a corresponding increase in compressive stresses of the concrete and the tensile stresses in the reinforcement TR. 829 (Saouma). Secondly, the beneficial effect of the chemical prestressing will diminish with time due to creep. Tr. 964 and 829 (Saouma). C10 contends that the beam cannot be relied on without undertaking a comprehensive analysis.

G. Size Effect

As discussed above in Section VIII.B, the dimensions of the LSTP testing beams were based on the B tunnel. As acknowledged by NextEra they were not scaled in accordance with the CEB. Tr. 1045-46 (Bayrak, Thomas). We agree with NextEra that the shear stress will decrease with size. Tr. 626 (Bayrak). However, we must also agree with C-10 that this observed size effect should also be carried in applying the test results to the CEB (which has a different depth) as

highlighted by C-10 in Dr. Saouma's Rebuttal Testimony, Fig. 3 (INT028). As Dr. Saouma explained:

To begin with, if the beam is flexurally over-reinforced, one cannot assume that for Seabrook Station the same effect will be observed. It may, or it may not. One has to make a more convincing argument to support such a comparison.

Another important difference between the test specimen and the CEB is that the test specimen was about [REDACTED] scale [REDACTED]-inch depth whereas the wall of a CEB is about 36 inches). This is not unusual in component testing. However, given the brittle nature of shear failure and associated size effect, the shear strength in the CEB will be lower than the one from the LSTP. This phenomenon is described by Figure 3, a depiction of the LSTP derived from Bentz, E.C. (2005).

Saouma Rebuttal Testimony, Exh. INT028, § D.3.2.

Finally, we find no merit to the assertion by NextEra that due to the prestressing effect of ASR it is unnecessary to account for size effect. NextEra has no scientific evidence for this position, and it is incorrect. As he stated, "to think that because we have a pre-stressing effect. . . is a panacea and absolves us from any other consideration is wrong." Tr. 627. As Dr. Saouma explained:

[A]ccompanying the prestressing effect is an increase in the tensile stresses in the reinforcement. These tensile stresses were not accounted for during the design process.

As a result of this, there is an increase in the compressive stresses which were not accounted for in the design process. So to say that ASR is beneficial in shear, it is correct partially. But then there is the reverse side of the coin which tells us that you get this at a price.

Tr. 628 (citing Saouma Rebuttal Testimony, Fig. 4 (INT028)). We agree that NextEra has oversimplified the issue, and we also find that Dr. Saouma has demonstrated a greater level of expertise. Therefore, we find for C-10.

H. Faulty Observations and Assumptions with Respect to Crack Indexing.

As Judge Trikouros noted during the hearing, the validity of the crack indexing method “is at the heart” of this licensing proceeding. Tr. 452. We find that NextEra failed to justify its reliance on crack index measurements in three key respects.

1. Failure to account for concrete’s internal humidity in crack index measurements

We agree with C-10 that surface ASR expansion will depend on the presence of sufficient relative humidity on the surface of concrete, as evidenced by a minimum of 80% relative humidity. Tr. 449-50 (Saouma). Dr. Saouma testified to a drying effect that takes place on the surface over time, while inside of the concrete humidity remains high. *Id.* Thus, most of the expansion will take place inside the wall, not on the surface. *Id.*

During the hearing, multiple NextEra witnesses testified that they had seen no evidence of subsurface cracking that was greater than surface cracking. For instance, Matthew Sherman testified that:

ASR is a geological phenomenon, even at the large-scale testing program where there was high temperature, extra-high humidity, where it was high alkali content, extra added reactivity, it still took on average a year to get to the point where we were within the LSTP. So in the plant environment, it doesn't occur that quickly. *We have never found a spot at the plant, and we've done cores, you know, tested different depths. It is never worse at depth within the core concrete than what is indicated at the surface.*

Tr. 397 (emphasis added). Similarly, Mr. Sherman stated that in previous petrographic studies, NextEra “found no substantial difference between near surface and what would be below the level of the reinforcing steel within the core of the structure.” Tr. 456. NextEra witness Edward Carley also testified that “we have done petrographic examination, those cores are similar across the plant . . . and through the depth.” Tr. 532. And Dr. Bayrak testified that on visual examination of 200 extensometer core samples, no delamination was found:

That expansion causing a hidden crack on the inside is directly refuted by 200 cores that have been taken by the plant and zero such observations have been reported.

