UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 1, 2016

Mr. Eric McCartney
Site Vice President
Seabrook Station
c/o Kenneth Browne
626 Lafayette Road
Seabrook, NH 03874

SUBJECT: SEABROOK STATION, UNIT 1 – SAFETY EVALUATION REGARDING IMPLEMENTATION OF MITIGATING STRATEGIES AND RELIABLE SPENT FUEL POOL INSTRUMENTATION RELATED TO ORDERS EA-12-049 AND EA-12-051 (CAC NOS. MF0836 AND MF0837)

Dear Mr. McCartney:

On March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond Design-Basis External Events" and Order EA-12-051, "Order to Modify Licenses With Regard To Reliable Spent Fuel Pool Instrumentation," (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML12054A736 and ML12054A679, respectively). The orders require holders of operating reactor licenses and construction permits issued under Title 10 of the *Code of Federal Regulations* Part 50 to modify the plants to provide additional capabilities and defense-in-depth for responding to beyond-design-basis external events, and to submit for review Overall Integrated Plans (OIPs) that describe how compliance with the requirements of Attachment 2 of each order will be achieved.

By letter dated February 26, 2013 (ADAMS Accession No. ML13063A438), NextEra Energy Seabrook, LLC (NextEra, the licensee) submitted its OIP for Seabrook Station, Unit 1 (Seabrook) in response to Order EA-12-049. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-049. These reports were required by the order, and are listed in the encloseded safety evaluation. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 25, 2014 (ADAMS Accession No. ML14030A552), and October 28, 2015 (ADAMS Accession No. ML15278A200), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated July 26, 2016 (ADAMS Accession No. ML16214A244), NextEra submitted a compliance letter and Final Integrated Plan (FIP) in response to Order EA-12-049. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-049.

By letter dated February 26, 2013 (ADAMS Accession No. ML13063A439), the licensee submitted its OIP for Seabrook in response to Order EA-12-051. At six month intervals following the submittal of the OIP, the licensee submitted reports on its progress in complying with Order EA-12-051. These reports were required by the order, and are listed in the enclosed safety evaluation. By letters dated December 4, 2013 (ADAMS Accession No. ML13267A388), and October 28, 2015 (ADAMS Accession No. ML15278A200), the NRC staff issued an ISE and audit report, respectively, on the licensee's progress. By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated December 15, 2015 (ADAMS Accession No. ML15356A102), NextEra submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of NextEra's strategies for Seabrook. The intent of the safety evaluation is to inform NextEra on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Jason Paige, Orders Management Branch, Seabrook Project Manager, at Jason.Paige@nrc.gov.

Sincerely,

Mandy K Halter

Mandy K. Halter, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No.: 50-443

Enclosure:
Safety Evaluation

cc w/encl: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO ORDERS EA-12-049 AND EA-12-051

NEXTERA ENERGY SEABROOK, LLC.

SEABROOK STATION, UNIT 1

DOCKET NO. 50-443

1.0 INTRODUCTION

The earthquake and tsunami at the Fukushima Dai-ichi nuclear power plant in March 2011 highlighted the possibility that extreme natural phenomena could challenge the prevention, mitigation and emergency preparedness defense-in-depth layers already in place in nuclear power plants in the United States. At Fukushima, limitations in time and unpredictable conditions associated with the accident significantly challenged attempts by the responders to preclude core damage and containment failure. During the events in Fukushima, the challenges faced by the operators were beyond any faced previously at a commercial nuclear reactor and beyond the anticipated design-basis of the plants. The U.S. Nuclear Regulatory Commission (NRC) determined that additional requirements needed to be imposed at U.S. commercial power reactors to mitigate such beyond-design-basis external events (BDBEEs).

On March 12, 2012, the NRC issued Order EA-12-049, "Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12054A736). This order directed licensees to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool (SFP) cooling capabilities in the event of a BDBEE. Order EA-12-049 applies to all power reactor licensees and all holders of construction permits for power reactors.

On March 12, 2012, the NRC also issued Order EA-12-051, "Order Modifying Licenses With Regard to Reliable Spent Fuel Pool Instrumentation" (ADAMS Accession No. ML12054A679). This order directed licensees to install reliable SFP level instrumentation (SFPLI) with a primary channel and a backup channel, and with independent power supplies that are independent of the plant alternating current (ac) and direct current (dc) power distribution systems. Order EA-12-051 applies to all power reactor licensees and all holders of construction permits for power reactors.

2.0 REGULATORY EVALUATION

Following the events at the Fukushima Dai-ichi nuclear power plant on March 11, 2011, the NRC established a senior-level agency task force referred to as the Near-Term Task Force

(NTTF). The NTTF was tasked with conducting a systematic and methodical review of the NRC regulations and processes and determining if the agency should make additional improvements to these programs in light of the events at Fukushima Dai-ichi. As a result of this review, the NTTF developed a comprehensive set of recommendations, documented in SECY-11-0093, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," dated July 12, 2011 (ADAMS Accession No. ML11186A950). Following interactions with stakeholders, these recommendations were enhanced by the NRC staff and presented to the Commission.

On February 17, 2012, the NRC staff provided SECY-12-0025, "Proposed Orders and Requests for Information in Response to Lessons Learned from Japan's March 11, 2011, Great Tohoku Earthquake and Tsunami" (ADAMS Accession No. ML12039A103), to the Commission. This paper included a proposal to order licensees to implement enhanced BDBEE mitigation strategies. As directed by the Commission in staff requirements memorandum (SRM)-SECY-12-0025 (ADAMS Accession No. ML120690347), the NRC staff issued Orders EA-12-049 and EA-12-051.

2.1 Order EA-12-049

Order EA-12-049, Attachment 2 (ADAMS Accession No. ML12054A736), requires that operating power reactor licensees and construction permit holders use a three-phase approach for mitigating BDBEEs. The initial phase requires the use of installed equipment and resources to maintain or restore core cooling, containment and SFP cooling capabilities. The transition phase requires providing sufficient, portable, onsite equipment and consumables to maintain or restore these functions until they can be accomplished with resources brought from off site. The final phase requires obtaining sufficient offsite resources to sustain those functions indefinitely. Specific requirements of the order are listed below:

1) Licensees or construction permit (CP) holders shall develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and SFP cooling capabilities following a beyond-design-basis external event.

2) These strategies must be capable of mitigating a simultaneous loss of all alternating current (ac) power and loss of normal access to the ultimate heat sink [UHS] and have adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

3) Licensees or CP holders must provide reasonable protection for the associated equipment from external events. Such protection must demonstrate that there is adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to this Order.

4) Licensees or CP holders must be capable of implementing the strategies in all modes of operation.

5) Full compliance shall include procedures, guidance, training, and acquisition, staging, or installing of equipment needed for the strategies.

On December 10, 2015, following submittals and discussions in public meetings with NRC staff, the Nuclear Energy Institute (NEI) submitted document NEI 12-06, Revision 2, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide" (ADAMS Accession No. ML16005A625), to the NRC to provide revised specifications for an industry-developed methodology for the development, implementation, and maintenance of guidance and strategies in response to the Mitigation Strategies order. The NRC staff reviewed NEI 12-06, Revision 2, and on January 22, 2016, issued Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2012-01, Revision 1, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML15357A163), endorsing NEI 12-06, Revision 2, with exceptions, additions, and clarifications, as an acceptable means of meeting the requirements of Order EA-12-049, and published a notice of its availability in the *Federal Register* (81 FR 10283).

2.2 Order EA-12-051

Order EA-12-051, Attachment 2 (ADAMS Accession No. ML12054A679), requires that operating power reactor licensees and construction permit holders install reliable SFP level instrumentation. Specific requirements of the order are listed below:

> All licensees identified in Attachment 1 to the order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.
>
> 1. The spent fuel pool level instrumentation shall include the following design features:
>
> 1.1 Instruments: The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.
>
> 1.2 Arrangement: The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel

separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.

1.3 Mounting: Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the spent fuel pool structure.

1.4 Qualification: The primary and backup instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the spent fuel pool water at saturation conditions for an extended period. This reliability shall be established through use of an augmented quality assurance process (e.g., a process similar to that applied to the site fire protection program).

1.5 Independence: The primary instrument channel shall be independent of the backup instrument channel.

1.6 Power supplies: Permanently installed instrumentation channels shall each be powered by a separate power supply. Permanently installed and portable instrumentation channels shall provide for power connections from sources independent of the plant ac and dc power distribution systems, such as portable generators or replaceable batteries. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to maintain the level indication function until offsite resource availability is reasonably assured.

1.7 Accuracy: The instrument channels shall maintain their designed accuracy following a power interruption or change in power source without recalibration.

1.8 Testing: The instrument channel design shall provide for routine testing and calibration.

1.9 Display: Trained personnel shall be able to monitor the spent fuel pool water level from the control room, alternate shutdown panel, or other appropriate and accessible location. The display shall provide on-demand or continuous indication of spent fuel pool water level.

2. The spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation of the following programs:

2.1 Training: Personnel shall be trained in the use and the provision of alternate power to the primary and backup instrument channels.

2.2 Procedures: Procedures shall be established and maintained for the testing, calibration, and use of the primary and backup spent fuel pool instrument channels.

2.3 Testing and Calibration: Processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup spent fuel pool level instrument channels to maintain the instrument channels at the design accuracy.

On August 24, 2012, following several NEI submittals and discussions in public meetings with NRC staff, the NEI submitted document NEI 12-02, "Industry Guidance for Compliance With NRC Order EA-12-051, To Modify Licenses With Regard to Reliable Spent Fuel Pool Instrumentation," Revision 1 (ADAMS Accession No. ML12240A307) to the NRC to provide specifications for an industry-developed methodology for compliance with Order EA-12-051. On August 29, 2012, the NRC staff issued its final version of JLD-ISG-2012-03, "Compliance with Order EA-12-051, Reliable Spent Fuel Pool Instrumentation" (ADAMS Accession No. ML12221A339), endorsing NEI 12-02, Revision 1, as an acceptable means of meeting the requirements of Order EA-12-051 with certain clarifications and exceptions, and published a notice of its availability in the *Federal Register* (77 FR 55232).

3.0 TECHNICAL EVALUATION OF ORDER EA-12-049

By letter dated February 26, 2013 (ADAMS Accession No. ML13063A438), NextEra Energy Seabrook, LLC (NextEra, the licensee) submitted an Overall Integrated Plan (OIP) for Seabrook Station, Unit 1 (Seabrook) in response to Order EA-12-049. By letters dated August 28, 2013 (ADAMS Accession No. ML13247A178), February 27, 2014 (ADAMS Accession No. ML14064A188), August 26, 2014 (ADAMS Accession No. ML14246A193), February 27, 2015 (ADAMS Accession No. ML15068A021), August 26, 2015 (ADAMS Accession No. ML15245A531), and February 11, 2016 (ADAMS Accession No. ML16048A261), the licensee submitted six-month updates to the OIP. By letter dated August 28, 2013 (ADAMS Accession No. ML13234A503), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-049 in accordance with NRC Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-111, "Regulatory Audits" (ADAMS Accession No. ML082900195). By letters dated February 25, 2014 (ADAMS Accession No. ML14030A552), and October 28, 2015 (ADAMS Accession No. ML15278A200), the NRC issued an Interim Staff Evaluation (ISE) and audit report, respectively, on the licensee's progress. By letter dated July 26, 2016 (ADAMS Accession No. ML16214A244), the licensee reported that full compliance with the requirements of Order EA-12-049 was achieved, and submitted a Final Integrated Plan (FIP).

3.1 Overall Mitigation Strategy

Attachment 2 to Order EA-12-049 describes the three-phase approach required for mitigating BDBEEs in order to maintain or restore core cooling, containment, and SFP cooling capabilities. The phases consist of an initial phase (Phase 1) using installed equipment and resources, followed by a transition phase (Phase 2) in which portable onsite equipment is placed in service, and a final phase (Phase 3) in which offsite resources may be placed in service. The timing of when to transition to the next phase is determined by plant-specific analyses.

While the initiating event is undefined, it is assumed to result in an extended loss of ac power (ELAP) with a loss of normal access to the UHS. Thus, the ELAP with loss of normal access to the UHS is used as a surrogate for a BDBEE. The initial conditions and assumptions for the analyses are stated in NEI 12-06, Section 3.2.1, and include the following:

1. The reactor is assumed to have safely shut down with all rods inserted (subcritical).
2. The dc power supplied by the plant batteries is initially available, as is the ac power from inverters sup
3. lied by those batteries; however, over time the batteries may be depleted.
4. There is no core damage initially.
5. There is no assumption of any concurrent event.
6. Because the loss of ac power presupposes random failures of safety-related equipment (emergency power sources), there is no requirement to consider further random failures.

Seabrook is a Westinghouse pressurized-water reactor (PWR) with a dry ambient pressure containment. The licensee's three-phase approach to mitigate a postulated ELAP event, as described in the FIP, is summarized below. To note, Seabrook's Phase 2 strategy consists of a primary and alternate strategy. The primary strategy utilizes at least one of two available installed supplemental emergency power system (SEPS) diesel generator sets, which are not credited in the station blackout (SBO) analysis, to reenergize an emergency ac bus. In conjunction with SEPS, the primary strategy utilizes the service water cooling tower (SWCT) as the UHS. The alternate strategy utilizes a full set of portable FLEX equipment. Since SEPS and the SWCT are not fully protected from all hazards as defined in NEI 12-06, Seabrook's Phase 2 strategy is determined by the availability of SEPS and the SWCT. The NRC staff identified the use of SEPS as an alternative to NEI 12-06 and is discussed in Section 3.14 of this safety evaluation (SE). In addition, the ELAP event that results from a hurricane has a significantly different sequence of events. As stated in the FIP, the plant will be shut down and cooled to Mode 5 two hours before arrival of a hurricane. This significantly reduces heat removal and makeup requirements. Therefore, the following discussions generally refer to the more limiting sequence of events from non-hurricane-induced ELAP. The variations of Seabrook's strategy for an hurricane event is discussed in Section 3.2.2 of this SE.

At the onset of an ELAP, the reactor is assumed to trip from full power. The reactor coolant pumps (RCPs) coast down and flow in the reactor coolant system (RCS) transitions to natural circulation. Operators will take prompt actions to minimize RCS inventory losses by isolating potential RCS letdown paths. Decay heat is removed by steaming to the atmosphere from the steam generators (SGs) through the atmospheric steam dump valves (ASDVs) or SG safety valves, and makeup to the SGs is initially provided by the turbine-driven emergency feedwater (TDEFW) pump taking suction from the condensate storage tank (CST). Subsequently, the operators will begin a controlled cooldown and depressurization of the RCS. If SEPS is available, operators will begin a cooldown within 2 hours of an ELAP event with the intent to reach residual heat removal (RHR) initiation criteria within 9 hours. If SEPS is unavailable, operators will begin a cooldown within 10 hours of an ELAP event. As a contingency, if the TDEFW pump fails, operators will deploy a portable, diesel-driven FLEX low-pressure pump (FLPP) for injection into the SGs.

The water supply for the TDEFW pump is initially from the CST. The CST will provide a minimum of 15 hours of RCS decay heat removal, in addition to absorbing the latent heat associated with the planned RCS cooldown. If SEPS is available, an emergency ac bus will energize the motor driven emergency feedwater (EFW) pump as a source of backup to the TDEFW pump in the event of a TDEFW pump failure. As mentioned above, operators will begin a cooldown with the intent to reach RHR initiation criteria within 9 hours. Placing RHR in service within 9 hours will ensure that the available water in the CST will provide an adequate supply without the need for refilling. If SEPS is unavailable, a portable submersible low-pressure (LP) FLEX pump would be deployed and provide makeup water to the CST within 11 hours. This pump would draw suction from either the demineralized water storage tank (DWST) or the circulating water pump cistern and refill the CST via hoses routed to the CST or provide water directly to the suction of the portable diesel driven FLPP.

Depressurizing the SGs reduces RCS temperature and pressure. The reduction in RCS temperature will result in inventory contraction in the RCS, with the result that the pressurizer would drain and a steam void would form in the reactor vessel upper head. The RCS leakage, particularly from the RCP seals, would also contribute to the decrease in RCS liquid volume. However, during the cooldown RCS pressure should drop below the safety injection accumulator pressure and the injection of some quantity of borated water into the RCS from the accumulators would then occur.

As discussed in its FIP, the licensee expects to terminate the cooldown once the RCS reaches a temperature and pressure of 350 degrees Fahrenheit (°F) and 360 per square inch gauge (psig), respectively. This temperature and pressure corresponds to the RHR initiation criteria. If SEPS is available, the cooldown will be completed and RHR placed into service within 9 hours of the event. If SEPS is unavailable, the cooldown will be completed within 13.1 hours. However, the licensee expects to use FLEX equipment from offsite response centers to restore the RHR system and supporting equipment. Prior to undertaking the additional cooling and depressurization of the RCS, operators would need to perform a number of supporting actions including injecting additional boric acid into the RCS to avoid the potential for recriticality and isolating the accumulators using electrical power from FLEX generators to avoid the potential for excessive accumulator injection to the point that the nitrogen cover gas could enter the RCS.

For RCS makeup and boration, if SEPS is available, the emergency power sequencer will automatically start a centrifugal charging pump, a thermal barrier cooling water pump, a primary component cooling water pump (PCCW), a motor driven EFW pump, and an ocean service water pump or a cooling tower pump. This combination of equipment will allow for a rapid boration via the charging pump with borated water provided from either the boric acid tanks (BATs) or the refueling water storage tank (RWST). If SEPS is unavailable, the licensee will use an alternate strategy of deploying a portable, diesel-driven FLEX high-pressure pump (FHPP) and providing makeup no later than 10 hours into the ELAP event to ensure that natural circulation, reactivity control, and boron mixing is maintained in the RCS. Similar to the primary strategy, the FHPP will take suction from either the BATs or RWST.

As mentioned above, the licensee's electrical strategy depends on the availability of SEPS. If SEPS is available, both of the SEPS generators will start automatically and run in standby until operators manually connect them to an emergency ac bus. Operators will utilize SEPS to restore power to required components to mitigate the ELAP event. If SEPS is available, the strategy does not require a deep load shed of the station batteries. Since one train of electrical distribution will be powered by SEPS, load shedding of non-essential loads from the nonenergized vital dc buses is not considered a time sensitive action. However, operators plan to complete load shedding within 2 hours of event initiation, along with swapping the supply of the more loaded vital dc bus to the more lightly loaded battery in the same train, which would result in a coping time of at least 12 hours for the bus that does not have its battery charger powered. If SEPS is unavailable, operators will perform a dc bus load shed within 2 hours following an ELAP event initiation to ensure safety-related battery life is extended up to 12 hours. Following dc load stripping and prior to battery depletion, one 405-kilowatt (kW), 480 volt alternating current (Vac) generator will be deployed from the FLEX storage location in the service water pump house (SWPH). The portable generator will be used to repower essential battery chargers within 8 hours of ELAP initiation, as well as repowering safety injection accumulator isolation valves.

In addition, a National Strategic Alliance of FLEX Emergency Response (SAFER) Response Center (NSRC) will provide high capacity pumps and large turbine-driven DGs which could be used to restore RHR equipment to cool the core in the long-term. There are two NSRCs in the United States.

The SFP for Seabrook is located in the unit's fuel storage building (FSB). Upon initiation of the ELAP event, the SFP will heat up due to the unavailability of the normal cooling system. The licensee has calculated that boiling could start as soon as 3 hours after the start of the event. To maintain SFP cooling capabilities, the licensee determined that it would take approximately 30 hours for SFP water level to boil-off to the top of the fuel at the maximum design heat load, with no operator action. If SEPS is available, makeup water will be provided by using the normal SFP cooling system once the emergency ac bus has been reenergized. If SEPS is unavailable, the RWST can be used to gravity feed the SFP. Operators can also deploy either the portable FLPP or submersible FLEX LP pump to supply water from the CST or the Unit 2 circulating water piping cistern to the SFP. The pump discharge can be routed via hoses to the refueling floor to provide direct makeup to the pool. Ventilation of the generated steam is accomplished by opening the FSB rollup door and personnel doors thus establishing a natural draft vent path.

For Phases 1 and 2, the licensee's calculations demonstrate that no actions are required to maintain containment pressure below design limits for over 120 hours. In Phase 2, the licensee will verify containment isolation using procedures, and monitor containment pressure using installed instrumentation. In Phase 2, the licensee's strategy is to continue monitoring containment pressure using installed instrumentation. During Phase 3, containment cooling and depressurization would be accomplished by obtaining additional electrical capability and redundancy for on-site equipment. Two mobile 4160 V generators and one 480 V generator will be supplied from the NSRC.

Below are specific details on the licensee's strategies to restore or maintain core cooling, containment, and SFP cooling capabilities in the event of a BDBEE, and the results of the staff's review of these strategies. The NRC staff evaluated the licensee's strategies against the endorsed NEI 12-06, Revision 2, guidance.

3.2 Reactor Core Cooling Strategies

Order EA-12-049 requires licensees to maintain or restore cooling to the reactor core in the event of an ELAP concurrent with a loss of normal access to the UHS. Although the ELAP results in an immediate trip of the reactor, sufficient core cooling must be provided to account for fission product decay and other sources of residual heat. Consistent with endorsed guidance from NEI 12-06, Phase 1 of the licensee's core cooling strategy credits installed equipment (other than that presumed lost to the ELAP with loss of normal access to the UHS) that is robust in accordance with the guidance in NEI 12-06. In Phase 2, robust installed equipment is supplemented by onsite FLEX equipment, which is used to cool the core either directly (e.g., pumps and hoses) or indirectly (e.g., FLEX electrical generators and cables repowering robust installed equipment). The equipment available onsite for Phases 1 and 2 is further supplemented in Phase 3 by equipment transported from the NSRCs.

To adequately cool the reactor core under ELAP conditions, two fundamental physical requirements exist: (1) a heat sink is necessary to accept the heat transferred from the reactor core to coolant in the RCS and (2) sufficient RCS inventory is necessary to transport heat from the reactor core to the heat sink. Furthermore, inasmuch as heat removal requirements for the ELAP event consider only residual heat, the RCS inventory should be replenished with borated coolant in order to maintain the reactor in a subcritical condition as the RCS is cooled and depressurized.

As reviewed in this section, the licensee's core cooling analysis for the ELAP with loss of normal access to the UHS event presumes that, per endorsed guidance from NEI 12-06, the unit would have been operating at full power prior to the event. Therefore, the SGs may be credited as the heat sink for core cooling during the ELAP with loss of normal access to the UHS event. Maintenance of sufficient RCS inventory, despite ongoing system leakage expected under ELAP conditions, is accomplished through a combination of installed systems and FLEX equipment. The specific means used by the licensee to accomplish adequate core cooling during the ELAP with loss of normal access to the UHS event are discussed in further detail below. The licensee's strategy for ensuring compliance with Order EA-12-049 for conditions where the unit is shut down or being refueled is reviewed separately in Section 3.11 of this evaluation.

3.2.1 Core Cooling Strategy and RCS Makeup

3.2.1.1 Core Cooling Strategy

3.2.1.1.1 Phase 1

In addition to having two emergency DGs, Seabrook also has two SEPS DG sets and a SWCT. The SEPS is protected against seismic events, but is not fully protected from wind-born missiles and flooding. The SWCT is protected from seismic and flooding events, but is not fully protected from wind-born missile hazards. The strategy for Seabrook in the event of an ELAP is determined by the availability of the SEPS system. In the event that the SEPS system is not available, Seabrook is also equipped with portable FLEX equipment, which is stored onsite in the robust SWPH.

In its FIP, the licensee stated that the heat sink for core cooling in Phase 1 is provided by the four SGs, which are fed simultaneously by the unit's TDEFW pump with inventory supplied from the CST. The lower portion of the CST is robust for all applicable hazards as defined in NEI 12-06 and contains approximately 194,000 gallons of water. Seabrook calculates that the CST water volume is sufficient to remove residual heat from the reactor for approximately 15 hours.

Following the closure of the main steam isolation valves (MSIVs), as would be expected in an ELAP event, steam release from the SGs to the atmosphere would be accomplished via the SG safety valves or the SG ASDVs. The SG ASDVs would typically be operated by the control air system which is assumed to be lost during the ELAP event. They can also be supplied from permanently installed backup nitrogen bottles that are located within a building robust to all applicable hazards as defined in NEI 12-06. The ASDVs are equipped with handwheels that allow for local manual operation should the nitrogen tanks be depleted. Strategies to extend nitrogen tank capacity as required for ASDV operation in jog or "Position Maintained" mode are provided.

After initiation of the ELAP, the SEPS generators will automatically start but will need to be manually connected to an emergency ac bus. If the auto start feature fails, operators can manually start the SEPS generators via digital control panels located in the train B essential switchgear room, or locally in each of the SEPS generator enclosures. Following energization of an emergency bus, the emergency power sequencer will energize a centrifugal charging pump, a thermal barrier cooling water pump, a PCCW, a motor driven EFW pump, and an ocean service water pump or a cooling tower pump.