So, once again, as an experimentalist I am going with data that I have in my hands, 200 cores -- cores, no delamination. I can bring in outside of Seabrook ASR experience, but perhaps that's not directly relevant. And those facts lead me to believe that the postulation that a big delamination is going to take place without going noticed is something I cannot wrap my head around.

Tr. 705.

During the hearing, Judge Trikouros asked Dr. Saouma to provide references for documents confirming his observation that subsurface cracking was more severe. Tr. 451. Dr. Saouma responded that the condition is a matter of "simple physics." *Id.* He also identified studies at other locations (tr. 451-52), but he had no evidence regarding conditions at Seabrook at that time.

After the hearing, in the course of reviewing some discovery documents produced by NextEra, C-10 found WJE Report No. 2014-3453.2 (May 26, 2016) ("WJE Report"). This report, prepared by one of NextEra's own petrographic consultants, Wiss, Janney, Elstner ("WJE"), documents the observation of ASR in at least one core sample taken from Seabrook, that was more severe in the interior of concrete structures than at the surface. WJE also concluded that the ASR was likely caused by factors in the interior of the concrete, not the surface. C-10 has submitted the WJE Report to the ASLB as Proposed Exhibit INT050. *See* discussion in Section V.B above. shows that in fact, NextEra's own petrographic consultant, WJE, observed ASR that was more significant at depth in Seabrook core samples.

Dr. Saouma also testified the relative humidity could be measured easily with a small wireless chip. 460. Under the circumstances, we found NextEra's various rationalizations for failing to address this issue to be unconvincing. And we are greatly concerned that multiple NextEra witnesses denied that NextEra had ever observed greater internal cracking than on the surface -- without mentioning their own consultant's report making exactly the opposite

observation. In light of Exh. INT050, Dr. Saouma's significant expertise on this issue, and NextEra's apparent disregard of the significance of the WJE Report, we find for C-10 on this issue. Evidently, NextEra staff was instructed to merely look for cracks with the naked eye, whereas they should have been looking more assiduously for initialing micro-cracks that will grow into visible cracks with time.

2. Inconsistencies in attributing cracks to ASR

We are concerned by some contradictions in NextEra's testimony with respect to the attribution of cracking to ASR. On one hand, NextEra claimed conservatism by assuming all observed cracks are caused by ASR. Tr. 333 (Sherman). At a different point in the hearing, however, NextEra testified that:

Everything in a CCI index, in a grid, a measuring grid, is assumed to be ASR until proven otherwise. And we have done that at some locations where we had a number that, when we went back and looked at the verification, the corroboration of the testing, it didn't make sense. So, that's when we would go back, mobilize, remove a core, and found that, in fact, the cracks were not related to ASR. So, that fundamental conservative assumption that every crack in the plant was due to ASR for our calculation purposes was found to be untrue, at which point we could remove those cracks and rerun the analysis.

Tr. 932 (Sherman). It raises a significant concern that NextEra would claim a conservatism and then suggest that it can be abandoned when results do not suit them. This is yet another example of either incompetence or disregard for basic principles of science and engineering.

3. Roles of micro-cracks and delamination

We are concerned by NextEra's apparent lack of understanding of micro-cracks, and their potential for delamination. As C-10 asserts, microcracks represent:

a lot of cracks, rather than one single localized crack. What's going to happen is that those microcracks, initially they will be everywhere, but eventually they will coalesce in one single crack. And this will be the predominant crack, which might cause delamination.

Tr. 534 (Saouma) (emphasis added). NextEra also admitted the potential existence of delamination due to micro-cracks during the hearing:

Dr. Saouma read portions of ISE guideline document, institutional structural engineers from the United Kingdom, where cracks forming parallel to rebar mats is one aspect of it that he drew our attention to in the context of some cracking that may form or micro-cracking may concentrate into a singular crack, delamination crack, to use the terminology in that document. And we have talked about that. So, again, the crack pattern ends up being important.

Tr. 1002 (Bayrak). And yet during the same hearing, NextEra denied observing any evidence of delamination:

Seabrook has performed over two hundred cores of the plant. And we have not seen any evidence of cracking beyond the rebar structure.

Tr. 358 (Carley). We are concerned that failure to look for micro-cracks from recovered cores would yield result in hidden undetected delamination later on once the cracks grew driven by the ASR expansion.

I. Leaching

We concur with C-10 that failure to account for leaching casts a serious doubt on the laboratory testing and surface measurements done by NextEra (especially for the Z frame used to develop the corroboratory method). Tr. 481 (Saouma); and *see* NER022, § 5.1.1. NextEra offers the following justification for its failure to account for leaching:

It is true that the alkalis can leach out of a concrete cover just like alkalis can leach out on the outside portion of a wall in Seabrook structures due to the presence of the water, but the expansions of concern are not that of the cover concrete. They are related to structural core, what the structural core is doing and are we getting a good indication from cracking index activity as it relates to structural core expansions?

Tr. 481 (Bayrak). Dr. Bayrak invoked the experts at the FSEL who prepared the FHWA reports as authorities whose “best practices recommendations” include crack indexing but not leaching of alkalis. Tr. 482. As Dr. Saouma testified, however, the only conclusion one can draw from

that omission is that the FHWA “does not discern leaching of alkalis affecting cracking index one way or the other.” Tr. 483. We find NextEra’s argument unconvincing and also not supported by adequate expertise. Therefore, we rule for C-10.

J. NextEra’s Failure to Perform adequate Structure Deformation Monitoring (Finite Element Analysis)

The finite element analysis, as an integral part of the Structural Evaluation, will start with expansion measurements from Seabrook as an input (Exh. NER001 Fig. 4), and will then subject the various structures (the CEB being of particular concern) to a battery of loads. Exh. NRC089, § 3.3. The loads include un-factored service loads (where one would expect an un-cracked concrete to be in the linear elastic zone), factored loads (where we would expect the response to be nonlinear) (tr.1093-94) (Saouma), and last but not least seismic load where the structure will be severely shaken. Ttr. 1091) (Thomas).

Given that visible external cracks are the trigger points for an analysis (Exh. INT021 §. 6.2.5), and given that the current inspection procedure will not necessarily detect internal cracks (tr. 557) (Saouma), it is evident that any analysis would have to account for cracking. In addition, ASR poses specific constraints on the finite element analysis . Exh. INT001-R § 5.2.5. Hence, a nonlinear analysis is the only reasonable way to ascertain the safety of Seabrook. Exh. INT007, § 5.2.2 item 2. However, NextEra found no need to perform nonlinear analysis. Exh. NER001, A 196.

However, one cannot initiate an analysis with a cracked section. This is the essence of nonlinear analysis where one has to start from zero load, or a “virgin concrete” and then capture the evolution of the stress redistribution and crack formation. Concrete has a “memory”, and the mere principle of superposition can not be applied. Tr. 919-20 (Saouma). Accordingly, we find there is insufficient evidence on which to rule for NextEra.