Seabrook's Phase 1 strategy directs operators to commence a cooldown and depressurization of the RCS within 2 hours (with SEPS) or 10 hours (without SEPS) from the initiation of the ELAP event. The RCS cooldown rate will be controlled by the ASDVs at approximately 75°F per hour. A minimum SG pressure of 350 psig is set to avoid the injection of nitrogen gas from the safety injection accumulators into the RCS. Cooldown and depressurization of the RCS will result in the injection of makeup to the RCS from the safety injection accumulators. This makeup will add negative reactivity and replace some of the RCS volume lost through leakage and temperature driven contraction.

3.2.1.1.2 Phase 2

In its FIP, the licensee stated that the primary and alternate strategy for core cooling in Phase 2 would be to continue using the SGs as a heat sink, with SG secondary inventory being supplied by the TDEFW pump. Although functionality of the TDEFW pump is expected throughout Phase 2 per the NEI 12-06 assumptions associated with the analyzed ELAP event, in order to maintain capability for core cooling in the event of a failure of the SEPS system coincident with a failure of the TDEFW pump, a portable, diesel driven FLPP will be staged and aligned for injection as soon as resources permit.

Per the FIP, Seabrook's primary strategy utilizes the SEPS system in conjunction with the SWCT. This strategy immediately reenergizes an emergency ac bus from the SEPS system. This will provide the capability to energize the motor driven EFW pump as a source of backup to the TDEFW pump in the event of a TDEFW pump failure. Using this strategy, Seabrook will begin a cooldown within 2 hours of the initiation of the ELAP with the intent to reach RHR initiation criteria (RCS temperature and pressure of 350 °F and 360 psig) within 9 hours. This can be performed using a cooldown rate of less than 75°F per hour. Placing RHR in service within 9 hours will ensure that the available water in the CST will provide an adequate supply without the need for refilling. The SEPS system will provide adequate power to run a SWCT pump and fan providing service water to restore the UHS function. This will provide for the transfer of heat from the core to the SWCT via the RHR system and associated support systems. The licensee will deploy a FLEX 405 kW FLEX DG to provide a source of backup power to the SEPS generator.

According to Seabrook's calculations, the CST is capable of supplying SG makeup for approximately 15 hours. In the event that the SEPS system cannot immediately reenergize an emergency ac bus, the licensee will not be able to utilize RHR core cooling within 9 hours. To provide an additional source of secondary makeup in Phase 2, the licensee stated that a portable submersible LP FLEX pump would be deployed at the circulating water pump cistern. This pump would draw suction from the cistern and refill the CST via hoses routed to the CST or provide water directly to the suction of the FLPP. Seabrook has evaluated the water supplied by the cistern and determined that the water quality will not cause a significant reduction in heat transfer through the SG tubes due to fouling within 72 hours. The quantity of water in the cistern, a structure robust to all applicable hazards as defined in NEI 12-06, is sufficient for greater than 72 hours. Per the FIP, the licensee plans on using the approximately 297,000 gallons of water available in the DWSTs, if available, which can be hardpiped to the CST.

In its FIP, the licensee stated that its core cooling strategy for an ELAP is to rely initially on the TDEFW pump taking suction from the CST. However, in the unanticipated event that flow from the TDEFW pump is interrupted early in the ELAP transient, the FLPP will maintain this function. The FLPP is rated for 325 gallons per minute (gpm) at 400 psig. The pump can take suction from either the CST or from the discharge of the FLEX submersible pump. The FLPP discharges through a three inch hose to a FLEX connection on the EFW discharge header (primary), or an alternate connection strategy connects the discharge of the FLPP to a supply manifold, from which four 2.5-inch hoses connect to the four individual feedwater headers.

3.2.1.1.3 Phase 3

According to its FIP, Seabrook's core cooling strategy for Phase 3 is a continuation of the Phase 2 strategy with additional offsite equipment and resources. In the primary strategy, SEPS will be running and powering the emergency ac bus. The RHR system will be in operation removing core decay heat and transferring it to the SWCT. The NSRC equipment will provide 4160 Vac generators, which can backup the SEPS generators. The combination of the low pressure high flow pump and submersible pump heads provided by the NSRC can be used to provide a backup source of UHS from the service water forebay.

In the licensees alternate strategy, the NSRC equipment will be necessary to restore the UHS and 4160 Vac power to initiate RHR cooling. In this scenario, Seabrook will be utilizing water from the cistern to provide SG cooling and maintaining the SGs at approximately 350°F. After the arrival of the NSRC equipment, the 4160 Vac generators will be utilized to energize a PCCW pump and an RHR pump. The NSRC pumping system will be deployed with the submersible pump heads in the service water forebay supplying the low pressure high flow (LPHF) pump. The LPHF pump will discharge into the service water discharge header such that it can supply 5000 gpm to the PCCW heat exchanger restoring the UHS function. The licensee has evaluated this flowrate and determined that it is adequate for the removal of the RHR heat load present in this event.

3.2.1.2 RCS Makeup Strategy

3.2.1.2.1 Phase 1

Per the FIP, Seabrook's primary strategy is to reenergize an emergency ac bus from the SEPS. Provided that the SEPS system remains available after the external event and an emergency ac bus is successfully repowered, Seabrook's RCS makeup strategy will begin with Phase 2 actions. Phase 1 actions are not required when SEPS remains available.

Per the FIP, the licensee's alternate strategy begins following unsuccessful efforts to repower an emergency ac bus. Following the reactor trip at the start of the ELAP event, operators will isolate RCS letdown pathways and confirm the existence of natural circulation flow in the RCS. A small amount of RCS leakage will occur through the low-leakage RCP seals, but because the expected inventory loss will not be sufficient to drain the pressurizer prior to the RCS cooldown, its overall impact on RCS behavior will be minor. Although the RCS cooldown planned for implementation starting prior to 10 hours into the event would be expected to drain the pressurizer and create a vapor void in the upper head of the reactor vessel, ample RCS volume should remain to support natural circulation flow throughout Phase 1. Likewise, there is no need to initiate boration during this period, since the reactor operating history assumed in the endorsed NEI 12-06 guidance implies that a substantial concentration of xenon-135 would be present in the reactor core. Nevertheless, as operators depressurize the RCS, some fraction of the borated inventory from the nitrogen-pressurized accumulators would be expected to passively inject. Following depressurization of the SGs to 350 psig, the licensee's procedures direct accumulator isolation once electrical power is restored to the corresponding isolation valves via FLEX equipment.

3.2.1.2.2 Phase 2

Per the FIP, Seabrook employs two very different strategies for inventory control and boration for Phase 2. In the primary strategy, emergency ac buses are energized shortly after the initiation of the ELAP. The licensee considers that the reenergization of these buses marks the beginning of Phase 2 actions. Upon energization of the buses, the emergency power sequencer will automatically start a centrifugal charging pump, a thermal barrier cooling water pump, a PCCW pump, a motor driven EFW pump, and an ocean service water pump or a cooling tower pump. This combination of equipment will allow for a rapid boration via the charging pump with borated water provided from either the BATs or the RWST. As the cooldown progresses, the safety injection accumulator will provide injection of borated water for reactivity and inventory control. Per the FIP, accumulators will be isolated by closing the outlet isolation motor operated valves (MOVs), which will be powered by either their normal power supply for 2 of the 4 valves, or by pre-made cables connected to the energized bus for the opposite train valves.

Per the FIP, following the isolation of the accumulators and the addition of adequate borated water for shutdown margin concerns, the licensee will transfer core cooling to the RHR system. After transferring the RCS heat removal function from the SGs to the RHR system, core heat will be transferred to the PCCW system, which will be cooled by the SWCT. The RCS will then be cooled to Mode 5 conditions, and the RHR system will maintain the RCS in Mode 5.

Per the FIP, in the event that Seabrook cannot restore an emergency ac bus from the SEPS, an alternate strategy will be used in Phase 2. The RCS inventory control and boration are accomplished with portable equipment stored in protected locations onsite. In the course of cooling and depressurizing the SGs to a target pressure of 350 psig, a significant fraction of the accumulator liquid inventory will inject into the RCS, filling volume vacated by the thermally induced contraction of RCS coolant and system leakage. In order to ensure long-term subcriticality as positive reactivity is added from the RCS cooldown and xenon decay, RCS boration will commence coincident with the RCS cooldown using a portable FHPP no later than 10 hours into the ELAP event. With low-leakage Westinghouse RCP seals installed on all RCPs, Seabrook calculates that FLEX RCS makeup is not necessary for a minimum of 59.8 hours. Therefore, the injection of borated RCS makeup water for reactivity control will be in progress long before entry into reflux cooling becomes a concern.

In the event of a failure of the SEPS, the method of boration and inventory control in Phase 2 is accomplished through the use of the FHPP, which has a capacity of 15 gpm at 1500 psig. The pump will be aligned to take suction from either the safety-related BATs, with a borated combined volume of at least 29,200 gallons, or from the RWST, with a usable volume of 415,000 gallons. The RWST is robust for all applicable external hazards as defined in NEI 12-06, with the exception that the top of the tank is vulnerable to wind-driven missiles. The BATs are robust for all applicable external hazards as defined in NEI 12-06. The FHPP can be aligned to discharge to either the charging header (primary strategy) or alternate connections in the safety injection system.

3.2.1.2.3 Phase 3

According to its FIP, Seabrook's core cooling strategy for Phase 3 is a continuation of the Phase 2 strategy with additional offsite equipment and resources. In the primary strategy, the SEPS will be running and powering an emergency ac bus. The RHR system will be removing core decay heat and transferring it to the SWCT. The NSRC equipment will provide 4160 Vac generators which can backup the SEPS generators. The combination of the LPHF pump and submersible pump heads can be used to provide a backup source of UHS from the service water forebay. Under these conditions the plant will be maintained in Mode 5. Additional makeup to the RCS in Mode 5 could be provided by a FLEX LP pump taking suction from the RWST and discharging into the charging pump discharge header. An NSRC provided pump will provide a backup to this function.

The licensee's alternate strategy assumes the NSRC equipment will be necessary to restore the UHS and 4160 Vac power to initiate RHR cooling. In this scenario Seabrook will utilize water from the cistern to provide SG cooling and will maintain the SGs at approximately 350°F. After the arrival of the NSRC equipment, the 4160 Vac generators will be utilized to energize a PCCW pump and an RHR pump. The NSRC pumping system will be deployed with the submersible pump heads in the service water forebay supplying the LPHF pump. The LPHF pump will discharge into the service water discharge header such that it can supply 5000 gpm to the PCCW heat exchanger restoring the UHS function. The licensee has evaluated this flowrate and determined that it is adequate for removal of the RHR heat load present in this event. Additional NSRC equipment delivered will provide the capability to replace Phase 2 equipment in the event that it should fail prior to the initiation of shutdown core cooling.

The NRC staff reviewed the list of NSRC equipment to be delivered to Seabrook, and noted that there is no discussion of a means of water purification or boron mixing to be provided to the site. However, the NRC staff recognize that the licensee's plan to transfer core cooling from the SG's to the RHR system will minimize water consumption at the site, and extend the coping time available given the quantity of borated water available in the RWST.

3.2.2 Variations to Core Cooling Strategy for Flooding and Hurricane Event

In its FIP, the licensee stated that the Seabrook current licensing basis flood protection includes the ability to withstand the combined effects of a standard projected storm and a probable maximum hurricane including the applicable wave run-up during these storms. For a beyond design-basis flooding or hurricane event, the licensee stated that access to some areas in the plant could be restricted, however, the flooding event will be a short duration and plant shutdown procedures will be initiated based off of the hurricane forecast with entry to Mode 5 at least 2 hours prior to sustained hurricane winds. The licensee stated that access to Phase 2 FLEX equipment will not be required until the high winds have subsided and the flood waters receded. The licensee's core cooling and makeup strategy implementation remain unchanged for a flooding event.

3.2.3 Staff Evaluations

3.2.3.1 Availability of Structures, Systems, and Components (SSCs)

Guidance document NEI 12-06 provides guidance that the baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for core cooling during an ELAP caused by a BDBEE.

3.2.3.1.1 Plant SSCs

Core Cooling

Phase 1

In its FIP, the licensee stated that the TDEFW pump automatically starts and delivers AFW flow from the seismic portion of the CST to the SGs following an ELAP event. In Section 3.2.4.1 of its FIP, the licensee stated that the TDEFW pump is located in a seismic Category I structure protected from all applicable design basis external events as defined in NEI 12-06. Furthermore, the Seabrook Updated Final Safety Analysis Report (UFSAR) Table 3.2-2, Revision 8, states that the EFW pumps, piping and valves are all seismic Category I. Two air-operated steam admission valves, one from each of the A and B main steam headers, supply steam to the TDEFW pump. These air-operated valves fail open on a loss of instrument air causing the pump to start. In the FIP, Section 3.2.4.1 states that in the event the TDEFW pump fails to start, procedures direct the operators to manually reset and start the pump, which the licensee states does not require electrical power for motive force or control. In Section 3.2.1 of the FIP, the licensee stated that procedures direct operators to locally adjust feed control valves to maintain SG level. The NRC staff concludes that the TDEFW pump is robust and is expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

The licensee plans to vent steam from the SGs by manually controlling the SG ASDVs and perform a controlled cooldown. As described in FIP Section 3.2.4.1, the ASDVs are safety-related, missile protected and seismically qualified valves. The ASDVs can be controlled from an existing backup nitrogen bottle that is fully protected, but can also be operated manually, if needed. The NRC staff concludes that the ASDVs are robust and are expected to be available at the start of an ELAP event consistent with NEI 12-06, Section 3.2.1.3. Further explanation and the NRC staff's evaluation of the robustness and availability of water sources for an ELAP event is discussed in Section 3.10 of this SE.

Phase 2

SEPS and SWCT Available

In Section 3.2.2 of its FIP, the licensee stated that the Phase 2 core cooling strategy with the SEPS and SWCT available starts when the emergency ac bus is repowered by the SEPS. Initially, core cooling will be provided by the TDEFW pump and ASDVs similar to Phase 1. However, the SEPS can be used to power a motor-driven EFW pump if the TDEFW pump is not available. The licensee will cool the RCS and transition to RHR (shutdown cooling). Shutdown cooling relies on the PCCW system, service water (SW) system, and RHR system. Although the FIP did not discuss how each of these systems are robust, the licensee does state that with the exception of the SEPS, SWCT and supporting switchgear, the installed plant equipment that is credited for FLEX is flood and missile protected and seismically qualified. Additionally, the Seabrook UFSAR Table 3.2-2, Revision 8, lists these systems as seismic Category I and they are located in structures that are designed to withstand all applicable hazards as defined in NEI 12-06. During RHR cooling, the licensee relies on the SWCT as the UHS. In Section 3.1 of its FIP, the licensee stated that although the SWCT is protected from seismic, flooding, and severe weather events, it is not fully protected from all wind-driven missiles. However, as described earlier, the Phase 2 strategy for events that render the SEPS and SWCT unavailable is fully protected from all wind-driven hazards. The staff concludes that these systems appear to be robust and are expected to be available during an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

SEPS and SWCT Unavailable

The licensee's Phase 2 core cooling strategy continues to use the SGs as the heat sink. Seabrook will continue to use the TDEFW pump as long as possible, or transition to using a portable FLPP discharging through a primary or alternate connection point to the SGs. The licensee does not plan to rely on any installed plant SSCs other than the installed systems with FLEX connection points and water sources discussed in Sections 3.7 and 3.10 of this SE, respectively.

Phase 3

SEPS and SWCT Available

The licensee's Phase 3 RCS inventory strategy for Seabrook does not rely on any additional installed plant SSCs other than those discussed in Phase 2. However, the licensee can supplement the onsite equipment with NSRC equipment as necessary.

SEPS and SWCT Unavailable

As described in Section 3.2.3 of the FIP, if the SEPS and SWCT are unavailable, the Phase 3 strategy is to use the NSRC equipment to establish RHR shutdown cooling. The NSRC pump will provide cooling to the PCCW heat exchanger which will cool the RHR heat exchanger. The NSRC LPHF pump will be used in series with a submersible booster pump that will be placed in the service water forebay which is located in the seismic Category I SWPH. The LPHF pump can be aligned to either SW header. The NSRC 4160 V generators will be used to power the PCCW and RHR pumps to provide cooling flow through the core. Given these systems are robust as discussed above, the staff concludes that they are expected to be available during an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

RCS Makeup

Phase 1

The licensee's Phase 1 RCS inventory control FLEX strategy relies on low-leakage RCP seals, and the licensee's analysis demonstrated that no FLEX RCS make up is needed during Phase 1.

Phase 2

SEPS and SWCT Available

If the SEPS and SWCT are available, the licensee will transition to RHR shutdown cooling as described in the core cooling section. Additionally, the licensee will be repowering an installed centrifugal charging pump and boric acid makeup pumps to perform a rapid boration. In the FIP, Section 3.2.2 states that the charging pump borated water flow path including the charging pumps is robust. Given this flowapth is robust as discussed above, the staff concludes that it is expected to be available during an ELAP event consistent with NEI 12-06, Section 3.2.1.3.

SEPS and SWCT Unavailable

If the SEPS and SWCT are unavailable, the licensee will use a FHPP and does not rely on any installed plant SSCs other than installed systems with FLEX connection points and borated water sources discussed in Sections 3.7 and 3.10 of this SE, respectively.

Phase 3

The licensee's Phase 3 RCS inventory strategy for Seabrook does not rely on any additional installed plant SSCs other than those discussed in Phase 2. However, the licensee will need the NSRC equipment to establish shutdown cooling if the SEPS and SWCT are unavailable.

3.2.3.1.2 Plant Instrumentation

According to the FIP, the following instrumentation will be relied upon to support the licensee's core cooling and RCS inventory control strategy. The following instruments are monitored from the control room and will be available throughout the event.

- SG level (wide range and narrow range)
- SG pressure
- RCS temperature wide range (hot-leg train A and cold leg train B)
- RCS pressure (wide range)
- Core exit thermocouples
- Pressurizer level
- Reactor vessel level indicating system (RVLIS)
- Condensate storage tank (CST) level
- Containment pressure (wide range)
- Emergency feedwater (EFW) flow rate

All of these instruments are powered by the installed safety-related station batteries. To prevent a loss of vital instrumentation, operators will extend battery life to a minimum of 12 hours for Train A and B by shedding unnecessary loads. The load shedding will be completed prior to 2 hours from the initiation of the ELAP event. A FLEX 480 Vac DG will be deployed to repower the battery chargers within 8 hours from ELAP event initiation. This leaves a margin of at least 4 hours prior to depletion of the associated batteries.

In its FIP, the licensee stated that as recommended by Section 5.3.3 of NEI 12-06, procedures have been developed to read the above instrumentation locally using portable instruments, where applicable. Guidance has been provided in procedure FSG-7.1.1, "Control Room Instrumentation Alternate Indication Readout." This document provides guidance for obtaining alternate instruments and field monitoring for the following parameters:

- SG level (wide range and narrow range)
- SG pressure
- RCS temperature wide range
- RCS pressure (wide range)
- Core exit thermocouples
- Pressurizer level
- Reactor vessel level indicating system (RVLIS)
- Condensate storage sank (CST) level
- Containment pressure (wide range)
- Emergency feedwater (EFW) flow rate

Furthermore, as described in its FIP, the licensee stated that portable FLEX equipment credited in the licensee's mitigating strategies is supplied with the instrumentation necessary to support local equipment operation.

The instrumentation available to support the licensee's strategies for core cooling and RCS inventory during the ELAP event appears to be consistent with the recommendations specified in the endorsed guidance of NEI 12-06. Based on the information provided by the licensee, the NRC staff understands that indication for the above instruments should be available and accessible continuously throughout the ELAP event.

3.2.3.2 Thermal-Hydraulic Analyses

In its FIP, the licensee stated that its mitigating strategy for reactor core cooling is based, in part, on a generic thermal-hydraulic analysis performed for a reference Westinghouse four-loop reactor using the NOTRUMP computer code. The NOTRUMP code and corresponding evaluation model were originally submitted in the early 1980s as a method for performing licensing-basis safety analyses of small-break loss-of-coolant accidents (LOCAs) for Westinghouse PWRs. Although NOTRUMP has been approved for performing small-break LOCA analysis under the conservative Appendix K paradigm and constitutes the current evaluation model of record for many operating PWRs, the NRC staff had not previously examined its technical adequacy for performing best-estimate simulations of the ELAP event. Therefore, in support of mitigating strategy reviews to assess compliance with Order EA-12-049, the NRC staff evaluated licensees' thermal-hydraulic analyses, including a limited review of the significant assumptions and modeling capabilities of NOTRUMP and other thermal-hydraulic codes used for these analyses. The NRC staff's review included performing confirmatory analyses with the TRACE code to obtain an independent assessment of the duration that reference reactor designs could cope with an ELAP event prior to providing makeup to the RCS.

Based on its review, the NRC staff questioned whether NOTRUMP and other codes used to analyze ELAP scenarios for PWRs would provide reliable coping time predictions in the reflux or boiler-condenser cooling phase of the event because of challenges associated with modeling complex phenomena that could occur in this phase, including boric acid dilution in the intermediate leg loop seals, two-phase leakage through RCP seals, and primary-to-secondary heat transfer with two-phase flow in the RCS. Due to the challenge of resolving these issues within the compliance schedule specified in Order EA-12-049, the NRC staff requested that industry provide makeup to the RCS prior to entering the reflux or boiler-condenser cooling phase of an ELAP, such that reliance on thermal-hydraulic code predictions during this phase of the event would not be necessary.

Accordingly, the ELAP coping time prior to providing makeup to the RCS is limited to the duration over which the flow in the RCS remains in natural circulation, prior to the point where continued inventory loss results in a transition to the reflux or boiler-condenser cooling mode. In particular, for PWRs with inverted U-tube SGs, the reflux cooling mode is said to exist when vapor boiled off from the reactor core flows out the saturated, stratified hot leg and condenses on SG tubes, with the majority of the condensate subsequently draining back into the reactor vessel in countercurrent fashion. Quantitatively, as reflected in documents such as the PWR Owners Group (PWROG) report PWROG-14064-P, "Application of NOTRUMP Code Results for Westinghouse Designed PWRs in Extended Loss of AC Power Circumstances," Revision 0, industry has proposed defining this coping time as the point at which the one-hour centered time-average of the flow quality passing over the SG tubes' U-bend exceeds one-tenth (0.1). As discussed further in Section 3.2.3.4 of this evaluation, a second metric for ensuring adequate coping time is associated with maintaining sufficient natural circulation flow in the RCS to support adequate mixing of boric acid.

With specific regard to NOTRUMP, preliminary results from the NRC staff's independent confirmatory analysis performed with the TRACE code indicated that the coping time for Westinghouse PWRs under ELAP conditions could be shorter than predicted in WCAP 17601-P, "Reactor Coolant System Response to the Extended Loss of AC Power Event for Westinghouse, Combustion Engineering and Babcock & Wilcox NSSS Designs." Subsequently, a series of additional simulations performed by the staff and Westinghouse identified that the discrepancy in predicted coping time could be attributed largely to differences in the modeling of RCP seal leakage. (The topic of RCP seal leakage will be discussed in greater detail in Section 3.2.3.3 of this SE.) These comparative simulations showed that when similar RCP seal leakage boundary conditions were applied, the coping time predictions of TRACE and NOTRUMP were in adequate agreement. From these simulations, as supplemented by review of key code models, the NRC staff obtained sufficient confidence that the NOTRUMP code may be used in conjunction with the WCAP-17601-P evaluation model for performing best-estimate simulations of ELAP coping time prior to reaching the reflux cooling mode.

Although the NRC staff obtained confidence that the NOTRUMP code is capable of performing best-estimate ELAP simulations prior to the initiation of reflux cooling using the one-tenth flow-quality criterion discussed above, the staff was unable to conclude that the generic analysis performed in WCAP-17601-P could be directly applied to all Westinghouse PWRs, as the vendor originally intended. In PWROG-14064-P, Revision 0, the industry subsequently recognized that the generic analysis would need to be scaled to account for plant-specific variation in RCP seal leakage. However, the staff's review, supported by sensitivity analysis performed with the TRACE code, further identified that plant-to-plant variation in additional parameters, such as RCS cooldown terminus, accumulator pressure and liquid fraction, and initial RCS mass, could also result in substantial differences between the generically predicted reference coping time and the actual coping time that would exist for specific plants.

During the audit, the NRC staff evaluated a comparison of the generic analysis values from WCAP-17601-P and PWROG-14064-P to the Seabrook plant-specific values. The NRC staff concluded that the generic plant parameters were bounding for the analyzed event. Seabrook has installed low-leakage SHIELD shutdown seals; therefore, the seal leakage expected for Seabrook is significantly less than assumed in the generic NOTRUMP analysis case. The NRC staff concluded based on the licensee evaluation, that the licensee could maintain adequate natural circulation without RCS makeup for at least 59 hours provided that the RCS cooldown was initiated by 10 hours into the event. The RCS makeup will be available per the licensee's mitigating strategy for shutdown margin at approximately 10 hours following initiation of an ELAP, thus, the licensee's strategy for RCS makeup appears to provide sufficient margin to the onset of reflux cooling.