K. Finite Element Modeling of ASR

We are concerned that NextEra's finite element analysis (ANSYS) (Exh. NER001, A92) does not exhibit any of the basic features essential to properly model ASR. Those have been listed by C-10 in Dr. Saouma's Rebuttal Testimony, § 5.2.5. We also note that NextEra did not provide for any of the basic requirements of a finite element code that are appropriate and necessary for an ASR evaluation. None was listed as a special feature of ANSYS by NextEra, yet they are prominently listed in NextEra's exhibit Gocevski, V., "Pathologies/Degradation Mechanisms Experienced by Hydro-Quebec During the Evaluation of Gentilly-2 NPP," Report Submitted to ASCET, (June 2015) (Exh. NER038). Indeed, NextEra's oversimplified finite element analysis stands in sharp contrast to the requirements for a finite element code that were used by Hydro Quebec at Gentilly-2. Saouma Rebuttal Testimony, § A.10. As Dr. Saouma has testified, Gentilly-2 is a good example of a high degree of professionalism and expertise. *Id.* Dr. Saouma has demonstrated that he is familiar with finite element modeling of ASR (he wrote the first and so far only book on the numerical analysis of ASR) and his worldwide expertise is unquestionable. Hence, we credit his considerable expertise here in comparison to NextEra's. We rule for C-10 on this issue.

We are also very concerned by what appear to be misleading statements by NextEra in regard to the handling of the radial ASR expansion by their finite element analysis. NextEra has acknowledged that due to the confinement, the expansion will be radial:

So the point of interest is as ASR related expansions and associated cracking is driving a primary expansion through the thickness out of plane,

Tr. 280. Thus, it is likely to cause a crack parallel to the surfaces of the walls (delamination).

Yet, NextEra modeled ASR as a thermal load:

The internal ASR expansion is determined via the field-measured CI expansion

strain; CI is measured in each of the in-plane orthogonal directions. CI represents an equivalent ASR strain. FEM codes do not provide direct inputs for ASR expansion, but thermal expansion can be used as a proxy, and therefore ASR strain is simulated by applying an equivalent thermal load to the concrete only. External ASR pressure may also be exerted by expansion of the moisture swelling). These total demands are then compared to the original code capacities for use in the structural evaluations

NER004, A76. NextEra also stated that:

There is a facility in finite element codes to, to input self-straining forces that is, the type of expansion similar to ASR by inputting a thermal load with expansion coefficients. So, we can use a thermal loading. We're not loading the temperature.

Tr. 861 (Bell).

Dr. Saouma questioned the un-conservativeness of having the same expansion in all three directions (thus ignoring the fact that most of the expansion is out of plane/radially). Tr. 351.

NextEra responded that:

We have put the expansion -- basically, we have expansion in each direction to a relative value that we have measured in each direction. Therefore, we have different expansion, different directions.

Tr. 1171 (Bolourchi). This assertion was challenged by Dr. Saouma:

This is not what I read from the report. I do not recall having seen, in the report, any place where they indicate that there is an anisotropic coefficient of thermal expansion used. I believe that question was asked previously. The answer was the same, coefficient of thermal expansion Alpha, with a Delta T so that the Alpha Delta T equals volumetric expansion. If, indeed, a different expansion is applied in the radial direction than in the vertical direction, I think we should be seeing where in the document it is specified.

Tr. 1172. NextEra's counsel proceeded to submit as supporting evidence a reference to INT022, an SGH report:

Yes, Your Honor, I believe the question with regard to the consideration of thermal loads. The document we were referring to was INT022, which is really -- which is the SEM methodology document that we've been really talking about all week. We refer you to Section 3.1 on calculation of ASR loads.

Tr. 1178 (Bessette). As Dr. Saouma testified, however, INT022 Section 3.1 contains no “specific line where it says that the expansion in the radial direction is different than the expansion in the other one, as stated this morning.” Tr. 1182 (Saouma). Thus, NextEra’s assertion that it had conducted the model appropriately was not supported by any document, and instead a misleading reference was provided. This shows a gross level of either incompetence or carelessness on NextEra’s behalf.

IX. CONCLUSIONS OF LAW

As discussed above in Section I, in this proceeding the ASLB must assess the testimony and exhibits presented by the parties and determine whether NextEra has satisfied its burden of proving that Seabrook can be safely operated for another 30 years from now (*i.e.*, the rest of the current operating license term plus a 20-year renewal term), despite the presence of ASR in a significant number of safety structures at the reactor. In particular, we must evaluate the LAR against C-10’s claim that the LSTP, relied on by NextEra as the linchpin for its assessment of ASR, is not representative of Seabrook as claimed by NextEra; and therefore it fails to provide an adequate basis for NextEra’s proposed program for monitoring the progress of ASR over coming decades. Our conclusions of law are as follows:

A. The ASLB Lacks an Adequate Basis to Make a Decision Because the Record Does not Contain a Competent or Independent Expert NRC Staff Safety Review.

As discussed above in Section IV, it is established Commission policy that before the ASLB can make a decision in an NRC licensing case, it must have before it a competent and independent NRC Staff safety evaluation. In this case, that requirement has not been satisfied. Therefore, we are unable to reach any decision in favor of NextEra. Therefore we rule that the issuance of the LAR must be reversed.

B. Assuming for Purposes of Argument That the ASLB is Entitled to Make a Decision Without a Competent or Independent Expert NRC Staff Safety Review, the ASLB Rules for C-10 Because NextEra Has Not Satisfied its Burden of Proving That the LAR Satisfies NRC Safety Standards and Adequately Protects the Public Health and Safety.

As discussed above in Section IX.A, we have concluded that we have no lawful basis to approve the issuance of the LAR to NextEra. Even assuming for purposes of argument that we did have such authority, however, we find that NextEra has not satisfied its burden of proving that the LAR is adequate to satisfy NRC regulations and protect public health and safety. Applicable legal standards, including burden of proof and safety standards, are set forth in Section III above. Our findings of fact regarding NextEra's failure to satisfy its burden of proof are set forth in Sections VII and VIII.

C. In Light of Our Ruling That the LAR Should Be Reversed, and in Light of the Acknowledged Dependence of NextEra's Renewed License on the LAR, We Refer Our Decision to the Commissioners for a Determination Regarding Whether the License Renewal Decision Should Also Be Reversed.

As discussed above in Section II.G, the 20-year license renewal approved by the NRC in the spring of 2019 incorporates key elements of the LAR as conditions for extended operation. Therefore, the validity of the license renewal decision is fatally undermined by our decision to reverse the issuance of the LAR. While we do not have the authority to reverse the license renewal decision, the Commission does. *NextEra Energy Seabrook, L.L.C.* (Seabrook Station, Unit 1), CLI-19-7, __ N.R.C. __, slip op. at 12 (2019). As the Commission noted there, "the renewed license could be revoked or modified, if necessary, to reflect the outcome of the hearing process." *Id.* Because the defective license amendment is part of NextEra's aging management plan for the license renewal term, any decision by the ASLB to invalidate the issuance of the license amendment should also have the effect of nullifying the license renewal decision that

depends on it. We therefore refer our decision to the Commission for consideration of further action consistent with CLI-19-7.

X. CONCLUSION

For the foregoing reasons, the ASLB should issue a decision consistent with these Proposed Findings of Fact and Conclusions of Law, reverse the LAR, and refer this decision to the NRC Commissioners for reversal of its recent decision to renew NextEra's operating license for the Seabrook nuclear power plant.

Respectfully submitted,

/signed electronically by/

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November 21, 2019

Corrected November 27, 2019

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

_____)	
In the Matter of)	
NextEra Energy Seabrook, LLC)	Docket No. 50-443
(Seabrook Station, Unit 1))	
_____)	

CERTIFICATE OF SERVICE

I certify that on November 27, 2019, I posted C-10 Research and Education Foundation's Corrected Proposed Findings of Fact and Conclusions of Law on the NRC's electronic hearing docket.

/signed electronically by/
Diane Curran