Therefore, based on the evaluation above, the NRC staff concludes that the licensee's analytical approach should appropriately determine the sequence of events for reactor core cooling, including time-sensitive operator actions, and evaluate the required equipment to mitigate the analyzed ELAP event, including pump sizing and cooling water capacity.

3.2.3.3 Reactor Coolant Pump (RCP) Seals

Leakage from the RCP seals is among the most significant factors in determining the duration that a PWR can cope with an ELAP event prior to initiating RCS makeup. An ELAP event would interrupt cooling to the RCP seals, resulting in increased leakage and the potential for failure of elastomeric O-rings and other components, which could further increase the leakage rate. As discussed above, as long as adequate inventory is maintained in the RCS, natural circulation can effectively transfer residual heat from the reactor core to the SGs and limit local variations in boric acid concentration. Along with cooldown-induced contraction of the RCS inventory, cumulative leakage from RCP seals governs the duration over which natural circulation can be maintained in the RCS. Furthermore, the seal leakage rate at the depressurized condition can be a controlling factor in determining the flow capacity requirement for FLEX pumps to offset ongoing RCS leakage and recover adequate system inventory.

Per the FIP, the licensee credits Generation 3 SHIELD low-leakage seals for FLEX strategies including RCS inventory control and boration. The low-leakage seals limit the total RCS leak rate to no more than 5 gpm (1 gpm per RCP seal and 1 gpm of unidentified RCS leakage in accordance with the technical specifications).

The SHIELD low-leakage seals are credited in the FLEX strategies in accordance with the four conditions identified in the NRC's endorsement letter of TR-FSE-14-1-P, "Use of Westinghouse SHIELD Passive Shutdown Seal for FLEX Strategies," dated May 28, 2014 (ADAMS Accession No. ML14132A128). In its FIP, the licensee describes compliance with each condition of SHIELD seal use as follows:

(1) Credit for the SHIELD seals is only endorsed for Westinghouse RCP Models 93, 93A, and 93A-1.

This condition is satisfied as NRC staff verified during the audit that the RCPs for Seabrook are Westinghouse Model 93A-1.

(2) The maximum steady-state RCS cold-leg temperature is limited to 571 °F during the ELAP (i.e., the applicable main steam safety valve setpoints result in an RCS cold-leg temperature of 571 °F or less after a brief post-trip transient).

The maximum steady-state RCP seal temperature during an ELAP response is expected to be the RCS cold leg temperature corresponding to the lowest SG safety relief valve setting of 1,200 per square inch absolute (psia). This results in a RCS cold leg temperature of approximately 567 °F.

(3) The maximum RCS pressure during the ELAP (notwithstanding the brief pressure transient directly following the reactor trip comparable to that predicted in the applicable analysis case from WCAP-17601-P) is as follows: For Westinghouse Models 93 and 93A-1 RCPs, RCS pressure is limited to 2250 psia; for Westinghouse Model 93A RCPs, RCS pressure is to remain bounded by Figure 7.1-2 of TR-FSE-14-1-P, Revision 1.

Normal operating RCS pressure for Westinghouse PWR's is less than 2,250 psia. Allowing for the possibility of a brief pressure transient directly following the reactor trip, the NRC staff concludes that the licensee's mitigating strategy of cooling the reactor core via the main steam safety valves and SG ASDVs will maintain reactor pressure within the limiting value for Model 93A-1.

(4) Nuclear power plants that credit the SHIELD seal in an ELAP analysis shall assume the normal seal leakage rate before SHIELD seal actuation and a constant seal leakage rate of 1.0 gpm for the leakage after SHIELD seal actuation.

Seabrook's FIP and supporting calculations assumed that after 15 minutes of ELAP initiation, a constant Westinghouse SHIELD RCP seal package leakage rate of 1 gpm per RCP, plus 1 gpm of unidentified RCS leakage, for a total RCS leakage of 5 gpm. For the first 15 minutes, the licensee assumed a leakage rate of 6 gpm per RCP. As noted previously, the licensee's calculation indicates that adequate cooling would be maintained for a minimum of 59.8 hours into the event, even if FLEX RCS makeup flow were not provided as planned. In that Seabrook's mitigating strategy directs RCS makeup to begin at a maximum of approximately 10 hours after event initiation; ample margin exists to accommodate the small additional volume of leakage that is expected to occur before actuation of the SHIELD seal.

Based upon the discussion above, the NRC staff concludes that the RCP seal leakage rates assumed in the licensee's thermal-hydraulic analysis may be applied to the beyond-design basis ELAP event for the site.

3.2.3.4 Shutdown Margin Analyses

In the analyzed ELAP event, the loss of electrical power to control rod drive mechanisms is assumed to result in an immediate reactor trip with the full insertion of all control rods into the core. The insertion of the control rods provides sufficient negative reactivity to achieve subcriticality at post-trip conditions. However, as the ELAP event progresses, the shutdown margin for PWRs is typically affected by several primary factors:

- the cooldown of the RCS and fuel rods adds positive reactivity
- the concentration of xenon-135, which (according to the core operating history assumed in NEI 12-06) would
    - initially increase above its equilibrium value following reactor trip, thereby adding negative reactivity
    - peak at roughly 12 hours post-trip and subsequently decay away gradually, thereby adding positive reactivity
- the passive injection of borated makeup from nitrogen-pressurized accumulators due to the depressurization of the RCS, which adds negative reactivity

At some point following the cooldown of the RCS, PWR licensees' mitigating strategies generally require active injection of borated coolant via FLEX equipment. In many cases, boration would become necessary to offset the gradual positive reactivity addition associated with the decay of xenon-135; but, in any event, borated makeup would eventually be required to offset ongoing RCS leakage. The necessary timing and volume of borated makeup depend on the particular magnitudes of the above factors for individual reactors.

The specific values for these and other factors that could influence the core reactivity balance that are assumed in the licensee's current calculations could be affected by future changes to the core design. However, NEI 12-06, Section 11.8 states that "[e]xisting plant configuration control procedures will be modified to ensure that changes to the plant design . . . will not adversely impact the approved FLEX strategies." Inasmuch as changes to the core design are changes to the plant design, the NRC staff expects that any core design changes, such as those considered in a core reload analysis, will be evaluated to determine that they do not adversely impact the approved FLEX strategies, especially the analyses which demonstrate that recriticality will not occur during a FLEX RCS cooldown.

During the audit, the NRC staff reviewed the licensee's shutdown margin calculation. The licensee has primary and alternate strategies for accomplishing a boration. The licensee's primary strategy is to reenergize an emergency ac bus from their permanently installed SEPS. This will provide the capability to operate a charging pump and inject borated water from either the BATs or the RWST via the charging pump suction. The alternate strategy is to deploy a portable FHPP to take suction from either the BATs (primary) or the RWST (alternate) and deliver the water through hoses to primary and alternate injection pathways to the RCS (i.e., FLEX connections to the Chemical Volume and Control System and safety injection systems). The licensee determined that either strategy will provide the required amount of boron necessary to maintain adequate shutdown margin (SDM). At a RCS temperature of 350 °F, the licensee determined that 3,150 gallons from the BATs (minimum concentration of 7,000 parts per million (ppm) boron) or 10,800 gallons from the RWST (minimum concentration of 2,400 ppm boron) will provide adequate SDM. The FHPP has a capacity of 15 gpm at 1500 psig. The addition of this boron can be accomplished in approximately 3.5 hours when the BATs are utilized as the suction source or in 12 hours when the RWST is utilized as the suction supply for the FHPP. Per its FIP, the licensee intends to start the boration no later than 10 hours after the initiation of the ELAP event. The SDM analysis requires that the boration be initiated no later than 20 hours after the start of the ELAP event, giving approximately 10 hours of margin.

Toward the end of an operating cycle, when RCS boron concentration reaches its minimum value, some PWR licensees may need to vent the RCS to ensure that their FLEX strategies can inject a volume of borated coolant that is sufficient to satisfy shutdown margin requirements. The licensee's FIP concluded that because the temperature induced RCS volume contraction combined with the available pressurizer volume exceeds 10,800 gallons, letdown from the RCS would not be necessary to accommodate the initial boration. The licensee determined that under certain conditions venting would be required. These conditions include a non-SEPS case where RCS pressure remains above 1500 psig for unforeseen reasons, and a SEPS case where the reactor head vent path is used as a means to maintain a sub-cooling band of 40-90 °F during the RCS cooldown. According to the licensee's procedures, RCS venting would be performed using the reactor vessel head vents and an associated flowpath that contains an orifice to prevent excessive letdown flow rates.

The NRC staff's audit review of the licensee's shutdown margin calculation determined that credit was taken for uniform mixing of boric acid during the ELAP event. The NRC staff had previously requested that the industry provide additional information to justify that borated makeup would adequately mix with the RCS volume under natural circulation conditions potentially involving two-phase flow. In response, the PWROG submitted a position paper, dated August 15, 2013, (withheld from public disclosure due to proprietary content), which provided test data regarding boric acid mixing under single-phase natural circulation conditions and outlined applicability limits intended to ensure that boric acid addition and mixing during an ELAP would occur under conditions similar to those for which boric acid mixing data is available. By letter dated January 8, 2014 (ADAMS Accession No. ML13276A183), the NRC staff endorsed the above position paper with three conditions:

> Condition 1: The required timing and quantity of borated makeup should consider conditions with no RCS leakage and with the highest applicable leakage rate.

This condition is satisfied because the licensee's planned timing for establishing borated makeup acceptably considered both the maximum and minimum RCS leakage conditions expected for the analyzed ELAP event.

> Condition 2: Adequate borated makeup should be provided either (1) prior to the RCS natural circulation flow decreasing below the flow rate corresponding to single-phase natural circulation, or (2) if provided later, then the negative reactivity from the injected boric acid should not be credited until one hour after the flow rate in the RCS has been restored and maintained above the flow rate corresponding to single-phase natural circulation.

This condition is satisfied because the licensee's planned timing for establishing borated makeup would be prior to RCS flow decreasing below the expected flow rate corresponding to single-phase natural circulation for the analyzed ELAP event.

> Condition 3: A delay period adequate to allow the injected boric acid solution to mix with the RCS inventory should be accounted for when determining the required timing for borated makeup. Provided that the flow in all loops is greater than or equal to the corresponding single-phase natural circulation flow rate, a mixing delay period of 1 hour is considered appropriate.

This condition is satisfied because the licensee's planned timing for establishing borated makeup allows a 1-hour period to account for boric acid mixing; furthermore, during this 1-hour period, the RCS flow rate would exceed the single-phase natural circulation flow rate expected during the analyzed ELAP event.

During the audit review, the licensee confirmed that Seabrook will comply with the August 15, 2013, position paper on boric acid mixing, including the above conditions imposed in the staff's corresponding endorsement letter. The NRC staff's audit review indicated that the licensee's shutdown margin calculations are generally consistent with the PWROG's position paper, including the three additional conditions imposed in the NRC staff's endorsement letter.

Therefore, based on the evaluation above, the NRC staff concludes that the sequence of events in the proposed mitigating strategy should result in acceptable shutdown margin for the analyzed ELAP event.

3.2.3.5 FLEX Pumps and Water Supplies

If the SEPS and SWCT are available, the licensee does not rely on any portable FLEX pumps, but the portable equipment serves a backup if the installed equipment becomes unavailable. However, the FLEX strategy for SEPS and SWCT unavailable relies on three different portable pumps during Phase 2. The licensee plans to use a portable FLPP to feed the SGs from the CST or Unit 2 circulating water piping cistern. Also, the licensee relies on a submersible pump that is lowered into the Unit 2 circulating water piping cistern to provide water to the FLPP or to the CST. Lastly, the licensee plans to use a portable FHPP to provide high pressure, low flow RCS makeup from the BATs or RWST. In Section 3.2.4.5 of its FIP, the licensee identified the performance criteria (e.g., flow rate, discharge pressure) for its Phase 2 portable pumps. The NRC staff noted that the performance criteria for the FLEX Phase 3 NSRC pumps are consistent with the FLEX Phase 2 portable pumps capacities. See Section 3.10 of this SE for detailed discussion of the availability and robustness of each water source.

During Phase 2 with the SEPS or SWCT unavailable, core cooling will be transferred to a portable diesel-driven centrifugal FLPP when the TDEFW pump is no longer available. The FLPP pump will take suction from the CST, which is refilled using the submersible pump, or the FLPP can take suction directly from the discharge of the submersible pump. A single pump provides full capability to feed all SGs. In the FIP, Section 3.2.4.5.1 states that the FLPP is rated at 325 gpm at 400 psig. The licensee performed calculation ND C-X-1-20718-CALC, "Diverse and Flexible Coping Strategy Hydraulic Analysis," Revision 1, to determine the fluid system hydraulic performance, and to validate that the FLPP has adequate performance characteristics using the PIPE-FLO software package. The NRC staff noted that this calculation assessed different possible lineups based on such variables as suction sources, connection points and hose paths to determine the flow to ensure that the FLPP procured by the licensee is adequate for providing injection into the SGs at the required flow rate and discharge pressure.

In order to use the FLPP and draw water from the Unit 2 circulating water piping cistern, the licensee determined a booster pump is needed to meet the net positive suction head (NPSH) requirements of the FLPP. The submersible pump is a trailer mounted motor-driven pump with a dedicated 30 kW generator. The calculation ND C-X-1-20718-CALC determined that the submersible pump can provide 325 gpm at 45 psig. As noted above, the calculation considered the different lineups including using the submersible pump to fill the SFP.

The last portable pump the licensee relies on is the FHPP. The FHPP is a trailer mounted diesel-driven positive displacement pump that can provide 15 gpm at a discharge pressure of at least 1500 psi. Furthermore, the calculation ND C-X-1-20718-CALC determined that the FHPP can provide the necessary flow given the different suction sources and discharge paths.

The staff was able to confirm that flow rates and pressures evaluated in the hydraulic analyses were reflected in the FIP for the respective SG and RCS makeup strategies based on the above FLEX pumps being diesel-driven and motor-driven and respective FLEX connections being made as directed by the FSGs. During the onsite audit, the staff conducted a walk down of the hose deployment routes for the above FLEX pumps to confirm the evaluations of the pump staging locations, hose run distances, and connection points as described in the above hydraulic analyses and FIP.

Based on the staff's review of the FLEX pumping capabilities at Seabrook, as described in the above hydraulic analyses and the FIP, the licensee has demonstrated that its FLEX pumps should perform as intended to support core cooling and RCS makeup during an ELAP caused by an external event, consistent with NEI 12-06, Section 11.2.

3.2.3.6 Electrical Analyses

The licensee's electrical strategies provide power to the equipment and instrumentation used to mitigate the ELAP and LUHS. The electrical strategies described in the FIP are practically identical for maintaining or restoring core cooling, containment, and SFP cooling, except as noted in Sections 3.3.4.4 and 3.4.4.4 of this SE.

The NRC staff reviewed the licensee's FIP conceptual electrical single-line diagrams, and summaries of calculations for sizing the FLEX generators and station batteries. The staff also reviewed the licensee's evaluations that addressed the effects of temperature on the electrical equipment credited in the FIP as a result of the loss of heating, ventilation, and air conditioning (HVAC) caused by the event.

During the first phase of an ELAP event, the licensee would initially cope by relying on installed plant equipment and on-site resources. In the licensee's primary strategy, at least one of two available SEPS DG sets, not credited in the SBO analysis, would provide rapid re-powering of an emergency ac bus. The SEPS is protected against severe weather (except hurricane/tornado missiles and flooding. The licensee has modified the SEPS to better protect them from seismic events. The primary strategy deviates from NEI 12-06 in that the SEPS and SWCT are not fully protected from all hazards. The SEPS and SWCT are available following design-basis flooding (only the SWCT), seismic, and hot/cold weather events, but may not be available following severe wind/wind driven missile events. However, SWCT provides protection of the SEPS from wind driven missiles from the north, reducing the probability that wind-driven missiles will damage the SEPS.

Both of the SEPS generators are assumed to start automatically as designed and run in standby until operators manually connect them to an emergency ac bus. Only one of two SEPS generators is required to repower an emergency bus during an ELAP. If necessary, the SEPS generators can also be started manually from the digital control panel in the Train B essential switchgear room or locally from the digital control panels in each generators enclosure.

If the SEPS is available, but the bus cannot be powered, then operators will enter procedure FSG-0.0, "Extended Loss of All AC Power With SEPS." The staff reviewed Revision 0 of this procedure and noted that it directs operators to utilize SEPS to restore power to required components, but it does not require a deep load shed of the station batteries. Since one train of electrical distribution will be powered by SEPS, load shedding of non-essential loads from the vital dc buses whose battery chargers are not being powered by the SEPS is not considered a time sensitive action. However, completing load shedding within 2 hours of event initiation, along with swapping the supply of the more loaded vital dc bus to the more lightly loaded battery in the same train (required on Train B only), would result in a coping time of at least 12 hours for the bus that does not have its battery charger powered.

If the SEPS is not available, then ECA-0.0 would direct operators to take further actions to disable automatic equipment loading, open control room cabinet doors, and isolate RCP seal injection and return, and operators will enter procedure FSG-0.1, "Extended Loss of All AC Power Without SEPS." In this situation, the licensee would rely on the Class 1E station batteries to provide power to key instrumentation for monitoring parameters and power to control the SSCs used to maintain the key safety functions (reactor core cooling, RCS/PCS inventory control, and containment integrity). The Seabrook Class 1E station batteries and associated dc distribution systems are located within seismic Category I structures. The Class 1E station batteries and associated dc distribution system are therefore protected from the applicable extreme external hazards as defined in NEI 12-06. The batteries power required essential instrumentation and applicable dc control components. Licensee procedure FSG-4, "ELAP Power Management," Revision 0, directs operators to conserve dc power during the event by stripping non-essential loads. Plant operators will strip or shed unnecessary loads to extend battery life until backup power is available. Plant operators would commence load shedding within 1 hour and complete load shedding within 2 hours from the onset of an ELAP event.

The safety-related dc system consists of four 125 Volt (V) dc batteries, chargers, and dc buses separated into two redundant trains, each with two distribution subsystems. Train A is made up of A and C components. Train B is made up of B and D components. Each subsystem consists of one battery, battery charger, switchgear bus and several distribution panels to power their respective load groups. Two 'portable' chargers are available to replace a normal charger. Each safety-related battery was manufactured by Exide Technologies (model NCN-31/NCX-225) and consists of 59 cells that have a nominal 8-hour rating of 2280-ampere hours.

The licensee's analysis showed that the dc system can provide power to the required BDBEE loads for at least 12 hours given that load shedding of non-essential loads is complete within 2 hours into an ELAP event. For Train A, completing the load shedding of non-essential loads within 2 hours would ensure that Train A dc loads provide an estimated total service time of at least 12 hours. For Train B, load shedding of non-essential equipment prior to 2 hours after the start of the ELAP event and transferring Bus 11B loads to Bus 11D when Battery 1B reaches 105 Vdc terminal voltage, would ensure that Train B dc loads provide an estimated total service time of at least 12 hours (Battery 1B is expected to last greater than 8 hours with load shedding while Battery 1D is expected to function for an additional 4 hours when cross connected). Operators will perform dc electrical train alignment using FSG-4, Revision 0.

The NEI white paper, "EA-12-049 Mitigating Strategies Resolution of Extended Battery Duty Cycles Generic Concern" (ADAMS Accession No. ML13241A186), provides guidance for calculating extended duty cycles of batteries (i.e., beyond 8 hours). This white paper was endorsed by the NRC (ADAMS Accession No. ML13241A188). In addition to the white paper, the NRC sponsored testing at Brookhaven National Laboratory that resulted in the issuance of NUREG/CR-7188, "Testing to Evaluate Extended battery Operation in Nuclear Power Plants," in May of 2015. The testing provided additional validation that the NEI white paper method was technically acceptable. The NRC staff reviewed the licensee's battery calculations and confirmed that they had followed the guidance in the NEI white paper.

The NRC staff reviewed the licensee's dc coping calculation SBC-227-CACL, "DC System Evaluation for Station Blackout and Beyond Design Basis External Events," Revision 5, which verified the capability of the dc system to supply the required loads during the first phase of the Seabrook FLEX mitigation strategy plan for an ELAP. The licensee's evaluation identified the required loads and their associated ratings (ampere (A) and minimum required voltage) and the non-essential loads that would be shed within 2 hours to ensure battery operation for least 12 hours.

Based on the staff's review of the licensee's analysis and procedures, the battery vendor's capacity and discharge rates for the Class 1E station batteries, the NRC staff concludes that Seabrook's dc systems appear to have adequate capacity and capability to power the loads required to mitigate the consequences during Phase 1 of an ELAP provided that the portable 480 Vac 405 kW FLEX DG energizes the battery chargers prior the batteries depleting to the minimum acceptable voltage (105 V) and the dc load shedding is completed within the times assumed in the licensee's analysis.

The licensee's Phase 2 strategy is dependent on the SEPS and SWCT availability. If SEPS and SWCT are available, an emergency bus would be re-powered from the SEPS. In accordance with FSG-4.1, "ELAP Power Management Equipment Deployment," Revision 0, and as a conservative measure, the licensee would deploy the portable 480 Vac 405 kW FLEX DG in case the SEPS fails. Operators would perform equipment electrical alignments to ensure that the emergency bus loading is within the capacity of one SEPS genset (2640 kW net). This would ensure that if one SEPS genset shuts down, the remaining genset unit will not be overloaded.

If SEPS and SWCT are not available, the licensee would deploy, stage, and connect a portable 480 Vac 405 kW FLEX DG to repower a station 480 Vac bus to ensure power is available to a portable battery charger for battery charging, dc control power, and instrumentation. The portable 480 Vac 405 kW FLEX DG is stored in a seismic Category I, missile protected structure (SWPH) located above the maximum design-basis flood elevation, thus providing protection that the portable FLEX equipment will remain available following a BDBEE. According to Table 2 of its FIP, the licensee expects being able to deploy the portable 480 Vac 405 kW FLEX DG within 8 hours upon initiation of an ELAP event to supply the dc loads and repower the battery chargers.

The NRC staff reviewed the licensee's analyses contained in engineering change (EC) document, "Loading of a Single SEPS Generator Set for a Beyond Design Basis Extended Loss of AC Power," Revision 00, and a study titled "405 kW and 30 kW FLEX Generator Sizing and Voltage Drop Study," dated February 23, 2016, to verify the capacity of the generators credited in the licensee's FLEX strategies.

The SEPS gensets are 4160 Vac and rated at 2700 kW each with a full load rating of 2640 kW (subtracting 60 kW for SEPS auxiliaries). The licensee's analysis of the SEPS generators (EC-280553) provided details on the minimum loads that are required on Bus 6 or 5 in response to an ELAP event. The minimum required loads on Bus 6 would be 2468.5 kW (171.5 kW margin). The minimum required loads on Bus 5 would be 2493 kW (147 kW margin). The licensee's analysis concluded that the minimum required loads could be powered using a single SEPS genset. The FLEX procedures (FSG-0.0) direct starting both SEPS gensets and then shed loads, as required, to maintain loading within the capability of one genset.

The licensee also credits use of a portable 405 kW 480 Vac and a 30 kW DG. The licensee's study ("405 kW and 30 kW FLEX Generator Sizing and Voltage Drop Study") analyzed the capability and capacity of the 405 kW to support powering the required loads during an ELAP event. For the 405 kW FLEX DG, power will be delivered to the required loads by three 480

Vac distribution centers and two of the larger loads (Train A or B control room ventilation supply and Motor Control Center (MCC)-111/MCC-231 control room lighting) will connect directly to the 405 kW FLEX DG. The expected required loading on the 405 kW FLEX DG is 270.89 kW. The licensee also analyzed the voltage drop for each of the planned cables connected to the 405 kW FLEX DG and 480 Vac distribution centers. The voltage drop was found to be within the design limits of the connected loads. Procedure FGS-4.1.1, "FLEX 405 kW Diesel Generator Operation," Revision 01, provides actions for the operators to operate the 405 kW FLEX DG.

When the Unit 2 circulating water piping cistern is the water source feeding the FLPP, a booster pump is needed to meet the FLPP NPSH requirements. The submersible LP pump is mounted on a trailer mounted 30 kW generator and would be deployed to the Unit 2 circulating water piping cistern access point. The 30 kW generator provides the power to run the submersible pump. The submersible pump can also be used in FLEX strategies for CST makeup. The expected loading on the 30 kW FLEX DG is 22.27 kW.

The NRC staff reviewed EC-280553, Revision 00, and the study titled "405 kW and 30 kW FLEX Generator Sizing and Voltage Drop Study," procedures FSG-0.0, Revision 0, FSG-0.1, Revision 0, FSG-4, Revision 0, FSG-4.1, Revision 0, FSG-5, "Initial Assessment and FLEX Equipment Staging," Revision 1, and FSG-5.1, "FLEX Equipment Deployment," Revision 1, conceptual single line diagrams, and the separation and isolation of the SEPS and FLEX DGs from the Class 1E emergency DGs. Based on the NRC staff's review, the expected minimum required loads for Phase 2 utilizing either the SEPS or portable FLEX DGs are within the limits of the each FLEX generator and/or formal controls/procedures are available to ensure that the loading stays within limits. Therefore, the FLEX generators appear to be adequate to support the electrical loads required for the licensee's Phase 2 strategies.

For Phase 3, the licensee will receive two 1-megawatt (MW) 4160 Vac combustion turbine generators (CTGs), one 1100 kW 480 Vac CTG, and distribution panels (including cables and connectors) from an NSRC. Each portable 4160 Vac CTGs is capable of supplying approximately 1 MW, but two CTGs could be operated in parallel to provide a total of approximately 2 MW.

The licensee's Phase 3 strategy is dependent on the SEPS and SWCT availability. If the SEPS and SWCT are available, the NSRC supplied equipment would be a backup to the SEPS since the plant will already be on shutdown cooling using the RHR system and the SWCT as the UHS.

If SEPS and SWCT are not available, Seabrook would rely on the NSRC supplied equipment to establish shutdown cooling. This will require an NSRC pumping system capable of cooling the PCCW heat exchanger that in turn cools the RHR heat exchanger, and the NSRC 4160 Vac CTGs to power a PCCW pump and an RHR pump. Once service water cooling is restored, the plant can then be placed on shutdown cooling using the repowered RHR and PCCW pumps.

The two 1-MW 4160 Vac CTGs would be connected to Bus E6 (Train B) or Bus E5 (Train A) via the corresponding SEPS supply breaker to energize ac loads required to maintain safe shutdown and core cooling indefinitely. Additionally, the 1-MW 480 Vac CTG will be connected to Unit Sub E63 (Train B) or Unit Sub E53 (Train A) to provide power to safety-related support systems. According to the licensee's studies EC282186-E-001, "4160V RRC Genset Bus 5 Loading," Revision 0, and EC282186-E-002, "4160V RRC Genset Bus 6 Loading," Revision 0, the expected loading on the Phase 3 CTGs when connected to Bus 5 would be 1987 kW for the 4160 Vac CTGs and 483 kW for the 480 Vac CTG. Furthermore, the expected loading on the Phase 3 CTGs when connected to Bus 6 would be 1754 kW for the 4160 Vac CTGs and 531 kW for the 480 Vac CTG. Based on its review, the NRC staff concludes that the FLEX DGs and NSRC supplied CTGs appear to have sufficient capacity and capability to supply the required loads.

3.2.4 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that should maintain or restore core cooling and RCS inventory during an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.3 Spent Fuel Pool Cooling Strategies

In NEI 12-06, Table 3-2 and Appendix D, summarize an approach consisting of two separate capabilities for the SFP cooling strategies. This approach uses a portable injection source to provide the capability for 1) makeup via hoses on the refueling floor capable of exceeding the boil-off rate for the design-basis heat load; and 2) makeup via connection to SFP cooling piping or other alternate location capable of exceeding the boil-off rate for the design-basis heat load. However, in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163), the NRC staff did not fully accept this approach, and added another requirement to either have the capability to provide spray flow to the SFP. However, since the Seabrook SFP is below grade and cannot be drained, Seabrook is not required to have spray flow capability to the SFP, consistent with JLD-SG-2012-01, Revision 1. During the event, the licensee selects the SFP makeup method to use based on plant conditions. This approach also requires a strategy to mitigate the effects of steam from the SFP, such as venting.

As described in NEI 12-06, Section 3.2.1.7, and JLD-ISG-2012-01, Section 1.1, strategies that must be completed within a certain period of time should be identified and a basis that the time can be reasonably met should be provided. In NEI 12-06, Section 3 provides the performance attributes, general criteria, and baseline assumptions to be used in developing the technical basis for the time constraints. Since the event is beyond-design-basis, the analysis used to provide the technical basis for time constraints for the mitigation strategies may use nominal initial values (without uncertainties) for plant parameters, and best-estimate physics data. All equipment used for consequence mitigation may be assumed to operate at nominal setpoints and capacities. In NEI 12-06, Section 3.2.1.2 describes the initial plant conditions for the at-power mode of operation; Section 3.2.1.3 describes the initial conditions; and Section 3.2.1.6 describes SFP initial conditions.

In NEI 12-06, Section 3.2.1.1 provides the acceptance criterion for the analyses serving as the technical basis for establishing the time constraints for the baseline coping capabilities to maintain SFP cooling. This criterion is keeping the fuel in the SFP covered with water.

The ELAP causes a loss of cooling in the SFP. As a result, the pool water will heat up and eventually boil off. The licensee's response is to provide makeup water. The timing of operator actions and the required makeup rates depend on the decay heat level of the fuel assemblies in the SFP. The sections below address the response during operating, pre-fuel transfer or post-fuel transfer operations. The effects of an ELAP with full core offload to the SFP is addressed in Section 3.11 of this SE.

3.3.1 Phase 1

No actions are required during Phase 1 of an ELAP for SFP makeup because the time to boil is sufficient to enable deployment of Phase 2 equipment. Adequate SFP inventory exists to provide radiation shielding for personnel well beyond the time of boiling. The licensee will monitor SFP water level using reliable SFPLI installed per Order EA-12-051. Additionally, Seabrook can gravity drain from the RWST to the SFP using installed plant piping, and this strategy does not rely on any portable equipment.

3.3.2 Phase 2

SEPS and SWCT Available

If the SEPS and SWCT are available for Phase 2, the licensee plans to reestablish SFP cooling once the emergency ac bus has reenergized.

SEPS and SWCT Unavailable

During Phase 2 with SEPS and SWCT unavailable, FIP Section 3.3.2 states that operators will deploy either the portable FLPP or submersible LP pump to supply water from the CST or the Unit 2 circulating water piping cistern to the SFP. The pump discharge can be routed via hoses to the refueling floor to provide direct makeup to the pool. The licensee also noted in its FIP, that they have additional non-robust pumps and water sources they can use to makeup to the SFP if they are available.

3.3.3 Phase 3

In its FIP, the licensee stated that the SFP cooling can be maintained indefinitely using the makeup strategies described in Phase 2 above. However, NSRC equipment is available during Phase 3 for SFP cooling and provide additional defense-in-depth.

3.3.4 Staff Evaluations

3.3.4.1 Availability of Structures, Systems, and Components

3.3.4.1.1 Plant SSCs

Condition 6 of NEI 12-06, Section 3.2.1.3, states that permanent plant equipment contained in structures with designs that are robust with respect to seismic events, floods, and high winds, and associated missiles, are available. In addition, Section 3.2.1.6 states that the initial SFP conditions are: 1) all boundaries of the SFP are intact, including the liner, gates, transfer canals, etc., 2) although sloshing may occur during a seismic event, the initial loss of SFP inventory does not preclude access to the refueling deck around the pool, and 3) SFP cooling system is intact, including attached piping.

The staff reviewed the licensee's calculation on habitability on the SFP refuel floor. This calculation and the FIP indicate that boiling begins at approximately 14 hours during a normal, non-outage situation. The staff noted that FSG-5, "Initial Assessment and FLEX Staging," Revision 1, indicates that operators will deploy hoses and stage makeup as a contingency for SFP makeup within 6 hours from event initiation if the SEPS is unavailable to ensure the FSB remains habitable for personnel entry.

As described in the licensee's FIP, the licensee's Phase 1 SFP cooling strategy does not require any operator actions. However, the licensee does establish a ventilation path to cope with temperature, humidity and condensation from evaporation and/or boiling of the SFP. The operators are directed to open the FSB exterior roll-up door and personnel doors to establish the ventilation path.

As stated above, the licensee's Phase 2 and 3 strategy with the SEPS and SWCT available relies on reestablishing the SFP cooling system. As described in UFSAR Table 3.2-2, Revision 8, the SFP cooling pumps, heat exchangers and cooling loop are all seismic Category I and located in the FSB, which is designed to withstand all applicable hazards as defined in NEI 12-06. The SFP cooling system is cooled by PCCW and service water, which were both discussed in SE Section 3.2.3.1.1 of this SE.

The licensee's Phase 2 and Phase 3 SFP cooling strategy without SEPS available involves the use of one of the portable FLPPs or submersible pumps (or NSRC supplied pump for Phase 3), with suction from the UHS, or Unit 2 circulating water piping cistern to supply water to the SFP. The staff's evaluation of the robustness and availability of FLEX connections points for the FLEX pump is discussed in Section 3.7.3.1 below. Furthermore, the staff's evaluation of the robustness and availability of the UHS for an ELAP event is discussed in Section 3.10.3 of this SE.

3.3.4.1.2 Plant Instrumentation

In its FIP, the licensee stated that the instrumentation for SFP level will meet the requirements of Order EA-12-051. Furthermore, the licensee stated that these instruments will have initial local battery power with the capability to be powered from the FLEX DGs. The NRC staff's review of the SFPLI, including the primary and back-up channels, the display to monitor the SFP water level and environmental qualifications to operate reliably for an extended period are discussed in Section 4 of this SE.

3.3.4.2 Thermal-Hydraulic Analyses

As described in Section 3.3.4.2 of the FIP, the SFP will boil in approximately 3 hours and boil off to the top of fuel in 30 hours from initiation of the event with no operator action at the maximum design heat load.

Calculation SBK-PRAE-15-005, "RCS and SFP Heat-up Studies for the Fukushima Project," Revision 0, states that the two bounding scenarios analyzed are: (1) maximum normal operation heat load and (2) the maximum normal/emergency refueling heat load which includes a full core offload. The heat loads, time to boil, and makeup rates can be found in the table below.

	Heat Load	Time to boil	Makeup rate
Case 1	1.58 million Btu/hr	14 hrs	33.97 gpm
Case 2	46.44 million Btu/hr	3.04 hrs	99.76 gpm

Therefore, the licensee conservatively determined that a SFP makeup flow rate of at least 100 gpm will maintain adequate SFP level above the fuel for an ELAP occurring during normal power operation. Consistent with this guidance in NEI 12-06, Section 3.2.1.6, the staff concludes that the licensee appears to have considered the maximum design-basis SFP heat load.

3.3.4.3 FLEX Pumps and Water Supplies

As described in the FIP, the SFP cooling strategy with the SEPS and SWCT unavailable relies on the same FLEX pumps that provide SG makeup during Phase 2. In the FIP, Sections 3.2.4.5 and 3.3.4.3 describe the hydraulic performance criteria (e.g., flow rate, discharge pressure) for the FLEX pumps. The staff noted that the performance criteria of a FLEX pump supplied from an NSRC for Phase 3 would allow the NSRC pump to fulfill the mission of the onsite FLEX pump if the onsite FLEX pump were to fail. As stated above, the SFP makeup rate of 100 gpm meet or exceed the maximum SFP makeup requirements as outlined in the previous section of this SE.

3.3.4.4 Electrical Analyses

The SFP will be monitored by instrumentation installed by Order EA-12- 051, which is described in other areas of this SE. The power for this equipment has backup battery capacity for 72 hours. The normal power for these instruments is provided by vital buses, one train of which will be repowered by the SEPS or the 405 kW generator (and in Phase 3, using the NSRC generators). As an alternate, each channel can be powered from an extension cord and a 120 Vac outlet.

The NRC staff reviewed the licensee's loading calculations (identified in Section 3.2.3.6 of this SE) for the FLEX DGs and NSRC CTGs and determined that they have sufficient capacity and capability to supply SFP cooling systems at Seabrook.

Based on its review, the NRC staff concludes that the licensee's electrical strategy appears to be acceptable to restore or maintain SFP cooling indefinitely during an ELAP event.

3.3.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore SFP cooling following an ELAP consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.4 Containment Function Strategies

The industry guidance document, NEI 12-06, Table 3-2, provides some examples of acceptable approaches for demonstrating the baseline capability of the containment strategies to effectively maintain containment functions during all phases of an ELAP event. One such approach is for a licensee to perform an analysis demonstrating that containment pressure control is not challenged.

The licensee performed a containment evaluation, C-X-1-28141-CALC, "Containment Response During ELAP – GOTHIC," Revision 1, which was based on the boundary conditions described in Section 2 of NEI 12-06. The calculation analyzed the strategy of containment isolation and monitoring containment pressure using installed instrumentation and concluded that, even with the licensee taking no mitigating actions related to removing heat from containment, the containment parameters of pressure and temperature remain well below the respective UFSAR Table 6.2-1 design limits of 52 psig and 296 °F for more than 120 hours. From its review of the evaluation, the NRC staff noted that the required actions to maintain containment integrity and required instrumentation functions have been developed, and are summarized below.

Eventual containment cooling and depressurization to normal values may utilize off-site equipment and resources during Phase 3 if onsite capability is not restored.

3.4.1 Phase 1

In the FIP, Section 3.4 states that the structural integrity of the reactor containment building, due to increasing containment pressure, will not be challenged during the first few weeks of an ELAP event. For Mode 1, the analysis shows that with no operator actions, containment pressure will slowly increase to less than 11.2 psig over 5 days and containment temperature will slowly increase to 200°F over the same 5 days. Since 11.2 psig is below containment design pressure of 52 psig (UFSAR Table 6.2-1) and 200°F is below the containment design temperature of 296°F (UFSAR Table 6.2-1), no mitigation actions are necessary to maintain or restore containment cooling during Phases 1 or 2.

The Phase 1 coping strategy for containment involves verifying containment isolation per procedure ECA-0.0, "Loss of All AC Power," Revision 47, and monitoring containment pressure using installed instrumentation. Containment pressure will be available via essential plant instrumentation.

3.4.2 Phase 2

The licensee's containment analysis shows that there are no mitigation actions necessary or planned, to maintain or restore containment cooling during Phase 2 for Modes 1 through 4. Containment temperature and pressure are expected to remain below design limits for more than 120 hours; however, containment status will be monitored.

The Phase 2 coping strategy is to continue monitoring containment pressure using installed instrumentation. Phase 2 activities to repower instruments are adequate to facilitate continued containment monitoring.

3.4.3 Phase 3

FLEX coping strategies will ensure no challenge to the containment function for at least the first 120 hours as shown in the licensee's containment analysis. In Phase 3, the necessary actions to reduce containment temperature and pressure and to ensure continued functionality of the key parameters will utilize existing plant systems restored by off-site equipment and resources. The most significant need is to provide power to station pumps and to restore the UHS with portable NSRC pumps (with SEPS not available). If the SEPS and SWCT are available, limited containment cooling would be available during Phases 2 and 3.

The Phase 3 coping strategy is to obtain additional electrical capability and redundancy for on-site equipment until such time that normal power to the site can be restored. This capability will be provided by portable generators provided by the NSRC. Two mobile 4160 V generators and one 480 V generator will be supplied from the NSRC in order to supply power to either of the emergency ac buses. The 4160 V generators are connected via the SEPS breaker and the 480 V generator is connected via a unit sub spare cubicle. By restoring the Class 1E 4 kV bus and 480 V unit substations, power can be restored to the 4160/480 Vac transformers to power selected safe shutdown loads. No additional specific Phase 3 strategy is required for maintaining containment integrity.

3.4.4 Staff Evaluations

3.4.4.1 Availability of Structures, Systems, and Components

Guidance document NEI 12-06 baseline assumptions have been established on the presumption that other than the loss of the ac power sources and normal access to the UHS, installed equipment that is designed to be robust with respect to design-basis external events is assumed to be fully available. Installed equipment that is not robust is assumed to be unavailable. Below are the baseline assumptions for the availability of SSCs for maintaining containment functions during an ELAP.

3.4.4.1.1 Plant SSCs

In the Seabrook UFSAR, Section 3.8.1.1 states that the containment is a seismic Category I reinforced concrete dry structure, which is designed to function at atmospheric conditions. It consists of an upright cylinder topped with a hemispherical dome, supported on a reinforced concrete foundation mat which is keyed into the bedrock by the depression for the reactor pit and by continuous bearing around the periphery of the foundation mat. The inside diameter of the cylinder is 140 feet (ft.) and the inside height from the top of the base mat to the apex of the dome is approximately 219 ft.; the net free volume is approximately 2,704,000 cubic ft. A welded steel liner plate, anchored to the inside face of the containment, serves as a leak-tight membrane. The liner on top of the foundation mat is protected by a 4 ft. thick concrete fill mat which supports the containment internals and forms the floor of the containment. The containment is designed to assure that the base mat, cylinder, and dome behave integrally to resist all loads. The staff noted that being a seismic Category I structure, the containment has been designed to maintain its function following a safe shutdown earthquake (SSE).

3.4.4.1.2 Plant Instrumentation

In NEI 12-06, Table 3-2, specifies that containment pressure is a key containment parameter which should be monitored by repowering the appropriate instruments. In its FIP, the licensee stated that the containment pressure instrumentation will be available prior to and after load stripping of the dc and ac buses during Phase 1 and indication is available in the control room or locally at the instrument (using Measuring & Test Equipment) throughout the event.

If SEPS is unavailable, the portable FLEX 480 V generator will be used to repower a battery charger for the vital dc bus inverters providing power to a train of safety related vital instrumentation. The portable generator has primary and alternate connections, using installed 480 V receptacles on Train A or Train B for powering safety related dc bus portable battery chargers.

In the unlikely event that neither SEPS nor the FLEX 480 V generator are able to restore vital instrumentation, or should any of the signal cabling to the control room indicators be damaged or dc power lost, the FSGs directs actions to obtain vital instrument readings from the control room cabinets or locally at the containment penetrations.

Procedure FSG-7.1.1, "Control Room Instrumentation Alternate Indication Readout," Revision 0, provides location and termination information in the control room for all essential instrumentation. For those containment transmitters where signal integrity is lost between the penetration and the control room, FSG-7.1.1 provides location and termination information at accessible field locations nearer to the signal sources. For other instruments not in the containment, measurements can be taken locally at the transmitter. Where applicable, scaling sheets are provided to convert the transmitter output to the process variable. The hand held devices have built in power supplies which can be used to provide loop power.

3.4.4.2 Thermal-Hydraulic Analyses

The NRC staff reviewed analysis C-X-1-28141-CALC, "Containment Response During ELAP – GOTHIC," Revision 1, which was based on the boundary conditions described in Section 2 of NEI 12-06. In this calculation, the licensee utilized the Generation of Thermal-Hydraulic Information for Containments (GOTHIC) version 8.0 code to model the containment response to an ELAP and was benchmarked against previous LOCA analyses. The only additions of heat and mass to the containment atmosphere under ELAP conditions are the heat loads from the RCS and main steam system (e.g., from the surfaces of hot equipment and the leakage of reactor coolant from the RCP seals). Specifically, Case 1 models the containment conditions for operating Modes 1 through 4 in which the SGs are available to remove RCS heat.

The RCS heat sink is maintained in Phase 1, which relies on installed plant equipment and on-site resources, by feeding the SGs using the TDEFW pump while steaming to the atmosphere via the ASDVs. The RCS cool-down rate is approximately 75°F/hr via the ASDVs to a SG pressure of approximately 350 psig. The SG is maintained at this pressure for two hours; at which point the RCS is further cooled to a SG pressure of 300 psig. The assumed reactor coolant leakage is 1 gpm per each of the four RCPs and a 1 gpm unidentified leak rate, for a total RCS leakage rate of 5 gpm into containment.

Using the input described above, the containment pressure and temperature at the end of the 120-hour period were calculated to peak at approximately 11.2 psig and 200°F, respectively. These values are still far below the UFSAR design parameters of 52 psig and 296°F, so the NRC staff concludes that the licensee appears to have adequately demonstrated that there is significant margin before a limit would be reached.

3.4.4.3 FLEX Pumps and Water Supplies

In the case where the SEPS and SWCT are unavailable, the NSRC LPHF pump and suction booster pumps will be used to restore the UHS. The submersible pump heads are placed in the service water forebay and supply the LPHF pump. The LPHF pump will discharge into the service water pump discharge, which can be fed to either service water loop.

3.4.4.4 Electrical Analyses

The licensee's calculation (ND C-X-1-28141-CALC, Revision 1) shows that FLEX coping strategies will ensure no challenge to the containment function for at least the first 5 days. The licensee's Phase 3 strategy is to utilize existing plant systems restored by off-site equipment and resources to reduce containment temperature and pressure and to ensure continued functionality of the key parameters. If the SEPS and SWCT are available, limited containment cooling would be available in Phases 2 and 3. If the SEPS was not available, NSRC supplied equipment could be used to provide power to station pumps and to restore the UHS with portable pumps.

The NRC staff reviewed the licensee's loading calculations (identified in Section 3.2.3.6 of this SE) for the FLEX DGs and NSRC CTGs and determined that they appear to have sufficient capacity and capability to supply the required loads to reduce containment temperature and pressure, if necessary, to ensure that key components including required instrumentation remain functional at Seabrook.

Based on its review, the NRC staff concludes that the licensee's electrical strategy appears to be acceptable to restore or maintain containment integrity and cooling indefinitely during an ELAP event.

3.4.5 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore containment functions following an ELAP event consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.5 Characterization of External Hazards

Sections 4 through 9 of NEI 12-06 provide the methodology to identify and characterize the applicable BDBEEs for each site. In addition, NEI 12-06 provides a process to identify potential complicating factors for the protection and deployment of equipment needed for mitigation of applicable site-specific external hazards leading to an ELAP and loss of normal access to the UHS.

Characterization of the applicable hazards for a specific site includes the identification of realistic timelines for the hazard, characterization of the functional threats due to the hazard, development of a strategy for responding to events with warning, and development of a strategy for responding to events without warning.

The licensee reviewed the plant site against NEI 12-06 and determined that FLEX equipment should be protected from the following hazards: seismic; external flooding; severe storms with high winds; and snow, ice and extreme cold. The licensee determined that the extreme high temperature hazard screens out for Seabrook.

References to external hazards within the licensee's mitigating strategies and this SE are consistent with the guidance in NEI-12-06 and the related NRC endorsement of NEI 12-06 in JLD-ISG-2012-01. Guidance document NEI 12-06 directed licensees to proceed with evaluating external hazards based on currently available information. For most licensees, this meant that the OIP used the current design-basis information for hazard evaluation. Coincident with the issuance of Order EA-12-049, on March 12, 2012, the NRC staff issued a Request for Information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (ADAMS Accession No. ML12053A340) (hereafter referred to as the 50.54(f) letter), which requested that licensees reevaluate the seismic and flooding hazards at their sites using updated hazard information and current regulatory guidance and methodologies. Due to the time needed to reevaluate the hazards, and for the NRC to review and approve them, the reevaluated hazards were generally not available until after the mitigation strategies had been developed. The NRC staff has developed a proposed rule, titled "Mitigation of Beyond-Design-Basis Events," hereafter called the MBDBE rule, which was published for comment in the *Federal Register* on November 13, 2015 (80 FR 70610). The proposed MBDBE rule would make the intent of Orders EA-12-049 and EA-12-051 generically applicable to all present and future power reactor licensees, while also requiring that licensees consider the reevaluated hazard information developed in response to the 50.54(f) letter.

The NRC staff requested Commission guidance related to the relationship between the reevaluated flooding hazards provided in response to the 50.54(f) letter and the requirements for Order EA-12-049 and the MBDBE rulemaking (see COMSECY-14-0037, Integration of Mitigating Strategies for Beyond-Design-Basis External Events and the Reevaluation of Flooding Hazards" (ADAMS Accession No. ML14309A256). The Commission provided guidance in an SRM to COMSECY-14-0037 (ADAMS Accession No. ML15089A236). The Commission approved the staff's recommendations that licensees would need to address the reevaluated flooding hazards within their mitigating strategies for BDBEEs, and that licensees may need to address some specific flooding scenarios that could significantly damage the power plant site by developing scenario-specific mitigating strategies, possibly including unconventional measures, to prevent fuel damage in reactor cores or SFPs. The NRC staff did not request that the Commission consider making a requirement for mitigating strategies capable of addressing the reevaluated flooding hazards be immediately imposed, and the Commission did not require immediate imposition. In a letter to licensees dated September 1, 2015 (ADAMS Accession No. ML15174A257), the NRC staff informed the licensees that the implementation of mitigation strategies should continue as described in licensee's OIPs, and that the NRC SEs and inspections related to Order EA-12-049 will rely on the guidance provided in JLD-ISG-2012-01, Revision 0, and the related industry guidance in NEI 12-06, Revision 0. The hazard reevaluations may also identify issues to be entered into the licensee's corrective action program consistent with the OIPs submitted in accordance with Order EA-12-049.

As discussed above, licensees are reevaluating the site seismic and flood hazards as requested in the NRC's 50.54(f) letter. After the NRC staff approves the reevaluated hazards, licensees will use this information to perform flood and seismic mitigating strategies assessments (MSAs) per the guidance in NEI 12-06, Revision 2, Appendices G and H (ADAMS Accession No.

ML16005A625). The NRC staff endorsed Revision 2 of NEI 12-06 in JLD-ISG-2012-01, Revision 1 (ADAMS Accession No. ML15357A163). The licensee's MSAs will evaluate the mitigating strategies described in this SE using the revised seismic hazard information and, if necessary, make changes to the strategies or equipment. Licensees will submit the MSAs for NRC staff review.

The licensee developed its OIP for mitigation strategies by considering the guidance in NEI 12-06 and the site's design-basis hazards. Therefore, this SE makes a determination based on the licensee's OIP and FIP. The characterization of the applicable external hazards for the plant site is discussed below.

3.5.1 Seismic

In its FIP, the licensee described the current design-basis seismic hazard, the SSE. As described in UFSAR Section 3.7(B), the SSE seismic criteria for the site is 0.25g peak horizontal ground acceleration and 0.167g peak ground acceleration acting vertically. It should be noted that the actual seismic hazard involves a spectral graph of the acceleration versus the frequency of the motion. Peak acceleration in a certain frequency range, such as the numbers above, is often used as a shortened way to describe the hazard.

As the licensee's seismic reevaluation activities are completed, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions as will potentially be required by the proposed MBDBE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.2 Flooding

In its FIP, the licensee described that the current design-basis for the limiting site flooding event is the effects of a combined standard project storm (SPS) and probable maximum hurricane (PMH). Seabrook's licensing basis also considers the effects of wave run-up during the SPS-PMH storm. As described in the FIP, the site grade is at elevation 20 ft. mean sea level (MSL) and the anticipated elevation of flood water (ponding) during the SPS-PMH storm is 20.7 ft. MSL. Wave run-up that can accompany the combined SPS-PMH is estimated to achieve an elevation of 21.8 ft. MSL on the east and south walls of specific site buildings for a short duration of approximately 1-2 hours. The licensee indicated that all safety-related equipment are protected from flooding by the structures that house them and/or by being located above a maximum water level not exceeding 21 ft. MSL, postulated to result during the combined PMH-SPS event.

As the licensee's flooding reevaluation activities are completed, the licensee is expected to assess the mitigation strategies to ensure they can be implemented under the reevaluated hazard conditions as will potentially be required by the proposed MBDBE rulemaking. The licensee has appropriately screened in this external hazard and identified the hazard levels to be evaluated.

3.5.3 High Winds

In NEI 12-06, Section 7, provides the NRC-endorsed screening process for evaluation of high wind hazards. This screening process considers the hazard due to hurricanes and tornadoes.

The screening for high wind hazards associated with hurricanes should be accomplished by comparing the site location to NEI 12-06, Figure 7-1 (Figure 3-1 of U.S. NRC, "Technical Basis for Regulatory Guidance on Design Basis Hurricane Wind Speeds for Nuclear Power Plants," NUREG/CR-7005, December, 2009); if the resulting frequency of recurrence of hurricanes with wind speeds in excess of 130 mph exceeds 1E-6 per year, the site should address hazards due to extreme high winds associated with hurricanes using the current licensing basis for hurricanes.

The screening for high wind hazard associated with tornadoes should be accomplished by comparing the site location to NEI 12-06, Figure 7-2, from U.S. NRC, "Tornado Climatology of the Contiguous United States," NUREG/CR-4461, Rev. 2, February 2007; if the recommended tornado design wind speed for a 1E-6/year probability exceeds 130 mph, the site should address hazards due to extreme high winds associated with tornadoes using the current licensing basis for tornados or Regulatory Guide 1.76, Revision 1.

According to Seabrook's UFSAR, Section 2.1.1.1, states that the site is located at 42° 53' 55.4" North latitude and 70° 50' 58.7" West longitude. In its FIP, the licensee stated that Seabrook is situated near the 160 mph hurricane contour shown in Figure 7-1 of NEI 12-06 and Region 2 with a recommended tornado wind speed of 170 mph shown in NEI 12-06 Figure 7-2. Therefore, the plant screens in for an assessment for high winds, hurricanes, and tornados, including missiles produced by these events.

Therefore, high-wind hazards are applicable to the plant site. The licensee has appropriately screened in the high wind hazard and characterized the hazard in terms of wind velocities and wind-borne missiles.

3.5.4 Snow, Ice, and Extreme Cold

As discussed in NEI 12-06, Section 8.2.1, all sites should consider the temperature ranges and weather conditions for their site in storing and deploying FLEX equipment consistent with normal design practices. All sites outside of Southern California, Arizona, the Gulf Coast and Florida are expected to address deployment for conditions of snow, ice, and extreme cold. All sites located north of the 35th Parallel should provide the capability to address extreme snowfall with snow removal equipment. Finally, all sites except for those within Level 1 and 2 of the maximum ice storm severity map contained in Figure 8-2 should address the impact of ice storms.

As stated above, regarding the determination of applicable extreme external hazards, the site is located at 42° 53' 55.4" North latitude and 70° 50' 58.7" West longitude, which is north of the 35th Parallel. In addition, the site is located within the region characterized by the Electric Power Research Institute (EPRI) as ice severity level 4 (NEI 12-06, Figure 8-2, Maximum Ice Storm Severity Maps). Consequently, the site is subject to severe icing conditions that could cause severe damage to electrical transmission lines. However, the licensee stated in its FIP that Seabrook UFSAR Section 2.3.2, 'Local Meteorology,' notes that extremes of temperature are uncommon due to the proximity of the site to the Atlantic Ocean. Winter arctic air masses can produce low minimum temperatures, but the frequency and persistence of such extreme values along the coast is less than inland locations. UFSAR Section 2.3.1 notes that the Seabrook site is subjected not only to storms that track across the continental United States, but also to intense winter storms, (i.e., "Nor'easters,") that move northeastward along the U.S. East coast. During the winter months, Nor'easters can produce heavy rain or snowfall, and occasionally bring ice storm conditions to the area. Nor'easter winds are typically less severe than those of postulated hurricanes. Seabrook structures are designed for snow and ice loads.

In summary, based on the available local data and Figures 8-1 and 8-2 of NEI 12-06, the plant site does experience significant amounts of snow, ice, and extreme cold temperatures; therefore, the hazard is screened in. The licensee has appropriately screened in the hazard and characterized the hazard in terms of expected temperatures.

3.5.5 Extreme Heat

In its FIP, the licensee stated that Seabrook screens out of the extreme high temperature hazard based upon the following information:

- Contrary to the assertion in Section 9 of NEI 12-06 that "virtually all of the 48 contiguous states have experienced temperatures in excess of 110°F," the record high temperature for the State of New Hampshire is 106°F which was recorded in Nashua, NH in 1911 (NOAA National Weather Service historical data for the State of New Hampshire). Nashua is located in the western part of the state away from the coast.

- Seabrook UFSAR Section 2.3.2, "Local Meteorology," notes that extremes of temperature are uncommon due to the proximity of the site to the Atlantic Ocean. During the spring and summer, a sea breeze usually moderates temperatures from reaching high extremes at the site.

- The highest recorded temperature for Portsmouth, NH, which is located on the seacoast 15 miles north of Seabrook, is 101°F which occurred in both 1964 and 2011 (NOAA National Weather Service historical data for the State of New Hampshire).

- The highest average maximum temperatures in Portsmouth, NH during the Summer months of June, July and August from 1960 to 2012 are (NOAA National Weather Service historical data for the State of New Hampshire):
  - June: 80.8°F (1999)
  - July: 83.5°F (1994)
  - August: 83.7°F (2002)

In summary, based on the available local data and the guidance in Section 9 of NEI 12-06, the plant site screens out for extreme high temperatures. The licensee has appropriately screened out the high temperature hazard and characterized the hazard in terms of expected temperatures.

3.5.6 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed a characterization of external hazards that appears to be consistent with NEI 12-06 guidance as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order in regard to the characterization of external hazards.

3.6 Planned Protection of FLEX Equipment

3.6.1 Protection from External Hazards

As mentioned above, the Seabrook Phase 2 primary strategy utilizes the SEPS and SWCT, which are not fully protected from all hazards as defined in NEI 12-06. The SEPS and SWCT are available following design-basis flooding (SWCT only), seismic, and hot/cold weather events, but may not be available following severe wind/wind driven missile events. The Seabrook Phase 2 alternate strategy utilizes portable FLEX equipment stored in an existing seismic Category I, missile protected structure, SWPH unused Unit 2 bays, located above the maximum design-basis flood elevation. Below are additional details on how the Phase 2 primary and alternate equipment is protected from each of the external hazards.

3.6.1.1 Seismic

In its FIP, the licensee stated that the SEPS has been modified to harden it for seismic events, and the SWCT is a seismic Category I structure. The alternate Phase 2 FLEX equipment is stored in the unsued portion of the Unit 2 SWPH, which is a seismic Category I structure. In document EC-282582, and calculation C-S-1-10181, "SWPH FLEX Storage Tie-Down Design," Revision 0, the licensee concluded that the Phase 2 portable FLEX equipment stored in the SWPH is not tied down; however, the equipment is stored in a configuration that provides a minimum of 2 ft. of separation and outriggers are extended, if applicable, to prevent overturning or interactions with other equipment or structures.

3.6.1.2 Flooding

In its FIP, the licensee stated that the SEPS gensets are protected from the elements by weather-proof enclosures and is protected from a design-basis flood. In addition, as mentioned above, the alternate Phase 2 FLEX equipment is protected in a structure (SWPH) located above the maximum design-asis flood elevation. Also, the licensee indicated that during flooding events, access to areas in the plant could be restricted due to flood waters and high winds. However, Seabrook flooding events are short in duration. Therefore, the licensee's strategy was developed such that access to FLEX equipment and access to potentially environmentally harsh areas is not required until the flood waters have receded.

3.6.1.3 High Winds

In its FIP, the licensee stated that the SWCT provides protection of the SEPS from wind driven missiles from the north, reducing the probability that wind driven missiles will damage SEPS. However, the SEPS is not fully protected from all wind-driven missiles; therefore, the primary Phase 2 strategy may not be available following severe wind/wind driven missile events. In addition, the SWCT was not originally evaluated for tornado missile impact and it has openings that make it potentially vulnerable to vertical and oblique trajectory missiles. These openings limit the pathways for wind driven missiles to damage SWCT equipment. Regardless, if either the SEPS or the SWCT are not available, the alternate Phase 2 FLEX equipment is stored in the SWPH, which provides protection from high winds, including wind-driven missiles. In addition, the existing SWPH entrance was modified with a new Barrier I missile door to allow for rapid deployment while maintaining the structure's missile protection.

For hurricane events, the licensee stated that plant procedures require that for a category 3, 4, or 5 hurricane, the unit shall be shutdown to Mode 5 at least two hours before the projected onset of sustained hurricane force winds within the owner controlled area. To assist with hurricane preparations, on-site resources and staffing are significantly increased in advance of the projected storm, and guidance is available to operators to ensure major fuel oil tanks are full and that the CST has significant inventory. Therefore, prior to the arrival of the projected hurricane, the plant is in a unique state and well prepared to cope with the event. Similar to flooding events, the licensee has developed strategies that access to the primary and alternate Phase 2 FLEX equipment and access to potentially environmentally harsh areas is not required until the high winds have subsided.

3.6.1.4 Snow, Ice, Extreme Cold and Extreme Heat

In its FIP, the licensee stated that the engine cooling systems of the SEPS gensets contain the required amount of glycol anti-freeze to protect the engines to at least minus 22°F. Also, the licensee has generated a snow and ice response for the site, which includes clearing the road to the SEPS gensets and guidance to clear snow around the SEPS gensets air intakes. Regarding the Phase 2 portable FLEX equipment, the licensee procured and is maintaining equipment to function in extreme cold conditions of at least minus 25°F.

As mentioned above, Seabrook screens out for extreme heat temperatures; therefore, it is not expected that the SEPS or alternate Phase 2 FLEX equipment would be affected by high temperatures. However, the alternate Phase 2 FLEX equipment stored in the SWPH has been selected to be capable of operating in hot weather at or in excess of the regional maximum 100-year return period temperature of 100.9°F, which is below the NEI 12-06 high temperature threshold of 110°F. In addition, the alternate Phase 2 FLEX equipment storage locations have a maximum design temperature of 104°F, in which normal temperatures in these locations will be significantly less.

3.6.2 Reliability of FLEX Equipment

Section 3.2.2.16 of NEI 12-06 states, in part, that in order to assure reliability and availability of the FLEX equipment, the site should have sufficient equipment to address all functions at all units on-site, plus one additional spare (i.e., an "N+1" capability, where "N" is the number of units on site). It is also acceptable to have a single resource that is sized to support the required functions for multiple units at a site (e.g., a single pump capable of all water supply functions for a dual unit site). In this case, the "N+1" could simply involve a second pump of equivalent capability. In addition, it is also acceptable to have multiple strategies to accomplish a function, in which case the equipment associated with each strategy does not require an additional spare.

Based on the SEPS and SWCT, the number of portable FLEX pumps, FLEX DGs, and support equipment identified in the FIP and during the audit review, the NRC staff concludes that, if implemented appropriately, the licensee's FLEX strategies include a sufficient number of portable FLEX pumps, FLEX DGs, and equipment for RCS makeup and boration, SFP makeup, and maintaining containment, and appears to be consistent with the "N+1" recommendation in Section 3.2.2.16 of NEI 12-06.

3.6.3 Conclusions

Based on the licensee's primary and alternate plan for Phase 2, in which the SEPS and SWCT is protected from all hazards, except wind-driven missiles, and the portable onsite FLEX equipment is stored in a fully protected structure, the NRC staff concludes that the licensee has provided a strategy and storage location that is appropriately protected from the applicable external hazards for the site in accordance with the provisions of NEI 12-06. Further, the NRC staff concludes that the licensee has stored sufficient equipment to accomplish the elements of their overall strategy that depend on this equipment (primarily Phase 2 operations). Therefore, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should protect the FLEX equipment during a BDBEE consistent with NEI 12-06, as endorsed, by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.7 Planned Deployment of FLEX Equipment

In its FIP, the licensee stated that pre-determined, preferred haul paths have been identified and documented in the FSGs. Figure 8 of the FIP shows the haul paths from the SWPH FLEX storage area to the various deployment locations. These haul paths have been reviewed for potential soil liquefaction and have been determined to be stable following a seismic event.

3.7.1 Means of Deployment

The deployment of onsite FLEX equipment to implement coping strategies beyond the initial plant capabilities (Phase 1) requires that pathways between the SWPH and various deployment locations be clear of debris resulting from seismic, high wind, or flooding events. The stored FLEX equipment in the SWPH includes debris removal equipment that provides a means to move or remove debris from the needed travel paths. In its FIP, the licensee indicated that the potential for debris in the SWPH area is limited because this is within the protected area and many of the surrounding structures are Category I buildings. However, the licensee noted that there are some sea-land containers and sheet metal structures that could be a source of debris. Therefore, the licensee's plan for removal would be to use the debris removal tractor stored in the SWPH. If debris is blocking the door, the debris removal tractor can use the front end loader attachment to push the hinged door that opens outward from the inside.

Additionally, the preferred haul paths attempt to avoid areas with trees, power lines, narrow passages, etc. when practical. However, high winds can cause debris from distant sources to interfere with planned haul paths. As mentioned above, debris removal equipment is stored inside the SWPH, which protects the equipment from severe storm and high wind hazards such that the equipment remains functional and deployable to clear obstructions from the pathway between the SWPH and its deployment location(s).

The licensee may need to open doors and gates that rely on electric power for opening and/or locking mechanisms. The licensee has contingencies for access upon loss of all ac/dc power as part of the security plan. Access to the owner-controlled area, the plant protected area, and areas within the plant structures will be controlled under this access contingency.

Phase 3 of the FLEX strategies involves the receipt of equipment from offsite sources including the NSRC and various commodities such as fuel and supplies. Transportation of this equipment can be through airlift or via ground transportation. Debris removal for the pathway between the site and the two NSRC receiving locations for Seabrook and from the various plant access routes may be required. The same debris removal equipment used for on-site pathways will be used to support debris removal to facilitate road access to the site.

3.7.2 Deployment Strategies

In its FIP, the licensee stated that the haul paths have been reviewed for potential soil liquefaction. The licensee's soil liquefaction study concluded for the postulated ground motions, the potential liquefaction results in little, if any, settlement and that travel would not be affected. In addition, the licensee analyzed the haul routes for the Phase 3 equipment. The licensee concluded that the staging areas and at least one travel path will be available and useable following a seismic event. The NRC staff reviewed document ND FP100956, Report of Liquefaction Potential Assessment FLEX Staging Areas, Helipads, Equipment Travel Paths and Temporary Pump Storage Area, Revision 0, to verify the licensee's conclusions and the NRC staff believes that liquefaction should not inhibit the necessary equipment deployment after an earthquake.

For the RCS cooling strategy, the licensee will deploy the portable, diesel-driven FLPP from the SWPH FLEX storage area to a location near the CST. The FLPP primary suction and discharge connections are located inside the seismic Category I, missile protected EFW pump house. In the case where the CST is unavailable, the FLPP will be deployed to take suction from one of the alternate water supplies as discussed in Section 3.10 of this SE.

For RCS makeup during Modes 5 and 6 without SGs, the licensee will deploy the portable FLPP from the SWPH to the south side of the primary auxiliary building (PAB). A suction hose will connect the RWST SFP makeup header to the FLPP suction using an adapter. The FLPP will discharge through a hose to the charging pump discharge header via a temporary valve installed during Modes 5 and 6, using an adapter. The connections are located in Category I structures, which are protected against all the applicable hazards as defined in NEI 12-06.
For SFP makeup, if the primary, existing piping is not available, a submersible pump and its associated 30 kW generator will be deployed to the Unit 2 circulating water piping cistern. A hose will be attached to the submersible pump, and the pump will be lowered into the cistern. A hose will be run from the submersible pump to the eastern FSB door and connected to the hoses that have been run to the monitor nozzles at the SFP.

For the electrical strategy, if SEPS is not available, the FLEX 480 VAC generator will be deployed in between the DG building and the waste processing building. If this location is obstructed, the FLEX 480 Vac generator can also be deployed in between the DG building and the administration building. The cables needed for the initial connections are pre-staged in the Train B essential switchgear room and the "B" DG room. Additional cables for the Train A essential and non-essential switchgear distribution center units are stored in the SWPH.

3.7.3 Connection Points

3.7.3.1 Mechanical Connection Points

Core Cooling

FIP Section 3.2.4.1.1 states that the primary connection point for the FLPP injects into the EFW pump discharge piping that feeds all SGs. The connection is on the existing EFW line that contains a hose connection and isolation valve that is normally closed. As described in SE Section 3.2.3.1.1, the EFW system pumps and piping are seismic Category I. In the FIP, the licensee stated that the primary AFW connection is located in a seismic Category I structure protected from all applicable hazards as defined in NEI 12-06. Also, FIP Section 2.3.5.2 states that the alternate connection will connect to the four main feed headers. The licensee further states in FIP Section 3.7.2.1 that the connections are located in the two steam and feed pipe chases which are protected from all applicable hazards as defined in NEI 12-06. More specifically, two connections are located in the east pipe chase and two in the west pipe chase. Additionally, the FLPP will take suction from either a connection to the CST or directly from the discharge of the submersible pump. As stated in FIP Section 3.2.4.1.1, the connection to the CST is located in the EFW pump house which was previously discussed as being robust with respect to all applicable hazards as defined in NEI 12-06.

As discussed above, the Phase 3 strategy is to establish shutdown cooling using the NSRC LPHF and submersible booster pumps to restore flow to the UHS. The submersible pumps will be placed in the service water forebay and will supply the LPHF pumps which are connected to the service water discharge header which operators can direct to either loop of service water. The forebay and connection are located in the SWPH, which is a seismic Category I structure protected from all applicable hazards as defined in NEI 12-06.

RCS Makeup

In the FIP, Section 3.2.4.1.1 states that the discharge from the FLEX RCS makeup pump will be piped to the primary RCS tie-in on the existing positive displacement charging pump discharge piping. The primary RCS connection and the entire flowpath are located inside the auxiliary building. In the FIP, Section 3.2.4.1.1 states that the alternate RCS connection is tied into the existing safety injection system header. The alternate connection and RCS tie-in piping is also located in the auxiliary building.

In NEI 12-06, Table D-1 states, in part, that the performance attributes for make-up with a portable pump should include primary and alternate injection points to establish capability to inject through separate divisions/trains, i.e., should not have both connections in one division/train. Based on the licensee's description and associated diagrams in the FIP, Seabrook appears to have the capability of RCS make-up with a portable pump through primary and alternate injection points through separate divisions/trains. Therefore, the NRC staff concludes that these injection points appear to be consistent with NEI 12-06, Table D-1.

SFP Cooling

FIP Section 3.3.4.1.1 describes the licensee's SFP makeup connections. The license has two independent flow paths for providing SFP make up from the same FLEX pumps that are used to provide core cooling. The FIP states that the primary flow path is gravity drain to the SFP from the RWST using the existing piping, all located in fully protected structures. This primary connection does not require access to the refueling floor. The alternate flow path outlined in the FIP is to route hoses through the FSB. Hoses can be routed up to the refueling floor and directly into the pool.

Containment Cooling

The licensee does not have any additional connections specifically to support containment cooling. However, the service water connection described above can be used to establish containment cooling, if necessary.

Given the design and location of the primary and alternate connection points, as described in the above paragraphs, the staff concludes that at least one of the connection points should be available to support core, SFP, and containment cooling via a portable pump during an ELAP caused by an external event, and appears to be consistent with NEI 12-06 Section 3.2.2.

3.7.3.2 Electrical Connection Points

Electrical connection points are applicable for all phases of the licensee's mitigation strategies for a BDBEE.

If the SEPS is available, Seabrook's Class 1E 4160 Vac and 480 Vac buses are energized from the SEPS generators using installed plant breakers and switchgear engineered to provide for the connection of the non-Class 1E SEPS generators to the plant Class 1E electrical distribution system. The SEPS breakers prevent from connecting to the Class 1E bus at the same time as other 1E sources by control circuit interlocks. In this case, the portable 480 Vac 405 kW FLEX DG could be used to provide power for additional instrumentation.

If the SEPS is not available, the 480 Vac 405 kW FLEX DG will be deployed to the slot between the DG building and the waste processing building. If this location is obstructed, it can also be deployed to the slot between the DG building and the administration building. The primary and alternate connections for the portable 480 Vac 405 kW FLEX DG are the existing Train B and A portable battery charger connections, respectively. The licensee would initially use the FLEX 480 Vac 405 kW DG to power transformer/distribution center units in the "B" essential switchgear room and the "B" DG room via flexible, weatherproof cables and color coded connectors. The cables needed for the initial connections are pre-staged in the Train B essential switchgear room and the "B" DG room to speed initial response. Additional cables for the Train A essential and non-essential switchgear distribution center units are stored in the SWPH. The transformer/distribution center units are used to power the Train A and B portable battery chargers using pre-made cables with connectors. They are also used to power two motor control centers (via 480 Vac weld receptacles) to support control room lighting and receptacles (to allow easy use of temporary fans). If Train B equipment is unavailable, Train A can be substituted. The normal portable battery charger input breaker provides coordinated protection for the battery charger and downstream equipment. Procedures are available (FSG-

4.1) to provide direction to the operators and will insure that multiple sources are not connected to a common load. During the onsite portion of the audit, the NRC staff confirmed that proper phase rotation of the portable 480 Vac, 405 kW FLEX DG would be verified by the licensee as part of post maintenance testing.

The portable 30 kW FLEX DGs are trailer mounted and dedicated to supply power to the submersible pump. It would be deployed and staged near the Unit 2 circulating water piping cistern, if needed. The licensee verified the color-code labeling to align with plant verified codes for phases during post maintenance testing (i.e., phase rotation was verified when the licensee connected the 30 kW FLEX DGs and pumped water from the circulation water piping).

During Phase 3, when SEPS is not available, 4160 Vac vital buses 5 and 6 would be energized from NSRC equipment on the load side of the SEPS bus 5/6 breaker. This method allows use of the engineered protective and interlock features and breaker tripping coordination of the SEPS incoming line breakers in the protection of the Class 1E system from a fault on the non-Class 1E portable equipment. The SEPS breakers prevent from connecting to the Class 1E bus at the same time as other 1E sources by control circuit interlocks. The licensee's FSGs provide operators with direction and will insure that multiple sources are not connected to a common load. The primary and alternate connections for the NSRC supplied 480 Vac CTG are at unit sub 53 and unit sub 63, respectively. They would be connected at the load side of a spare 1200 amp breaker on either unit sub 53 or unit sub 63. This configuration allows for the protection of the Class 1E electrical distribution system by relying on the existing installed protective devices. Procedures are available to provide direction to the operators and will insure that multiple sources are not connected to a common load. The license would stage the NSRC CTGs near the FLEX generator they would replace. FSG-4 contains steps to verify proper phase rotation of the NSRC supplied CTGs prior to energizing required loads.

Based on its review of conceptual single electrical diagrams and station procedures, the NRC staff concludes that the licensee's approach appears to be acceptable given the protection and diversity of the power supply pathways, the separation and isolation of the SEPS and the FLEX generators from the Class 1E EDGs, and availability of procedures to direct operators how to align, connect, and protect associated systems and components.

3.7.4 Accessibility and Lighting

In its FIP, the licensee stated that the potential impairments to required access are: 1) doors and gates, and 2) site debris blocking personnel or equipment access. The coping strategy to maintain site accessibility through doors and gates is applicable to all phases of the FLEX coping strategies, and is immediately required as part of the immediate activities required during Phase 1. Doors and gates serve a variety of barrier functions on the site. One primary function is security and is discussed below. However, other barrier functions include fire, flood, radiation, ventilation, tornado, and high energy line break. As barriers, these doors and gates are typically administratively controlled to maintain their function as barriers during normal operations.

The licensee noted that following an BDBEE and subsequent ELAP event, FLEX coping strategies require the routing of hoses and cables to be run through various barriers in order to connect beyond-design-basis (BDB) equipment to station fluid and electric systems or require the ability to provide ventilation. For this reason, certain barriers (gates and doors) will be opened and remain open. This deviation of normal administrative controls is acknowledged and is acceptable during the implementation of FLEX coping strategies. The ability to open doors for ingress and egress, ventilation, or temporary cables/hoses routing is necessary to implement the FLEX coping strategies.

In its FIP, the licensee described that control room emergency lighting is powered by the plant batteries and adequate portable lighting is provided to support activities outside of the control room. During an ELAP, it assumed that the majority of plant lighting is lost. Therefore, for the loss of plant lighting, the licensee will utilize flashlights, head lamps and batteries, which are maintained in FLEX cabinets in the control room, Train B essential switchgear room, and in the SWPH. In addition, flashlights are maintained in numerous other FLEX cabinets. If SEPS is available, it will reenergize one train of the vital battery chargers as soon as the units are loaded, in which normal control room lighting will be restored later in the event. If SEPS is unavailable, FSG-4.1 directs operators to restore normal lighting using the portable generator. Plug in connections are utilized to back-feed the MCCs supplying the control room lighting and power outlets.

3.7.5 Access to Protected and Vital Areas

During the audit process, the licensee provided information describing that access to protected areas will not be hindered. The licensee has contingencies in place to provide access to areas required for the ELAP response if the normal access control systems are without power.

3.7.6 Fueling of FLEX Equipment

In the FIP Section 3.7.4, the licensee stated that all portable FLEX equipment stored in the SWPH will be stored with a half tank or less. Periodic testing uses some fuel and requires adding fuel to the tanks either prior to the testing or after testing is complete. Therefore, the stored fuel is periodically refreshed. The SEPS diesels have a minimum of 4775 gallons in each storage tank, one for each SEPS diesel. A fuel trailer is stored in the SWPH and has a 1,000 gallon capacity. The basic strategy the licensee stated in the FIP is to transfer fuel from the emergency fuel oil storage tanks to the fuel trailer and then to the SEPS and FLEX equipment as necessary. The fuel oil storage tanks (2 total) are located in seismic Category I structures protected from all applicable hazards as defined in NEI 12-06. Each tank has a technical specification controlled minimum supply of 62,000 gallons of fuel. Based on the design and location of these emergency DG fuel tanks and protection, the staff concludes that the tanks are robust and the fuel oil contents should be available to support the licensee's FLEX strategies during an ELAP event.

As stated above, fuel oil storage tanks have approximately 120,000 gallons total. The FIP Section 3.7.4 states that the licensee calculated that the Phase 2 FLEX equipment consumption is that the fuel oil storage tanks should last for greater than 10 days. Given the information above, the licensee should have sufficient fuel onsite for diesel-powered equipment, and that diesel-powered FLEX equipment should be refueled to ensure uninterrupted operation to support the licensee's FLEX strategies.

The licensee states that the fuel oil in the FLEX equipment will be tested and refreshed during period testing. Existing sampling requirements for the emergency fuel oil storage tanks are delineated in station procedures. Therefore, the diesel fuel oil onsite should be maintained such that the diesel-driven equipment will be available during an ELAP.

3.7.7 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow deploying the FLEX equipment following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.8 Considerations in Using Offsite Resources

3.8.1 Seabrook SAFER Plan

The industry has collectively established the needed off-site capabilities to support FLEX Phase 3 equipment needs via the SAFER team. SAFER consists of the Pooled Equipment Inventory Company and AREVA Inc. and provides FLEX Phase 3 management and deployment plans through contractual agreements with every commercial nuclear operating company in the United States.

There are two NSRCs, located near Memphis, Tennessee and Phoenix, Arizona, established to support nuclear power plants in the event of a BDBEE. Each NSRC holds five sets of equipment, four of which will be able to be fully deployed to the plant when requested. The fifth set allows removal of equipment from availability to conduct maintenance cycles. In addition, the plant's FLEX equipment hose and cable end fittings are standardized with the equipment supplied from the NSRC.

By letter dated September 26, 2014 (ADAMS Accession No. ML14265A107), the NRC staff issued its assessment of the NSRCs established in response to Order EA-12-049. In its assessment, the staff concluded that SAFER has procured equipment, implemented appropriate processes to maintain the equipment, and developed plans to deliver the equipment needed to support site responses to BDBEEs, consistent with NEI 12-06 guidance; therefore, the staff concluded in its assessment that licensees can reference the SAFER program and implement their SAFER response plans to meet the Phase 3 requirements of Order EA-12-049.

The NRC staff noted that the licensee's SAFER Response Plan contains (1) SAFER control center procedures, (2) NSRC procedures, (3) logistics and transportation procedures, (4) staging area procedures, which include travel routes between staging areas to the site, (5) guidance for site interface procedure development, and (6) a listing of site-specific equipment (generic and non-generic) to be deployed for FLEX Phase 3.

3.8.2 Staging Areas

In general, up to four staging areas for NSRC supplied Phase 3 equipment are identified in the SAFER Plans for each reactor site. These are a Primary (Area C) and an Alternate (Area D), if available, which are offsite areas (within about 25 miles of the plant) utilized for receipt of ground transported or airlifted equipment from the NSRCs. From Staging Areas C and/or D, the SAFER team will transport the Phase 3 equipment to the on-site Staging Area B for interim staging prior to it being transported to the final location in the plant (Staging Area A) for use in

Phase 3. For Seabrook, the primary staging area is the southeast corner of the general office building parking lot. The alternate staging area and primary helipad is the western side of the "B" employee parking lot.

Use of helicopters to transport equipment from Staging Area C to Staging Area B is recognized as a potential need within the Seabrook SAFER Plan and is provided from either the Portsmouth International Airport or the Manchester-Boston Regional Airport

3.8.3 Conclusions

Based on this evaluation, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should allow utilization of offsite resources following a BDBEE consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.9 Habitability and Operations

3.9.1 Equipment Operating Conditions

3.9.1.1 Loss of Ventilation and Cooling

Following a BDBEE and subsequent ELAP event at Seabrook, ventilation that provides cooling to occupied areas and areas containing required equipment will be lost. The primary concern with regard to ventilation is the heat buildup which occurs with the loss of forced ventilation in areas that continue to have heat loads. A loss of ventilation analysis was performed to quantify the maximum steady state temperatures expected in specific areas related to FLEX implementation to ensure the environmental conditions remain equipment limits. The key areas identified for all phases of execution of the FLEX strategy activities are the control room, EFW pump house, main steam and feedwater pipe chases, the essential switchgear rooms (including the battery rooms), and containment.

During the onsite audit, the NRC staff reviewed engineering evaluation EE-15-017, "Fukushima Project ELAP Ventilation Evaluation," Revision 1. Evaluation EE-15-017 includes a GOTHIC computer model developed to determine the temperature response during an ELAP event for the rooms listed above. According the evaluation, if the SEPS is unavailable, the licensee's ventilation strategy is to monitor temperature in key areas. The temperature monitoring requirements are identified in FSG-5, "Initial Assessment and FLEX Equipment Staging." If temperatures in these key areas approach the identified limits, FSG-5 requires entry into FSG-5.1, "FLEX Equipment Deployment," Revision 1, which provides the steps for deployment of portable fans or heaters. The mitigating actions also includes opening doors to promote natural circulation cooling from adjacent rooms or the outdoors.

In summary, procedure FSG-5 provides guidance for monitoring the temperatures in various rooms for both high and low temperature limits. FSG-5 and FSG-5.1 provide guidance for mitigating actions to establish ventilation for the control room, and the SFP area, battery rooms, essential switchgear room, east and west pipe chases, EFW pump house, CST enclosure rooms, and PAB. In addition, FSG-5 and FSG-5.1 provide guidance for aligning the 405 kW DG to power fans, and lights. Use of fans and lights will be as needed. FSG-5.1 provides mitigating guidance for establishing ventilation in battery rooms when the battery room fans are not operating.

Below are additional details on the licensee's ventilation strategy for the key areas identified for execution of the FLEX strategy.

Control Room

The licensee's strategy involves opening doors to promote natural circulation cooling, deploying portable ventilation equipment, and restoring the normal control room ventilation fans. The licensee will monitor temperature (FSG-5) to a limit of 110°F. The control room cabinets will be opened within 30 minutes following initiation of an ELAP event. The control room doors will be opened no later than 4 hours following initiation of an ELAP event. If opening the doors does not stop the temperature from increasing, deployment of portable ventilation is required no later than 8 hours into the ELAP scenario. The calculation shows that these actions are sufficient until at least the 72-hour mark after ELAP initiation. At this point, it is reasonable to expect that the licensee could restore control room ventilation after receiving the NSRC equipment, if necessary.

Based on the control room temperatures remaining below 120°F (the temperature limit, as identified in NUMARC-87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," Revision 1, for electronic equipment to be able to survive indefinitely), the NRC staff concludes that the electrical equipment in the control room should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Main Steam and Feedwater Pipe Chases

The NRC staff reviewed the licensee's engineering evaluation EE-15-018, "MSFW Pipe Chase ELAP Ventilation Evaluation," Revision 0 (EC-284892, Revision 0), to assess the impact of losing ventilation in the main steam and feedwater pipe chases. The evaluation showed that the temperature profile does not exceed equipment operability limits (225°F), specifically for the ASDVs and its supporting nitrogen supply system. As a contingency, the licensee plans to monitor temperature in the main steam and feedwater pipe chases in accordance with FSG-5 to ensure that it remains at or below 133°F. Therefore, the NRC staff concludes that the electrical components in the main steam and feedwater pipe chases should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

EFW Pump House

The maximum equipment operating temperature limit for the EFW pump house is 134°F for a short-term period of up to 24 hours. The licensee's analysis (EC-284811, Revision 1) indicates that a final steady-state temperature of 128°F would be reached 4 hours into the event. Large fail open ventilation dampers on the north and east walls of the EFW pump house will provide natural circulation air flow within the room following an ELAP event. This natural circulation was not credited in the licensee's original SBO calculation. Based on this, temperatures in the EFW pump house are not expected to exceed the equipment qualification temperatures. As a contingency, the licensee plans to monitor the EFW pump house temperature in accordance with FSG-5 to ensure that it remains at or below 125°F.

Based on temperatures remaining below the maximum operating limits of the required electrical equipment, the NRC staff concludes that the electrical components in the EFW pump house should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Essential Switchgear Rooms A and B

Based on the licensee's analysis (SBC-513, "Seabrook Station Control Building Thermal Analysis for Station Blackout, Using GOTHIC Computer Code," Revision 0), elevated temperatures between 120°F and 130°F may be experienced in the first two hours of an ELAP event; however, equipment in this area is non-operational at this time. Additionally, the potential elevated temperature is below the maximum temperature for mild environment equipment qualification; therefore, no adverse impact on electrical equipment is expected. The licensee's calculation indicates that the temperatures in the essential switchgear rooms A and B are about 110°F 4 hours after event initiation. The analysis shows that temperatures in the switchgear rooms continue to decrease at the four-hour mark due to lack of any appreciable heat load present in the rooms. Based on the licensee's extrapolation, the temperature in the essential switchgear rooms would drop below 102°F after approximately 8 hours before reaching steady state. As a contingency, the licensee plans to monitor the essential switchgear rooms temperatures in accordance with FSG-5 to ensure that the rooms remain below 120°F (after the initial (i.e., 2 hours into the ELAP event) temperature peak of approximately 130°F). FSG-5.1 includes provisions for deployment of portable ventilation for essential switchgear rooms A and B temperature control. Heat additions are expected to occur in this area during an ELAP event when equipment is restored; however, normal ventilation would be restored to these rooms before that point.

Based on temperatures exceeding 120°F for only a short period of time (but still within equipment limits) and remaining below 120°F thereafter, the NRC staff concludes that the electrical components in the essential switchgear rooms A and B should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Battery Rooms A and B

Licensee calculation SBC-513, Revision 0, shows that battery rooms A and B will not experience any appreciable heat-up or cool-down after a loss of ventilation. As a contingency, the licensee will monitor the battery room temperatures in accordance with FSG-5 to ensure that the battery rooms remain below 120°F (the temperature limit of the batteries, as specified by the manufacturer). While the battery vendor's analysis shows that the batteries are capable of performing their function up to 120°F, periodic monitoring of electrolyte level may be necessary to protect the battery since the battery may gas more at higher temperatures. FSG-5.1 includes provisions for deployment of portable ventilation for battery room A and B temperature control with a temperature limit of 120°F.

Based on the above, the NRC staff concludes that the licensee's ventilation strategy should maintain the battery room temperature at or below the temperature limit (120°F) of the batteries, as specified by the battery manufacturer (Exide Technologies). In addition, the NRC staff concludes that the batteries should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

Containment

FSG-13, "Alternate RHR Cooling," Revision 00, provides actions to restore containment cooling measures to maintain containment temperature and pressure below applicable limits and to maintain containment pressure low enough to support core cooling during shutdown modes. According to the licensee's analysis (ND C-X-1-28141-CALC, Revision 1), the calculated temperature results at 72 hours and 120 hours are approximately 183°F and 200°F, respectively. The licensee plans to establish containment cooling within 72 hours. See Section 3.4.4.4 of this SE for further details.

Miscellaneous

The safety injection accumulator outlet valves at Seabrook are qualified for the harsh containment environment following a design basis accident. According to the licensee, the design-basis accident profile bounds the non-LOCA ELAP analysis. Based on this, the NRC staff concludes that the safety injection accumulator outlet valves should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

The charging pump motors at Seabrook are qualified for the harsh environment following a design-basis accident. The licensee's calculation (EC284811, Revision 1) showed that the normal to adverse temperature of 200°F is never exceeded in the 120 hours calculated transient time and that no equipment qualification limits would be challenged. Beyond this time, additional offsite resources and personnel would be available to ensure that temperature in the area of the charging pump remains below limits. Based on this, the NRC staff concludes that the charging pump motors should not be adversely impacted by the loss of ventilation as a result of an ELAP event.

3.9.1.2 Loss of Heating

The licensee evaluated the effects of a loss of heating on necessary equipment in evaluation EE-15-017. FSG-5 and FSG-5.1 provide guidance for aligning the 405 kW DG to power fans, lights, and heaters. Use of fans, lights, and heaters will be used as needed. Areas addressed for the loss of heating include the control room, SFP area, battery rooms, essential switchgear rooms, east and west pipe chases, EFW pump house, CST enclosure rooms, and PAB.

Regarding the battery rooms, when sizing the batteries, the licensee applied temperature correction factors to the calculated minimum required cell size to allow for operation at the minimum design temperature (65°F for batteries B-1A and B-1C, and 60°F for batteries B-1B and B-1D). The licensee's calculation SBC-513, Revision 0, shows the temperature profiles for the battery rooms for a worst-case cool-down during an SBO event assuming an outdoor temperature of 0°F. The calculation shows that after an initial 2°F cool-down, the battery room A and B temperature remains constant at roughly 68°F. This is primarily due to the concrete walls that makeup the outside shell of the control building. Furthermore, the calculation also shows that the switchgear room temperature for the cool-down case does not drop below 66°F when there is natural circulation flow between the battery rooms and the essential switchgear rooms. Therefore, any flow of air from the switchgear room to a battery room would not reduce battery room temperature below 66°F. However, as a contingency, the licensee will monitor battery room temperature in accordance with FSG-5 to ensure that the battery rooms remain above the lower temperature limit of 65°F. FSG-5.1 includes provisions for deployment of portable heaters for battery room A and B temperature control.

Based on its review of the licensee's loss of heating evaluation, the NRC staff concludes that the Seabrook equipment needed to mitigate an ELAP, including the safety-related batteries, should perform their required functions as a result of loss of heating during an ELAP event.

3.9.1.3 Hydrogen Gas Control in Vital Battery Rooms

An additional ventilation concern that is applicable to Phases 2 and 3, is the potential buildup of hydrogen in the battery rooms as a result of loss of ventilation during an ELAP event.

Hydrogen is only produced during battery charging operations. The battery room exhaust system is composed of two battery room exhaust fans, each having pneumatically operated isolation in its suction line. These fans are mounted in the Train A and B t mechanical rooms, each providing the exhaust function for their train's two battery rooms. The two suction lines are cross-connected before the isolation dampers to enable one fan to exhaust all four battery rooms, if necessary. The fans exhaust to the outside atmosphere via a common exhaust line. In addition to removing heat, the fans also assist in preventing hydrogen gas from building up.

In both cases where SEPS is either available or not available, the battery chargers and battery room exhaust fans are eventually repowered to preclude any significant buildup of hydrogen (FSG 5.1 initially directs operators to open the battery doors and install portable fans, then repower the battery exhaust fans). The repowering of the battery room ventilation is performed in the same procedure step as repowering of the battery chargers to ensure that the battery room ventilation is restored at nearly the same time as the battery chargers.

Based on its review of the licensee's battery room ventilation strategy, the NRC staff concludes that hydrogen accumulation in the Seabrook safety-related battery rooms should not reach the combustibility limit for hydrogen (4 percent) during an ELAP event.

3.9.2 Personnel Habitability

3.9.2.1 Main Control Room

During the audit, the NRC staff reviewed engineering evaluation EE-15-017, "Fukushima Project ELAP Ventilation Evaluation," Revision 1, which was developed to determine the control room temperature in response to an ELAP event. The calculation assumed a steady outdoor temperature of 104°F. With no action to mitigate the temperature rise, the control room temperature is estimated to reach 119°F at 72 hours. The licensee indicated that to remain within NUMARC 87-00 habitability recommendations (NUMARC 87-00, Revision 1, Section 2.7.2(3) allows for a dry bulb temperature of 110°F for a 4 hour period) selected doors are to be opened by 4 hours into the event. Procedures FSG-5 and FSG-5.1 provide time sensitive actions to open selected doors within the required time limits. In addition, the procedures direct operators to deploy portable ventilation if the control room temperature exceeds 100°F. FSG-5.1 provides guidance for powering control room ventilation fans from the 405 kW portable DG. However, the portable 405 kW DG does not have the load capacity to power the control room chiller. Therefore, the licensee expects to restore control room chillers during Phase 3 using the NSRC equipment.

3.9.2.2 Fuel Storage Building

The licensee did not reference any evaluation for area heat up for the FSB area. The Phase 2 plan of using the SEPS to repower the SFP cooling system maintains the FSB area temperature. In the event the SEPS is not available, the FIP indicates that the ventilation requirements can be satisfied by opening selected doors and opening ventilation system access doors to establish natural circulation through the FSB. Attachment J to FSG-5 addresses mitigating actions to establish ventilation flow path.

3.9.2.3 Other Plant Areas

EFW Pump House

As part of the audit process, staff reviewed engineering evaluation EE-15-017, Revision 1 which included the effect of a loss of ventilation on the EFW pump house. The evaluation concluded the pump house would reach a steady state temperature of 128°F. The evaluation indicated that large fail-open dampers on multiple walls will provide natural circulation air flow. This natural circulation was not credited in the calculation, which the licensee considers conservative. The evaluation indicated the maximum equipment operating temperature limit for the pump house is 134°F for up to 24 hours. Temperature monitoring is included in FSG-5. FSG-5.1 provides contingency ventilation guidance along with guidance for deployment of heaters as required.

Main Steam and Feedwater Pipe Chase

The licensee performed engineering evaluation EE-15-018 to review the main steam and feedwater pipe chase temperature profile. The licensee noted that entry into the main steam and feedwater pipe chases is only required if the TDEFW pump fails and the FLEX primary low pressure SG feed connection is not available. FSG-3.1, "Alternate Low Pressure Feedwater Equipment Deployment," provides guidance and precautions to obtain proper personnel protection equipment such as protective suits if access to the pipe chase is required. As noted above, entry into the pipe chase area is not needed unless primary mitigating actions cannot be accomplished.

3.9.3 Conclusions

The NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore equipment and personnel habitability conditions following a BDBEE consistent with NEI 12-06 guidance as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.10 Water Sources

3.10.1 Steam Generator Make-Up

In its FIP, the licensee described that the credited water sources for SG make-up are the CST and the Unit 2 circulating water piping cistern. The lower portion of the CST provides the initial 15 hours of inventory to the TDEFW pump at the initial onset of the event because only the lower portion is fully protected from seismic and missile events. The Unit 2 circulating water piping cistern is a portion of the unused, buried Unit 2 circulating water system. The licensee has modified it to hold approximately 824,000 gallons of water and to protect it from all applicable hazards as defined in NEI 12-06. Table 3 in the FIP provides a list of additional, potential water sources that may be used, their capacities, and an assessment of availability following the applicable hazards.

As discussed in Section 3.2.3.1.1, the service water forebay can be used following an ELAP because it is protected from all applicable hazards as defined in NEI 12-06.

3.10.2 Reactor Coolant System Make-Up

In its FIP, the licensee described that two credited sources for borated water are available onsite, which are the BATs and the RWST. The BATs are maintained with greater than 14,600 gallons of water with a boron concentration of 7,000 ppm. The BATs are fully protected and qualified for all applicable external events as defined in NEI 12-06. The RWST is a seismic Category I structure with a minimum borated concentration of 2,400 ppm boron and a minimum volume of 415,000 gallons of usable water. However, the RWST is not missile protected; therefore, it is not credited for all external hazards as defined in NEI 12-06.

3.10.3 Spent Fuel Pool Make-Up

In its FIP, the licensee stated that the Unit 2 circulating water piping cistern or the RWST provide makeup to the SFP. Both water sources are discussed above.

3.10.4 Containment Cooling

In its FIP, the licensee stated that no additional specific Phase 3 strategy is required for maintaining containment integrity. With the initiation of service water provided from the NSRC LPHF pump as described earlier, no direct water sources are required for containment cooling.

3.10.5 Conclusions

Based on the evaluation above, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain satisfactory water sources following a BDBEE consistent with NEI 12-06 guidance as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.11 Shutdown and Refueling Analyses

Order EA-12-049 requires that licensees must be capable of implementing the mitigation strategies in all modes. In general, the discussion above focuses on an ELAP occurring during power operations. This is appropriate, as plants typically operate at power for 90 percent or more of the year. When the ELAP occurs with the plant at power, the mitigation strategy initially focuses on the use of the steam-driven TDEFW pump to provide the water initially needed for decay heat removal. If the plant has been shut down and all or most of the fuel has been removed from the RPV and placed in the SFP, there may be a shorter timeline to implement the makeup of water to the SFP. However, this is balanced by the fact that if immediate cooling is not required for the fuel in the reactor vessel, the operators can concentrate on providing makeup to the SFP. The licensee's analysis shows that following a full core offload to the SFP, about 30 hours are available to implement makeup before boil-off results in the water level in the SFP dropping far enough to uncover fuel assemblies, and the licensee has stated that they have the ability to implement makeup to the SFP within that time.

When a plant is in a shutdown mode in which steam is not available to operate the steam-powered pump and allow operators to release steam from the SGs (which typically occurs when the RCS has been cooled below about 300°F), another strategy must be used for decay heat removal. On September 18, 2013 (ADAMS Accession No. ML13273A514), NEI submitted to the NRC a position paper entitled "Shutdown/Refueling Modes," which described methods to ensure plant safety in those shutdown modes. By letter dated September 30, 2013 (ADAMS Accession No. ML13267A382), the NRC staff endorsed this position paper as a means of meeting the requirements of the order.

The position paper provides guidance to licensees for reducing shutdown risk by incorporating FLEX equipment in the shutdown risk process and procedures. Considerations in the shutdown risk assessment process include maintaining necessary FLEX equipment readily available and potentially pre-deploying or pre-staging equipment to support maintaining or restoring key safety functions in the event of a loss of shutdown cooling. The NRC staff concludes that the position paper provides an acceptable approach for demonstrating that the licensees are capable of implementing mitigating strategies in shutdown and refueling modes of operation. The licensee stated in the FIP that Seabrook will abide by the guidance in the September 18, 2013, position paper. During the audit process, the NRC staff observed that the licensee had made progress in implementing this position paper.

Based on the licensee's incorporation of the use of FLEX equipment in the shutdown risk process and procedures, the NRC staff concludes that the licensee has developed guidance that, if implemented appropriately, should maintain or restore core cooling, SFP cooling, and containment following a BDBEE in shutdown and refueling modes consistent with NEI 12-06 guidance, as endorsed by JLD-ISG-2012-01, and appears to adequately address the requirements of the order.

3.12 Procedures and Training

3.12.1 Procedures

Regarding procedures, the licensee stated in its FIP that the inability to predict actual plant conditions that require the use of BDB equipment makes it impossible to provide specific procedural guidance. As such, the FSGs will provide guidance that can be employed for a variety of conditions. Clear criteria for entry into FSGs will ensure that FLEX strategies are used only as directed for BDBEE conditions, and are not used inappropriately in lieu of existing procedures. ECA-0.0, "Loss of All AC Power," is the implementing procedure for mitigating strategies for an ELAP coincident with the loss of normal access to the UHS.

FLEX strategy support guidelines have been developed in accordance with PWROG guidelines. FSGs will provide available, preplanned FLEX strategies for accomplishing specific tasks in the EOPs or ONOPs. The FSGs will be used to supplement (not replace) the existing procedure structure that establishes command and control for the event. The licensee also stated in its FIP that FSG maintenance will be performed by the operations department group via PR8.1, "FLEX Support Guideline (FSG) Maintenance." In addition, the licensee stated that validation has been accomplished via walk-throughs or drills of the guidelines to ensure the strategy is feasible.

3.12.2 Training

In its FIP, the licensee stated that initial training has been provided and periodic training will be provided to site emergency response leaders on beyond-design-basis emergency response strategies and implementing guidelines. In addition, personnel assigned to the direct execution of mitigation strategies for BDBEEs have received the necessary training to ensure familiarity with the associated tasks, instructions, and mitigating strategy time constraints. The training plan development was done in accordance with the Systematic Approach to Training (SAT).

Based on the description provided above, the NRC staff concludes that, as described, the licensee's established procedural guidance appears to meets the provisions of NEI 12-06, Section 11.4 (Procedure Guidance). Similarly, the NRC staff concludes that the training plan, including use of the SAT for the groups most directly impacted by the FLEX program, appears to meet the provisions of NEI 12-06, Section 11.6 (Training).

3.13 Maintenance and Testing of FLEX Equipment

As a generic issue, NEI submitted a letter dated October 3, 2013 (ADAMS Accession No. ML13276A573), which included EPRI Technical Report 3002000623, "Nuclear Maintenance Applications Center: Preventive Maintenance Basis for FLEX Equipment." By letter dated October 7, 2013 (ADAMS Accession No. ML13276A224), the NRC endorsed the use of the EPRI report and the EPRI database as providing a useful input for licensees to use in developing their maintenance and testing programs. Preventative maintenance templates for the major FLEX equipment have also been issued.

In its FIP, the licensee stated that Seabrook followed the EPRI generic industry guidance program for maintenance and testing of FLEX equipment, as endorsed by the NRC staff on October 7, 2013. The licensee described that FLEX mitigation equipment has been initially tested to verify performance conforms to the limiting FLEX requirements. In its FIP, the licensee stated that preventive maintenance procedures and intervals have been established to ensure FLEX equipment reliability is being achieved. Similarly, in its FIP, the licensee stated that surveillance procedures and intervals have been created to perform testing to verify design requirements of the FLEX equipment.

Based on the use of the endorsed program, which establishes and maintains a maintenance and testing program in accordance with NEI 12-06, Section 11.5, the NRC staff concludes that the licensee appears to have adequately addressed equipment maintenance and testing activities associated with FLEX equipment.

3.14 Alternatives to NEI 12-06, Revision 2

In its FIP, the licensee stated that Seabrook has not adopted the N+1 provision for spare equipment due to the planned utilization of SEPS as a primary strategy in all but wind-driven missile scenarios. The NRC staff considers the licensee's use of the SEPS as an alternative to the guidance in NEI 12-06, which was communicated to the licensee during the audit process.

In its FIP, the licensee stated that to compensate for this, the unavailability period for FLEX equipment (when the SEPS is not available) will be 45 days as opposed to the 90 days recommended in NEI 12-06. Connections to plant equipment required for FLEX strategies can be unavailable for 90 days provided alternate capabilities remain functional.

To further assure its availability and reliability, the licensee analyzed the robustness of the SEPS (including the enclosure) for all applicable external hazards, which was discussed above in Section 3.6 of this SE. In summary, the SEPS equipment and enclosures (including SEPS-SWG01 and exhaust piping) have been seismically hardened to ensure they will remain available during a seismic event. In addition, the licensee stated that the SEPS gensets are protected from the elements by weather-proof enclosures. Lastly, the engine cooling systems of the SEPS gensets contain the required amount of glycol anti-freeze to protect the engines to at least minus 22°F. Based on its review of the licensee's assessment ("SEPS missile enclosure design details – Open Item 3.2.4.8.A," Revision 2B) of the SEPS enclosures, the NRC staff concludes that the SEPS should remain available for all applicable external hazards with the exception to wind-driven missile events. In addition to the SEPS, the licensee has an alternate strategy to deploy portable FLEX equipment, including a portable 480 Vac 405 kW FLEX DG, that will be stored in a seismic Category I, missile protected structure located above the maximum design-basis flood elevation. Therefore, the NRC staff concludes that the portable FLEX equipment will remain available following a BDBEE for all applicable external hazards as defined in NEI 12-06. The NRC staff concludes that the licensee's Phase 2 strategies appear to meet the intent of NEI 12-06 by having two diverse sets of strategies that can be used to fulfill the required functions (N and N+1). Based on the above, the NRC staff concludes that the licensee's alternate approach is acceptable.

In conclusion, the NRC staff concludes that although the guidance of NEI 12-06 has not been met, if these alternatives are implemented as described by the licensee, they appear to meet the requirements of the order.

3.15 Conclusions for Order EA-12-049

Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance to maintain or restore core cooling, SFP cooling, and containment following a BDBEE which, if implemented appropriately, should adequately address the requirements of Order EA-12-049.

4.0 TECHNICAL EVALUATION OF ORDER EA-12-051

By letter dated February 26, 2013 (ADAMS Accession No. ML13063A439), the licensee submitted its OIP for Seabrook in response to Order EA-12-051. By email dated July 18, 2013 (ADAMS Accession No. ML13193A074), the NRC staff sent a request for additional information (RAI) to the licensee. By letter dated August 28, 2013 (ADAMS Accession No. ML13247A177), the licensee provided a response. By letter dated December 4, 2013 (ADAMS Accession No. ML13267A388), the NRC staff issued an ISE and RAI to the licensee.

By letters dated August 28, 2013 (ADAMS Accession No. ML13247A177), February 27, 2014 (ADAMS Accession No. ML14064A189), August 26, 2014 (ADAMS Accession No. ML14246A192), February 27, 2015 (ADAMS Accession No. ML15068A007), and August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee submitted status reports for the

Integrated Plan. The Integrated Plan describes the strategies and guidance to be implemented by the licensee for the installation of reliable SFPLI which will function following a BDBEE, including modifications necessary to support this implementation, pursuant to Order EA-12-051. By letter dated December 15, 2015 (ADAMS Accession No. ML15356A102), the licensee reported that full compliance with the requirements of Order EA-12-051 was achieved.

The licensee installed a SFPLI system designed by Westinghouse. The NRC staff reviewed the vendor's SFPLI system design specifications, calculations and analyses, test plans, and test reports. The staff issued an audit report on August 18, 2014 (ADAMS Accession No. ML14211A346).

The NRC staff performed an onsite audit to review the implementation of SFPLI related to Order EA-12-051. The scope of the audit included verification of (a) site's seismic and environmental conditions enveloped by the equipment qualifications, (b) equipment installation met the requirements and vendor's recommendations, and (c) program features met the requirements. By letter dated October 28, 2015 (ADAMS Accession No. ML15278A200), the NRC issued an audit report on the licensee's progress. Refer to Section 2.2 above for the regulatory background for this section.

4.1 Levels of Required Monitoring

In its OIP, the licensee identified the SFP levels of monitoring as follows:

- Level 1 is at plant elevation of 22 ft. 6 inches (in.). This level is based on a preliminary calculation that assumes mitigating effects by the installed suction strainer on vortexing.
- Level 2 is at plant elevation of 10 ft. 9.5 in. This elevation is approximately 13 ft. above the top of the spent fuel positioned in the pool (Nominal Elevation -1 ft. 5-3/4 in.). With 13 ft. of water above the highest fuel element position, the calculated dose rate at the surface of the SFP is less than 2.5 mrem/hr.
- Level 3 is at plant elevation of -1 ft. 0 in. This is the nominal water level approximately 6 in. above the top of the fuel racks.

In its letter dated August 28, 2013 (ADAMS Accession No. ML13247A177), the licensee revised Level 1 from 22 ft. 6 in. to 23 ft. 4 in. and Level 3 from -1 ft. 0 in. to -0 ft. 6 in. For the Level 1 change, the licensee stated that the following was taken into consideration to determine the higher of the two levels:

1) The SFP water level at which reliable suction loss occurs due to uncovering the coolant inlet pipe or any weirs or vacuum breakers associated with suction loss. This level was established based on nominal suction strainer inlet elevation and conservative estimate for the onset of vortexing. The actual effect of the strainer on this level has been formally determined by calculation C-S-1-24606, "Spent Fuel Pool Level

for Reliable Pump Suction." The elevation for reliable pump suction is plant elevation 23 ft. 4 in.

2) The SFP water level at which the normal SFP cooling pumps lose required NPSH [net positive suction head] assuming saturated conditions in the pool. Calculation C-S-1-24606 demonstrates that the point of zero NPSH margin is 22 ft. 4 in. of plant elevation. With the SFP at 212°F, saturated conditions, the NPSHA [NPSH available] is approximately 11.2 ft. The NPSHR [NPSH required] for the pump is 10 ft. at 212°F. This results in a ratio of NPSHA/NPSHR value of approximately 1.12. Therefore, the NPSHA is greater than the NPSHR at saturated conditions.

The higher of the above points is the level where the inlet strainer will lose suction. Therefore, Level 1 has been revised to elevation 23 ft. 4 in. for both the primary and backup instrumentation. For the Level 3 change, the licensee stated that Level 3 has been revised to provide margin for instrument sensitivity band and uncertainty. Level 3 is an indicated level on either the primary or backup instrument channel of greater than plant elevation, in which - 0 ft. 6 in. will ensure that the fuel remains covered.

In its letter dated August 28, 2013 (ADAMS Accession No. ML13247A177), the licensee also provided a sketch depicting the elevations identified as Levels 1, 2 and 3 and the SFP level instrument sensitivity band. The NRC staff noted that Level 1 is identified at the elevation of 23 ft. 4 in, Level 2 is at an elevation of 10 ft. 9 ½ in., and Level 3 is at an elevation of - 0 ft. 6 in.

During the onsite audit, the NRC staff reviewed engineered change (EC) 281849, "Spent Fuel Pool Instrumentation Upgrade for NRC Order EA-12-051," Revision 2. The staff noted that the elevation of the top of fuel rack is -1 ft. 5 ¾ in. The licensee set the Level 3 at elevation of – 0 ft. 6 in. This will allow at least 12 in. of water level above of the top of the fuel rack.

The NRC staff concluded that the licensee's selection of the SFP measurement levels adequate based on the following:

- Level 1 is the level where the inlet strainer will lose suction. Thus, the designated Level 1 setpoint would allow the licensee to identify a level in the SFP adequate to support operation of the normal SFP cooling system and represent the higher of the options described in NEI 12-02.

- Level 2 meets the first option described in NEI 12-02 for Level 2, which is 10 ft. (+/- 1 foot) above the highest point of any fuel rack seated in the SFPs. The designed Level 2 represents the range of water level where any necessary operations in the vicinity of the SFP can be completed without significant dose consequences from direct gamma radiation from the SFP consistent with NEI 12-02.

- Level 3 is approximately 1 ft. above the highest point of any fuel storage rack seated in the SFP. This level allows the licensee to initiate water make-up with no delay meeting the NEI 12-02 specifications of the highest point of the fuel

> racks seated in the SFP. Meeting the NEI 12-02 specifications of the highest point of the fuel racks conservatively meets the Order EA-12-051 requirement of a level where the fuel remains covered.

Based on the evaluation above, the NRC staff concludes that the licensee's proposed Levels 1, 2, and 3 appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appear to adequately address the requirements of the order.

4.2 Evaluation of Design Features

Order EA-12-051 required that the SFPLI shall include specific design features, including specifications on the instruments, arrangement, mounting, qualification, independence, power supplies, accuracy, testing, and display. Refer to Section 2.2 above for the requirements of the order in regards to the design features. Below is the staff's assessment of the design features of the SFPLI.

4.2.1 Design Features: Instruments

In its OIP, the licensee stated that the instrumentation will consist of permanent, fixed primary and backup SFP level monitoring instrument channels and that the minimum measured span of each channel will be continuous from a high pool level elevation of 24 ft. to approximately 6in. above the top of the spent fuel racks (total span 25 ft.).

In its letter dated August 28, 2013 (ADAMS Accession No. ML13247A177), the licensee further stated, in part, that:

> The SFP level instrument upper range will be at least 12 in. above Level 1 to account for upper instrument sensitivity band and instrument loop uncertainly. From a practical perspective, the upper range capability will extent even higher (e.g. above normal operating level).
>
> Level 3 has also been revised to provide margin for instrument sensitivity band and uncertainty. For the purposes of this submittal and indicated level on either the primary or backup instrument channel of greater than plant elevation (-) 0 ft. 6 in. will be used to ensure that the fuel remains covered. The actual effect of the instrument sensitivity band and accuracy on this level will be determined during the engineering and design phase of the project.

The NRC staff noted that the specified measurement range will cover Level 1, 2, and 3, as described in Section 4.1 above. The staff concludes that the licensee's design, which in respect to the number of channels and measurement range for its SFPLI, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.2 Design Features: Arrangement

In its OIP, the licensee stated, in part, that:

> Redundant Train A and Train B cables will be routed from the FSB through the containment enclosure building (CEB) and into the PAB to connect each probe to a signal conditioning processor module. The signal conditioning processor module for each channel will be mounted in a separate stainless steel enclosure located in the PAB so that the instruments will not be subject to the radiation, high temperature and high humidity conditions that could result from postulated loss of water inventory in the SFP. The primary operator indication and backup battery systems will be provided in the Train A and Train B essential switchgear rooms (Elev. 21 ft., 6 in.) located in the control building (CB). Channel separation (independence) will be provided as part of the design of the SFP level instrumentation. The guided wave radar sensors (GWS) will be physically located in different areas of the SFP. The GWS probes will be installed on the north and south sides of the pool. Sensor conditioning electronics, battery backup power supplies and level indicators will also be located in separate areas of the plant. Interconnecting cabling for channel power and indication will be routed in separate conduits and raceways from the cabling for the opposite channel.

In its letter dated August 28, 2013 (ADAMS Accession No. ML13247A177), the licensee provided sketches depicting a plan view of the proposed arrangement for the portions of the instrument channel including the inside dimensions of the SFP, planned placement of the primary and backup level sensors in the SFP, the proposed routing of cables that will connect the sensors to the level transmitters, and the planned location of the uninterrupted power suuply (UPS)/remote display in the Train A and Train B essential switchgear rooms. In its August 28, 2013, letter, the licensee further stated that the location of the signal conditioning processor module (level Transmitter) for each channel has been revised from the PAB to the CEB.

The NRC staff reviewed these sketches and noted that the Train A and B conduits appeared to run side by side in parts of the FSB, then through the CEB and finally into the PAB. The NRC staff questioned the routing of these two channels in accordance with the guidance on channel separation as described in NEI 12-02.

In response to the staff's questions, in its letter dated August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that the permanently installed primary and backup instrument channels are redundant and will be installed independent of each other with respect to physical separation and electrical power sources. The physical and electrical separation will minimize the potential for a common cause event to adversely affect both channels. The level transmitters will be mounted in separate locations within the CEB. The cables will be routed in dedicated rigid steel conduits maintaining maximum physical separation between the primary and backup channel routings. The spatial separation of the transmitters and associated conduits will minimize the potential for a common cause event in the SEP area to adversely affecting both channels.

During the walkdown of the SFP area, the NRC staff noted that the coax cable from one of the SFPLI probe was on the floor of the SFP building, which could create a tripping hazard with the potential of causing system damage/inoperability. The NRC staff expressed its concern to the licensee. In response to the staff's concern, the licensee initiated condition report (AR 02063248) to evaluate and incorporate shielding into the design to protect the flexible conduit at the west end of the SFP. The staff concluded that the AR addressed the staff's concern. The staff concluded that there appears to be sufficient channel separation within the SFP area between sensor electronics, and routing cables to provide protection against loss of indication of SFP level due to missiles that may result from damage to the structure over the SFP.

The NRC staff concludes that, if implemented appropriately, the licensee's proposed arrangement for the SFPLI appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.3 Design Features: Mounting

In its letter dated August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that:

> All SFPLI equipment will be designed in accordance with the Seabrook SSE design requirements. Simple static analyses will be used to evaluate the anchorage design for the SFP level sensor, electronic enclosures, conduits and associated supports. This conservative analysis methodology will use peak acceleration in each of three orthogonal directions obtained from the building response spectra at the mounting location. Those accelerations are increased by 50% to account for multi-modal response (multiplied by 1.5). Attachment loads are calculated in each of the three directions, loads are combined by Square Root Sum of the Squares (SRSS), and then combined with dead weight loads and compared with allowable loads.
>
> Westinghouse evaluated the structural integrity of the SFP sensor mounting brackets in calculation CN-PEUS-14-16. The GTSTRUDL model, used by Westinghouse to calculate the stresses in the bracket assembly, considers load combinations for the dead load, live load including hydrodynamic load and seismic load on the bracket. The reactionary forces calculated from these loads become the design inputs for the mounting bracket and it's anchorage to the refuel floor to withstand a SSE. The seismic load input for this analysis was obtained from the Amplified Response Spectra (ARS) for the spent fuel building, and the following methodology was used by Westinghouse to determine the stresses on the sensor bracket assembly:
>
> - Frequency analysis, taking into account the dead weight and the hydrodynamic mass of the structure, was performed to obtain the natural frequencies of the structure in all three directions.
> - SSE response spectra analysis was performed to obtain member stresses and support reactions.
> - The seismic loads for each of the three directions were combined by the SRSS method.
> - Sloshing analysis was performed to obtain liquid pressure and its impact on bracket design and anchorage.
> - The seismic results are combined with the dead load results and the hydrodynamic pressure results in absolute sum. These combined results are compared with the allowable stress values.

Sloshing

Sloshing forces were obtained by analysis. The TID-7024, Nuclear Reactors and Earthquakes, 1963, by the US Atomic Energy Commission, approach has been used to estimate the wave height and natural frequency. Horizontal and vertical impact forces on the bracket components were calculated using the wave height and natural frequency obtained using the TID-7024 approach. Using this methodology, sloshing forces were calculated and added to the total reactionary forces that would be applicable for the bracket anchorage design. The analysis also determined that the level probe can withstand a design basis seismic event.

During the design basis event, the SFP water level is expected to rise and parts of the level sensor probe are assumed to become submerged in borated water. The load impact due to the rising water and submergence of the bracket components has also been considered for the overall sloshing impact. Reliable operation of the level measurement sensor with temporary submerged interconnecting cable has also been demonstrated by Westinghouse. Boron build up on the probe has been analyzed to determine the potential effects on the sensor.

The following Westinghouse documents provide information with respect to the design criteria used, and a description of the methodology used to estimate the total loading on the device.

a) CN-PEUS-14-16 - Pool-side Bracket Seismic Analysis

b) WNA-TR-O3149-GEN - Sloshing Analysis

c) EQ-QR-269, WNA-TR-O3149-GEN, EQ-TP-353 - Seismic Qualification of other components of SFPIS

d) Westinghouse Letter LTR-SEE-II-13-47 - Determination of the Proposed Spent Fuel Pool level instrumentation can be sloshed out of the spent fuel pool during a seismic Event.

The design criteria used in this calculation met the requirements to withstand SSE and will meet the Seabrook seismic Category I installation requirements. The methods used in the calculation followed the Institute of Electrical and Electronics Engineers [IEEE] 344-2004 and IEEE 323-2003 requirements for seismic qualification of the SFP instrument and raceway installations.

The Westinghouse designed SFP level sensor consists of a stainless steel cable probe suspended from a launch plate via a coupler/connector assembly. The launch plate is a subcomponent of the bracket assembly, will be mounted to the refuel floor via four concrete expansion anchors.

The bracket assembly that supports the sensor probe and launch plate will be mechanically connected to the SFP structure. The mechanical connection consists of four concrete expansion anchors that will bolt the bracket assembly to the SFP structure via the base plate. The loads for the bracket concrete anchors were established by Seabrook based on translation of loads established by Westinghouse for the pool-side bracket in seismic analysis CN-PEUS-14-16. The concrete expansion anchors will be designed by Seabrook to meet the calculated Westinghouse loads (tension and shear loads) for the Seabrook modified bracket design with appropriated safety margin. Seabrook design change EC 281849 modified the Westinghouse sensor probe 2 in. shaped, stainless steel, probe bracket to allow for installation along the west side of the SEP. Each of the modified probe mounting plate will bolted to the west pool side concrete using four 5/8" diameter Hilti III stainless steel anchors each having a 4 in. minimum concrete embedment. Eccentric loads on the cantilever plate bolt group are checked based on forces and moments at the center of the Hilti Plate/cantilever plate taken from the Westinghouse analysis.

During the onsite audit, the NRC staff reviewed the mounting specifications and seismic analyses for the SFP instrument, including the methodology and design criteria used to estimate the total loading on the mounting devices. The staff also reviewed the design inputs and the methodology used to qualify the structural integrity of the affected structures for each of the SFP level instrument mounting attachments. Based on its review, the staff concluded that the criteria established by the licensee appears to adequately account for the appropriate structural loading conditions, including seismic and hydrodynamic loads.

Based on the evaluation above, the NRC staff concludes that the licensee's proposed mounting design appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.4 Design Features: Qualification

4.2.4.1 Augmented Quality Process

Appendix A-1 of the guidance in NEI 12-02 describes a quality assurance process for non-safety systems and equipment that are not already covered by existing quality assurance requirements. In JLD-ISG-2013, the NRC staff concluded that the use of this quality assurance process to be an acceptable means of meeting the augmented quality requirements of Order EA-12-051.

In its OIP, the licensee stated that augmented quality requirements, similar to those applied to fire protection equipment in the NextEra Energy Seabrook Quality Assurance Topical Report would be applied to this project.

The NRC staff concludes that, if implemented appropriately, this approach appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.4.2 Instrument Channel Reliability

Section 3.4 of NEI 12-02 states, in part:

> The instrument channel reliability shall be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of channel components for the following sets of parameters, as described in the paragraphs below:
>
> - conditions in the area of instrument channel component use for all instrument components,
> - effects of shock and vibration on instrument channel components used during any applicable event for installed components, and
> - seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

Equipment reliability performance testing was performed to (1) demonstrate that the SFP instrumentation will not experience failures during beyond-design-basis conditions of temperature, humidity, emissions, surge, and radiation, and (2) to verify those test envelope the plant-specific requirements.

The NRC staff reviewed the Westinghouse SFPLI's qualification and testing during the vendor audit for temperature, humidity, radiation, shock and vibration, and seismic. The staff further reviewed the anticipated Seabrook's environmental conditions during the onsite audit.

For SFP level instrument qualifications with respect to temperature, humidity and radiation, in its OIP, the licensee stated that:

> Temperature, humidity and radiation levels consistent with conditions in the vicinity of the SFP and the area of use considering normal operational, event and post-event conditions for no fewer than seven days post-event or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049 will be addressed in the engineering and design phase. Examples of post-event (beyond-design-basis) conditions to be considered are:
>
> - radiological conditions for a normal refueling quantity of freshly discharged (100 hours) fuel with the SFP water level 3 as described in this order,
> - temperature of 212°F and 100% relative humidity environment,
> - boiling water and/or steam environment, and
> - a concentrated borated water environment.

In its letter dated August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee further stated that:

> The plant service environment chart 1-NHY-300219, "Service Environment Chart," Revision 28, summaries the environmental conditions for the ESRs where the SFPI [spent fuel pool instrumentation] displays will be located and

containment enclosure fan area (CEVA) where the level transmitters will be mounted. The referenced calculation support the noted environmental conditions for radiation, pressure, and humidity. The specified normal conditions are not expected to change in these areas as a result of an ELAP event.

Seabrook calculation MSVCS-FAG-08 calculates the temperature response of the environmental zones outside of containment following a loss of all non-Class 1E HVAC system. This calculation concluded that the steady-state temperature in the CEVA would not exceed 98°F when one train of the Class 1E ventilation is running (1-EAH-FN-31-A/B, 1-EAH-FN-5-A/B and 1-EAH-FN-108-A/B). Therefore, one train of Class 1E, safety related ventilation is assumed to be available as part of the FLEX strategies to ensure area temperature is not exceed long term operation of the SFP instrument following a BDBE.

The essential switchgear rooms A and B supply and exhaust fans (1-CBA-FN-19, -20, -32, and -33) are capable of maintaining temperature in the A and B switchgear room below 104°F.

During the interim to re-establishing power to the area ventilation systems noted above, compensatory operator actions may be required to induce natural circulation cooling in the SFP, CEVA and/or essential switchgear rooms. These actions will include the opening of doors to the outside environment and the deployment of portable equipment to initiate area cooling. Assessment of these areas for high temperature will be directed by the new FSG procedures.

Seabrook contracted AREVA NP Inc. to determine the total integrated dose to the pool side SFP instrument equipment for reduced SFP inventory conditions. The results of the calculation are documented in FP 700488, "Spent Fuel Pool Instrumentation System Dose Assessment." The 7 day total integrated dose (TID) to the pool side SFP instrument equipment was calculated by Seabrook based on the results of the AREVA analysis with consideration of the shielded that would be provided by the water in the pool during drain down. The TID to the pool side equipment considering worst case normal operation conditions and post event conditions, for no less than 7 days post event is 8.872E6 rad. This TID is bounded by the Westinghouse qualification of pool side SFP instrument equipment to 1E7 rad. This dose calculation is also considered to be conservative since the Seabrook FLEX strategies initiate makeup to the SFP well in advance of inventory loss to Level 3. Therefore, the duration of SFP instrument operation at Level 3 will be much less than the 120.55 hours assumed in the analysis above.

During the onsite audit, the NRC staff reviewed document 1-NHY-300219 and verified that the environmental conditions for temperature, humidity, and radiation in the areas where the equipment located are bounded by the manufacturer equipment qualification.

In its letter dated December 15, 2015 (ADAMS Accession No. ML15356A102), the licensee stated that since the FLEX storage area and portable generators that were used to power the one train of safety-related plant ventilation will not be available, a heat up analysis was performed for the area where the SFP level transmitters and electronics are located (essential switchgear rooms and CEVA). Engineering evaluation EE-15-016, "CEVA and ESWGR Rooms Beyond-Design Basis External Event Ventilation Evaluation," documented the results of the analysis. This evaluation confirmed that during an ELAP event and/or loss of the UHS, area temperature will remain below the 140°F temperature to which Westinghouse qualified the SFP level instrument. The operation of one train of safety-related plant ventilation is no longer required to maintain operation of the SFP level instrument. Since the CEVA and essential switchgear area room temperatures will remain below the equipment qualification when the safety related ventilation fans are not available, the staff concluded that the SFP level instrument equipment are still bounded by the manufacturer equipment qualification.

During the onsite audit, the NRC staff inquired about an assessment of potential susceptibilities of electromagnetic interferences (EMI) and radio-frequency interference (RFI) in the areas where the SFP instruments are located and how the licensee plans to mitigate those susceptibilities. In response, the licensee stated that the Westinghouse supplied SFP level instrument equipment was subjected to EMI/ RFI emissions and susceptibility type testing in accordance with the guidance provided in Regulatory Guide 1.180, Revision 1. The EMI qualification program included tests for low and high frequency radiated susceptibility (magnetic fields), low and high frequency conducted susceptibility, low and high frequency radiated emissions (Electric Field), electrostatic discharge, surge and electrical fast transients. Radiated electromagnetic emissions from the equipment were also measured. Westinghouse identified that the suite of EMI tests and acceptance criteria were established based mainly on the non-safety related classification of the SFP level instrument. A summary of the results of the EMC qualification testing are provided in the following Westinghouse reports:

a. FP700469, Design Verification Testing Summary Report for the Spent Fuel Pool Instrumentation System (EQ-QR-269)

b. FP 700483, SFPIS Standard Product Final Summary Design Verification Report (WNA-TR-03149-GEN)

Based on the results of the EMI qualification testing, Westinghouse confirmed that the SFPIS could only be qualified to the operational requirements for a performance criterion B system. The requirements for performance criterion A ensure that the equipment under test will continue to operate during and after the test. Performance criterion B only requires that the equipment under test continue to operate after the test, but not during the test. Both performance criterion A and B require that there is no degradation or loss of function below the performance level specified by the manufacturer when the equipment is used as intended. For the EMI qualification testing, Westinghouse monitored performance of the system level reading with an acceptance criteria based on the capability to provide level readings within the established accuracy of the system (+/- 3 inches).

The licensee also stated that since the SFP level instrument could not be fully qualified to the operational requirements for performance criterion A due to RFI susceptibility of the probe, Seabrook contracted National Technical Systems to perform EMI/ RFI surveys of the spent fuel building and CEVA areas where the new equipment will be located. The results of the surveys are documented in FP 700466, Evaluation of Spent Fuel Pool Area EMI/ RFI Background Conditions. Comparison of the survey results to the results of the additional EMI testing that was performed by Westinghouse indicates that there are no EMI/ RFI sources in the spent fuel building during normal plant operation that would negatively affect proper operation or the capability to calibrate the SFP level instrument. Since the use of portable transmitters could have an effect on operation of the equipment, administrative controls will be implemented to ensure that radio use within the spent fuel building is precluded during periods when the system is being calibrated and/or level readings are being taken in response to an BDBEE.

Following a discussion with the NRC staff, the licensee initiated AR 02063219 to evaluate and add signs at the entrance doors to the SFP, CEVA, and essential switchgear rooms to identify that radios shall not be used in these areas during an ELAP event. The staff concluded that the licensee's response is acceptable. The licensee has provided an assessment of the potential susceptibilities of EMI/RFI in the areas where the SFP instrument is located and will put signs for exclusion zones to mitigate these susceptibilities during an ELAP event.

Based on the evaluation above, the NRC staff concludes that the licensee's proposed instrument qualification process appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.5 Design Features: Independence

In its OIP, the licensee stated that the backup instrument channel would be redundant to, and independent of, the primary instrument channel. The licensee also stated that independence will be obtained through separation of the sensors, indication, backup battery power supplies, associated cabling and channel power feeds.

In a letter August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that one of the requirements of NRC Order EA-12-051 is that permanently installed SFP instrument channels shall be powered by separate power supplies. To satisfy this requirement, instrument loop L-2616 will be supplied 120 Vac power from Train A diesel backed MCC E515 via an existing spare circuit (CKT 20) in distribution panel E3E. Similarly, Train B diesel backed 120 Vac power from an existing spare circuit in MCC E615 distribution panel E3F (CKT 20) will be used to power instrument loop L-2617. During the onsite audit, the NRC staff reviewed drawing 1-NHY-310002, "Unit Electrical Distribution one Line Diagram," Revision 2, and verified that the 120 Vac power supplies to the primary and the backup SFP level instrument channel are independent so that loss of power supply in one channel will not result in loss of power to the other channel.

The NRC staff concludes that the licensee appears to have adequately addressed the instrument channel independence, including the power sources. With the licensee's proposed power arrangement, the electrical functional performance of each level measurement channel would be considered independent of the other channel, and the loss of one power supply would not affect the operation of other independent channel under beyond-design-basis event conditions. The instrument channel physical separation is discussed in Section 4.2.2 of this SE. Based on the evaluation above, the NRC staff concludes that the licensee's proposed design, with respect to instrument channel independence, appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.6 Design Features: Power Supplies

In its letter dated August 28, 2013 (ADAMS Accession No. ML13247A177), the licensee stated, in part, that:

> Each level measurement channel will be powered by an independent emergency DG backed power source. The primary level channel will be powered from the 120 Vac distribution panel for MCC 615 (Train "B"). The backup level channel will be powered from the 120 Vac distribution panel for MCC 515 (Train "A"). On a loss of offsite power MCC 615 and MCC 515 are powered from separate independent emergency DGs. In the event that the primary or backup power source from these panels are unavailable the respective channel UPS will automatically swap from 120 Vac to the battery backup power supply. Battery sizing will be in accordance with IEEE 485-2010. The design criteria for each channel will assume continuous level measurement system operation for at least 72 hours following a loss of the normal ac power source. Calculation of system power consumption will be based on the specified values listed in component manufacturer specifications. Margin will be added to the battery sizing calculations, following the guidelines of IEEE 485-2010, Section 6.2.2. The specified 72 hour battery mission time will provide ample margin to allow the implementation of Phase II FLEX actions as described in Section IX of the Overall Integrated Plan. The 72 hour battery life will be tested and verified during the factory acceptance test or site acceptance test prior to final acceptance of the system.

During the audit, the NRC staff reviewed drawing 1-NHY-310002, "Unit Electrical Distribution one Line Diagram," Revision 2, and verified that the 120 Vac power supplies to the primary and the backup SFP level instrument channels are independent so that loss of power supply in one channel will not result in loss of power to the other channel. The staff also performed an audit at the Westinghouse facility and concluded that the battery backup duty cycles are acceptable. NEI 12-02 specifies that electrical power for each channel be provided by different sources and that all channels have the capability of being connected to a source of power independent of the normal plant power systems. The NRC staff reviewed the SFP level power supply configuration and noted that upon a loss of normal power, the UPS arrangement would provide power for level indication until the power is restored by portable generators provided from Order EA-12-049.

The NRC staff concludes that the licensee's proposed power supply design appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.7 Design Features: Accuracy

In its OIP, the licensee stated that:

> The instrument channels will be designed such that they will maintain their design accuracy following a power interruption or change in power source without recalibration. Channel accuracy will consider SFP conditions, e.g., saturated water, steam environment, or concentrated borated water.

> Additionally, instrument channel accuracy will be sufficient to allow trained personnel to determine when the actual level exceeds the key spent fuel pool water levels (Levels 1, 2 and 3) without conflicting or ambiguous indication. The accuracy will be within the resolution requirements of Figure 1 of NEI 12-02.

In its letter dated August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that:

> Westinghouse documents WNA-CN-00301-GEN, "Spent Fuel Pool Instrumentation System Channel Accuracy Analysis," Revision 1, and WNA DS 02957-GEN, "Spent Fuel Pool Instrumentation System Design Specification," Revision 4, describe the channel accuracy under both (a) normal SFP level conditions and (b) at the beyond-design-basis conditions that would be present if SFP level were at Level 2 and Level 3 datum points. The overall channel accuracy for the SFP level indication was established by Westinghouse based on individual component accuracies using the SRSS methodology as stated in ISA RP67.04.02-2010, "Methodologies for the Determination of Setpoints for Nuclear Safety Related Instrumentation." Each instrument channel will be accurate to within +/- 3 inches during normal SFP level conditions. The instrument channels will retain this accuracy during and following an BDBEE. This accuracy is within the ±1 foot channel accuracy requirements of the order.

The staff noted that the licensee appears to have adequately addressed instrument channel accuracy through a combination of statements in the OIP and in the FIP. The 3 in. design accuracy is more conservative than the 1-foot accuracy specified by NEI 12-02 for SFP Level 2 and Level 3. With the licensee's proposed design and controls, the instrument channels should maintain their accuracy during both normal and beyond-design-basis event conditions.

Based on the evaluation above, the NRC staff concludes that the licensee's proposed instrument accuracy appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately addresses the requirements of the order.

4.2.8 Design Features: Testing

In its OIP, the licensee stated that instrument channel design would provide for routine testing and calibration consistent with Order EA-12-051 and the guidance in NEI 12-02.
In its letter dated August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that:

> Westinghouse calibration procedure WNA-TP-O4709-GEN, "Spent Fuel Pool instrumentation System Calibration Procedure," Revision4, describes the capabilities and provisions for periodic verification and calibration of the SFP level instrument, including in-situ testing. Seabrook will utilize the methodology provided in the Westinghouse calibration procedure in plant procedures for the functional check at the pool side bracket. The level displayed by the SFP level instrument channels will be verified every 24 hours as part of Nuclear System Operator (NSO) rounds. This verification will compare level readings from the SFP level instrument channels to the existing control room SFP level indication

> (1-SF-LI-2607). Channel maintenance, including channel calibration(s), will be initiated if the deviation between indicated level readings exceeds the bounding 3.0 inch uncertainty of SFP level readings between the existing SFP level indicator (1-SF-LI-2607, +/- 2 in.) and the new SFP level instrument indicators (+/- 3 in).
>
> Procedures developed by Seabrook will follow the guidance provided in Westinghouse calibration procedure WNATP-O4709-GEN. Calibration will be performed once per refueling cycle within 60 days of a planned refueling outage considering normal testing scheduling allowances (e.g. 25%). This frequency is in compliance with the NEI 12-02 guidance for SFPI. New I&C maintenance procedures will be written to incorporate the Westinghouse calibration methods. Standard checks will also be completed as part of the calibration to ensure that the SFP level instrument channels are operating properly. These checks will include verification of the power supply performance, transmitter waveform inspection, cleaning of or damage. Calibration procedure implementation will be tracked as a preventive maintenance activity under the work control program.
>
> The level displayed by the SFP level instrument channels will be verified every 24 hours as part of NSO rounds as described above. Channel maintenance or calibrations that result from unacceptable deviations in level indications will be tracked by the corrective action program and associated maintenance activities under the work control program. Seabrook will develop preventive maintenance tasks for the SFP level instrument per Westinghouse recommendations identified in the technical manual WNA-GO-OO127-GEN to assure that the channels are fully accurate and reliable to perform their functions.

In accordance with the licensee's OIP and its letters, the NRC staff noted that by comparing the levels in the instrument channels and the maximum level allowed deviation, the operators could determine if recalibration or troubleshooting is needed. The staff also noted that the licensee's proposed design has the ability to be tested and calibrated in-situ, consistent with the provision of NEI 12-02. The NRC staff concludes that the licensee's proposed SFPI design and testing appears to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.2.9 Design Features: Display

In its OIP, the licensee stated that:

> The location for primary and backup SFP level indication will be accessible during and following an event. The operator indication (primary and backup indication) will be provided in the Train A and Train B essential switchgear rooms (Elev. 21 ft., 6 in.) which are located in the seismic Category I control building. The Train A and Train B essential switchgear rooms are in close proximity to the main control room and emergency planning technical support center located on elevation 75 ft. of the control building.

In its letters August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that:

> Seabrook procedure SM 7.20, "Control of Time Critical Actions and Operator Response Times," established a conservative 2 minute transit time for an operator to travel from the control room to the Train B essential switchgear room. The Train A essential switchgear room is directly adjacent to the Train B switchgear room. Conservatively assuming a 1 minute transit time between the essential switchgear rooms and 5 minutes to read and communicate the SFP level reading to the control room, the maximum time to achieve a SFP level reading from the control room is conservatively assumed to be 8 minutes. This time is considered to be reasonable with respect to the requirement for prompt accessible indication of SFP level indications.
>
> The plant service environment chart (Doc. 1-NHY-300219) summarizes the environmental conditions for the essential switchgear rooms where the SFPI displays will be located. The calculation supports the noted environmental conditions for radiation, pressure, and humidity. Radiological conditions will not prevent access to the indication. The 60 year TID for the area is specified as 1.5E3 rad. (2.85 mrad/hr.). The maximum relative humidity specification for the area is 60%. The specified normal conditions are not expected to change in these areas as a result of an ELAP event.

During the onsite audit, the NRC staff walked down and verified that the SFP level instrument display locations should be promptly accessible and should remain habitable. Guidance Document NEI 12-02 specifies that the SFP level indication be displayed at an appropriate and accessible location. An appropriate and accessible location shall include: occupied or promptly accessible to the appropriate plant staff, outside of the area surrounding the SFP floor, inside a structure providing protection against adverse weather, and outside of any high radiation areas during normal operation. Since the licensee has installed the indicators in an appropriate and accessible location where they are able to be monitored by trained personnel, the staff concludes that the licensee's proposed display location appears to be acceptable.

Based on the evaluation above, the NRC staff concludes that the licensee's proposed location and design of the SFPI displays appear to be consistent with NEI guidance, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.3 Evaluation of Programmatic Controls

Order EA-12-051 specified that the SFPI shall be maintained available and reliable through appropriate development and implementation programmatic controls, including training, procedures, and testing and calibration. Below is the NRC staff's assessment of the programmatic controls for the SFPI.

4.3.1 Programmatic Controls: Training

In its OIP, the licensee stated that:

> A SAT will be used to evaluate what training is required for station personnel based upon changes to the plant equipment, implementation of FLEX portable equipment, and new or revised procedures that result from implementation of the strategies described in this report.

Guidance document NEI 12-02 specifies that the SAT process can be used to identify the population to be trained, and also to determine both the initial and continuing elements of the required training. Based on the licensee's OIP statement above, the NRC staff concludes that the licensee's plan to train personnel in operation, maintenance, calibration, and surveillance of the SFPLI, including the approach to identify the population to be trained appears to be consistent with NEI 12-02, as endorsed by JLD-ISG-2012-03, and appears to adequately address the requirements of the order.

4.3.2 Programmatic Controls: Procedures

In its OIP, the licensee stated that:

> Procedures will be developed using guidelines and vendor instructions to address the maintenance, operation, and abnormal response issues associated with the new SFP instrumentation.

In its August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that:

> Modification review process will be used to ensure all necessary procedures are developed for maintaining and operating the spent fuel level instruments after installation. These procedures will be developed in accordance with NextEra procedural controls. The objectives of each procedural area are described below:
>
> - Inspection, Calibration and Testing - Guidance on the performance of periodic visual inspections, as well intrusive testing, to ensure that each SFP channel is operating and indicating level within its design accuracy.
> - Preventative Maintenance - Guidance on scheduling of, and performing, appropriate preventative maintenance activities necessary to maintain the instruments in a reliable condition.
> - Maintenance - To specify troubleshooting and repair activities necessary to address system malfunctions.
> - Programmatic Controls - Guidance on actions to be taken if one or more channels are out of service.
> - System Operations - To provide instructions for operation and use of the system by plant staff.
> - Response to Inadequate Levels - Action to be taken on observations of levels below normal level will be addressed on-site using off normal procedures and /or FSGs.

The licensee further stated that Westinghouse calibration procedure WNA-TP-04709-GEN describes the capabilities and provision for periodic testing and calibration of the SFP level instrument, including in-situ testing. Seabrook utilized the methodology described in the Westinghouse calibration procedure for the functional channel checks at the pool side bracket and channel calibrations. The following procedures have been developed to maintain the system:

- SF-L-2616-CAL-1, Train A Spent Fuel Pool Level (BDB) Calibration - every year
- SF-L-2616-BR-1, Train A SFP Level 1-SF-CP-300 - Battery A replacement every 3 years
- SF-L-2616-MAN-2, Train A SFP Level Power Supply 1-SF-UQ-2616 - Replacement every 10 years
- SF-L-2617-CAL-1, Train B Spent Fuel Pool Level (BDB) - Calibration every year
- SF-L-2617-BR-1, Train B SFP Level 1-SF-CP-300 - Battery B replacement every 3 years
- SF-L-2617-MAN-1, Train B SFP Level XMTR 1-SF-LIT-2617 - Replacement every 7 years
- SF-L-2617-MAN-2, Train B SFP Level Power Supply 1-SF-UQ-2617 - Replacement every 10 years

During the onsite audit, the licensee provided a sample of procedures identified to date. The NRC staff reviewed these procedures and noted that they were developed using the guidelines and vendor instructions to address the testing, calibration, maintenance, operation and abnormal response, in accordance with the provisions of NEI 12-02.

The NRC staff concludes that the licensee's proposed procedure development appears to be consistent with NEI 12-02 guidance, as endorsed by JLDISG-2012-03, and appears to adequately address the requirements of the order.

4.3.3 Programmatic Controls: Testing and Calibration

In letter August 27, 2015 (ADAMS Accession No. ML15245A338), the licensee stated that:

> SFPI channel/equipment maintenance/preventative maintenance and testing program requirements to ensure design and system readiness will be established in accordance with NextEra's processes and procedures. The design modification process will take into consideration the vendor recommendations to ensure that appropriate regular testing, channel checks, functional tests, periodic calibration, and maintenance is performed (and available for inspection and audit).
>
> Once the maintenance and testing program requirements for the SFP are determined, the requirements will be documented in maintenance program documents.

Performance checks, described in the vendor operator's manual, and the applicable information will be contained in plant procedures. Operator performance tests will be performed periodically as recommended by the vendor.

Channel functional tests with limits established in consideration of vendor equipment specifications will be performed at appropriate frequencies.

Channel calibration tests per maintenance procedures with limits established in consideration of vendor equipment specifications are planned to be performed at frequencies established in consideration of vendor recommendations.

Both primary and backup SFPI channels incorporate permanent installations (with no reliance on portable, post-event installation) of relatively simple and robust augmented quality equipment. Permanent installation coupled with stocking of adequate spare parts reasonably diminishes the likelihood that a single channel (and greatly diminishes the likelihood that both channels) will be out-of-service for an extended period of time. Planned compensatory actions for unlikely extended out-of-service events are summarized as follows:

If one channel is out of service, initiate actions to restore channel to functional status within 90 days. If channel restoration is not expected to be completed within 90 days, initiate compensatory action. If 2 channels are out of service, initiate action to restore at least one channel to functional status within 24 hours. Implement compensatory actions within 72 hours. Compensatory action includes to initiate an evaluation in accordance with the corrective action program. The evaluation shall initiate compensatory actions to implement an alternate method of monitoring and schedule required actions for restoring the instrumentation channel(s) to functional status.

Guidance document NEI 12-02 contains provisions for the establishment of processes that will maintain the SFP level instrument at their design accuracy. It also contains provisions for the control of surveillance and out-of-service time for each channel. Based on the licensee's OIP and compliance letter, the NRC staff concludes that the licensee's proposed testing and calibration processes a consistent with vendor recommendations and the provisions of NEI 12-02. Further, the licensee's proposed restoration actions and compensatory measures for the instrument channel(s) being out-of-service appear to be consistent with NEI 12-02.

Based on the evaluation above, the NRC staff concludes that the licensee's proposed testing and calibration plan appear to be consistent with NEI 12-02 guidance, as endorsed by JLD-ISG-2012-03, and appear to adequately address the requirements of the order.

4.4 Conclusions for Order EA-12-051

In its letter dated December 15, 2015 (ADAMS Accession No. ML15356A102), the licensee stated that they would meet the requirements of Order EA-12-051 by following the guidelines of NEI 12-02, as endorsed by JLD-ISG-2012-03. In the evaluation above, the NRC staff concludes that, if implemented appropriately, the licensee has conformed to the guidance in NEI 12-02, as endorsed by JLD-ISG-2012-03. In addition, the NRC staff concludes that if the SFPLI is installed at Seabrook according to the licensee's proposed design, it should adequately address the requirements of Order EA-12-051.

5.0 CONCLUSION

In August 2013 the NRC staff started audits of the licensee's progress on Orders EA-12-049 and EA-12-051. The staff conducted an onsite audit in July 2015 (ADAMS Accession No. ML15278A200). The licensee reached its final compliance date on July 26, 2016 (ADAMS Accession No. ML16214A244), and has declared that both of the reactors are in compliance with the orders. The purpose of this safety evaluation is to document the strategies and implementation features that the licensee has committed to. Based on the evaluations above, the NRC staff concludes that the licensee has developed guidance and proposed designs that if implemented appropriately should adequately address the requirements of Orders EA-12-049 and EA-12-051. The NRC staff will conduct an onsite inspection to verify that the licensee has implemented the strategies and equipment to demonstrate compliance with the orders.

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Date: December 1, 2016

By letter dated March 26, 2014 (ADAMS Accession No. ML14083A620), the NRC notified all licensees and construction permit holders that the staff is conducting audits of their responses to Order EA-12-051 in accordance with NRC NRR Office Instruction LIC-111, similar to the process used for Order EA-12-049. By letter dated December 15, 2015 (ADAMS Accession No. ML15356A102), NextEra submitted a compliance letter in response to Order EA-12-051. The compliance letter stated that the licensee had achieved full compliance with Order EA-12-051.

The enclosed safety evaluation provides the results of the NRC staff's review of NextEra's strategies for Seabrook. The intent of the safety evaluation is to inform NextEra on whether or not its integrated plans, if implemented as described, appear to adequately address the requirements of Orders EA-12-049 and EA-12-051. The staff will evaluate implementation of the plans through inspection, using Temporary Instruction 191, "Implementation of Mitigation Strategies and Spent Fuel Pool Instrumentation Orders and Emergency Preparedness Communications/Staffing/ Multi-Unit Dose Assessment Plans" (ADAMS Accession No. ML14273A444). This inspection will be conducted in accordance with the NRC's inspection schedule for the plant.

If you have any questions, please contact Jason Paige, Orders Management Branch, Seabrook Project Manager, at Jason.Paige@nrc.gov.

Sincerely,

/RA/

Mandy K. Halter, Acting Chief
Orders Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No.: 50-443

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